

# How My Predictions Are Faring

---

Ray Kurzweil  
October 2010

# TABLE OF CONTENTS

Overview .....	1
Predictions made for 2009 in <i>The Age of Spiritual Machines</i>	
The Computer Itself .....	11
Education .....	34
Disabilities .....	45
Communication.....	50
Business and Economics.....	68
Politics & Society .....	84
The Arts .....	91
Warfare .....	102
Health & Medicine.....	110
Philosophy.....	120
Predictions made in <i>The Age of Intelligent Machines</i> .....	124
<i>The Singularity is Near</i>	
Predictions for 2010.....	129
<i>The Singularity is Near: Graphs</i> .....	135
<i>Library Journal</i> Predictions .....	146



## OVERVIEW

### How my predictions are faring

In this essay I review the accuracy of my predictions going back a quarter of a century. Included herein is a discussion of my predictions from *The Age of Intelligent Machines* (which I wrote in the 1980s), all 147 predictions for 2009 in *The Age of Spiritual Machines* (which I wrote in the 1990s), plus others. Perhaps my most important predictions are implicit in my exponential graphs. These trajectories have indeed continued on course and I discuss these updated graphs below.

My core thesis, which I call the “law of accelerating returns,” is that fundamental measures of information technology follow predictable and exponential trajectories, belying the conventional wisdom that “you can’t predict the future.” There are still many things — which project, company or technical standard will prevail in the marketplace, or when peace will come to the Middle East — that remain unpredictable, but the underlying price/performance and capacity of information is nonetheless remarkably predictable. Surprisingly, these trends are unperturbed by conditions such as war or peace and prosperity or recession.

The quintessential example of the law of accelerating returns is the perfectly smooth, doubly exponential growth of the price/performance of computation, which has held steady for 110 years through two world wars, the Cold War, the Great Depression, the collapse of the Soviet Union, the re-emergence of China, and other notable events of the late nineteenth, twentieth and early twenty-first centuries.

Some people refer to this phenomenon as “Moore’s law,” but that is a misconception. Moore’s law (which states that you can place twice as many components on an integrated circuit every two years and they run faster because they are smaller) is just one paradigm among many. It was the fifth, not the first, paradigm to bring exponential growth to the price/performance of computing.

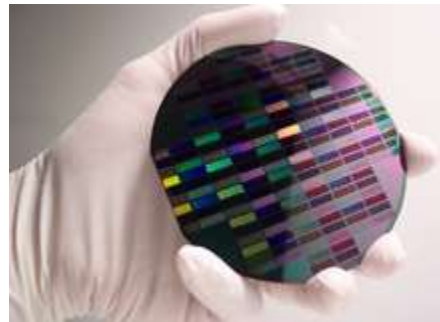
The exponential rise of computation started with the 1890 U.S. census (the first to be automated), decades before Gordon Moore was even born. In my 2005 book, *The Singularity is Near*, I provide this graph through 2002, and I update it through 2008, below. The smoothly predictable trajectory has continued, even through the recent economic downturn.

Computation is the most important example of the law of accelerating returns (LOAR), because of the amount of data we have for it, the ubiquity of computation, and its key role in ultimately revolutionizing everything we care about. But it is far from the only example. Once a technology becomes an information technology, it becomes subject to the LOAR.

Biomedicine is becoming the most important area of technology and industry to be transformed in this way. Progress has historically been based on accidental discoveries, so progress has been linear, not exponential. This has still been useful: life expectancy has grown from age 23 as of one thousand years ago, to age 37 as of two hundred years ago, to close to age 80 today.

However, medicine and human biology have just undergone a grand transformation to become an information technology. We have gathered the software of life: the genome. The human genome project itself was perfectly exponential, with the amount of genetic data doubling and the cost per base-pair coming down by half each year since the project was initiated in 1990.

*(Right) This wafer, developed by BioNanomatrix, contains nano-sized channels for analyzing DNA molecules. The wafer contains many nanoanalyzer chips, each lined with 50,000 channels. (Photo courtesy of BioNanomatrix)*



We now have the ability to design biomedical interventions on computers and to test them on biological simulators, the scale and precision of which are also doubling every year.

Now we can also update this obsolete software: RNA interference can turn genes off and new forms of gene therapy can add new genes, not just to a newborn but to a mature individual. The spatial resolution of brain scanning and the amount of data on the brain we are gathering are also doubling each year.

There are many other manifestations of this integration of biology and information technology, as we move beyond genome sequencing to genome synthesizing.

### **More references**

*Wired* magazine | [“DNA Technology Posts Dramatic Speed Increases”](#)

Xconomy news | [“Sequencing DNA for less than \\$100 in under an hour”](#)

MIT *Technology Review* | [“The \\$100 Genome”](#)

Another information technology that has seen smooth exponential growth is our ability to communicate with each other and transmit vast repositories of human knowledge. There are many ways to measure this. [Cooper's law](#), which states that the total bit capacity of wireless communications in a given amount of radio spectrum doubles every 30 months, has held true since Marconi used the wireless telegraph for Morse code transmissions in 1897, to today's [4G communications](#) technologies. According to Cooper's law, the amount of information that can be transmitted over a given amount of radio spectrum has been doubling every 2.5 years for more than a century.

Other examples include the number of nodes on the Internet and the number of bits per second transmitted on the Internet, which are both doubling each year.

### More references

*NewScientist* magazine | "[Exploring the Exploding Internet: growing at a remarkable speed since inception](#)"

PhysOrg | "[Internet Growth Follows Moore's Law Too](#)"

I examine these and many other examples, manifestations, and implications of the law of accelerating returns in *The Singularity is Near (SIN)*. Below, I've updated these graphs, demonstrating how these trends have continued unabated in the six years since the graphs in *SIN* were compiled. The reason that I became interested in trying to predict certain aspects of technology is that I realized about 30 years ago that the key to being successful as an inventor (a profession I adopted when I was five years old) was timing. Most inventions and inventors fail, not because they are unable to get their gadgets to work, but because their timing is wrong, either introducing their innovation before all of the enabling factors are in place, or too late, missing the window of opportunity.

Being an engineer, I started to gather data on measures of technology in different areas. When I began this effort, I did not expect that this study would present a clear picture, but I hoped that it would provide some guidance and enable me to make educated guesses. My goal was — and still is — to time my own technology projects so that they will be appropriate for the world that exists when I complete the projects — which I realized would be very different from the world that existed when I started.

Consider how much the world has changed recently. Just a few years ago, people did not use social networks (Facebook, for example, was founded in 2004 and now has over 800 million active users), wikis, blogs, or tweets. Most people did not use search engines or cell phones in the 1990s. Imagine the world without social networks, wikis, blogs, tweets, cell phones, and search engines. That sounds like ancient history, but that was not so long ago. The world will change even more in the near future.

In the course of this investigation, which began three decades ago, I made a startling discovery: if a technology is an information technology, the basic measures of price/performance and capacity (per unit of time or cost, or other resource) follow amazingly precise exponential trajectories.

These trajectories outrun the specific paradigms they are based on (such as Moore's law). But when one paradigm runs out of steam (for example, when engineers were no longer able to reduce the size and cost of vacuum tubes in the 1950s), it creates research pressure to create the next paradigm, and so another S-curve of progress begins.

The exponential portion of that next S-curve for the new paradigm then continues the ongoing exponential of the information technology measure. So vacuum-tube-based computing in the 1950s gave way to transistors in the 1960s, and then to integrated circuits and Moore's law in the late 1960s, and beyond. Moore's law, in turn, will give way to three-dimensional computing, the early examples of which are already in place.

(Right) A map of the Internet in 2009. (Image courtesy of the [Internet Mapping Project](#), Bell Labs/Lumeta Corp.)



My law of accelerating returns (LOAR) forms the basis and fundamental thesis for my three books on the future of technology (*The Age of Intelligent Machines*, *The Age of Spiritual Machines*, and *The Singularity is Near*) and two health books co-authored with Terry Grossman, M.D. (*Fantastic Voyage* and *TRANSCEND*).

However, the primary application of the LOAR, in terms of my own career, remains the timing of my specific technology projects.

We might wonder, are there fundamental limits to our ability to compute and transmit information, regardless of paradigm? The answer is yes, based on our current understanding of the physics of computation. There are limits, but they are not very limiting. Ultimately we can expand our intelligence trillions fold based on molecular computing. By my calculations, we will reach these limits late in this century.

It is important to point out that not every exponential phenomenon is an example of the law of accelerating returns. Some observers misconstrue the LOAR by citing exponential trends that are not information-based: for example, how men's shavers have gone from one blade to two to four, and then asking, where are the eight-blade shavers? Shavers are not (yet) an information technology.

The LOAR does not apply to non-information technologies, but does apply to information technologies such as computing, the Internet, the understanding of the genome and the brain. The reason information technologies are able to consistently transcend the limitations of any particular paradigm is that the resources required to compute or remember or transmit a bit of information are vanishingly small.

In *SIN*, I provide a theoretical examination, including a mathematical treatment of why the LOAR is so remarkably predictable. Essentially, we always use the latest technology to create the next: technologies build on themselves in an exponential manner, and this phenomenon is readily measurable if it involves an information technology. More broadly speaking, this acceleration and exponential growth applies to any process in which patterns of information evolve. So, we see acceleration in the pace of biological evolution, and similar (but much faster) acceleration in technological evolution, which is itself an outgrowth of biological evolution.

I now have a public track record of more than a quarter of a century of predictions based on the law of accelerating returns, starting with the book *The Age of Intelligent Machines* (*AIM*), which I wrote in the mid-1980s.

Examples of accurate predictions from that book include: the emergence in the 1990s of a vast, worldwide web of communications tying together people around the world to each other and to all human knowledge; a great wave of democratization emerging from this decentralized communication network, sweeping away the Soviet Union; the defeat of the world chess champion by 1998; and many other timely predictions. I discuss these predictions from *AIM*, below.

I described the law of accelerating returns, as it is applied to computation, extensively in *The Age of Spiritual Machines* (*ASM*), a book I wrote in the mid to late 1990s. On pages 22-24, I provided a century of data showing the doubly exponential progression of the price/performance of computation through 1998. I updated this graph through 2002 in *SIN*, and through 2008 in this essay.

*ASM* included hundreds of predictions for specific decades (2009, 2019, 2029, and 2099). With 2009 now concluded, some observers have commented on my 2009 predictions from *ASM*. Many of these are reasonable reviews. However, a few critics have distorted the accuracy of my predictions in a number of ways. The most interesting type of misrepresentation is the critics' selection bias.

As I discuss in detail below, I made 147 predictions for 2009 in *ASM*, which I wrote in the 1990s. Of these, 115 (78 percent) are entirely correct as of the end of 2009, and another 12 (8 percent) are "essentially correct" (see below) — a total of 127 predictions (86 percent) are correct or essentially correct. Another 17 (12 percent) are partially correct, and 3 (2 percent) are wrong.

So, it is easy to focus on the few predictions that were incorrect, excluding the majority of predictions — which were accurate — and craft a biased analysis. This selection bias may be combined with a misunderstanding of what the prediction meant in the first place, or ignorance of the current situation, resulting in citing an accurate prediction as inaccurate. For example, one commentator lists only three accurate predictions and cites five that are "false," leaving out almost all of the 127 predictions that are accurate or essentially accurate.



Of these “false” predictions, a number are, in fact, true. The remaining are only a few years away, and I consider them “essentially correct,” given that these predictions were specified by decades (not years) in *ASM*. More about this point, below.

An example of a prediction that was cited as “false” when it is, in fact, true is, “Personal computers are available in a wide range of sizes and shapes, and are commonly embedded in clothing and jewelry.” When I wrote this prediction in the 1990s, portable computers were large heavy devices carried under your arm.

Today, they are indeed embedded in shirt pockets, jacket pockets, and hung from belt loops. Colorful iPod nano models are worn on blouses as jewelry pins or on a sleeve while running, health monitors are woven into undergarments, computers are built into hearing aids, and there are many other examples. The prediction does not say that all computers would be small devices integrated in these ways, just that this would be “common,” which is indeed the case. And “personal computers” should not be restricted to the marketing category we happen to call “personal computers” today.

All of these devices (iPods, smartphones, etc.) are in fact sophisticated “computers” and are “personal,” meaning they serve the needs of individuals. It is not appropriate to use today’s marketing categories to interpret the meaning of these earlier predictions. By a reasonable interpretation of the prediction and the current reality, the prediction is correct.

“Most portable computers will not have keyboards” is listed by this same observer as “false.” When I wrote this more than a decade ago, every portable computer had an (alphanumeric) keyboard. Today, the majority of portable computers such as MP3 players, cameras, phones, tablets, game players and many other varieties indeed do not have keyboards. The full quote of my prediction makes it clear that I am referring to computerized devices that “make phone calls, access the Web, monitor body functions, provide directions, and provide a variety of other services.”

Another observer cites my prediction that “there will be computer displays that project images directly onto the eyes” as “false.” The prediction did not say that all displays would be this way or that it would be the majority, or even common. There are indeed wearable displays, such as those made in the United States by [Microvision](#) for both [military](#) and other [mobile applications](#).



In Japan, companies like [Brother](#) and [NEC](#) have already been producing different series of wearable displays that are available to consumers. [Virtual retinal displays](#), initially developed for military use, have been deployed by several military units, such as the [U.S. Army’s Stryker Brigade](#), for several years.

*(Left) NEC’s “Tele Scouter” Retinal Imaging Display uses glasses and lasers to send images to the retina. (Photo courtesy of NEC)*



Beyond virtual retinal displays, [Stanford University researchers](#) are also developing a new generation of retinal implants that allow blind people to see and that could also enhance normal human vision.

This same observer said that “three-dimensional chips are commonly used” was “false.” But it is not false. While not yet commonly used in all chips, most semiconductors fabricated today for [MEMS and CMOS image sensors](#) are in fact 3D chips, using vertical stacking technology.

These first 3D circuits were developed by [Matrix Semiconductor](#) (now SanDisk) in 2001, [Tachyon Semiconductor](#) in 2002, [MagnaChip Semiconductor and Tezzaron Semiconductor](#) in 2004, and [Ziptronix and Raytheon in 2007](#).

In December 2010, Samsung [announced](#) a new 8GB dual inline memory module (DIMM) that stacks memory chips on top of each other using “[through silicon via](#)” (TSV), which increases the density of the memory by 50% compared to conventional DIMM technology.

Using the TSV technology will also improve speed, while reducing power consumption. The TSV technology creates micron-sized holes through the chip silicon vertically instead of just horizontally, creating a much denser architecture. The chips are likely to be generally available to equipment manufacturers by the end of 2011.

IBM is also developing 3D microchips with stacked cores capable of higher data transfer rates with less heat and required energy. Semtech Corp. is [working with IBM](#) and its 3D through-silicon via (TSV) technology to develop a high-performance ADC/DSP platform. The proposed device has applications in fiber optic telecommunications, high performance RF sampling and filtering, test equipment and instrumentation, and sub-array processing for phased array radar systems.

TSV 3D technologies are expected to be used for [memory in 2012 and microprocessors in 2014](#). Analysts predict that by 2015, 3D chips with TSVs will be [6% of the overall semiconductor market](#).

The existence of “translating telephone technology” (speech-to-speech translation) by 2009 has been cited as incorrect. I have been demonstrating a prototype of a translating telephone since 2008, but as of June 2009, there were no translating telephones commercially available.

(Right) The Jibbigo Spanish-English voice translator app for iPhone (Photo courtesy of Mobile Technologies, LLC)

However, just a few months later, in December 2009, translating telephone applications were not only available, but among the most popular applications for BlackBerry, Symbian, iPhone, and Android phones.

[Sakhr Software](#) launched its first real-time, spoken Arabic translator for BlackBerry and iPhone systems in June 2009, followed by the [Jibbigo](#) two-way Spanish-English voice translator for iPhones in October 2009, and its Japanese-English, Chinese-English, and Iraqi-English versions in 2010.



I suppose one could argue how “common” the use of speech-to-speech translation is today, but it is already a popular application. For example, Jibbigo became the number one iPhone app in Japan just a few days after its official launch in Tokyo. Translating telephone technology is likely to become quite popular on many smartphones worldwide in 2010.

In Japan, NEC is developing [Tele Scouter](#), a head-mounted optical display that will also work as a universal translator, scheduled for commercial release in late 2010. My prediction was that speech-to-speech would be “commonly used,” not that it would be ubiquitous.

The \$4.99 Word Lens iPhone app from [QuestVisual](#) uses optical character recognition to identify words in an image and translate them, and then draw them back on the screen. It currently offers only English to Spanish and Spanish to English translation. Other languages are planned.

### More references

*Los Angeles Times* | [“Need a translation? Google awaits your call”](#)

*The New York Times* | [“I, Translator”](#)

The status of these predictions changes very quickly. In November 2009, the idea of large-vocabulary, continuous, speaker-independent speech recognition using a cell phone appeared to some observers as still far off in the future.

Just one month later, this became the most popular free app for the iPhone ([Dragon Dictation from Nuance](#), which used to be Kurzweil Computer Products, my first major company) as well as the popular [Google Mobile App](#) on iPhone, Blackberry, and Nokia S60 mobile phones, and on Google Nexus One and other Android phones.

Just a few days after its official launch, the Dragon app made it to the top rankings in [Gizmodo's Essential iPhone Apps "Best of 2009"](#) and the [Chorus Community top iPhone apps in December 2009](#), as reported by CNET News.

Another prediction that has been cited as wrong is "Warfare is dominated by unmanned intelligent airborne devices." This prediction is certainly true in Afghanistan and recently in America's undeclared war in Pakistan. As *Wired* recently noted, "The unmanned air war... has escalated under McChrystal's watch." UAVs (unmanned aerial vehicles) were also commonly used in the second Iraq war, and countries like [Israel](#) are using them regularly for their own military operations, among [many other nations](#).

One critic cites my prediction that "by 2009, a top supercomputer would be capable of performing 20 petaflops (quadrillion operations per second)" and dismisses my contention that this is "off by a few years," saying it is "not just a little bit wrong, but wildly, laughably wrong."

*(Below) IBM's 20 petaflop Sequoia supercomputer, to be delivered to Lawrence Livermore National Laboratory in 2011, runs nearly 8 times faster than the world's current fastest supercomputer, the Chinese Tianhe-1A system. (Photo courtesy of IBM)*



Yet, [IBM's 20 petaflop Sequoia supercomputer](#) is already under construction and IBM has announced that it will begin operation in 2012. The Sequoia supercomputer is the latest of the [Blue Gene series by IBM](#), dedicated to exploring the frontiers in supercomputing.

As noted, of the 147 predictions for 2009 in *ASM*, 115 (78 percent) were entirely correct by the end of 2009, and an additional 12 (8 percent) are what I would call "essentially correct," for a total of

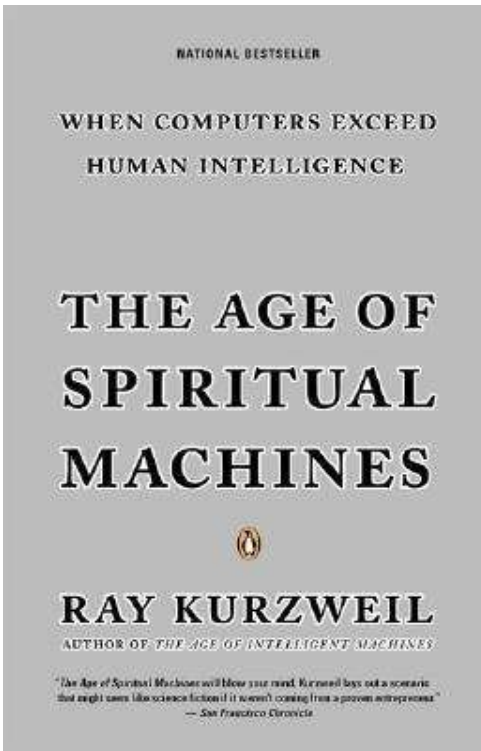
127 predictions (86 percent) out of 147 that are correct or essentially correct. Also, my predictions in *ASM* were specified by decades.

When I make these predictions, my critics are not saying that they are off by a few years; they are saying that they are off by decades or centuries, or will never happen. I make this very point in my forthcoming movie *The Singularity is Near: A True Story About the Future*.

One of my key (and consistent) predictions is that a computer will pass the Turing test by 2029. The [first long-term prediction](#) on the [Long Now Foundation website](#) is a bet that I have with Mitch Kapor regarding this prediction. Mitch and I put up \$20,000 in 2002, and this amount plus interest will go to the foundation of the winner's choice. I will win if a computer passes the Turing test by 2029 (and we have elaborate rules that we negotiated for how to implement the Turing test), and Mitch will win if that does not happen.

In the movie, I create an AI-based avatar named Ramona; she fails the test in 2029 and Mitch wins the bet. However, she goes on to pass the test in 2033. If that is indeed what happens in the future, whose vision of the future can we say was correct?

From a strictly literal point of view, and in terms of the rules of the bet, Kapor will have won the wager. The money will go to his foundation, not mine. But Kapor's critique is not that "Kurzweil's prediction of a computer passing the Turing test in 2029 is ridiculous, it won't happen until 2033." Rather he is implying that I am off by centuries if it ever happens at all.



My point is that if a computer passes the Turing test by 2033, rather than 2029, then it will still be my vision of the future that is "essentially correct." And so it is with the 12 predictions out of 147 that I made in ASM that are likely to come true in the next year or couple of years. By my calculation, 127 out of 147 predictions (86 percent) are either correct or essentially correct.

In the rest of this essay, I will examine the specific predictions that I made for 2009 in *The Age of Spiritual Machines*, followed by the predictions I made for the 1990s and 2000s in *The Age of Intelligent Machines*, followed by an examination of the exponential trajectories of information technologies discussed in *The Singularity is Near*, and how they have continued since that book was written in 2004 and published in 2005. I conclude with a set of predictions I made for the emergence of e-books and e-readers, in a series of essays I wrote in 1992 and 1993 for the *Library Journal*.

## THE COMPUTER ITSELF

### Predictions made for 2009 in *The Age of Spiritual Machines*

The following is an analysis of predictions for 2009 made about the future of computing in the book *The Age of Spiritual Machines*, which was written in the mid to late 1990s.

#### 1. Computers | The rise & ubiquity of portable computers

**PREDICTION:** Individuals primarily use portable computers.

**ACCURACY:** Correct

**DISCUSSION:** When this prediction was written, computers were primarily desktop systems. Today, portable computers greatly outnumber desktops. In 2003, laptops began catching up with desktop computers.

An article in *Ars Technica* named 2007 as the “Year of the Laptop.” Since then, laptop sales have been steadily overtaking desktop sales in the United States. By December 2008, the same trend was seen in worldwide computer shipments. According to research firm iSuppli, “For the first time ever, laptop sales have exceeded desktop sales on the global level. In the third quarter of 2008, PC laptop sales increased forty percent over Q3 2007, to 38.6 million units sold. This is in contrast to desktop PCs, which dropped 1.3%, with a total of 38.5 million units sold.”

This trend continues: two thirds of all computers sold today in some countries are laptops, and this percentage could grow as high as 80% by 2012, according to some IDC forecasts, which claim that “the desktop is going the way of the dinosaur.” IDC says that the percentage of laptop computers sold in 2009 was 60% and is projected to be 70% by 2012 (both in the US and worldwide).

(Below) Ubiquitous laptop computing at a conference. (Photo courtesy of PRthoughts.com blog)





## 2. Computers | Portable computers lighter, thinner

**PREDICTION:** Portable computers will have become dramatically lighter and thinner than the notebook computers of ten years earlier.

**ACCURACY:** Correct

*(Right) Apple's 2010 MacBook Air features an 11.6-inch LED-backlit widescreen display with native 1366 by 768 pixel resolution. It weighs 2.3 pounds, with a thickness of only 0.11-0.68 inches. (Photo courtesy of Apple Inc.)*



**DISCUSSION:** In 1999, most of the computers were bulky desktop models with large CRT (cathode ray tube) displays — that is, museum pieces compared to current technology. Even the laptops in those days were large, thick, heavy and extremely slow compared to today's computers.

Most laptops had sluggish Internet access, floppy disk drives, short battery life, and slow processors. A typical laptop in the late 1990s was the IBM ThinkPad 380, which ran on Intel Pentium chips at 150 MHz and weighed 7.1 lbs. The [laptops of today](#) have more powerful and faster processors (with billions of transistors running at gigahertz speeds), and wireless connections for fast broadband access.

Today's Lenovo ThinkPad X series runs on an Intel Core i7 processor at 2.6 GHz, is ultrathin, and only weighs 2.43 lbs. Laptops today are also becoming more stylish, with additional accessories like video cameras and fingerprint sensors.

A new generation of notebooks has arrived since 2007: “netbooks,” sometimes also called “mininotebooks” or “ultraportables.” This is a [rapidly evolving category of small, light and inexpensive laptop computers](#) suited for general computing and using Web-based applications. Another new kind of computer, just emerging now, is the “smartbook,” which are [mobile devices that combine the features of smartphone and netbook](#).

## 3. Computers | Wearable personal computers & devices

**PREDICTION:** Personal computers are available in a wide range of sizes and shapes, and are commonly embedded in clothing and jewelry such as wristwatches, rings, earrings and other body ornaments.

**ACCURACY:** Correct

**DISCUSSION:** When I wrote this prediction in the 1990s, portable computers were large, heavy devices carried under your arm. Today, they are commonly found in shirt pockets and jacket pockets, and hung from belt loops.

Colorful iPod nano models are worn on blouses or on sleeves while running. Health monitors can be [woven into undergarments](#). There are now computers in hearing aids, and there are many other examples.

According to [VDC Research](#), about 500 million processors in 2009 went to the “wearable market segment.”

*(Right) SCOTTEVEST Essential Travel Jacket conceals 18 pockets for today’s gadget users. (Photo courtesy of SCOTTEVEST)*



The prediction does not say that *all* computers would be small devices integrated in these ways, just that such personal computers would be “common,” which indeed is the case. “Personal computers” should not be restricted to the marketing category that we happen to call “personal computers” today. All of these devices (iPods, smartphones, etc.) are in fact sophisticated “computers” and are “personal,” meaning they serve the needs of individuals.

There are numerous examples of computers now embedded in clothing. The [SCOTTEVEST](#) “iPad-Compatible” [jackets, vests, and pants](#) have up to 24 hidden pockets for gadgets, etc. A patented “Personal Area Network” (PAN) allows for running earbud and other cables through hidden secret passages in the fabric to link up the devices.

[Other examples mentioned by BusinessWeek](#): Adidas “1” sneakers have a magnetic sensor in the heel that sends 1,000 impact measurements a second to a microprocessor in the sole, adjusting the shoe’s firmness in real time; the T-Shirt TV from the Brand Marketers includes a built-in LCD TV; Burton’s iPod jacket has an embedded device controller in the sleeve for remote operation of gadgets; and Motorola & Oakley’s Razrwire sunglasses are Bluetooth-enabled.

#### 4. Computers | Small but high-resolution interfaces

**PREDICTION:** Computers with a high-resolution visual interface range from rings and pins and credit cards up to the size of a thin book.

**ACCURACY:** Essentially correct



**DISCUSSION:** There are many small book-sized computers available today, including computers designed specifically as e-books. Small computers, such as the iPod nano have built-in displays, and are not much larger than a credit card. They also come in decorative colors, and are commonly worn on clothing.

*(Right) The Zypad wearable wrist computer by Eurotech. (Photo courtesy of Eurotech)*



Computers and other [communications devices](#) are also becoming [fashion items](#), with very small displays. The continual convergence of information and communications technologies (ICT) has transformed computers and mobile telephones into jewelry items.

[Japanese KDDI](#) and [Korean LG](#) are launching new fashion mobile phone models, and the U.S. company [iStyles](#) will “skin” laptop computers, gaming machines, mobile telephones and e-book readers to any personal taste.



*(Left) O'Neill's NavJacket (Image courtesy of O'Neill)*

“Wearable computer technology” is a growing field. There are already some companies producing [wrist computers, like the model from Zypad shown in the photo](#), and combined-function devices, like the [computer-watch-telephone-camera-radio-TV](#) by LG, which looks like a James Bond gadget. A multitude of compact, [wearable devices with embedded computing and sensing technologies](#) are now commonplace, such as O'Neill's [NavJacket](#), with a GPS unit embedded into a sleeve that connects to your mobile phone via Bluetooth and a sleeve display.

## 5. Computers | Networked computers on and around us

**PREDICTION:** People typically have at least a dozen computers on and around their bodies, which are networked using “body LANs” (local area networks).

**ACCURACY:** Essentially correct

**DISCUSSION:** Consider someone sitting at their desk. In their pockets, you might find a cell phone, a digital camera, an iPod, or a Bluetooth headset, each with one or more computers. On their desk, you might find their desktop or notebook computer, a printer, and various communication devices, each with one or more computers. Many of these devices, such as “personal computers,” have more than one computer in them. So that’s close to a dozen computers typically right now.

With the advent of multi-core architectures, these devices are starting to have 2, 4, 8... computers each in them, so we'll exceed a dozen computers "on and around their bodies" very soon. One could argue that it is "typical" already, but it will become very common within a couple of years.

These computers provide communication facilities similar to cellular phones, pagers, and Web browsers; they provide automated identity verification (to conduct financial transactions and allow entry into secure areas), give directions for navigation, and handle a variety of other services. Using Bluetooth, Wi-Fi, and broadband data services, communication links between the multiple computers are highly effective.

## 6. Computers | No moving parts, electronic memory

**PREDICTION:** For the most part, these truly personal computers have no moving parts. Memory is completely electronic.

**ACCURACY:** Correct

**DISCUSSION:** The number of computerized personal devices, such as MP3 players, that use all-electronic flash memory significantly outnumbers those with disk drives and CD or DVD drives.

*(Right) A SanDisk G3 solid state drive. (Image courtesy of SanDisk Corp.)*

Since electronic flash memories were introduced commercially in the 1990s, their applications have been growing steadily. [SSD \(solid state drives\)](#) using electronic flash memories have begun substituting for hard disk drives (HDD) with movable parts in the last few years, primarily in smaller, portable computers like smartphones and tablets.



The [advantages of SSD are numerous](#) and include more robustness (no moving parts), wider temperature range, almost-instant startup, silent operation and faster processing, although their [costs are still higher than those of HDDs](#). [Samsung](#), the Korean flash memory leader, was the first company to make computers using SSD technology, in 2006, followed by Japanese companies like Sony and Fujitsu, and U.S.-based [Dell in 2007](#).

Toshiba launched [the world's first 512GB SSD laptop](#) in 2009, announcing that its new computer would "provide customers with an enhanced level of protection, portability, reliability, and fast data access." The company claims that the adoption of this 512GB solid-state technology enables the user to enjoy shorter boot times, faster application loading, and access times that are 300 percent faster than 128GB or smaller SSDs. And Apple Inc. launched its first SSD laptop in 2010, the new MacBook Air.

## 7. Computers | Keyboardless computers

**PREDICTION:** Most portable computers do not have keyboards.

**ACCURACY:** Correct

**DISCUSSION:** When I wrote this, every laptop had an alphanumeric keyboard. Today, most portable computers, such as MP3 players, cameras, smartphones, tablets, game players and many other varieties, indeed do not have keyboards.

*(Right) Apple's iPad has a touchscreen that can transform into various types of keyboards and other input interfaces. (Photo courtesy of Apple Inc.)*



The full quote of my prediction makes it clear that I am referring to computerized devices that “make phone calls, access the Web, monitor body functions, provide directions, and provide a variety of other services.”

In this broader context today, it is clear that most portable computers do not use traditional alphanumeric keyboards as input devices; they have been replaced by simple keypads, trackballs, pointing devices, joysticks, touch screens, voice recognition, and movement detection.

Moreover, with touch-sensitive screens now in wide use, new form factors have emerged with multi-purpose displays that can change on-demand: from a virtual musical keyboard to a standard alphanumeric keyboard, to exotic interfaces with elaborate control panels based solely on icons and imagery. One device can become many, since users no longer rely on fixed, physical keyboards to define the capability of a single device based on its inherent input limitations.

Today's unrestricted devices are not tethered to a parade of clunky attachments; hardware with dynamic user interfaces and more organic input modes is the trend.

*(Left) The many faces of Apple's iPhone: switching functions no longer means switching devices. Top: music creation and editing app. Bottom Right: Full e-mail editor. Bottom Left: An SMS app. (Photo courtesy of Apple Inc.)*



Tablet computers and smartphones, for example, can function as laptop computers, media and music players, design tablets for graphics, audio control boards, DJ turntables, e-mail editors, portable GPS guides, bar-code readers, language translators, video cameras, gaming consoles, scanners, and even full-screen e-book readers, simply by switching interfaces (apps).

## 8. Computers | Digital objects on personal servers

**PREDICTION:** Most users have servers in their homes and offices where they keep large stores of digital “objects,” including their software, databases, documents, music, and movies.

**ACCURACY:** Correct

**DISCUSSION:** Most computer users have a main computer (whether it is their desktop or notebook) where they keep documents, personal databases, music, TV shows, movies, e-books, and other digital objects. In some cases, these objects may be distributed among multiple computers, for example keeping digital books on a computerized digital book device.

Users now also keep their music, movies, television programs, software, e-books on a variety of other computerized devices, which act as servers serving up this digital content. These servers include DVRs (digital video recorders), such as those from cable providers and Tivo.

Another popular use of servers, such as Apple TV, is to send movies directly to TVs, in addition to local networks (wired and Wi-Fi) used to distribute music and movies throughout a house or building. Many people use such servers informally, but it is now very easy to [build simple home and office servers](#) as well.

*(Right) Apple TV server stores movies, TV shows, music, and photos. (Image courtesy of Apple Inc.)*

An example is the [Philips' Streamium series](#): a line of IP-enabled entertainment products by Philips Consumer Electronics.

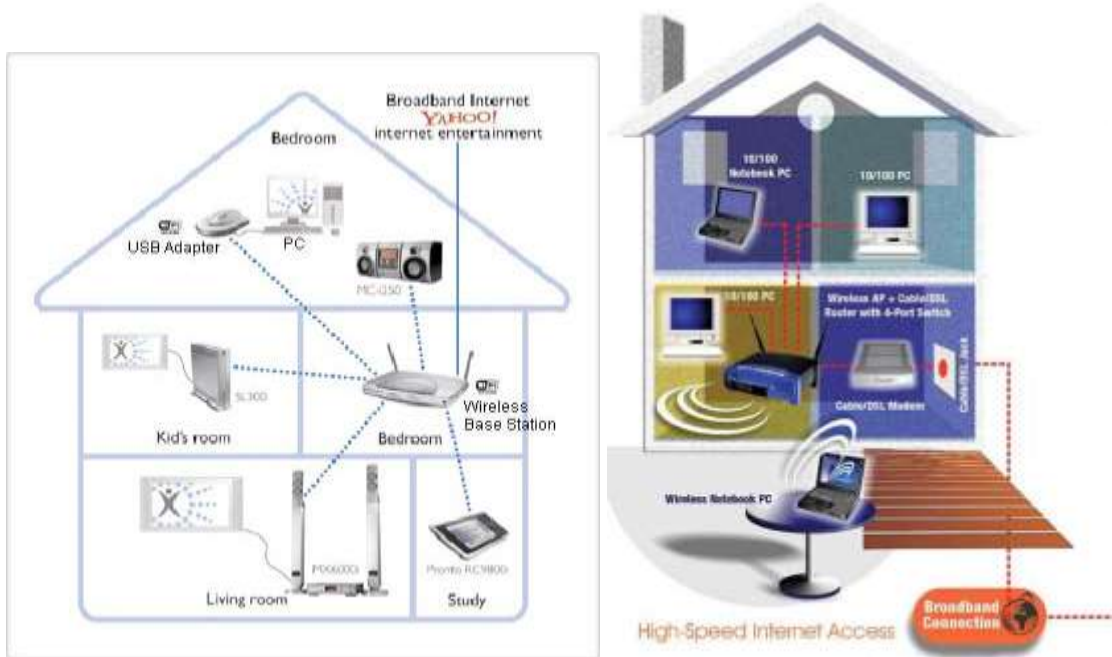
Streamium products allow users to consume digital entertainment and multimedia content — whether stored on their desktop computers or delivered through Internet-based services — on their home entertainment and/or audio sets.



Using [Wi-Fi](#), music streams wirelessly to almost any type of audio equipment, anywhere in a house. With a [Wireless Multimedia Adapter](#), it is also possible to play downloaded movies directly on an analog television set or to access the Internet wirelessly.

A Streamium device plugged into the local home network can see multimedia files that are in different [UPnP](#)-enabled computers, PDAs and other networking devices (loaded with UPnP AV MediaServer software); for example, network-attached storage (NAS) that supports UPnP, or even a UPnP enabled phone like the [Nokia N93](#) or [Nokia N80](#).

(Below, Left) Diagram for the Philips Streamium SL400i Wi-Fi enabled Multimedia Receiver for home and Internet entertainment. (Image courtesy of Philips); (Below, Right) A typical wireless home network with high-speed Internet access. (Image courtesy of MultiLayer Networks)



## 9. Computers | Digital media and software

**PREDICTION:** Digital objects such as books, music albums, movies, and software are rapidly distributed as data files through the wireless network, and typically do not have a physical object associated with them.

**ACCURACY:** Correct

**DISCUSSION:** Electronic versions of books, music, movies and software are indeed distributed wirelessly as data files.

The [iTunes Store](#) started in 2003 as the iTunes Music Store. Since that time, the iTunes Store has diversified and grown to become the largest software-based online digital media store in the world, with more than 12 million items to purchase.

[In April 2008, the iTunes Store became the number one music vendor in the United States](#), followed by Wal-Mart and Best Buy. [In February 2010, the store served its 10 billionth song download](#), less than 7 years after going online. Currently, iTunes accounts for 70% of worldwide online digital music sales, making the service the largest legal music retailer in the world. The iTunes Store today sells not just music, but also movies, audiobooks, games, podcasts, applications and other services via the Internet.



Separately, Amazon.com is the worldwide leader in e-book sales, and Netflix is still a major player in digital movies (and is now starting [online sales in Europe](#)). Amazon.com and [Netflix are quickly growing](#) in their respective Internet markets. [Amazon.com is the world's largest online retailer](#), with revenues close to \$25 billion in 2009, and has moved from selling print books to many other products since its founding in 1994.

For Christmas 2009, e-books were some of the most successful sale items for Amazon.com and other online retailers. In fact, [Amazon.com e-book sales overtook print book sales for the first time December 2009](#).

My company, K-NFB Reading Technology, Inc., in a joint venture with Baker & Taylor, the world's largest book distributor, is introducing Blio, a free software-based reader (see [www.Blio.com](#)), which comes with a million free books and allows users to purchase books from the 44,000 publishers that Baker & Taylor has a relationship with.

## 10. Computers | Users' servers store virtual reality environments

**PREDICTION:** Most users have servers where they keep digital "objects" such as virtual reality environments (although these are still at an early stage).

**ACCURACY:** Correct

**DISCUSSION:** The best examples today of "early stage" virtual reality environments are games, especially where the game involves the movement of the player using devices such as the [Nintendo Wii](#). In 2010, Microsoft released [Kinect for Xbox 360](#), which is a controller-free way to enable body movement to enter the virtual game environment.

For example, you will be able to play virtual volleyball with just your hands as in a real volleyball game. These are truly virtual reality environments in which you become part of the environment. Video games are also becoming three-dimensional, with more full immersion. For example, [50 titles are currently being converted into 3D](#) for the Sony PlayStation 3.

## 11. Computers | Most people prefer to keep their private information under their own control

**PREDICTION:** There are services to keep one's digital objects in central repositories, but most people prefer to keep their private information under their own physical control.

**ACCURACY:** Correct

DISCUSSION: “Cloud” computing and storage services enable people to keep their files and digital objects in central storage facilities accessed through the Internet, so they can access their files on any computer while traveling, for example.

Examples of popular cloud services for home media include [MobileMe](#), a service that pushes e-mail, contacts, and calendar events wirelessly to iPhone, iPad, Mac, and PC to allow them to stay in sync, [Google Docs](#), which provides storage for documents, spreadsheets, and added drawings, and DropBox, which allows users to store, sync, and, share files online on multiple devices and with other users.

According to the [2008 report of the Pew Internet and American Life Project](#), “Some 69% of online Americans use Webmail services, store data online, or use software programs such as word processing applications whose functionality is located on the Web,” but “90% of cloud application users say they would be very concerned if the company at which their data were stored sold it to another party,” and “an overwhelming majority of cloud computing services users expressed serious concern regarding the possibility that a cloud computing services provider would disclose their data to others.”

Because of these concerns, along with the rapidly increasing cost-effectiveness of storage on flash drives and terabyte drives, many people are keeping their private information in their own homes.

However, privacy concerns do not appear to have stopped consumers entirely from putting their private data online. Social networks, such as Facebook, [have exploded in popularity](#); 48% of teens and adults now have a social networking profile, compared to [only 24% in 2008](#).

A survey of CMU students (“[Information Revelation and Privacy in Online Social Networks](#)” by Ralph Gross and Alessandro Acquisti) showed that a large majority of people with Facebook profiles gave the network private information, such as their physical address, sexual preferences, and political beliefs. [Increasingly permissive privacy policies](#) do not appear to have stopped the explosive growth of social networking services, but privacy is still a major concern for users.

## 12. Computers | Cables are disappearing

**PREDICTION:** Cables are disappearing. Communication between components, such as pointing devices, microphones, displays, printers, and the occasional keyboard uses short-distance wireless technology.

**ACCURACY:** Correct

DISCUSSION: Cables are indeed disappearing (the prediction does not say that they have already fully disappeared). There is already increasing use of Bluetooth, Wi-Fi and other wireless technologies in an attempt to eliminate physical cables.





*(Above, Left) Cisco's Valet™ home Wi-Fi router series is designed for easy personal installation. (Image courtesy of Cisco); (Above, Right) Wireless power charging pad from eCoupled™. (Photo courtesy of Fulton Innovation, LLC)*

It is common today for wireless communication to exist between pocket devices such as cell phones and cameras, and for desktop devices such as printers and desktop computers to be completely wireless. This technology is becoming more widespread with time.

People are increasingly using notebook computers and pocket-sized computers, and using one form of wireless communication or another to communicate with printers and other devices.

### 13. Computers | Computers have wireless Internet connectivity

**PREDICTION:** Computers routinely include wireless technology to plug into the ever-present worldwide network, providing reliable, instantly available, very high bandwidth communication.

**ACCURACY:** Correct

**DISCUSSION:** Wireless Internet access as of 2009 is available through direct broadband connections nationwide, via mobile broadband devices through cellular networks in the United States, such as AT&T, Verizon, and Sprint, and via Wi-Fi in thousands of locations. All 2009-era smartphones are able to connect ubiquitously to the Internet via pre-installed mobile broadband electronics.

In addition, virtually all laptops and netbooks manufactured in 2009 had Wi-Fi capabilities, and the number and location of [“hotspots” with Internet access has mushroomed, both in the United States and elsewhere.](#)

Hotspots can be found today at many restaurants, train stations, airports, military bases, libraries, hotels, hospitals, coffee shops, bookstores, fuel stations, department stores, supermarkets, parks and campgrounds, public pay phones, and other public places. Many universities and schools also have wireless networks on their campus.

Additionally, [a rapidly growing number of cities around the world are creating their own municipal wireless networks](#) to let citizens connect to the ubiquitous Internet, and some companies are also funding wireless community networks.

#### 14. Computers | Most text created using speech recognition

**PREDICTION:** The majority of text is created using continuous speech recognition (CSR) dictation software, but keyboards are still used. CSR is very accurate, far more so than the human transcriptionists who were used up until a few years ago.

**ACCURACY:** Partially correct

**DISCUSSION:** People are migrating to pocket-sized computers, but these devices do not provide easy-to-use keyboards, so this situation has created a demand for effective large-vocabulary speech recognition for text entry.

Up until recently, handheld devices such as cell phones did not have computers able to support large-vocabulary speech recognition (or adequate communication to access server-based speech recognition), but that has now changed.

As I discussed above, the status of predictions such as this one changes *very* quickly. In November 2009, the idea of large-vocabulary, continuous, speaker-independent speech recognition using a cell phone appeared to many to be still far off in the future.

Just one month later, [Dragon Dictation from Nuance](#), which used to be Kurzweil Computer Products, my first major company) became one of the most popular free apps for the iPhone, and the [Google Mobile App](#) likewise became popular on iPhone, Blackberry, and Nokia S60 mobile phones, and on Google Nexus One and other Android phones.

Just a few days after its official launch, the Dragon app made it to the top rankings in [Gizmodo's Essential iPhone Apps "The Best of 2009"](#) and [Chorus Community top iPhone apps in December 2009 as reported by CNET News](#).

This capability was just introduced to the market late in 2009, so it should become increasingly popular in the next few years. Although it does not represent the “majority” of text created, it will nonetheless become increasingly common. For generating text directly, Google Voice is a telecommunications service that also transcribes voicemail online.

## 15. Computers | Language interfaces & animated personalities

**PREDICTION:** Also ubiquitous are language user interfaces (LUIs), which combine continuous speech recognition (CSR) and natural language understanding. For routine matters, such as simple business transactions and information inquiries, LUIs are quite responsive and precise. They tend to be narrowly focused, however, on specific types of tasks. LUIs are frequently combined with animated personalities. Interacting with an animated personality to conduct a purchase or make a reservation is like talking to a person using videoconferencing, except that the person is simulated.

**ACCURACY:** Partially correct

**DISCUSSION:** All of these capabilities exist today. Dragon Dictate from Nuance Communications (formerly Kurzweil Computer Products, Inc.) combines continuous speech recognition and natural language commands for word processing as well as controlling your computer generally.

*(Right) Apps like Vlingo allow cell phone customers to use their voice to send e-mails and text messages, search the Web, use Google Maps, update Facebook and Twitter status, and call contacts. (Photo courtesy of Vlingo Corporation)*



There are animated personalities that combine an animated face with natural language processing; these can be controlled by voice via a speech recognition system such as Dragon Dictate as the input to a computer.

One example is [Ramona version 4.0](#) from KurzweilAI.net. Some of these “bot” systems are used to conduct simple business transactions. These capabilities are not yet ubiquitous and probably won’t be over the next few years.

MIT’s *Technology Review* considered the “intelligent software assistant” one of its 10 emerging technologies in its [2009 TR10 special report](#). After a public announcement in 2009, [Siri \(recently acquired by Apple Inc.\) launched its free personal assistant application for the iPhone](#) in early February 2010.

Siri uses natural language processing to answer questions and make recommendations on many different subjects. The company says that Siri adapts to the user’s individual preferences over time and personalizes results, as well as accomplishing tasks such as making dinner reservations while trying to catch a cab.

There are also intelligent assistants for simple business needs and “artificially intelligent agents” for call centers. “The ‘virtual assistant’ experience will be like hiring a new assistant that doesn’t yet know you, but eventually becomes so familiar that you can’t live without him or her,” [says Dag Kittlaus](#), co-founder and CEO of [Siri](#). “Keep your eyes on this space, try out these products as they emerge, and prepare to make your life a bit simpler over the next few years.”



*(Right) The Voici Pad from eviGroup features the Seline10 AI virtual personal assistant. (Image courtesy of eviGroup)*

## 16. Computers | Computer displays have all the qualities of paper

**PREDICTION:** Computer displays have all the display qualities of paper — high resolution, high contrast, large viewing angle, and no flicker. Books, magazines, and newspapers are now routinely read on displays that are the size of, well, small books.

**ACCURACY:** Correct

**DISCUSSION:** The e-book has been one of the most notable technological successes of this decade. More than [3 million Kindles](#) have been sold as of January 2010, as well as [millions of other e-book readers](#). Additionally, virtually all magazines and newspapers are now online. People routinely read their articles on portable computers and smartphones, such as the iPhone, of which more than [50 million have now been sold](#) as of April 2010. Smartphones are now [the fastest growing segment](#) of the mobile phone market, with more than 45 million in active use.

The latest generation of e-book readers provides a flexible viewing angle, and flicker-free contrast at least equal to paperback books. The e-book readers of 2009 such as the Nook from Barnes & Noble and the Kindle from Amazon.com are now available in black & white, using E Ink technology. Several [color versions](#) were introduced in 2010.

A variety of tablet computers, such as the iPad from Apple, have been introduced in 2010, with display qualities comparable to e-book readers, while providing general PC capabilities. There is [evidence suggesting that electronic paper](#) (e-paper), including E Ink, used in the latest displays is more comfortable to read than conventional computer displays, and the contrast ratio available in e-reader displays is comparable to that of newspapers.

Blio, a free software-based e-reader from my company, [K-NFB Reading Technology, Inc.](#), can be run on these new tablet computers (as well as most other platforms). [Blio preserves typography, illustrations and color, and it lets users insert highlights, notes,](#)

[videos, and even Web pages](#). Blio diverges from traditional e-readers in a few ways: it is software, intended to be loaded on a variety of devices, from tablets to iPhones to laptops; and it is full-color, animated and interactive. It also supports embedded Web content, video and audio.

### 17. Computers | Computer displays built into eyeglasses

**PREDICTION:** Computer displays built into eyeglasses are also used. These specialized glasses allow users to see the normal visual environment, while creating a virtual image that appears to hover in front of the viewer. The virtual images are created by a tiny laser built into the glasses that projects the images directly onto the user's retinas.

**ACCURACY:** Correct

**DISCUSSION:** As discussed before, people indeed use such wearable displays, such as those made in the United States by [Microvision](#) for both [military](#) and other [mobile applications](#).

In Japan, companies like [Brother](#) and [NEC](#) have already been producing different series of wearable displays that are available to consumers. [Virtual retinal displays](#), initially developed for military use, have been deployed by several military units, such as the [U.S. Army's Stryker Brigade](#), for several years.

Beyond virtual retinal displays, [Stanford University researchers](#) are also developing a new generation of retinal implants that allow blind people to see and also enhance normal human vision thanks to sophisticated electronics.



*(Above) Augmented reality glasses for work and play by Vuzix. (Photo courtesy of Vuzix)*

Vuzix Corporation's eyewear (currently on the market) projects images for "big screen viewing" that hover in front of view, and for 3D gaming environments, military, low-vision, and medical applications. The Vuzix Wrap 920 video eyewear is a sunglasses-style display that delivers a virtual 67-inch screen as seen from 10ft away. It displays 2D and 3D video and is claimed to be the most advanced wearable display available.

The Vuzix Wrap 920 connects to all NTSC or PAL audio/video devices with video-out capabilities and composite video connections. The eyewear comes with a composite A/V adapter for iPod/iPhone for simple plug-and-play connection to a portable media player. There are optional connections for HDMI-equipped devices, desktop PCs, and laptops for watching movies.

## 18. Computers | Computers include video cameras, face recognition

**PREDICTION:** Computers routinely include moving picture image cameras and are able to reliably identify their owners from their faces.

**ACCURACY:** Correct

**DISCUSSION:** Most notebooks include cameras for both still and video images. Smartphones, such as the iPhone and Android-based phones, also include cameras, and a large percentage of "dumb" phones now have them as well.

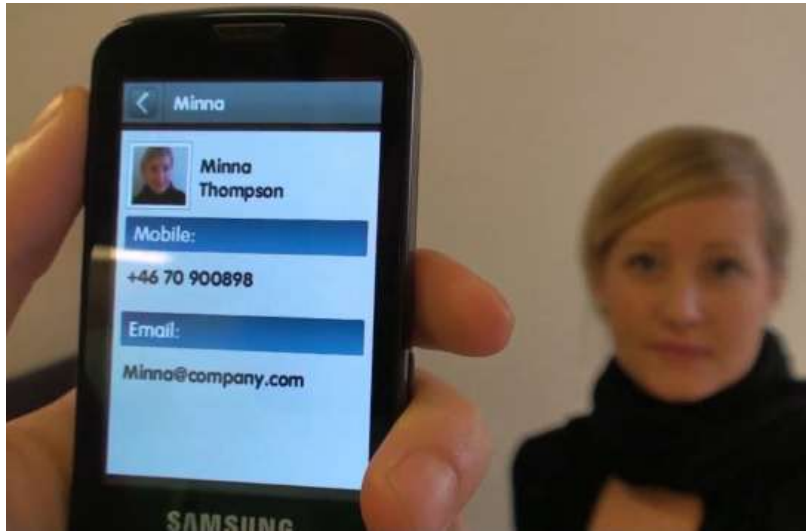
Identity recognition systems that utilize face recognition are also available, even if not widely used yet. A growing number of [digital cameras now include a "face recognition" mode](#).

In fact, some cameras even detect [faces with smiles, and the shutter can be programmed to wait until it detects open eyes and smiling faces](#), as with Sony's "smile shutter" feature. The latest versions of [Google Picasa](#) and [Apple iPhoto](#) have built-in face detection and recognition features for tagging and identification purposes.

Some Toshiba laptops now offer "[login through face recognition](#)": instead of typing in a password, the user just looks at the laptop's camera, and the computer is able to identify their profile and log them in based on their facial features.

The Swedish company TAT has demonstrated a prototype of an Android app called Recognizr that allows you to use your phone to identify a person who has been entered in an image database along with their social networking sites. Recognizr detects the subject's face and creates a unique signature by combining measurements of facial features and building a 3D model.





(Above) TAT's Recognizr app for Android phones. (Photo courtesy of TAT)

## 19. Computers | 3D chips

**PREDICTION:** In terms of circuitry, three-dimensional chips are commonly used, and there is a transition taking place from the older single-layer chips.

**ACCURACY:** Correct

DISCUSSION: Most semiconductors fabricated today for [MEMS and CMOS image sensors](#) are in fact 3D chips, using vertical stacking technology. These first 3D circuits were developed by [Matrix Semiconductor](#) (now SanDisk) in 2001, [Tachyon Semiconductor](#) in 2002, [MagnaChip Semiconductor and Tezzaron Semiconductor](#) in 2004, and [Ziptronix and Raytheon](#) in 2007.

Future 3D chips are expected to use through-silicon via (TSV), a shorter interconnect method that allows for faster speed and lower power consumption. TSV 3D technologies are expected to be used for [memory in 2012 and microprocessors in 2014](#). Analysts predict that by 2015, 3D chips with TSVs will be [6% of the overall semiconductor market](#).

Outside the United States, for example, [IMEC](#) in the Netherlands and several [Japanese groups](#) are developing [3D ICs](#). In 2005, the 3D-IC Alliance was created, and issued the first [Standards for 3D-ICs in 2008](#).

Note that the prediction contrasts “three-dimensional chips” with “older single-layer chips,” so it is specifically referring to multi-layer chips, which are indeed “commonly used,” not to self-organizing molecular circuits.



## 20. Computers | High-resolution sound anywhere in 3D space

**PREDICTION:** Sound producing speakers are being replaced with very small chip-based devices that can place high-resolution sound anywhere in three-dimensional space. This technology is based on creating audible frequency sounds from the spectrum created by the interaction of very high frequency tones. As a result, very small speakers can create very robust three-dimensional sound.

**ACCURACY:** Partially correct

**DISCUSSION:** This prediction is based on the principle that ultrasonic sound modulated by audible audio signals can generate audible sounds at any location in nearby 3D space.

“It works by using harmless ultrasonic tones that we can’t hear. These tones use the property of air to create new tones that are within the range of human hearing. The result is audible sound. The acoustical sound wave is created directly in the air molecules by down-converting ultrasonic energy to the frequency spectrum we can hear,” according to inventor [Elwood G. Norris](#).



*(Above, Right) HSS 450 directs sound to specific 3D locations. (Photo courtesy of LRAD Corporation)*

HyperSonic Sound (HSS) from [LRAD Corporation](#) (formerly American Technology Corporation) is based on this principle. “The HSS H450 offers display-point audio that is so focused that only the intended listener will hear your audio message.”

Through the combination of an ultrasonic-powered emitter and a signal processor/amplifier, LRAD’s HSS focuses sound into a tight beam for optimal directionality and intelligibility.

While this technology is not yet incorporated in consumer products, “this ability to direct or focus sound into a tight beam has a wealth of applications. Museums, aquariums, zoos, monuments and other self-guided or tour-led facilities can enhance the visitor experience through targeted communication about artistic displays, historical documents, artifacts, animal and marine life, without the need for headphones.

“In high ambient noise environments such as airports, rail lines, busses, commuter train stations, or port terminals, HSS can intelligibly target traveling information and local area tourist information to a specific area. Retailers of all types can provide targeted, unobtrusive advertising directly at the point of purchase.”

## 21. Computers | \$1,000 PC at a trillion calculations per second

**PREDICTION:** A \$1,000 personal computer can perform about a trillion calculations per second.

**ACCURACY:** Correct

**DISCUSSION:** By 2009, it became possible to achieve approximately a teraflop (a trillion floating point calculations per second) on a personal computer using high-performance GPU (graphics processing unit) cards. The complete computer motherboard (\$100 or less), everything else (\$300), and graphics card (up to \$600) costs \$1000.

For example:

- Nvidia's GTX280 reaches 0.9 teraflop peak for about \$500 (adding the rest of the computer is about another \$500).
- Nvidia's GeForce 8800 Ultra provides about 0.5 teraflops for about \$500 (the rest of the computer is another \$500).
- ATI's 4870X2 (2×480) provides 2 teraflops peak for about \$500.



*(Above, Right) Nvidia's Tesla GPU. (Photo courtesy of Nvidia)*

Several supercomputers are already being built from boards such as the above, such as the current [Cray XT5 Supercomputer](#), nicknamed “Jaguar.”

In addition, the popular PlayStation 3 video game console, [with 33.5 million sold](#), is capable of computing at [2 trillion FLOPS](#) (floating-point operations per second). Most of this capability is used for graphics coprocessing for real-time animation, etc.

## 22. Computers | Supercomputers match capacity of human brain

**PREDICTION:** Supercomputers match at least the hardware capacity of the human brain — 20 million billion calculations per second (20 petaflops).

**ACCURACY:** Essentially correct

DISCUSSION: IBM's RoadRunner system, capable of more than 1 petaflop (1 quadrillion, or 1,000 trillion) sustained floating-point operations per second, is already in operation.

IBM's 20 petaflop (20 quadrillion floating-point operations per second) Sequoia supercomputer is already under construction; IBM has announced that it will be delivered in 2011 and begin operation in 2012. The Sequoia supercomputer is the latest of the Blue Gene series by IBM, dedicated to exploring the frontiers of supercomputing.

*(Right) Prototype of IBM's Sequoia supercomputer.  
(Photo courtesy of IBM)*



In December 2009, Cray Inc. launched its Exascale Research Initiative, with the objective of providing exaflop (quintillion floating-point operations per second) computing by 2019. Other companies like HP, Intel and NEC have also recently announced their plans for exaflop computing in the 2010s.

### 23. Computers | Virtual parallel supercomputers

**PREDICTION:** Unused computers on the Internet are being harvested, creating virtual parallel supercomputers with human brain hardware capacity.

**ACCURACY:** Correct

DISCUSSION: Since the late 1990s, distributed computing has been used to create “virtual parallel supercomputers” by connecting thousands of computers through the Internet. There are currently several of these distributed supercomputers using distributed computing that have passed one petaflop.

[Folding@home](#) is the most powerful distributed computing cluster in the world, currently operating at 3.874 petaflops — almost one quarter of the estimated processing speed of the human brain. The Folding@home project is designed to perform computationally intensive simulations of protein folding. Launched in 2000, it is currently managed at [Stanford University](#). There are many other [distributed computing projects](#) on the BOINC (Berkeley Open Infrastructure for Network Computing) platform. These include [SETI@home](#) and [Milkyway@Home](#), operating at 1,382 petaflops as of March 11, 2010, which would rank it the second-largest distributed computing project. Additional distributed computing networks have been set up to [find Mersenne prime numbers](#), [crack encryption schemes](#), [cure cancer](#), and [solve the Sierpinski problem](#).

A similar phenomenon, cloud computing, is increasingly becoming the computing and storage medium of the Internet. Google's server cloud has been growing exponentially.

[According to one 2004 estimate](#), Google had more than 100,000 servers, providing a supercomputing capacity up to 316 teraflops; by 2006, Google had about 450,000 servers, as reported in [The New York Times](#). [Another analyst](#) estimated that by 2008, “Google has perhaps 20 to 100 petaflops of processing power in their distributed computing system.” Other companies like Microsoft and Yahoo! are developing similar distributed supercomputers, which will be interconnected worldwide through cloud computing.

#### 24. Computers | Increasing interest in complexity theory computing

**PREDICTION:** There is increasing interest in massively parallel neural nets, genetic algorithms and other forms of “chaotic” or complexity theory computing, although most computer computations are still done using conventional sequential processing, albeit with some limited parallel processing.

**ACCURACY:** Correct

**DISCUSSION:** Most advanced pattern recognition systems (such as character recognition, speech recognition, face recognition, models of population growth, medical studies of epilepsy, pattern recognition applied to financial “quant” investing, and many other scientific, business, and industrial applications) use algorithms based on chaos or complexity theory.

[Wolfram Alpha](#), launched in May 2009, is a recent example. It’s an online answer engine that answers factual queries directly by computing the answer from structured data, rather than providing a list of documents or Web pages that might contain the answer, as other search engines do.

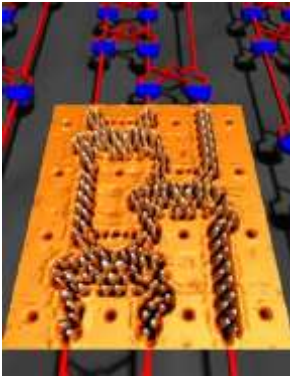
Most business PCs today ship with parallel “dual-core” or “quad-core” CPUs, such as AMD’s Athlon II and [Opteron](#) series and [Intel’s Core 2 Duo series](#). However, the majority of the processing power of such chips still comes from the very high rate of serial computation, usually over two billion operations per second.

#### 25. Computers | Autonomous nanoengineered machines

**PREDICTION:** Autonomous nanoengineered machines (i.e., machines constructed atom by atom and molecule by molecule) have been demonstrated and include their own computational controls. However, nanoengineering is not yet considered a practical technology.

**ACCURACY:** Partially Correct

**DISCUSSION:** Significant progress has been made on demonstrating the key elements of nanoengineered systems, including the ability to place atoms and molecules in precise locations, and to build systems in which the key features are measured in a modest number of nanometers.



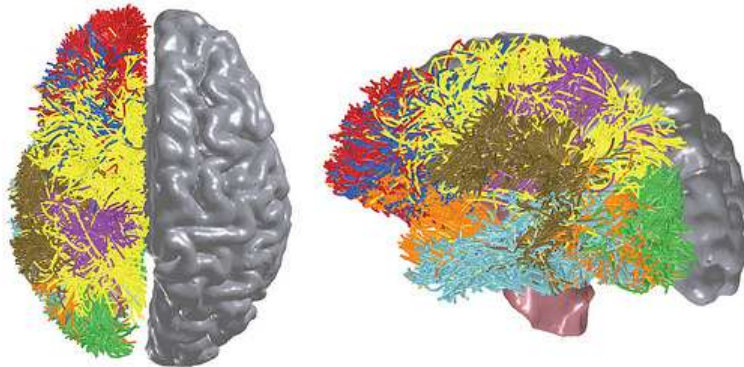
Semiconductor electronics is now an example of this, with key features in the latest generation of semiconductors running around 30 nanometers. Full-scale nanoengineering in which we can build macroscale objects constructed at the molecular scale is still considered a middle to late 2020s technology.

*(Left) Scanning Tunneling Microscopy image (12 nm by 17 nm) of a three-input sorter. The symbol + denotes logic OR, and denotes logic AND. Images with one or more inputs triggered are not shown. (Image courtesy of IBM Research)*

## 26. Computers | Reverse-engineering the human brain

**PREDICTION:** Research has been initiated on reverse-engineering the human brain through both destructive scans of the brains of recently deceased persons as well as noninvasive scans using high-resolution magnetic resonance imaging (MRI) of living persons and animals.

**ACCURACY:** Correct



*(Above) BlueMatter, a new algorithm created in collaboration with Stanford University, exploits the Blue Gene supercomputing architecture in order to noninvasively measure and map the connections between all cortical and sub-cortical locations within the human brain using magnetic resonance diffusion weighted imaging. (Image courtesy of IBM Research)*

**DISCUSSION:** The scale and resolution of simulations of brain regions is rapidly scaling up. Several of these, as of 2004, are discussed in chapter 4 of my book *The Singularity is Near*. I am currently writing a new book on this topic called *How the Mind Works and How to Build One*.



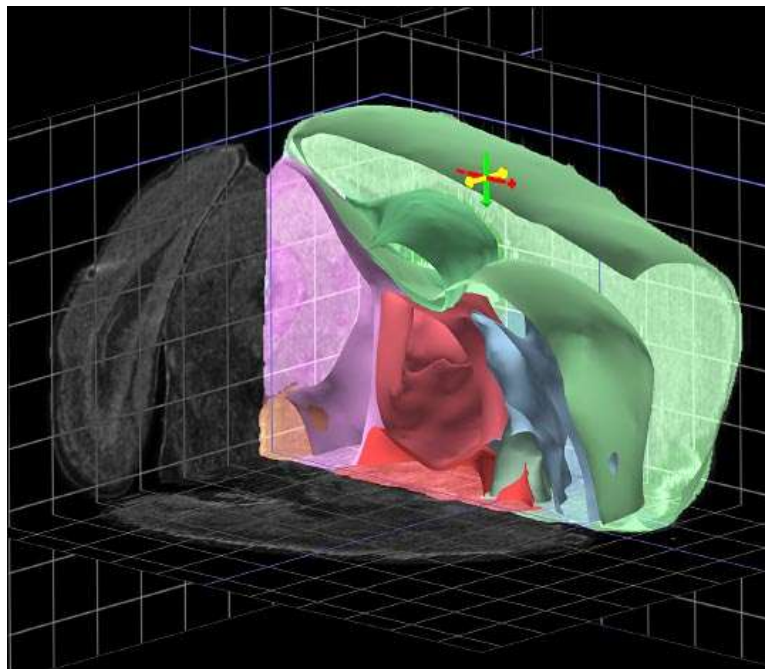
There are already detailed simulations of significant slices of the human neocortex, the region of the brain where we do our hierarchical thinking, which is responsible for language and higher-level decisions.

IBM is leading the SyNAPSE (Systems of Neuromorphic Adaptive Plastic Scalable Electronics) [project, funded by DARPA](#), with the [objective of creating “cognitive computers” as systems](#) that can simulate the abilities of the human brain. [The Blue Brain Project](#), supported by IBM at École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland, expects to have a human brain-scale simulation of the neocortex running by 2018.

Another institute, the [Allen Institute for Brain Science](#), completed the [Allen Mouse Brain Atlas](#) in 2006, and has begun work on a similar initiative for mapping the human brain using “gene expression maps” — a technique that combines genomics with neuroanatomy.

In general, based on current research and developments, we can certainly say that research on reverse-engineering the human brain has been “initiated”; indeed, it is already far along.

*(Below) Image from the Allen Mouse Brain Atlas project, where researchers have completed a digital map of the entire mouse brain, allowing for better understanding of the human brain. This image is a 3D view of mouse-brain anatomy, displayed against reference planes that function as a coordinate grid. The image was compiled from computerized scans that track how more than 20,000 mouse genes express themselves at a cellular level. (Image courtesy of the Allen Institute for Brain Science)*



## EDUCATION

### Predictions made for 2009 in *The Age of Spiritual Machines*

The following is an analysis of predictions for 2009 made about the future of education in the book *The Age of Spiritual Machines*, which was written in the mid to late 1990s.

#### 1. Education | Computers are essential knowledge tools

**PREDICTION:** In the twentieth century, computers in schools were mostly on the trailing edge, with most effective learning from computers taking place in the home. Now in 2009, while schools are still not on the cutting edge, the profound importance of the computer as a knowledge tool is widely recognized.

**ACCURACY:** Correct

**DISCUSSION:** It is now commonly accepted that computer technology is an integral part of 21st century education. [Recent studies](#) at Boston College have shown that children learn better when every student and teacher is given their own, school-provided laptop computer, a technique known as “1:1 computing.” 1:1 computing is becoming increasingly [popular with schools nationwide](#), with more than a quarter of districts having at least a partial 1:1 program.

Virtually all American public school districts have [their own computer networks](#), and a large majority give their students access to online libraries and databases. A full 88% of districts say that technology is a priority for the administration, while 83% say that teachers are interested in using technology for classroom instruction.

#### 2. Education | Computers play central role in education

**PREDICTION:** Computers play a central role in all facets of education, as they do in other spheres of life.

**ACCURACY:** Correct

**DISCUSSION:** Personal computers, from notebooks to mobile devices, are ubiquitous among students. Students interact with each other through extensive, online social networks.

“The number of computers in public elementary and secondary schools has increased,” according to the “[Digest of Education Statistics 2009](#),” U.S. Dept. of Education’s National Center for Education Statistics. “In 2005, the average public school contained 154 instructional computers, compared with 90 in 1998.... One important technological



advance that has come to classrooms following the introduction of computers has been connections to the Internet. The percentage of instructional rooms with access to the Internet increased from 51 percent in 1998 to 94 percent in 2005.... Nearly all schools had access to the Internet in 2005.”

Course materials and student submissions are routinely communicated through the Internet. Research by students (and everyone else) is conducted online. Search engines, Wikipedia, and other vast knowledge resources are routinely used by students and everyone else, with [half of all Internet users](#) searching for information on any given day.

### More references

“There’s much more need for just-in-time, just-right education. The Internet is becoming central to education because it allows you to meet these kinds of needs.” — Kim Clark, former dean of Harvard Business School (in Shojai, Siamack, and Robert Christopherson. *The Virtuous Vice: Globalization*. Westport, CT: Praeger, 2004, pg. 188.)

“IT is increasingly central to education. As solutions such as the student information system (SIS) or learning management system (LMS) become increasingly central to the day-to-day operation of education institutions, ensuring that these solutions keep working regardless of whatever disaster may have befallen the institution becomes a core objective of the IT department.” — [“Ensuring Business Continuity in Higher Education IT: Preparing for the Unexpected.”](#) Rep. Apr. 2007 by Datamonitor PLC.

“There is no doubt that ICTs [information and communication technologies] are seen as central to education in the 21st century.” — Knight, Cecily, Bruce A. Knight, and Daniel Teghe. [“Releasing the Pedagogical Power of Information and Communication Technology for Learners: A Case Study.”](#) *International Journal of Education and Development Using Information and Communication Technology* 2.2 (2006): 27-34.

### 3. Education | Most reading done on displays

**PREDICTION:** The majority of reading is done on displays, although the “installed base” of paper documents is still formidable.

**ACCURACY:** Correct

**DISCUSSION:** Most reading is now done on computer displays. For example, e-mail messages, social networking messages, instant and text messaging, online research of all kinds, and now e-books are all forms of reading done on displays.

[Surveys show](#) that children from ages 8-18 now spend more than twice as much time on the computer, not including video games, as they spend reading print media. There are more than 10,000 children’s book titles available on Amazon right now, [for use on the Kindle](#). That number is beginning to increase by the day as more publishers begin to sit up and take notice. Scholastic, the largest publisher of children’s books, is set to enter the market for children’s e-books, as are major publishers of textbooks for children.

#### 4. Education | Electronic documents replace paper

**PREDICTION:** The generation of paper documents is dwindling, as the books and other papers of largely twentieth century vintage are being rapidly scanned and stored.

**ACCURACY:** Essentially correct

**DISCUSSION:** It is certainly correct that books and other significant documents are being (or already have been) scanned, and are becoming available online. Most books, both contemporary (for a fee, although some are made available for free) and classical literature (generally for free) are becoming available as e-books. Large numbers of books are also available on e-readers, some of which are free (such as [Blio, from my company K-NFB Reading Technology, Inc.](#)). Google Books now stores more than [ten million books](#) in its online database, most of which are no longer in print, increasing the global availability of written information.

Overall sales of print media are in a long-term decline, which has been exacerbated by the 2008 recession. Newspaper sales are declining even more rapidly than they have over the last decade, [dropping 8%](#) from September 2009 to March 2010, according to the Audit Bureau of Circulations (ABC). The ABC also noted that magazine sales are in decline, [falling sharply](#) in 2009. [Sales of books fell](#) from 8.27 per capita in 2001 to 7.93 in 2006, according to the Book Industry Study Group. As of the summer of 2010, Amazon is [selling more e-books than hardcover books](#).

#### 5. Education | Multimedia embedded in documents

**PREDICTION:** Documents, circa 2009, routinely include embedded moving images and sounds.

**ACCURACY:** Correct

**DISCUSSION:** Modern Web applications, such as [YouTube](#), make it very easy for any website owner to include video and audio along with text and images. Many Web documents now include images, moving images, sounds, and interactive video auditory experiences of various types. Adobe Flash video/audio software [is now supported by 99%](#) of Internet viewers, and the emerging Internet standard [HTML5](#) will include native support for these forms of multimedia. The new generation of e-books, such as [those from Blio](#), also have the option of including video, interactive images, and other Web-based experiences.

## 6. Education | All students have a computer of their own

**PREDICTION:** Students of all ages typically have a computer of their own, which is a thin tablet-like device weighing under a pound with a very high-resolution display suitable for reading.

**ACCURACY:** Essentially correct

**DISCUSSION:** Students do typically have a computer of their own, ranging from smartphone computers such as the iPhone to notebook computers. A [2006 survey](#) by the University of Pennsylvania showed that 97% of college undergraduates owned their own computer. Smartphones typically weigh less than a pound, and are suitable for reading.

There are many e-book applications available for the iPhone and other smartphone computers. Netbooks, which are rapidly gaining market share, according to a [2009 report](#) by IDC, weigh from under 1 pound to about 3 pounds. The new generation of light-weight tablet computers, such as Apple's iPad, which weighs 1.5 pounds, is designed to be ideal for students and includes high-resolution displays for reading. So the main aspect of this prediction that we'll have to wait for is the weight of under a pound, although mobile computers (smartphones) today weigh well [under a pound](#), and [analysts predict](#) that the 2011 iPad will be thinner and lighter.

## 7. Education | Interacting with computers by voice and stylus

**PREDICTION:** Students interact with their computers primarily by voice and by pointing with a device that looks like a pencil.

**ACCURACY:** Partially correct

**DISCUSSION:** Pointing refers to a tablet computer or smartphone with a touch-sensitive screen, which can use a stylus or the user's finger. These devices, such as the iPad, are emerging as ideal devices for students. According to [Gartner Research](#), the market for devices with touchscreens is growing extremely rapidly, and is expected to double in 2010.

The iPad and iPhone both feature apps that allow text entry and creation of notes and messages by voice, notably [Dragon Dictation from Nuance](#) (formerly Kurzweil Computer Products). Google Voice for Android mobile platforms and Dragon Dictation for the iPhone and iPad allow routine voice entry of text. These applications are popular today, although are not yet universally used.

## 8. Education | Keyboards exist, but most text is created by speaking

**PREDICTION:** Keyboards still exist, but most textual language is created by speaking.

**ACCURACY:** Wrong

DISCUSSION: Text creation by speaking is certainly common: [Dragon Dictate from Nuance](#) is used by millions of consumers, and Dragon Dictation for the iPhone, iPod touch, and iPad is one of the most popular iPhone apps. Nuance Technologies, Dragon Dictate's parent company, now [has more than \\$1 billion in revenue](#) and has consistently experienced 50% annual growth. However, it is not the case that "most textual language" is created this way. This will probably not be the case in several years either, but may plausibly become the case within ten years.

## 9. Education | Materials accessed wirelessly

**PREDICTION:** Learning materials are accessed through wireless communication.

**ACCURACY:** Correct

DISCUSSION: It is now common for course materials and student submissions to be transmitted wirelessly over the Internet. [International Digital Publishing Forum statistics](#) show explosive growth in the electronic book market, and textbook publishers are gearing up for rapid introduction of interactive e-textbooks.

Textbooks now routinely include electronic and Web-based supplements. The prediction does not say that all learning materials are accessed this way, but that learning materials are accessed wirelessly. This is true today and the market for online educational materials is rapidly growing.

## 10. Education | Intelligent courseware is common

**PREDICTION:** Intelligent courseware has emerged as a common means of learning.

**ACCURACY:** Partially correct

DISCUSSION: [The New York Times](#) points out that over the past decade there has been rapid growth in free interactive games and learning sites, with advertising-supported software made available for free downloading. Interactive courseware from many sources has become increasingly popular, although not yet ubiquitous.

## 11. Education | Students learn basic skills with software

**PREDICTION:** Recent controversial studies have shown that students can learn basic skills such as reading and math just as readily with interactive learning software as with human teachers, particularly when the ratio of students to human teachers is more than one to one. Although the studies have come under attack, most students and their parents have accepted this notion for years.

**ACCURACY:** Correct

**DISCUSSION:** The research shows that educational software can play a significant role in enhancing student achievement. Studies have demonstrated that reading software can benefit [poor and minority](#) students, students with attention deficit disorder (Hecker, Linda, Liza Burns, Lynda Katz, Jerome Elkind, and Kenneth Elkind. “Benefits of Assistive Reading Software for Students with Attention Disorder.” *Annals of Dyslexia* 52.1 (2002): 243-72.), and at-risk students (Bishop, M.J., and Lana E. Santoro. “Evaluating Beginning Reading Software for At-risk Learners.” *Psychology in the Schools* 43.1 (2005): 57-70).

Schools are [experimenting](#) with computer systems to replace human teachers in the classroom for specific skills, such as reading and math, and a recent [article in the journal Science](#) argued that learning from “social robots” will become more and more commonplace over the next decade.

## 12. Education | Schools rely on software-based instruction

**PREDICTION:** The traditional mode of a human teacher instructing a group of children is still prevalent, but schools are increasingly relying on software approaches, leaving human teachers to attend primarily to issues of motivation, psychological well-being, and socialization.

**ACCURACY:** Essentially correct

**DISCUSSION:** Arguably, this is correct already, in that software approaches are indeed being increasingly used. However, to say that they are being relied on is still a few years off. Examples include the new British primary school curriculum, which focuses increasingly on computer and software skills.

According to a [report on the primary school curriculum](#) by the British government, “Along with literacy, numeracy and personal development, ICT [information and communication technology] should therefore be at the core of the primary curriculum and be taught both discretely to capture its essential knowledge and skills and through its application across the whole curriculum.”

With the increasing adoption of 1:1 computing, schools are increasingly reliant on interactive software, online courseware, and online educational materials as an integral part of their approach to education.

### 13. Education | Young children learn to read with software tools

**PREDICTION:** Many children learn to read on their own using their personal computers before entering grade school.

**ACCURACY:** Correct

**DISCUSSION:** While this may not be the case yet for “most” children, it is certainly true for “many” children. [Research has shown](#) that 3- and 4-year-old children who use computers have significantly greater developmental gains, compared to children without computer experiences in similar classrooms.

These gains are in the areas of intelligence, nonverbal skills, structural knowledge, long-term memory, manual dexterity, verbal skills, problem solving, abstraction, conceptual skills, and many others. [The potential gains](#) for kindergarten and primary children are tremendous, including improved motor skills, enhanced mathematical thinking, increased creativity, higher scores on tests of critical thinking and problem solving, and increased scores on standardized language assessments. In addition, computers enhance children’s self-concept, and children demonstrate increasing levels of spoken communication and cooperation.

[Research shows that 9% of four-year-olds](#) can already read out of books on their own, before starting kindergarten. Computer technology has proven to be highly useful for learning how to read; according to a [2005 study](#) of precocious readers, “computers were a common factor mentioned as an important influence on literacy.”

### 14. Education | Children use print-to-speech reading software

**PREDICTION:** Preschool and elementary school children routinely read at their intellectual level using print-to-speech reading software until their reading skill level catches up.

**ACCURACY:** Correct

**DISCUSSION:** This is an area that my companies and I have pioneered. [Kurzweil Educational Systems, Inc.](#) (KESI), which I founded in 1996, created and markets the [Kurzweil 3000](#), which has been the leading product for children with dyslexia (KESI was sold to Cambium Learning in 2005, and I have not been affiliated with it since that time). It can present both print books (which the user scans or has scanned for them) and electronic materials with a combined visual and auditory presentation. The book is read



aloud, with synchronized highlighting on an image of the original print of the book or other reading material. This enables a dyslexic child, or just any child who has not yet learned to read at their intellectual level (which is basically true of all children up until grades 4 or 5), by having the book read to them. The synchronized visual presentation helps build their reading skills.

My new reading technology company, [K-NFB Reading Technology, Inc.](#) (which is a joint venture between Kurzweil Technologies, Inc. and the National Federation of the Blind) has introduced [Blio](#), a new free e-reader that presents e-books and other electronic documents with a visual presentation, text-to-speech, and synchronized highlighting. It also combines print and audio books together.

If a human-read audio book exists for a book, a student can use Blio to read the book by viewing the visual book, listening to the human read an audio book, and having the words highlighted on the screen as they are read, synchronized with the voice. Blio is a joint venture between K-NFB Reading Technology, Inc. and Baker & Taylor, the world's leading book distributor, with relationships with 44,000 publishers.

## 15. Education | Reading systems visually display documents

**PREDICTION:** These print-to-speech reading systems display the full image of documents, and can read the print aloud while highlighting what is being read.

**ACCURACY:** Correct

**DISCUSSION:** As discussed above, that is exactly what the Kurzweil 3000 does. Blio will display the text of a book and read it out loud, using either text-to-speech or a human-read audio track if available. These capabilities allow people to simultaneously read, view, and listen to an electronic book or other document.

## 16. Education | Synthetic voices sound fully human

**PREDICTION:** Synthetic voices sound fully human.

**ACCURACY:** Partially correct

**DISCUSSION:** The better, large-footprint text-to-speech engines, such as those available from [Nuance Communications](#) (formerly Kurzweil Computer Products, Inc.), do sound remarkably natural, especially when listened to for a few sentences. The inflection and intonation patterns have become more natural and are impressive. But if you listen to them for extended passages, it is clear that they are not yet “fully” human.

## 17. Education | Reading software systems readily accepted

**PREDICTION:** Although some educators expressed concern in the early '00 years that students would rely unduly on reading software, such systems have been readily accepted by children and their parents.

**ACCURACY:** Correct

**DISCUSSION:** Such concerns were indeed expressed early in the preceding decade, but the benefits of print-to-speech reading systems — such as the Kurzweil 3000 from Kurzweil Educational Systems, Inc. and now Blio from K-NFB Reading Technology, Inc. — are well accepted by the educational community and by parents. Teachers now show generally positive attitudes towards reading assistance software in the classroom:

“A majority of teachers (63%) felt that the software’s usage led to improvement in student skills. Frequency of use may be a key factor; of the ten teachers whose students used Kurzweil 3000 daily or at least several times per week, nine believed that the software’s usage led to improvement in student skills.” — [Tech and Learning](#).

“The results of the study indicated teachers believed that Accelerated Reader was helping them in the classroom. Teachers believed that Accelerated Reader was motivating their students to read. Some teachers believed that Accelerated Reader helped their students with comprehension, but on the lowest level. Teachers indicated that there were some benefits to having the Accelerated Reader in their classroom.” — [Teacher’s Perceptions of the Accelerated Reader Program](#)”

## 18. Education | Synchronized visual-auditory text presentation

**PREDICTION:** Studies have shown that students improve their reading skills by being exposed to synchronized visual and auditory presentations of text.

**ACCURACY:** Correct

**DISCUSSION:** Such studies were conducted over the past decade by Kurzweil Educational Systems. The study, [“Benefits of Assistive Reading Software for Students with Attention Deficit Disorder,”](#) by Linda Hecker, Liza Burns, Jerome Elkind, Kenneth Elkind, and Lynda Katz, showed that reading software was important in improving these students’ reasoning abilities.

## 19. Education | Remote learning is commonplace

**PREDICTION:** Learning at a distance (e.g., lectures and seminars in which the participants are geographically scattered) is commonplace.

**ACCURACY:** Correct

DISCUSSION: E-learning is certainly commonplace today, with lectures and seminars being routinely streamed live and archived on the Web. MIT has put all of its courseware online for free, through its [MIT OpenCourseWare](#) project. Many other universities [have followed suit](#).

[Two-thirds](#) of accredited U.S. colleges now offer distance learning courses, and distance learning has been [growing rapidly](#) because of computer technology. [A 2007 study](#) by the Sloan Consortium found that online enrollments have continued to grow at rates far in excess of the total higher education student population, albeit at slower rates than for previous years.

- Almost 3.5 million students were taking at least one online course during the Fall 2006 term, a nearly 10 percent increase over the number reported the previous year.
- The 9.7 percent growth rate for online enrollments far exceeds the 1.5 percent growth of the overall higher-education student population.
- Nearly 20 percent of all U.S. higher education students were taking at least one online course in the fall of 2006.

## 20. Education | Ongoing professional education

**PREDICTION:** Learning is becoming a significant portion of most jobs.

**ACCURACY:** Correct

DISCUSSION: Most jobs today are beginning to require (or already require) [computer skills](#), and demand significant ongoing learning. Even jobs that are traditionally considered blue collar, such as jobs in manufacturing plants, increasingly require reading and analytical skills and [technical knowledge](#). As the [knowledge economy grows](#), less-skilled jobs are gradually [being replaced](#) by more skilled jobs.

According to the [Georgetown University Center on Education and the Workforce](#), “The demand for an increasingly skilled and educated workforce is growing.”

## 21. Education | Occupational education is required

**PREDICTION:** Training and developing new skills is emerging as an ongoing responsibility in most careers, not just an occasional supplement, as the level of skill needed for meaningful employment soars ever higher.

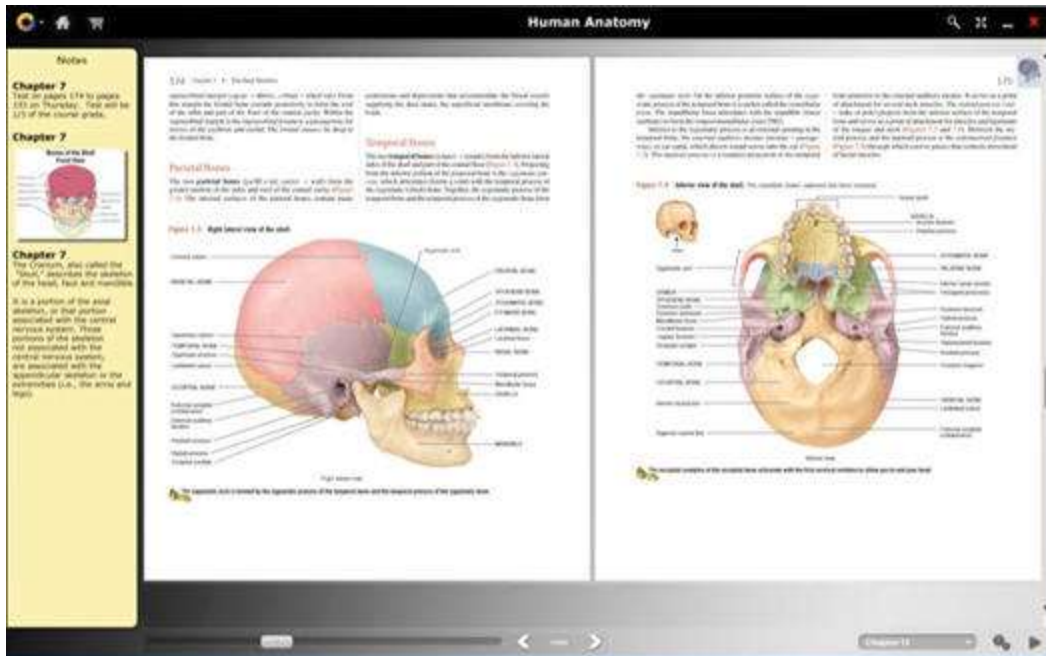
**ACCURACY:** Correct

**DISCUSSION:** There has indeed been a [boom](#) in “continuing education,” which refers to training and skill development after the end of formal schooling.

Reasons for pursuing continuing education include [the increased importance](#) of technology, the desire to get an edge over other job applicants, and the dearth of [less-skilled manufacturing jobs](#), which were hit hard by the 2009 recession and outsourcing.

Julian Alssid, executive director of the Workforce Strategy Center, a nonprofit consulting company based in New York City, [said related forces](#) are driving interest in continuing education. “It’s not just [the] downturn in the economy; it’s the shift from an industrial economy to a knowledge economy, and that requires a new set of skills.”

*(Below) The Blio e-reader from K-NFB Reading Technology, Inc. displays a full-color, interactive digital textbook with embedded multimedia, a major trend in the display and distribution of educational print materials. (Image courtesy of K-NFB Reading Technology, Inc.)*



## DISABILITIES

### Predictions made for 2009 in *The Age of Spiritual Machines*

The following is an analysis of predictions for 2009 made about the future of disabilities in the book *The Age of Spiritual Machines*, which was written in the mid to late 1990s.

#### 1. Disabilities | Disabled people fast overcoming handicaps

**PREDICTION:** Persons with disabilities are rapidly overcoming their handicaps through the intelligent technology of 2009.

**ACCURACY:** Correct

DISCUSSION: This is clearly true. According to the [U.S. federal government](#), technology [creates gateways](#) to jobs, training and education for people with disabilities and “[levels the playing field](#)” for many people with disabilities at home, school, and in the workplace. Blind persons can read with print-to-speech reading machines built into their four-ounce cell phones, and also use these devices to navigate with full speech output (using, for example, the [K-NFB Reader Mobile](#) from my company [K-NFB Reading Technology](#), Inc.). Audio and audio-video recordings can be transcribed to text by accurate, continuous speech recognition, such as [Dragon NaturallySpeaking](#) from [Nuance](#) (formerly Kurzweil Computer Products, Inc.). Systems are also being developed to assist the physically disabled, such as a Japanese [intelligent wheelchair](#) that can automatically scan its surroundings and detect obstacles.

#### 2. Disabilities | Software helps overcome learning disabilities

**PREDICTION:** Students with reading disabilities routinely ameliorate their disability using print-to-speech reading systems.

**ACCURACY:** Correct

DISCUSSION: This is an area in which I have been heavily involved for over three decades. The Kurzweil 3000 from [Kurzweil Educational Systems](#), Inc. (note that I founded this company in 1996; it was sold to [Cambium Learning](#) in 2004 and I have no current affiliation with it) has been a leading print-to-speech reading system for students with reading disabilities.

[Blio](#), a free e-reader that comes with a million free books, was recently introduced by my company K-NFB Reading Technology, Inc. It has extensive features for students with reading disabilities, such as the ability to read aloud (with either a human-read voice if an audio book is available or text-to-speech) and highlight what is being read with a synchronized highlighter.

### 3. Disabilities | Palm-size devices read to the blind, go anywhere

**PREDICTION:** Print-to-speech reading machines for the blind are now very small, inexpensive, palm-sized devices that can read books (those that still exist in paper form) and other printed documents, and other real-world text such as signs and displays.

**ACCURACY:** Correct

**DISCUSSION:** This is exactly what the [K-NFB Reader Mobile](#) from my company K-NFB Reading Technology, Inc. does. It was introduced to the market in 2008.

### 4. Disabilities | Handhelds read aloud any digital document

**PREDICTION:** These reading systems are equally adept at reading the trillions of electronic documents that are instantly available from the ubiquitous wireless worldwide network.

**ACCURACY:** Correct

**DISCUSSION:** The [K-NFB Reader Mobile](#) can read aloud printed text in books and other documents including ATM displays, signs, and other real-world print, as well as any electronic document that can be downloaded from the Web or transmitted by electronic communication.

### 5. Disabilities | Hand-held GPS devices help the blind navigate

**PREDICTION:** After decades of ineffective attempts, useful navigation devices have been introduced that can assist blind people in avoiding physical obstacles in their path, and finding their way around, using global positioning system (“GPS”) technology.

**ACCURACY:** Correct

**DISCUSSION:** Devices for both of these functions have been introduced. The [K-NFB Reader Mobile](#) from my own company K-NFB Reading Technology, Inc. includes navigation for the blind using GPS and text-to-speech output. Other examples include the [Trekker](#) talking GPS system, which includes route planning, location information and many other functions for the blind and visually impaired.

Other systems currently in development include an [optical radar system](#) that helps blind people maneuver around obstacles, and a wearable system that [tracks a blind person’s position using GPS, emitting sounds](#) to alert them to obstacles.



## 6. Disabilities | Voice-operated assistive technology for the blind

**PREDICTION:** A blind person can interact with her personal reading-navigation systems through voice communication, kind of like a Seeing Eye dog that reads and talks.

**ACCURACY:** Correct

**DISCUSSION:** As mentioned, the K-NFB Reader Mobile from my company K-NFB Reading Technology is a personal reading-based navigation system. It can be driven by [voice commands](#). The iPhone 3GS, introduced in 2009, also provides “[Voice Control](#)” for [making phone calls and playing music](#) that can help blind and mobility-impaired users. In addition, there are [personal tracking devices using GPS, with two-way voice communications](#).

## 7. Disabilities | Portable speech-to-text for the hearing impaired

**PREDICTION:** Deaf persons — or anyone with a hearing impairment — commonly use portable speech-to-text listening machines, which display a real-time transcription of what people are saying. The deaf user has the choice of either reading the transcribed speech as displayed text, or watching an animated person gesturing in sign language. These have eliminated the primary communication handicap associated with deafness.

**ACCURACY:** Partially correct

**DISCUSSION:** The technology for this exists. [Dragon NaturallySpeaking](#) (which is a combination of technology originally from Dragon Systems and Kurzweil Applied Intelligence) from Nuance Communications (formerly Kurzweil Computer Products) provides very high accuracy for speech recognition from unconstrained, continuous speech, with speaker independence.

This technology could also be used as a speech-to-text listening machine for the deaf. However, this market has not yet been targeted by Nuance, so its use by the deaf is not yet “common.” There are systems for displaying text using animated sign language, but these have not yet been integrated with speech-recognition systems.

## 8. Disabilities | Real-time language translation

**PREDICTION:** Listening machines can also translate what is being said into another language in real time, so they are commonly used by hearing people as well.

**ACCURACY:** Correct

**DISCUSSION:** This refers to a “translating telephone,” that is, translating speech from one language to another. The [Jibbig](#) iPhone application, now available on the iPhone App Store, does this for five languages (English, Iraqi Arabic, Spanish, Chinese and Japanese). Jibbig was named as a “best iPhone app” by [Gizmodo](#) in April 2010.

## 9. Disabilities | Computerized prosthetics

**PREDICTION:** Computer-controlled orthotic devices have been introduced. These “walking machines” enable paraplegic persons to walk and climb stairs. The prosthetic devices are not yet usable by all paraplegic persons, as many physically disabled persons have dysfunctional joints from years of disuse. However, the advent of orthotic walking systems is providing more motivation to have these joints replaced.

**ACCURACY:** Correct

**DISCUSSION:** This is what Dean Kamen’s [iBot](#) system enables paraplegic persons to do. With the iBot, they can climb stairs, go over rough terrain, and stand at eye level. One paraplegic user used it so that he could be at eye level with his bride at their wedding. The product has been introduced and is used by paraplegic persons, but it is not yet in widespread use.

Another example is “[Robot Suit HAL](#),” a cyborg-type robot. When a disabled person attempts to move, nerve signals are sent from the brain to the muscles, moving the musculoskeletal system as a consequence. Very weak biosignals can then be detected on the surface of the skin by a sensor, and HAL controls a power unit to move the joint in sync with the wearer’s muscle movement, enabling it to support the wearer’s daily activities. Also, in October 2010, Berkeley Bionics unveiled [eLEGS](#), an exoskeleton that allows wheelchair users to walk.

## 10. Disabilities | “Handicap” redefined

**PREDICTION:** There is a growing perception that the primary disabilities of blindness, deafness, and physical impairment do not necessarily impart handicaps. Disabled persons routinely describe their disabilities as mere inconveniences. Intelligent technology has become the great leveler.

**ACCURACY:** Correct

DISCUSSION: Indeed, the perception of disabled persons (such as blind persons) being profoundly handicapped has changed dramatically over the past 15 years. This is the result both of technologies — such as portable reading machines that overcome the handicaps associated with these disabilities — and civil rights advocacy by groups such as the [National Federation of the Blind](#).

Blind people, for example, are routinely taking every category of jobs. According to [Laura Sloate](#), the blind managing [director of a Wall Street firm](#), “blindness was a disability. Now it’s just a minor, minor impairment.” Perhaps most encouraging is that when [David Paterson](#), a blind man, became Governor of New York State, it was considered a routine development.

(Below) [Innovative assistive technologies](#) — like the [touchcolor thermal ring and tablet](#), which could someday enable the blind to paint in color — are enabling people with physical disabilities to live full, productive lives and are redefining the limits of handicaps. (Image courtesy of designers Yun Li, Guopeng Liang & Ke Zhao)



## COMMUNICATION

### Predictions made for 2009 in *The Age of Spiritual Machines*

The following is an analysis of predictions for 2009 made about the future of communication in the book *The Age of Spiritual Machines*, which was written in the mid to late 1990s.

#### 1. Communication | Two-way translating telephones common

**PREDICTION:** Translating telephone technology (where you speak in English and your Japanese friend hears you in Japanese, and vice versa) is commonly used for many language pairs. It is a routine capability of an individual's personal computer.

**ACCURACY:** Essentially correct

**DISCUSSION:** Translating telephone technology is indeed available on personal computers. For example, in 2006, IBM delivered [MASTOR](#), two-way, free-form speech translator software, to the United States Joint Forces Command (USJFCOM) for use on laptop computers. The bidirectional English-to-Arabic translation software was designed to improve communication between military personnel and Iraqi forces and citizens. And [Fluential](#) has developed a prototype cloud-server-based speech-to-speech translation system, with funding from the U.S. Defense Advanced Research Projects Agency (DARPA) and other government sources.

However, with the accelerating price/performance and miniaturization of mobile phone technology, the focus of development of speech translation has largely moved to computers in smartphones. I have been demonstrating our own prototype of translating-telephone software since 2008. [Sakhr Software](#) launched its first real-time, speech-to-speech Arabic translator for BlackBerry and iPhone systems in 2009, and in October 2009, the popular [Jibbig](#) Spanish-English speech-to-speech translator for iPhones and iPod touch (third-generation) was introduced, followed by Japanese-English, Chinese-English, and Iraqi-English versions in early 2010.

[Mobile Technologies](#), a company founded by Carnegie Mellon University Professor Alex Waibel, has delivered Japanese, Chinese, and Arabic versions of speech-to-speech translators, and plans to add five languages by year-end 2010. [Novauris](#) has developed a proof-of-concept "flexible phrase translator" for Windows Mobile, iPhone and Linux mobile phones.

And in Japan, NEC is developing the [Tele Scouter](#), a head-mounted optical display that will also work as a universal translator, scheduled for commercial release in late 2010.

In addition, users can search [Google Mobile App by voice](#) in English, Mandarin, or Japanese on Android, Blackberry, iPhone, Nokia S60, and Windows phones. But Google Translate also provides [voice output](#) in English for text translated from 51 languages, and Google plans call for “combining voice recognition with our language translation infrastructure to provide in-conversation translation” — the “universal translator” of *Star Trek*.

My prediction was that translating telephone technology would be “commonly used,” not that it would be ubiquitous. I suppose one could argue how “common” its use is today, but it is already available in a popular application, with Jibbigo, for example, becoming the number one iPhone app in Japan just a few days after its official launch in Tokyo.

Translating telephone technology is likely to become even more popular on many phones worldwide in 2010 and 2011. On May 6, 2010, Google introduced an [image-based text translation feature for its Goggles Android app](#) that allows you to point your phone’s camera at any block of text and have it instantly translated into text in your native language.

## 2. Communication | Personal computers as telephones

**PREDICTION:** ...which also serves as her phone.

**ACCURACY:** Correct

**DISCUSSION:** With the development of VOIP (Voice over Internet Protocol) technology in the past several years, the use of personal computers (in desktops, laptops, and smartphones) for telephone communication has become widespread. [Examples of popular VOIP telephone products](#) include Skype (used by more than 500 million people worldwide), Google Voice, Vonage, Truphone, and magicJack.

## 3. Communication | Telephones are primarily wireless

**PREDICTION:** “Telephone” communication is primarily wireless.

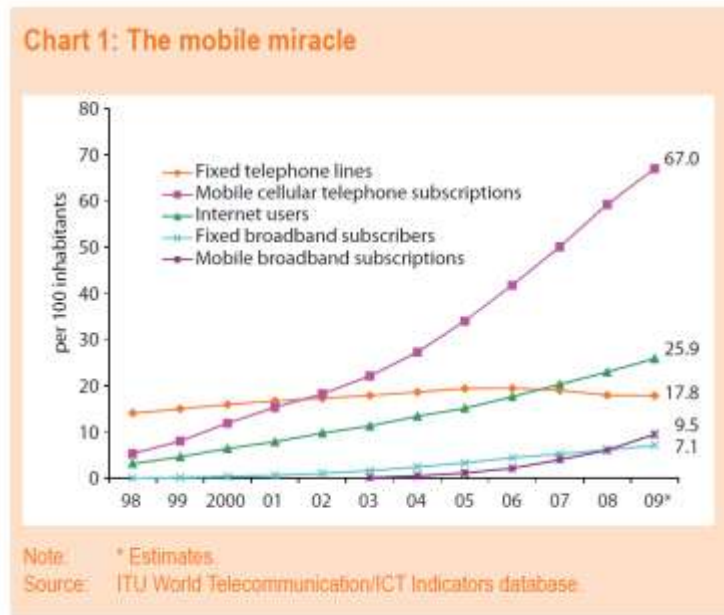
**ACCURACY:** Correct

**DISCUSSION:** Indeed, people do not have wires trailing from their mobile phones connecting the phones to the phone system. Recall that when I wrote this prediction in the 1990s, there were still very few mobile phones around the world and they were very expensive and did not work very well. Telephones were devices that were wired to the phone system then.

However, the growth of mobile telephones has been so impressive that by 2000 there were [more cell phone users than fixed landline telephone users](#) in the United States. In 2002, there were more mobile phone users worldwide than fixed telephone users,

according to the International Telecommunication Union’s (ITU) “[Measuring the Information Society 2010](#)” report, and by 2009, an estimated [67 percent of inhabitants worldwide used mobile telephones, while only an estimated 17.8 percent used fixed telephone lines](#) — almost four times more mobile telephone users than fixed telephone users.

(Below) Percentage of fixed vs. mobile telephone and Internet users worldwide 1998-2009 (courtesy of ITU’s “[Measuring the Information Society 2010](#)” report)



In the U.S., in the last half of 2009, one of every four American homes (24.5%) had only mobile phones, and nearly half of adults aged 25-29 years (48.6%) lived in households with only mobile phones, according to the [July-December 2009 National Health Interview Survey](#) by the National Center for Health Statistics of the Centers for Disease Control and Prevention.

#### 4. Communication | Telephone communication has moving images

**PREDICTION:** ...and routinely includes high-resolution moving images.

**ACCURACY:** Correct

**DISCUSSION:** While most U.S. wireless carriers do not yet provide mobile video calling, the technology has been here since 2007 from AT&T’s one-way [Video Share](#) service, starting at \$4.99 a month and compatible with a [wide variety of mobile phones](#). Several other carriers and vendors are planning to offer mobile video calling products in North America in 2010. These include Saygus, which introduced its [VPhone](#) — an Android-based smartphone with two-way video calling capability — at CES in January 2010, and Canadian mobile networks [Bell, Rogers and TELUS](#), which completed two-way mobile video calling trials between carriers in February 2010.





(Above) AT&T's mobile video calling service, Video Share (Image courtesy of AT&T Wireless)

In June 2010, Apple introduced its iPhone 4 with [FaceTime](#), allowing two-way video calling with high-resolution moving images.

In addition, one-way video calling has been available since December 2009 over Wi-Fi (using Skype via [Fring](#)'s iPhone app) and two-way with supported Nokia phones. Until it was banned by Skype in July 2010, Fring allowed for free video calls to other mobile phone users with Fring and Skype installed or to Skype users on their Mac or PC.

Using Fring with a mobile-broadband Wi-Fi device such as the MiFi from Verizon or the Overdrive from Sprint, mobile video calling anywhere in the U.S. — where these carriers offer 3G (or 4G) service — has been tested by my staff.



(Left) Left: Apple FaceTime (photo courtesy of Apple Inc.); Right: Fring/Skype mobile video call via mobile-broadband Wi-Fi on iPhone 3G S (Image courtesy of Fring)

As I am writing this, there are more than [22 million users currently online on Skype](#) who are able (with the necessary peripherals) to transmit both video images and voice on personal computers to other Skype users at no cost.

*BusinessWeek* reported in January 2010 that “Skype has [more than 520 million users and is the largest provider of international calling](#), accounting for 12 percent of cross-border voice traffic, according to Washington-based research firm [Telegeography](#).” In fact, Skype has more users than China Mobile, which is the largest mobile telephone operator in the world, and it also has more users than the four major U.S. mobile operators put together (AT&T, Sprint, T-Mobile and Verizon).

But Skype is not the only Voice over Internet Protocol (VoIP) service; [there are several other companies](#) offering voice, video, data, encryption and many other capabilities for calls across the world.

The fast spread of videophones, computer webcams, and smartphones with cameras ([30 percent](#) of all mobile phones in the United States are now smartphones, as of December 1, 2010) has helped the expansion of online video services around the planet. For example, [Qik](#) (supporting 29 mobile phone brands) and [Ustream](#) (supporting iPhone, Android and Nokia brands) allow for streaming one-way live video from mobile phones. Both services are free, with professional options.

## 5. Communication | Virtual meetings

**PREDICTION:** Meetings of all kinds and sizes routinely take place among geographically separated participants.

**ACCURACY:** Correct

DISCUSSION: A variety of free and paid [Internet telephony](#) services allow for conducting meetings using Voice over Internet Protocol (VoIP) via the Internet. These are available from Skype, Google Talk, Windows Live Messenger, and Yahoo Messenger, all of which offer video capabilities, with the capability of connecting more than two people together in a virtual meeting.

There are also paid services like [Vidyo](#) with services ranging from conventional videoconferencing to whiteboards, document sharing, joint document markup, and other capabilities. Vidyo is [packaging complete videoconferencing solutions for universities](#), with a service called VidyoCampus that starts with licenses for 5,000 students at a yearly cost of \$50,000.

Cisco WebEx, IBM Lotus Sametime, Microsoft Live Meeting and WebTrain are some of the paid Web conferencing software products that also support simultaneous real-time chatting, uploading and downloading documents, co-browsing, breakout sessions and some mobile device support. [Cisco Telepresence](#) allows for ready-made virtual videoconferencing, connecting up to 48 sites simultaneously. *Telepresence Options*, an annual multimedia survey of telepresence technologies, reviews telepresence systems, telepresence-managed service providers, telepresence sub-systems/peripherals, and inter-networking telepresence.

Another approach to teleconferencing is virtual meetings. Second Life (SL) is the current leader in virtual telepresence, where users are represented by an avatar that they design. Beginning in 2010, [there were more than 18 million residents in Second Life](#). Virtual meetings have become [a common application of Second Life](#), which claims to be “the leader of virtual meeting, event, training, prototyping, and simulation solutions that catalyze innovation while reducing the cost and environmental impact of travel.” [Major companies like Accenture, BT, Cisco, Dell, Intel, Unilever and Xerox hold virtual meetings](#) in Second Life.

## 6. Communication | All media is digital with global support

**PREDICTION:** There is effective convergence, at least on the hardware and supporting software level, of all media, which exist as digital objects (i.e., files).

**ACCURACY:** Correct

**DISCUSSION:** This is exactly what has happened. Today, music, books, magazines, videos, television shows, some feature movies, and other media exist as (and are being distributed as) digital files. This was not the case when the prediction was made. Through the continuous evolution and improvement of hardware and software standards, either by single providers or common platforms, the use of digital objects experienced a rapid expansion in the last decade.

Additionally, the convergence of information and communications technologies (ICT) is providing the needed support for the exponential growth of digital services, from data to video, including bandwidth-intensive services like YouTube. “Images, captured by more than 1 billion devices in the world, from digital cameras and camera phones to medical scanners and security cameras, comprise the largest component of the digital universe,” according to IDC’s [“The Expanding Digital Universe”](#) 2007 report. “They are replicated over the Internet, on private organizational networks, by PCs and servers, in data centers, in digital TV broadcasts, and on digital projection movie screens.”

In 2010, television started to move from broadcasting and cable to delivery via the Internet, using services such as Hulu, Netflix, Amazon Video On Demand, and Blockbuster On Demand.

## 7. Communication | Digital objects on wireless, high-bandwidth web

**PREDICTION:** ...distributed by the ever-present, high-bandwidth, wireless information web.

**ACCURACY:** Correct

**DISCUSSION:** Indeed, these digital media objects are increasingly distributed through broadband wireless communication over the Internet via wireless carriers such as AT&T, Sprint, and Verizon to smartphones, tablets, and other devices.

## 8. Communication | Instantly download media to portable devices

**PREDICTION:** Users can instantly download books, magazines, newspapers, television, radio, movies, and other forms of software to their highly portable personal communication devices.

**ACCURACY:** Correct

**DISCUSSION:** All of these types of objects are available now as digital files, and are downloaded to portable devices such as Apple's iPhone and iPad, notebooks, netbooks, e-book readers, and tablet devices.

The product Blio, from my company K-NFB Reading Technology, in partnership with Baker & Taylor, the world's largest book distributor, is a free software product that runs on many platforms (such as PCs) and [will read books, magazines, and newspapers](#).

The [iTunes Store](#) has become the largest software-based online digital media store in the world. In April 2008, the iTunes Store [became the number-one music vendor in the United States](#), with more than 12 million songs, 8,500 movies, 55,000 TV episodes, 200,000 apps, and 175,000 podcasts, according to an Apple spokesperson.

Amazon.com is the worldwide leader in e-book sales and [the world's largest online retailer](#), with revenues close to \$25 billion in 2009. For Christmas 2009, e-books were some of the most successful sale items for Amazon.com and other online retailers. [Amazon.com e-book sales overtook print book sales for the first time on December 2009](#).

## 9. Communication | Encrypted communications

**PREDICTION:** Virtually all communication is digital and encrypted...

**ACCURACY:** Partially correct

**DISCUSSION:** Routine telecommunication is digital and often encrypted. Mobile telephone transmissions are also completely digital and encrypted since second-generation (2G) systems, and all current landline telecommunication systems use digital communication except for legacy "final mile" copper wiring.

The GSM (Global System for Mobile Communications) standard for cell phones is [used by close to 80% of all mobile users worldwide](#); [GSM was first encrypted in 1988](#).

In 2001, the U.S. government [adopted a new encryption standard called the Advanced Encryption Standard \(AES\)](#) with [key](#) sizes of 128, 192 and 256 bits for increased security purposes. The AES was announced by the U.S. National Institute of Standards and Technology (NIST) after a 5-year standardization process among 15 competing designs. The AES ciphers have been analyzed extensively and are now used worldwide for many types of communications, as was the case with its predecessor, the Data Encryption Standard (DES).

Digital books, magazines, and newspapers also use simpler encryption systems called Digital Rights Management (DRM) from Adobe, Microsoft and other providers. Games, movies, music and software also use DRM for online file distribution.

## 10. Communication | Decryption keys made available to authorities

**PREDICTION:** ...with keys available to government authorities.

**ACCURACY:** Correct

**DISCUSSION:** Based on security concerns, government agencies such as the U.S. National Security Agency (NSA) have accessed private keys used in public-key cryptography to break digital encryption. After the September 11, 2001 terrorist attacks, the Bush administration acted under the “Terrorist Surveillance Program,” part of the broader President’s Surveillance Program, and the [NSA was authorized by executive order to monitor suspicious phone calls, e-mails, Internet activity, text messaging and other communications](#).

In 2009, a U.S. court [ratified electronic wiretapping without warrants](#): “In a rare public ruling, a secret federal appeals court has said telecommunications companies must cooperate with the government to intercept international phone calls and e-mail of American citizens suspected of being spies or terrorists.”

[Governments around the world have used their power to get “backdoor keys”](#) to access private messages. For example, [the government of India recently forced RIM to cooperate](#) or leave India: “BlackBerry uses a very high level of encryption — at 256 bits — while sending data. BlackBerry scrambles messages before sending and unscrambles them at the receiver’s BlackBerry. Owing to security concerns, the government wants to be able to intercept and decode the data. However, the government’s decryption software can decode messages encrypted only up to 40 bits. India wants RIM to either hand over the decryption keys or reduce encryption to 40 bits.”

## 11. Communication | Secret encryption, with no oversight

**PREDICTION:** Many individuals and groups, including but not limited to criminal organizations, use an additional layer of virtually unbreakable encryption codes with no third party keys.

**ACCURACY:** Correct

**DISCUSSION:** To avoid wiretapping of Internet communication and mobile phone calls, there are additional “secret-key” security measures that can be taken by private individuals or corporations. Some [current encryption methods](#) are more powerful than the 128, 192 and 256-bit AES codes used by the U.S. government.

For example, the MDC/SHA method uses 512-bit keys, which make the decryption process much longer and more complicated than without the proper keys or ciphers.

[Some systems use no public keys](#), and all information is handled with specific, private keys, avoiding even third party keys or escrow keys that can be discovered by surveillance mechanisms.

[EncryptionAndDecryption.com](#) and [SecureVoiceGsm.com](#) are two such encryption services, for different types of digital telecommunications. [Crypto AG](#) self-defines as the “preferred top-security partner for civilian and military authorities worldwide” from Switzerland.

The encryption industry has grown to provide all kinds of services to individual users, including [companies that provide anonymous](#) Web surfing. In fact, [private enhancing technologies \(PET\) is a new general term for a set of computer tools](#), applications and mechanisms which (when integrated in online services or applications, or when used in conjunction with such services or applications) allow online users to protect their privacy.

Many people use such services for their confidential and private communications, including money transactions, signature encoding and password transfers, but they can be used for criminal purposes as well. To distinguish both and to safeguard the individual, the American Civil Liberties Union (ACLU), the Electronic Frontier Foundation (EFF) and the Electronic Privacy Information Center (EPIC) [issued a joint statement](#) emphasizing that they “have long recognized the importance of technologies such as encryption for the protection of personal privacy.”

## 12. Communication | Haptics let people touch and feel remotely

**PREDICTION:** Haptic technologies are emerging that allow people to touch and feel objects and other persons at a distance.

**ACCURACY:** Correct



DISCUSSION: Haptics is a [tactile feedback technology that employs a user's sense of touch by applying forces, vibrations, and motions to the user](#). Such mechanical stimulations may be used to assist in the creation of virtual objects (objects existing only in a computer simulation), for control of such virtual objects, and for the enhancement of the remote control of machines and devices. Haptics has been described as “[\(doing\) for the sense of touch what computer graphics does for vision](#).”

Haptics is a rapidly growing field, with institutions like the [International Society for Haptics](#), specialized journals like [Haptics-e \(The Electronics Journal of Haptics Research\)](#), and regular conferences like the [Haptics Symposium](#) organized by the Institute of Electrical and Electronics Engineers (IEEE), as well as special sessions on the [conference on Computer Human Interaction](#) (CHI) sponsored by Association for Computing Machinery (ACM).

Some smartphones like the iPhone and Android models [now come with touch sensing](#) provided by different haptic technologies. [Immersion](#) is a leading company in such high-resolution haptics for consumer electronics, medical, automotive, industrial, commercial, and gaming applications, using quiet actuators. Piezoelectronic technology [provides tactile sensations](#) for some touchscreens.

[Microsoft Surface is a multitouch product](#) developed as a software and hardware combination technology that allows a user or multiple users to manipulate digital content using gesture recognition and pressure-sensing. In Japan, some groups are working on “[haptic rings](#)” that let you feel objects in augmented reality, while other researchers are using [ultrasonic waves to create sensations](#) of virtual objects in mid-air, which produce “[touchable holograms](#).” In Korea, there is a very active haptics community [working on telerobotics and virtual reality](#).

### **Additional examples**

FlexTorque aims at [new levels of ultra-realism](#) in virtual reality [environments through force-feedback for virtual objects and worlds](#).

JPL and Rutgers' [MEMICA Project](#) is “intended to provide human operators intuitive and interactive feeling of the stiffness and forces at remote or virtual sites in support of space, medical, underwater, virtual reality, military, and field robots performing dexterous manipulation operations.”

### **More references**

Accelerating Future blog | “[Full Body Haptic Suits](#)”

“[Towards Full-Body Haptic Feedback: The Design and Deployment of a Spatialized Vibrotactile Feedback System](#),” George Washington University, NRL

“[Immersion, Inc. demos new piezoelectric force feedback mechanisms for a new generation of haptic-enabled consumer electronics like mobile phones](#)” at CES 2010 [video]

[Senseg's motorless haptic system](#) for textured screen surfaces [video]

### 13. Communication | Haptics common in gaming and simulation

**PREDICTION:** These force feedback devices are widely used in games and in training simulation systems.

**ACCURACY:** Correct

**DISCUSSION:** [Some analysts suggest](#) that haptic technology has launched a “virtual reality and telepresence revolution.” There are currently [hundreds of computer games](#) that use force feedback to provide tactile feedback through the input device.

Some early games used the Nintendo [Rumble Pak](#) controller, and other games used different versions of the [Sony DualShock](#) vibration-feedback gamepads. But now there are [many more possibilities](#) with the latest video game consoles.

In 2007, [Novint](#) released the Falcon, the first consumer 3D touch device with high-resolution, three-dimensional force feedback, allowing haptic simulation of objects, textures, recoil, momentum, and physical presence of objects in games.

[The Falcon](#) has tiny motors that “are updated approximately 1000 times a second, letting you feel texture, shape, weight, dimension, and dynamics. The Falcon lets you control and interact with games in a more realistic way, allowing you to develop real physical skill and muscle memory, adding a new dimension to gaming.”

The [CyberGlove](#) is another product with uses in many kinds of simulations, including motion capture and industrial training.

Advanced flight simulators can also “simulate the aerodynamic forces perceived when using the controls of the aircraft through control force feedback. Equipment used varies from spring-loaded control sticks to computer-controlled servos,” according to aerospace engineer [Jonathan Gabbai](#).

In medicine, [RoSS \(Robotic Surgical Simulator\)](#), made by Simulated Surgical Systems, uses virtual reality to realistically introduce the user to the operation and feel of a robotic surgical console. RoSS [has been called](#) the “flight simulator” of robotic surgery. Virtual-reality [simulators are also being developed](#) for brain surgeons to provide better training and safer operations.

#### 14. Communication | Gaming includes immersive VR

**PREDICTION:** Interactive games routinely include all-encompassing visual and auditory environments...

**ACCURACY:** Correct

DISCUSSION: Interactive devices such as the Nintendo Wii provide a visual and auditory environment where, for example, you can play sports or musical instruments with other players. In fact, all [seventh-generation video game consoles](#), like the Microsoft Xbox 360 and the Sony PlayStation 3, use very sophisticated hardware and software systems that [show substantial progress](#) since video games were first invented. Note that the prediction does not say “full immersion.”

With [3D television introduced](#) in 2009, full-immersion 3D environments for games are coming in full force. There are already some 3D video games; Nvidia is a leader in hardware for many such products. Additionally, the [French company Total Immersion](#) is using augmented reality technology with camera capture and 3D imaging techniques to blend surrounding and simulated environments in real time.

#### More references

The Virtual Cocoon/Real Virtuality project: [“Revealed: The headset that will mimic all five senses and make the virtual world as convincing as real life.”](#)

[“First Virtual Reality Technology To Let You See, Hear, Smell, Taste And Touch.”](#)

#### 15. Communication | Virtual tactile environments

**PREDICTION:** ...but a satisfactory, all-encompassing tactile environment is not yet available.

**ACCURACY:** Correct

DISCUSSION: The force feedback and haptic technologies described above allow you to feel tactile sensations that are appropriate for a game or other situation and to feel objects, but we still don't have a satisfactory way of hugging or kissing each other at a distance.

That's coming, however, and several other computer interfaces are currently being developed. According to MIT's [Technology Review](#), the keyboard, mouse and joystick are being replaced by new technologies like the touchpad, multitouch screen, [gesture sensing, force feedback, voice recognition](#), augmented reality, [spatial interfaces, and brain-computer interfaces](#).

With better interfaces, we might indeed be moving soon from virtual reality to real virtuality. “The crucial thing for ‘real virtuality’ is that it will hit all five senses in a highly realistic manner,” said Alan Chalmers, a professor at the University of Warwick Digital Lab. Haptics is still in its infancy, but [researchers are already working](#) on how to add touch, taste and smell to virtual reality.

## 16. Communication | Virtual reality chat rooms

**PREDICTION:** The online chat rooms of the late 1990s have been replaced with virtual environments where you can meet people with full visual realism.

**ACCURACY:** Correct

**DISCUSSION:** There are different ways to do this. One is with video conferencing where you can see the person you are talking to. These systems range from free services such as Skype to highly realistic systems where it feels like you are sitting with other people.

There are also webinars (Web seminars) within virtual environments, some of them using simple instant messaging (IM) services like free Google Talk or Yahoo! Messenger, or paid systems like [ooVoo](#).

Telepresence is a growing business. Cisco [offers 3D virtual videoconferencing](#) over the Internet, and has sold over two thousand virtual rooms internationally.

Besides the [Cisco Telepresence systems](#), I personally use a system called [Teleportec](#) to give about twenty speeches a year where I appear at the remote venue with apparent three-dimensional fidelity.

*(Below) Ray Kurzweil delivers a speech using Teleportec (Photo courtesy of KurzweilAI.net)*



When I move around, the audience sees their local background behind me. It appears that I am standing behind a podium. I am the only speaker in the world who has one of these Teleportec systems in their personal office. We send a technician out with the other half of the equipment.

Another approach to virtual presence is online virtual environments, such as Second Life, where an avatar represents you. Virtual meetings are also a very common application in [Second Life](#), as previously noted.

## 17. Communication | Virtual sexual encounters

**PREDICTION:** People have sexual experiences at a distance with other persons as well as virtual partners.

**ACCURACY:** Correct

DISCUSSION: There are multiple ways to achieve this. One is to use video conferencing over the Internet, [which has certain advantages like safety, health, and convenience](#). Just as “phone sex” became popular (which is sex at a distance just using the auditory sense), adding the visual sense makes the experience that much more realistic. Cybersex is virtual sex over the Internet, including two-way communication and interaction through e-mail, instant messaging, chat rooms, webcams, role-playing games, etc.

Increases in Internet connectivity and bandwidth, together with the proliferation of webcams, have led to the growth of cybersex. [According to an article in \*The Village Voice\*](#), “if you like to watch,” there are four increasing levels of cybersex that you can have using a webcam.

Virtual sexual encounters are also possible in virtual environments like Second Life. Virtual sex is probably the most popular of the virtual world’s activities: “[Second Life is, among other things, a world of sex](#). It’s also a world with its own free market economy. Put those two things together, and you get one of the biggest markets in Second Life: the market for adult services. For the right number of Lindens — the game’s local currency — players can choose from literally thousands of online escorts: users who specialize in text cybersex, sexy voice chat, or even video cybering,” according to *The Village Voice*.

In 2007, as reported by the Second Life Bureau of Reuters, [a major transaction was made within this virtual world](#) when one of the landmark businesses in Second Life, the virtual town “Amsterdam,” was sold on eBay for \$50,000. Virtual Amsterdam is known for its sexually explicit “red light district.”

## 18. Communication | Virtual sex limited by virtual-touch technology

**PREDICTION:** But the lack of the “surround” tactile environment has thus far kept virtual sex out of the mainstream.

**ACCURACY:** Correct

DISCUSSION: Indeed, the tactile sense is an important part of sensual and sexual communication and activity. This is not yet available, but coming.

I filed a series of patent applications on a technology that would enable realistic auditory, visual, and tactile communication with a partner. It would look, sound, and feel as if you were with that other person.

The five patent applications are in series of increasing realism. The first just allows you to see the other as if you were together. The third allows you to feel the other. The fourth allows you to actually move around as if you were with your partner, and so on.

The idea is that each partner has a mannequin, but it does not appear or feel like you are with a mannequin; it looks and feels as if you are with your partner. You see out of the eyes of your partner's mannequin and s/he does the same with you. You touch and feel out of the limbs and senses of your partner's mannequin and s/he does the same with you. The effect is as if you were with your partner even though your real bodies are far apart.

Here are the abstracts of the five patents with the embedded hyperlinks to the full, published patent applications for the series of possible virtual encounters described:

### [Patent Abstract 1](#)

A virtual encounter system includes a mannequin coupled to a camera for receiving a video image. The camera sends the video image to a communications network. The virtual encounter system also includes a processor for overlaying a virtual environment over one or more portions of the video image to form a virtual scene and a set of goggles to render the virtual scene.

### [Patent Abstract 2](#)

A virtual encounter system includes a mannequin coupled to a camera for receiving a video image. The camera sends the video image to a communications network. The virtual encounter system also includes a processor for morphing the video image and a set of goggles to display a morphed video image.

### [Patent Abstract 3](#)

A virtual encounter system includes a humanoid robot having tactile sensors positioned along the exterior of the humanoid robot. The tactile sensors send tactile signals to a communications network. The virtual encounter system also includes a body suit having tactile actuators. The tactile actuators receive the tactile signals from the communications network.

### [Patent Abstract 4](#)

A virtual reality encounter system includes motion sensors positioned on a human user. The motion sensors send motion signals corresponding to movements of the user as detected by the motion sensors relative to a reference point, the motion signals are transmitted over a communications network. The system also includes a humanoid robot, receiving, from the communications network, the motion signals to induce movement of the robot according to movement of the human user.



## [Patent Abstract 5](#)

A virtual encounter system includes a mannequin having life-like features. The mannequin includes a body, a camera, coupled to the body, for sending video signals over a communications network, and a microphone, coupled to the body, for sending audio signals to the communications network. The system also includes a set of goggles that includes a display to render video signals received from the camera and a transducer to transduce the audio signals received from the microphone.

## **More references**

Sinulate, Inc. "[installs on Mac, PC, Linux, Palm, WebTV, airport kiosk, etc. You'll be able to call or e-mail anyone anywhere and let them control your sex toy over the Internet.](#)"

MSNBC, "[Will technology revolutionize boinking?](#)": "Web-based outfits like [www.Sinulate.com](#) and [www.HighJoy.com](#) enable users to engage in sex play when they connect a vibrator to a computer that receives electronic instructions submitted by somebody sitting at another computer. The user interfaces, which resemble airplane cockpit controls or stereo sound leveling dials, change the speed and direction of a vibrator hooked up to the receiver's computer."

Wired, "[Reaching Through the Net to Touch](#)": "Researchers at the University at Buffalo, NY, announced a system that lets one person experience the sense of touch felt by another. They said they could transmit the sensation across the Internet."

[SensAble Technologies, Inc.](#): "The SensAble Technologies PHANTOM product line of haptic devices makes it possible for users to touch and manipulate virtual objects. Different models in the PHANTOM product line meet the varying needs of both research and commercial customers."

## **19. Communication | Virtual sex partners on the rise**

**PREDICTION:** Virtual partners are popular as forms of sexual entertainment, but they are more game-like than real.

**ACCURACY:** Correct

DISCUSSION: One good example of this is the popularity of virtual sex in the virtual environment Second Life. [An article in the Village Voice](#) describes "Getting Started with Sex in Second Life." However, you can never [tell for sure who the other avatars really are](#), and some avatar interactions might possibly be better or worse than the real thing.

According to the [British Telecom Technology Timeline](#) published in 2005, the first "orgasmatrons" might appear between 2011 and 2015.

In January 2010, [Roxxy was presented](#) as the first life-sized sexbot (or sex robot) that can even talk about football. Several experts have [discussed the possibilities of sex with robots](#) in the next few years.

In Japan, there is a large market of “eroge” (a Japanese portmanteau of “erotic game”): [video games with virtual partners with erotic content](#) presented in anime style, including online sex, role-playing games and even some massively multiplayer virtual sex games.

There is a new field called “teledildonics” (also known as “cyberdildonics”) dealing with electronic sex [toys that can be controlled by a computer](#). Teledildonics is also concerned with the integration of telepresence and sex that these toys make possible, since [some can be manipulated remotely by another person](#) online as well. [SexGamesReport.com](#) and [TheVirtualSexReview.com](#) follow the latest developments on virtual sex and games.

[Porn 2.0](#), named after Web 2.0, is a developing concept where websites feature explicit, user-generated content. Porn 2.0 is sometimes described as an intermediate social networking medium, with users hosting dynamic webcam content, compared to the static content of Porn 1.0. “[Porn 3.0](#)” is already in development, utilizing interactive, 3D viewing technologies.

## 20. Communication | Routine video-phone sex

**PREDICTION:** And phone sex is a lot more popular now that phones routinely include high resolution real-time moving images of the person on the other end.

**ACCURACY:** Correct

DISCUSSION: Phone sex is virtual sex over the telephone. People can also have virtual sex via mobile phone text messages, [known commonly as “sexting”](#) (a portmanteau for sex texting), which is popular among teens. The advent of cell phones with built-in digital cameras has added new dimensions to these activities.

Phone sex using video images from video conferencing (such as the free video conferencing provided by Skype) between partners in a relationship, as well as between sex service providers and clients, is indeed a popular activity. [Statistics about phone sex and cybersex](#) are always difficult to verify, but this is [already a multi-billion dollar business](#).

[According to CIO magazine](#), telephone companies earn close to \$500 million every year from phone sex. Vonage Canada reported that [the telephone was the safest and most powerful sex toy](#) for Valentine’s Day in 2006. Indeed, the telephone [can be a very sexy toy](#), and there are [already Skype phone sex services](#) for iPhones and other smartphones.

According to an [article in TopTenReviews.com](#), phone (including cable, pay-per-view and mobile) sex represented about \$2 billion and Internet sex \$2.84 billion in the United States during 2006.

Additionally, [12% of all websites were pornographic, 25% of total search engines requests were also pornographic, 42.7% of the Internet users viewed porn, 34% received unwanted exposure to sexual material, 35% of the total downloads were pornographic,](#) and 1 in 7 youth reported being solicited for sex on the Internet.

At the time of this writing, Google found 607 million results for sex and 852 million for water, Yahoo! found 2,430 million results for sex and 3,360 million for water, and Bing showed 2,200 million results for sex and only 482 million for water!

## BUSINESS AND ECONOMICS

### Predictions made for 2009 in *The Age of Spiritual Machines*

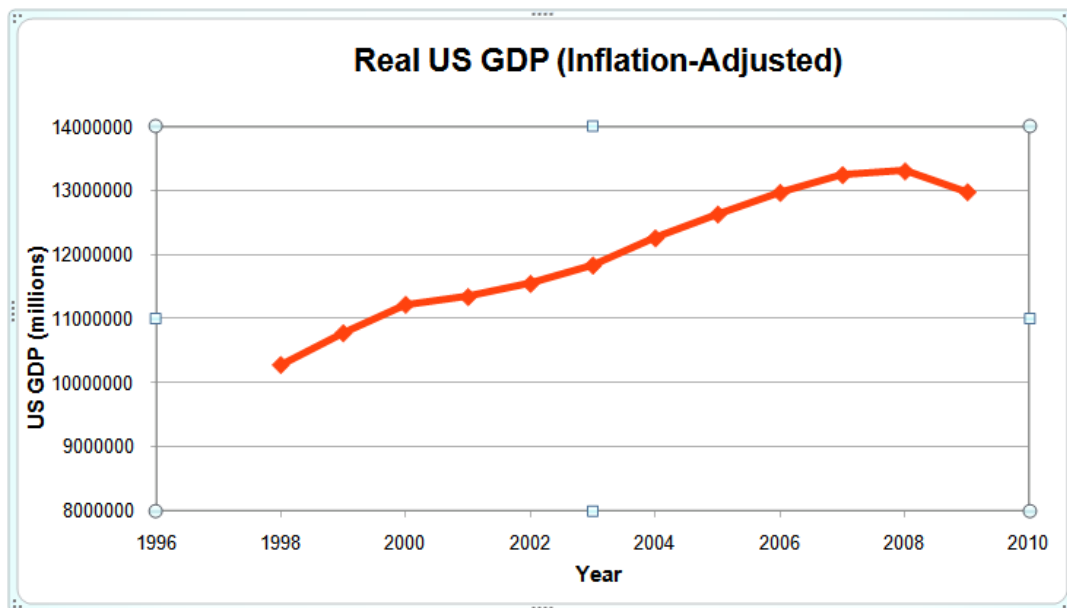
The following is an analysis of predictions for 2009 made about the future of business and economics in the book *The Age of Spiritual Machines*, which was written in the mid to late 1990s.

#### 1. Business & Economics | Steady economic progress

**PREDICTION:** Despite occasional corrections, the ten years leading up to 2009 have seen continuous economic expansion and prosperity due to the dominance of the knowledge content of products and services.

**ACCURACY:** Correct

**DISCUSSION:** Given the modifier, “Despite occasional corrections,” this is clearly correct. Consider U.S. real gross domestic product (Real GDP), shown in constant 2005 dollars in the [“What Was the U.S. GDP Then?” data on MeasuringWorth.com](#), by Louis Johnston and Samuel H. Williamson, 2010.



(Source: MeasuringWorth.com)

Aside from a small decline in 2009, there was growth in all of the other years. Overall there was growth by 21 percent in constant dollars (10 percent on a per capita basis and in constant dollars). Looking at “nominal GDP” (GDP before adjustment for CPI), we also see increases in every year, except for a small decline in 2009. Nominal GDP increased 52 percent from 1999 to 2009, and 39 percent on a per capita basis.

### Nominal GDP — 1999 to 2009

Year	Nominal GDP (millions of Dollars)	Real GDP (millions of 2005 dollars)	GDP Deflator (index 2005=100%)	Population (in thousands)	Nominal GDP per capita (current dollars)	Real GDP per capita (year 2005 dollars)
1999	9353500	10779800	86.77	279328	33485.72	38591.91
2000	9951500	11226000	88.65	282413	35237.4	39750.3
2001	10286200	11347200	90.65	285294	36054.74	39773.71
2002	10642300	11553000	92.12	288055	36945.38	40106.92
2003	11142100	11840700	94.1	290729	38324.69	40727.62
2004	11867800	12263800	96.77	293348	40456.39	41806.32
2005	12638400	12638400	100	296000	42697.3	42697.3
2006	13398900	12976200	103.26	298820	44839.37	43424.8
2007	14077600	13254100	106.21	301737	46655.2	43926
2008	14441400	13312200	108.48	304530	47421.93	43713.92
2009	14256300	12987400	109.77	307483	46371	42247

(Source: *MeasuringWorth.com*)

These measurements do not take into account the profound improvements in capability of technology, especially information technologies. How much would a circa 2009 iPhone be worth in 1999? Just in terms of memory and processing power it would cost hundreds of thousands of dollars. But then such a device in 1999 would require a moving crew to move around. So an actual circa 2009 iPhone wasn't even possible at any price in 1999.

Conversely, how much would a circa 1999 laptop be worth in 2009? It might actually have some value as a museum piece, but it would be essentially worthless as a computer. We can make similar observations about genetic sequencing data, communication costs, and essentially all examples of information technology.

But even as we move away from strictly information products, and consider products such as automobiles, what would the value of 2009 features such as navigation (including, now, showing traffic patterns), collision avoidance, and improved safety and convenience features be in 1999? Clearly the value would be significant.

Since there is no straightforward way to measure these improvements in product quality, they are generally left out. What would the value be of a new product category that didn't even exist in the earlier time period, such as improved therapies for health conditions? Even without a direct measurement of product quality improvements and new product categories, GDP, both nominal and CPI adjusted, shows gains in every year except one over the past decade.

Despite the approximately 50 percent deflation rate inherent in every form of information, information is the source of this economic growth. As price/performance improves, whole new applications become feasible and open up new markets. People would not pay thousands of dollars for an iPod, which is what it would have cost 15 years ago. The iPad was not economically feasible to introduce until 2010. The National Institutes of Health would not be collecting a database of a thousand full human genomes (the [1000 Genomes Project](#)), with more planned after completion, if they still cost [\\$2.7 billion](#) each (in FY 1991 dollars), which is what the first one cost (completed in 2003).

The non-information technology industries are gradually contracting as more and more industries become dominated by information technology. The most recent such industry that is undergoing this transformation is health and medicine, now that we are gaining the means of reprogramming the information processes underlying biology.

Note: Nominal GDP (GDP without adjustment for CPI changes) is measured in millions of U.S. Dollars. Real GDP is the value of production adjusted for changes in CPI using a given base year, here presented in constant (2005) dollars, shown in millions of U.S. Dollars.

## 2. Business & Economics | Greatest gains are in the stock market

**PREDICTION:** The greatest gains continue to be in the value of the stock market

**ACCURACY:** Partially correct

**DISCUSSION:** As the previous discussion illustrates, the size of the U.S. economy grew substantially during the decade (an increase of 52 percent in nominal GDP). One of the problems in appreciating this is that the gains in product quality are largely factored out. In 1999 you received \$100 worth of products for \$100, and that remained true in 2009,



and will always be true. But look at the fantastic increase in capabilities in computerized products circa 2009, which are generally about a thousand times more capable than comparably priced 1999 products. Consider also all of the free products and services in 2009 that did not exist in 1999.

The economic gains (increases in real GDP) were largely not obtained through asset investments of any kind, but the stock market did perform better than other categories of investment, such as bonds and real estate, which had significant losses, especially in the latter period of the decade.

The Dow Jones Industrial Average (DJIA) started 1999 under 10,000 and ended 2009 over 10,000. As of December 16, 2010, the DJIA has recovered and is now 11,500. Looking at a broader index, the Morgan Stanley Capital International (MSCI) World Index — a stock market index of 1,500 world companies from 23 countries, excluding emerging economies — gave an overall return of over 20 percent during the decade (through the end of 2009).

The Chinese Hang Seng showed an overall return of 42 percent over the decade (through the end of 2009). The average return for all world stock market indices, including emerging markets, was 22 percent (through the end of 2009).

### 3. Business & Economics | Deflation as a positive development

**PREDICTION:** Price deflation concerned economists in the early '00 years, but they quickly realized it was a good thing. The high tech community pointed out that significant deflation had existed in the computer hardware and software industries for many years earlier without detriment.

**ACCURACY:** Partially correct

**DISCUSSION:** The comment regarding deflation is correct, but it is not correct to say that this is widely appreciated by most economists, who continue to ignore the true value of products, treating a \$100 of electronics in 2009 as equivalent to \$100 of electronics in 1999, despite a thousand-fold increase in capability.

The deflation rate for computer memory is 34 percent per year on a bit basis, but when increases in speed are considered, the overall price/performance of computers and digital electronics has an approximately 50 percent deflation rate. For example, you can buy an iPhone today that is twice as good as the model two years earlier for half the price. That's a four-fold improvement in price/performance in two years, or a doubling each year.

This approximate rate of improvement is universally true across every category of information product. Despite this approximately 50 percent deflation rate, the revenue of information technologies is increasing significantly as a result of products becoming more attractive and new product categories opening up.

This source of deflation is to be contrasted with the deflation that occurred during the Great Depression of the 1930s, which was caused not by improved price/performance but by a collapse in consumer confidence, and the drying up of pools of capital and credit. These two sources of deflation need to be distinguished.

More and more industries are becoming information technologies. Industries that are not thought of as part of the “IT” industry are increasingly becoming dominated by information technologies. Examples include all of media (music, movies, television, books) and medicine.

At least the research part of health and medicine has also become an information technology, now that we have gathered the software of life, we have the means of modifying it (with RNA interference to turn genes off and new forms of gene therapy to add new genes and many other means of modifying genetic and epigenetic factors), and we are making exponential gains in reverse-engineering (understanding) the information processes underlying biology. These methods will enter clinical practice as we go through this next decade.

#### 4. Business & Economics | U.S. still global economic leader

**PREDICTION:** The United States continues to be the economic leader due to its primacy in popular culture and its entrepreneurial environment.

**ACCURACY:** Correct

**DISCUSSION:** The United States continues to have the world’s largest economy, and continues to lead in areas that rely on innovation, entrepreneurial activity, and media products. The U.S. also continues to lead the world in such cultural expressions as movies, television shows, and music.

The unique venture-capital industry in the United States has still not been fully replicated anywhere else (except perhaps in Israel, but it is a small country with a population only two percent of the size of the U.S.). According to the [World Intellectual Property Organization](#) (WIPO), one in every four patent applications in the world is actually filed in the United States.

The U.S. is by far the leading nation in innovation, according to [Science and Engineering Indicators: 2010](#), published by the National Science Foundation. Such developments are also reflected in the entrepreneurial spirit found in regions like Silicon Valley in California and “Route 128” in Massachusetts.

Venture capital is still led by the United States, [with \\$28.8 billion invested in 2550 deals in 2008](#), compared to international funds with \$13.4 billion invested everywhere else. There has been an average 5 percent growth in venture capital deals outside of the United States, mainly in China, Europe and Israel.

The U.S. leads in the export of popular culture, from music to fashion. American singers and writers are among the top worldwide bestsellers, and U.S. film-production companies produce more revenues than all other national film industries combined ([even if there is important competition by Bollywood](#) in India and Cairo in the Arab world, for example, among some other regional markets).

## 5. Business & Economics | U.S. multiculturalism an asset

**PREDICTION:** Since information markets are largely world markets, the U.S. has benefited greatly from its immigrant history. Being comprised of all the world's peoples — specifically, the descendants of peoples from around the globe who had endured great risk for a better life — it has the ideal heritage for the new knowledge-based economy.

**ACCURACY:** Correct

**DISCUSSION:** The economy is much more an information economy than it was in 1999, and the world is also much more interconnected, so the importance of immigrants has grown.

A [2009 report](#) by the Ewing Marion Kauffman Foundation found that “Among technology and engineering companies started in the U.S. during the 1995-2005 period, 25 percent had at least one immigrant key founder... In Silicon Valley, over 50 percent of the startups in that period had at least one immigrant key founder. Additionally, foreign nationals account for 25 percent of international patent applications filed from the U.S.”

## 6. Business & Economics | China as economic powerhouse

**PREDICTION:** China has also emerged as a powerful economic player.

**ACCURACY:** Correct

**DISCUSSION:** Indeed, China has emerged as a powerful economic player, and has demonstrated impressive economic growth, generally growing 8 to 10 percent per year. It is now the second largest economy in the world, having recently surpassed Japan. This was not so clear when this prediction was made in the 1990s.

In the fourth quarter of 2009, [China overtook Japan](#) as the second largest economy of the world, based on its GDP in nominal terms. Also, a few years earlier, [China had also overtaken Japan's GDP](#) in PPP (purchasing power parity) terms. Even during the global financial crisis in 2009, China managed to grow 8.7%, and it is expected to grow 10.0% in 2010, [according to the IMF](#), and had comparable growth rates throughout the '00 years.

## 7. Business & Economics | Europe adopts U.S. entrepreneurship

**PREDICTION:** Europe has been somewhat quicker than Japan and Korea in adopting the American emphasis on venture capital, employee stock options, and tax policies that encourage entrepreneurship, although these practices have become popular throughout the world.

**ACCURACY:** Correct

**DISCUSSION:** In 1998, venture investments in Europe were well under half of what they were in the United States. However, in 2002, Europe briefly reached parity with the U.S., with \$25B in annual VC investments each, according to [Venture capital in Europe](#), by Greg N. Gregoriou, Maher Kooli, and Roman Kräussl. Although the European entrepreneurship sector still lags behind that of the U.S. as a percentage of GDP (see [Entrepreneurship: U.S. and Europe](#)), it is growing, with employment in venture-capital-backed enterprises [growing](#) an average of 30% per year from 1997 to 2004.

Entrepreneurial policies have also spread elsewhere in the world, with the most dramatic example being China. Chinese law first started to [encourage the development](#) of venture capital in 1996. Since then, China's nascent VC industry has experienced [rapid growth](#), and has been supported with funding from the Chinese government. China has also become more favorable to [stock options](#) than it was under the old Communist system.

Largely as a result of these policies, China has experienced a remarkable [boom in entrepreneurship](#) since reforms started in the 1980s under Deng Xiaoping. [Surveys](#) show that more Chinese people have experience in starting a business than Americans, who in turn have more experience than the Japanese and South Koreans. This boom has greatly helped the Chinese economy, which has sustained an average growth rate of [9 percent since 1978](#).

By comparison, the Japanese have been sluggish in creating a startup sector, with most Japanese workers remaining employed in large companies. Although the U.S. economy is only twice the size of Japan's, U.S. startups receive [ten times as much venture funding](#). Stock options are also uncommon in Japan. They were effectively illegal until 1998, and even after legalization, in 2006, the Japanese government passed a [law](#) making issuing options less favorable from an accounting perspective. Japan has stagnated economically since the early 1990s. Its share of the global economy is now [less than 10%](#), compared to 18% in 1994.

South Korea, despite its high level of technology friendliness, has been described as "[probably the least serviced](#)" of emerging markets by the Western VC industry. As of 2005, South Korea only had \$3 billion [under management](#) by VC firms, compared to [\\$180 billion](#) in the United States.

## 8. Business & Economics | Ubiquity of online transactions

**PREDICTION:** At least half of all transactions are conducted on-line.

**ACCURACY:** Correct

**DISCUSSION:** [The banking industry was one of the first to go truly global](#), and it quickly moved to online services, thanks to the rapid advances in information technology. The Internet is now part of the financial market infrastructure. The many factors include companies such as Bloomberg and Reuters, who rely on the Internet for the financial market trading platforms they sell to financial institutions.

Just a couple of decades ago, almost all financial transactions were still made in person or using dedicated telephone and fax lines that connected a trader at one institution to his counterpart at another institution. This was still the dominant paradigm when this prediction was written in the late 1990s. Markets in stocks and other tradable instruments such as bonds and commodities are now created electronically using online communication.

Moreover, automated trading programs initiate vast numbers of transactions, especially when it is considered that movements of even small amounts of capital are broken into tiny pieces to avoid market impact. Virtually all banking, stock, bond, and commodity transactions have an online component.

Now, the global financial industry functions rapidly and efficiently, thanks to online transactions, which have greatly reduced [transaction costs](#) as well. The largest financial transactions in the world occur in foreign exchange markets, which have been handling more than one trillion dollars per day since the beginning of this century, and which are fully automated through the Internet.

According to the latest [Triennial Central Bank Survey](#) published by the Bank for International Settlements (BIS) in Basel, Switzerland, in December 2007, “the average daily turnover has grown by an unprecedented 69% since April 2004, to \$3.2 trillion...

This increase was much stronger than the one observed between 2001 and 2004.” That year, the average daily turnover in global foreign exchange markets was estimated at \$4.0 trillion, with trading in the world’s main financial markets accounting for \$3.2 trillion of the total.

This approximately \$3.2 trillion in main foreign exchange market turnover was broken down as \$1.7 trillion in foreign exchange swaps, \$1.0 trillion in spot transactions and \$0.4 trillion in outright forwards.

Estimating an increase of 60% from 2007 to 2010, smaller than that from 2004 to 2007, global foreign exchange transactions are on the order of \$6.4 trillion per day or higher, and all of those transactions, at least in the major foreign exchange markets, are essentially conducted online. In fact, many of such transactions are done automatically, following specific programs, including over-the-counter transactions.

## 9. Business & Economics | Ubiquity of intelligent virtual assistants

**PREDICTION:** Intelligent assistants which combine continuous speech recognition, natural language understanding, problem solving, and animated personalities routinely assist with finding information, answering questions and conducting transactions. Intelligent assistants have become a primary interface for interacting with information-based services, with a wide range of choices available. A recent poll shows that both male and female users prefer female personalities for their computer-based intelligent assistants. The two most popular are Maggie, who claims to be a waitress in a Harvard Square café, and Michelle, a stripper from New Orleans. Personality designers are in demand, and the field constitutes a growth area in software development.

**ACCURACY:** Partially correct

**DISCUSSION:** All of these elements exist: continuous speech recognition, natural language understanding sufficient for basic inquiries, problem-solving capabilities, and animated personalities; and combinations of some of these elements exist. But all of these elements have not yet been fully combined in a single intelligent assistant. However, significant advances in this field were recognized when MIT's *Technology Review* named "intelligent software assistant" [one of its 10 emerging technologies in its 2009 TR10 special report](#).

One product does come close. After a [public announcement in 2009](#), Siri, Inc. (since acquired by Apple Inc.) launched Siri, its free personal assistant app for the iPhone in February 2010. Siri uses natural language processing to answer questions and make recommendations on many different subjects. Siri is focused on AI apps for easy communications with humans. The company claims that the app adapts to the user's individual preferences over time and personalizes results, as well as accomplishing tasks such as making dinner reservations while trying to catch a cab.

Google and Microsoft have also announced that they plan product introductions in this space in the near future.

## 10. Business & Economics | New models for distributing media

**PREDICTION:** Most purchases of books, musical "albums," videos, games and other forms of software do not involve any physical object, so new business models for distributing these forms of information have emerged.

**ACCURACY:** Essentially correct



**DISCUSSION:** Indeed, these new business models have been introduced and have become well established during the last few years.

The past decade started with Napster, which led to the iTunes Store and other digital distribution of music; and the book, magazine, television-show, and movie industries have followed suit. Amazon.com developed an early recommendation system that included past purchases, content search, products reviewed, and recommendations by other users, among many features to attract customers who don't visit physical stores. The majority of music is now purchased online. As of July 2010, Amazon is selling [twice as many e-books as hardcover books](#).

Most games are downloaded, many for free. Movies are only slightly behind these other forms of media due to the large bandwidth and storage required for movies, but online distribution of movies began in earnest in 2010.

The statement "most purchases do not involve any physical object" was not quite realized in 2009 but became largely true in 2010, and the trends continue strongly in this direction.

## 11. Business & Economics | Online shopping and instant downloading

**PREDICTION:** One shops for these information objects by "strolling" through virtual malls, sampling and selecting objects of interest, rapidly (and securely) conducting an on-line transaction, and then quickly downloading the information using high-speed wireless communication.

**ACCURACY:** Correct

**DISCUSSION:** Online stores for music, videos, movies, television shows, books, magazines, and software applications indeed provide all of these capabilities, including the ability to sample the information object, and to conduct an on-line transaction and download the object through wireless communications.

For example, Amazon.com and the iTunes Store have no physical stores in real malls, but advertise all their items through their own large Internet virtual malls. These were copied later by more traditional retailers like [Barnes and Noble](#) and [Tower Records](#), which still have their large chain stores in real malls. In the last few years, both Barnes and Noble and [Tower Records had to close](#) many stores due to the high competition from direct online sales.

Today, thanks to the continuing development of online services, Amazon's [total sales](#) are about five times larger than [Barnes and Noble's revenues](#), and Tower Records had to [file for bankruptcy](#), while the iTunes Store became [the largest music seller in the world](#).

## 12. Business & Economics | New digital purchasing models

**PREDICTION:** There are many types and gradations of transactions to gain access to these products. You can “buy” a book, musical album, video, etc. which gives you unlimited permanent access.

**ACCURACY:** Correct

**DISCUSSION:** Buying a book for unlimited permanent access is indeed a common mode for transactions for electronic books, music, videos, and other digital media objects. Many online purchases involve continued connection of the user with the seller, or the digital object is moved to the “cloud” for later retrieval.

Thus, users can have continuous online access to their products while using proper identification, regardless of the type of device being used. For example, Apple iTunes songs and apps can be used on up to five authorized devices (iPhone, iPad, PC, etc.). Different services offer varying levels of access over multiple personal devices, including varying levels of ability to share content with friends.

There are also music services that allow unlimited access to any music for a periodic (e.g., monthly) fee within a large online collection.

## 13. Business & Economics | Renting digital material

**PREDICTION:** Alternatively, you can rent access to read, view, or listen once, or a few times. Or you can rent access by the minute.

**ACCURACY:** Correct

**DISCUSSION:** Just as with mobile phones, there are many types of online plans for different transactions to suit as many types of users as possible. Indeed, depending on the type of seller, buyer and product, some items can be rented or sold to single users or shared by a certain number of users, simultaneously or at different times.

Additionally, [many sellers have special plans](#) targeted to [different user categories](#) — for example, daily services, monthly unlimited plans, pay-by-item rents or purchases, and many other possible combinations, including special offers for students or people in developing countries.

#### 14. Business & Economics | Digital download management

**PREDICTION:** Access may be limited to one person or to a group of persons (for example, a family or a company). Alternatively, access may be limited to a particular computer, or to any computer accessed by a particular person or by a set of persons.

**ACCURACY:** Correct

**DISCUSSION:** As indicated above, there are many types of online plans for different transactions to suit as many types of users as possible. Additionally, it is possible today to have mass customizing and [micromarketing particularly targeted](#) to special groups of users.

The [changing pricing systems](#) provided by Amazon.com and iTunes Store are good examples of the continuous evolution of online services. Microsoft and other companies also sell “basic,” “home,” “business,” and “office” services, for example, which can be accessed by a single user, a family, or a specific number of people, ranging in groups from 10 to 100, or even unlimited users (multiuser accounts with different pricing schemes). This type of pricing is now very common for a broad variety of information products.

Since there are also many business practices and legal systems around the world, several types of [“digital rights management” \(DRM\)](#) have been developed over time, and large online retailers like [Apple](#) and [Microsoft](#) have their own DRM policies for most of their products.

However, some organizations like [the Electronic Frontier Foundation \(EFF\)](#) oppose DRM as an anti-competitive practice. The [Creative Commons](#) project provides licensing options encouraging the expansion of and building upon creative work without the use of DRM. Creative Commons is devoted to [expanding the range of creative works](#) available for others to build upon legally and to share.

Apple announced that DRM was removed from 80% of their entire music catalog in the United States in January 2009, and full iTunes Plus availability was achieved in April 2009, coinciding with the [introduction of a three-tiered pricing model](#) in the United States. In addition, there are now numerous online services that provide unlimited access to extensive music libraries for a set fee per month.

#### 15. Business & Economics | Global workplace telecommuting

**PREDICTION:** There is a strong trend towards the geographic separation of work groups. People are successfully working together despite living and working in different places.

**ACCURACY:** Correct

**DISCUSSION:** My own work groups are one good example of this. Teleworking (sometimes also called telecommuting, e-commuting or simply e-work) is a work arrangement in which employees enjoy flexibility in working location and hours. The daily commute to a central place of work is replaced by telecommunication links.

Many work from home, while others, occasionally also referred to as nomad workers or Web commuters, utilize mobile telecommunications technology to work while traveling to or from other locations. Long distance teleworking is facilitated by such tools as groupware, virtual private networks, conference calling, videoconferencing, and Voice over IP (VOIP), in addition to e-mail, IM and text messaging.

Teleworking offers many [benefits](#) to communities, employers, and employees, by reducing environmental pressures, travel costs, and time expenditures, and [increasing personal satisfaction](#).

The [Telework Trendlines 2009 survey](#), published by WorldatWork.com, reported that there are 33.7 million “total telecommuters at least 1 day per month” and that the top five teleworking locations are: home, client’s place of business, car, café or restaurant, and hotel or motel, in that order. Teleworking is not only [popular in the United States](#), but also in many [other countries, like Japan](#).

## 16. Business & Economics | Households average +100 computers

**PREDICTION:** The average household has more than a hundred computers, most of which are embedded in appliances and built-in communication systems.

**ACCURACY:** Essentially correct

**DISCUSSION:** Computers are ubiquitous in today's household; "98 percent of computing devices are embedded in all kinds of electronic equipment and machines, such as credit cards, mobile phones, cars, and planes and are being used throughout our lives in places such as homes, offices, and factories," according to a [Microsoft executive](#).

In addition to general-purpose personal computers and laptops, there are many types of embedded computers called "microprocessors" and "microcontrollers" found in the home. As noted in [Programming Embedded Systems: with C and GNU Development Tools](#), these “invisible” microprocessors are in fact special-purpose computers, complete with RAM memory for storing data (such as cooking time), software included in ROM (read-only memory), and I/O (input/output) devices. Their functions are specialized, unlike general-purpose computers, such as PCs and laptops, tablets, mobile phones, and e-book readers.

Examples of embedded microprocessors in a modern home include microwave ovens, washing machines, dishwashers, alarm clocks, and high-end home automation systems. They are also found in virtually all consumer electronics devices, including TV sets,

remote controls, videogame consoles, Blu-ray and DVD players, digital cameras, digital watches, digital telephones, electronic toys, calculators, digital audio recorders, digital camcorders, GPS devices, digital video recorders, electronic musical instruments, and MP3 players. Embedded microprocessors are also found in routers, Wi-Fi access points, and cable modems, as well as in computer peripherals such as mice, keyboards, external USB drives, scanners, and printers.

According to [VDC Research](#), as of 2010, the number of embedded computers in each home range from 5 to 100, with the average estimated at about 30 per home, not including those in cars. Cars alone have between 30 or more computers, while luxury cars have as many as 100, says [Bruce Emaus](#), chairman of SAE International's Embedded Software Standards Committee, who notes, "These embedded computers control many functions, including braking, cruise control, fuel efficiency, emission control, ventilation, lights, entertainment, climate, traction control, safety systems, air bags, windows and doors plus many aspects of the engine."

With several dozen embedded computers in a home and three dozen more in a car, the total for many homes does indeed approximate 100 — or more for households with luxury cars. These numbers are rapidly increasing.

## 17. Business & Economics | Household robots not yet ubiquitous

**PREDICTION:** Household robots have emerged, but are not yet fully accepted.

**ACCURACY:** Correct

DISCUSSION: A good example of a mainstream household robot is [iRobot's](#) bestselling [Roomba](#) robotic vacuum cleaner. As of 2010, iRobot has [sold more than 5 million home robots worldwide](#), in a variety of models.

iRobot markets a wide range of small but smart robotic tools, including the Scooba robotic floor washer, [telepresence robots](#), [education and research robots](#), and even [military robots](#).

Israel has also begun [commercializing some robots](#) for military and domestic applications, and companies like Friendly Robotics are manufacturing automated household taskers like the [Robomow](#) automatic lawn mower.

In Japan, many companies have been commercializing home robots for years, like Sony with its AIBO models, [launched for under \\$500 in 1999](#). The AIBO (meaning "Artificial Intelligence roBOt," and homonymous with "pal" in Japanese) was able to walk, "see" its environment via a camera, and recognize spoken commands in Spanish and English. The AIBO robotic pets were autonomous robots able to learn and mature based on external stimuli from their owner or environment, or from other AIBOs. Sony discontinued the AIBO robot series in 2006, but continued with other robots like the [humanoid QRIO](#) (meaning "Quest for cuRIOsity," originally named Sony Dream Robot or SDR).

Many other Japanese companies are manufacturing home robots, like Toyota with its [Partner Robots](#), NEC with [PaPeRo](#), Fujitsu with [HOAP](#), Hitachi with [EMIEW](#), Mitsubishi Heavy Industries with [Wakamaru](#), AIST with [Paro](#), and Honda with its popular [ASIMO](#) humanoid companion (which has [gone through an evolution](#) from crawling and walking to running and moving up and down the stairs).

The Japanese are also starting to produce [humanoid disability robots](#) to assist its rapidly aging population, and this is becoming a multibillion dollar industry. The Korean company Samsung has launched its [Navibot vacuum cleaner](#), and other groups are also working on [humanoid robots like HUBO](#). And [Rovio](#), a Wi-Fi-enabled remote-controlled mobile robot with webcam, microphone, and speaker, can be [modified to allow for remote monitoring](#) of a home.

## 18. Business & Economics | Intelligent highway systems

**PREDICTION:** Intelligent roads are in use, primarily for long-distance travel. Once your car's computer guidance system locks onto the control sensors on one of these highways, you can sit back and relax. Local roads, though, are still predominantly conventional.

**ACCURACY:** Wrong (about ten years off)

**DISCUSSION:** Driverless cars have been demonstrated with the DARPA driverless car competitions. DARPA has held three such competitions in 2004, 2005 and 2007. The 2004 and 2005 [DARPA Grand Challenges](#) were mainly through the Mojave Desert, but the 2007 Urban Challenge was through an urban area.

The 2004 and 2005 Grand Challenges were more physically challenging for the vehicles in the desert; the robots operated in isolation and only encountered other vehicles on the course when attempting to pass each other; the [2007 Urban Challenge](#) required designers to build vehicles able to obey all traffic laws while they detected and avoided other vehicles on the course, as well as other elements of a typical urban situation.

The 2007 competition operated in a cluttered urban environment and required the cars to perform sophisticated interactions with each other, such as maintaining precedence at a 4-way stop intersection.

Google's self-driving cars have safely logged over 140,000 miles in traffic from Mountain View to Santa Monica and back in California. In October 2010, [four driverless electric vans](#) successfully ended a 13,000-kilometer test drive from Italy to China.

Experts in this field currently predict that these technologies will be available to consumers in about ten years and that one third of specialized military vehicles [will be driverless by 2015](#).



Meanwhile, computerized systems are routinely used to avoid accidents Toyota has already been commercializing its accident avoidance systems in Japan for several years, and the company is now introducing such systems in some of its top U.S. models, like the Lexus. Toyota has also pioneered [self-parking systems](#) in Japan since 2003, and its [intelligent parking](#) system has also become a [feature in its current Lexus](#) models.

Separately, General Motors has announced that they will begin [testing driverless cars](#) by 2015 (and they could be on the road by 2018), and France as well as other European countries have been working on [intelligent transportation](#) systems.

### 19. Business & Economics | Microsoft \$1 trillion market cap

**PREDICTION:** A company west of the Mississippi and north of the Mason-Dixon Line has surpassed a trillion dollars in market capitalization.

**ACCURACY:** Wrong

**DISCUSSION:** This prediction refers to Microsoft, and was somewhat tongue-in-cheek. Microsoft today has a quarter of a trillion dollars in market cap, [although it passed the half-trillion dollars mark in mid-2000](#), when some financial analysts believed that the company would climb to one trillion dollars, followed by Cisco and other companies.

Since then, [PetroChina became the first company in the world to reach briefly a market capitalization of one trillion dollars in November 2007](#). Since PetroChina is based in Beijing, China, it can be argued that the company is west of the Mississippi and north of the Mason-Dixon Line :). It can be argued, therefore, that the prediction was briefly true in that a company west of the Mississippi and north of the Mason-Dixon Line did surpass a trillion dollars in market capitalization. However, I have counted this prediction as wrong, as I was not intending to refer to companies outside the United States.

## POLITICS & SOCIETY

### Predictions made for 2009 in *The Age of Spiritual Machines*

The following is an analysis of predictions for 2009 made about the future of politics and society in the book *The Age of Spiritual Machines*, which was written in the mid to late 1990s.

#### 1. Politics & Society | Privacy is a critical issue

**PREDICTION:** Privacy has emerged as a primary political issue. The virtually constant use of electronic communication technologies is leaving a highly detailed trail of every person's every move.

**ACCURACY:** Correct

DISCUSSION: Governments such as Iran and China are using the Internet to monitor private communications. Privacy issues have appeared in many democracies as well. The concerns range from social networks to political surveillance. As just one recent example, Google's introduction of [Buzz](#) created a major stir because its default settings, which let anyone see the names of the people you e-mailed most frequently, were regarded as an invasion of privacy.

[Facebook has also gone through several major privacy challenges](#), and [founder Mark Zuckerberg implied that privacy is basically dead](#) in the new world of social networks. That is overstated, but it is clear that [the concept of privacy is changing](#) under the new realities of a more interconnected world. The increasing use of information technology for all kinds of communications is obviously having an impact on how people can be tracked and monitored, for better and for worse.

One major scandal in 2008 was the [resignation of New York Governor Eliot Spitzer](#). His financial transactions identified him patronizing prostitutes, after bank monitoring systems reported suspicious money payments for relatively small amounts. A separate case that year was the hacking of the Yahoo! e-mail account of vice presidential candidate Sarah Palin. Privacy has become such an important issue that major companies like [Facebook](#), [Google](#), [Microsoft](#) and [Yahoo!](#) have had to reconsider their privacy terms.

A recent international movement in several Western countries created [Privacy Day](#) in 2008, recognized by the U.S. Congress in 2009 and celebrated for the third consecutive year on January 28, 2010 by Canada, the United States and 27 European countries.

We do leave electronic traces of almost everything we do: where we go, whom we call, what we buy, all of our health data, every transaction and every click. Ubiquitous and surreptitious spyware can record everything that is done on your computer and mobile device. The technical means to protect privacy still exist and it is encouraging to note that encryption (that can protect privacy) has made greater advances than decryption (which can destroy it).

It is clear, however, that the issue of privacy has grown enormously in significance over the past decade. It used to be sufficient to just close the curtains in our bedrooms to maintain our privacy. Now we have hundreds of virtual windows that peer in on our lives.

## 2. Politics & Society | Privacy laws

**PREDICTION:** Litigation, of which there has been a great deal, has placed some constraints on the widespread distribution of personal data.

**ACCURACY:** Correct

**DISCUSSION:** Privacy law, the area of law concerned with the protection and preservation of the privacy rights of individuals, has been growing rapidly as a result of the concerns created by new technologies. Increasingly, governments and other public and private organizations collect vast amounts of personal information about individuals for a variety of purposes. In the United States, the [Electronic Privacy Information Center \(EPIC\)](#), founded in 1994, is one of the oldest and most recognized public interest groups to focus public attention on emerging civil liberties issues and to protect privacy, the First Amendment, and constitutional values. In the United Kingdom, [Privacy International \(PI\)](#), founded in 1990, is a human rights group working as a watchdog on surveillance and privacy invasions by governments and corporations.

EPIC and PI have also campaigned across different countries to protect people against intrusion by governments and corporations that seek to erode this fragile right, and they have been jointly publishing the “privacy index” in their [Privacy International Survey](#). A series of recent [legal cases](#) resulted from privacy concerns about Google Street View.

Such litigation has indeed constrained governments, like the United Kingdom’s, in their plans to access public texts and e-mails, and companies like Google, Microsoft and Yahoo!, which have [been requested to](#) delete user data after six months in several European countries. [Microsoft has announced](#) it will delete Bing user data for all users after six months.

### 3. Politics & Society | The government can access personal data

**PREDICTION:** Government agencies, however, continue to have the right to gain access to people's files...

**ACCURACY:** Correct

**DISCUSSION:** Indeed, there is a law in effect that makes it easy for the U.S. government to access private communications. The [Communications Assistance for Law Enforcement Act](#) (CALEA) is a U.S. law passed in 1994 that requires all telecommunications companies to modify their equipment to allow easy wiretapping of telephones, and it was later extended to cover VoIP and Internet traffic.

The [Electronic Frontier Foundation](#) (EFF), a leading civil liberties group defending individual rights in the digital world, has been following other recent developments, like the finding that "[Sprint received over 8 million requests for its customers' information in the past 13 months.](#)" The Federal Bureau of Investigation (FBI) has been [updating](#) its technology to build a [surveillance system](#) that performs wiretaps on almost any telephone, according to restricted documents released under the Freedom of Information Act. The FBI's secret [spyware](#) has helped to track down bomb threats and other security problems, but also creates the [real worry that "Big Brother" is watching you](#). The tension between legitimate law enforcement and the need for personal privacy will grow as the underlying technologies continue to become more sophisticated.

The "[Fusion Centers](#)" were created as terrorism prevention and response centers under the joint direction of the U.S. Department of Homeland Security and the Department of Justice after 2003, and their power has been increasing since then, making some people think that [too much private information is being accessed and shared](#).

### 4. Politics & Society | Unbreakable encryption is popular

**PREDICTION:** ...which has resulted in the popularity of unbreakable encryption technologies.

**ACCURACY:** Correct

**DISCUSSION:** The pervasive intrusion into the lives of individuals has made many people rely on encryption systems to maintain their privacy. The American Civil Liberties Union (ACLU), together with EPIC and PI, wrote a joint [statement](#) supporting encryption for the protection of personal privacy in 1998, and the ACLU has been involved in many [legal cases](#) supporting encryption. Encryption has long been used by governments and militaries around the world to facilitate secret communication.

Encryption is also now commonly used in protecting information by many types of civilian users, from private companies to single individuals. According to the [2008 CSI Computer Crime & Security Survey](#), published by the Computer Security Institute: “71% of companies surveyed utilized encryption for some of their data in transit, and 53% utilized encryption for some of their data in storage.”

Encryption can be used to protect data “at rest” (computers and other storage devices) and also data “in transit” (information being transferred via networks, mobile telephones, wireless microphones, Bluetooth devices, and bank automatic teller machines, for example). Encrypting data in transit helps to secure such information, since it is often difficult to physically secure all access to networks. One of the oldest and largest encryption companies is [PGP](#) (formerly Pretty Good Privacy) from the United States, but Swiss [Crypto AG](#) self-defines as the “preferred top-security partner for civilian and military authorities worldwide.”

The encryption industry has grown to provide all kinds of services to individual users, including companies that provide [anonymous Web surfing](#). [Privacy enhancing technologies](#) (PET) is a new generic term for computer tools, applications and mechanisms that (when integrated in online services or applications, or when used in conjunction with such services or applications) allow online users to protect their privacy.

## 5. Politics & Society | Growing neo-Luddite movement

**PREDICTION:** There is a growing neo-Luddite movement, as the skill ladder continues to accelerate upwards.

**ACCURACY:** Correct

**DISCUSSION:** There is a vocal anti-technology movement that is stronger in Europe than in Asia or the United States, and it is also partially related to the higher European unemployment levels. The influence of such anti-technology “radical green,” “return-to-nature,” and similar movements can be seen in many ways, including [the opposition to genetically modified organisms \(GMO\) in several European countries](#).

In addition to the continued [elimination of less-skilled manufacturing and trade jobs](#), the anti-technology movement cites technology’s dangers and environmental damage. Some of these dangers are valid, and concerns stem in part from my own writings (see, for example, chapter 8, “The Deeply Intertwined Promise versus Peril of GNR,” in *The Singularity is Near*).

Much of the damage discussed by the movement stems from older, First-Industrial-Revolution technologies, such as fossil fuels, not from modern information technologies. When Ned Ludd and his followers were reported to be destroying textile machinery in 1811 to reduce the unemployment among “traditional” textile workers, [there was also an apparent fear of change](#).

## 6. Politics & Society | Neo-Luddite movement has limited influence

**PREDICTION:** As with earlier Luddite movements, its influence is limited by the level of prosperity made possible by new technology.

**ACCURACY:** Correct

**DISCUSSION:** The philosophical belief in “progress” through human solutions to problems (that is, through technology) is deeply rooted in, and reinforced by, economic competition, which is largely innovation-based. Even though it might not always be evident, there is no doubt that the human condition has substantially improved during the last few centuries.

English philosopher Thomas Hobbs once said, “(Life is) solitary, poor, nasty, brutish and short.” [Life expectancy has radically increased](#) from 37 in 1800 to close to 80 today. Technology is helping to increase productivity levels around the world, from agriculture to services. [Genetically modified \(GMO\) crops are becoming standard in the United States](#), and are helping to increase the yields in poor countries. The [E.U. Parliament President declared recently](#) that he was still “against genetically modified foods,” but said, “they are an unavoidable part of the future.”

Such reluctance in accepting technological advances can be seen in many fields, but throughout human history, the benefits eventually become visible and overwhelming. Neo-Luddite writer [Nicholas Carr](#) has long been campaigning against information technology. He lays out his arguments in his 2004 book *Does IT Matter?* and in his 2008 article “[Is Google Making Us Stupid?](#)” in *The Atlantic* magazine.

However, a survey called [The Future of the Internet IV](#) by the Pew Internet and American Life Project in February 2010 found that four out of five experts [agreed with the prediction](#): “By 2020, people’s use of the Internet has enhanced human intelligence; as people are allowed unprecedented access to more information, they become smarter and make better choices. Nicholas Carr was wrong: Google does not make us stupid.” The Chief Economist of Google also answered: “Google will make us more informed. The smartest person in the world could well be behind a plow in China or India. Providing universal access to information will allow such people to realize their full potential, providing benefits to the entire world.”

## 7. Politics & Society | Continuing education for employees

**PREDICTION:** The movement does succeed in establishing continuing education as a primary right associated with employment.

**ACCURACY:** Partially correct



DISCUSSION: According to [Industry Market Trends newsletter](#), Oct. 12, 2009, “In a survey from the [Society for Human Resource Management](#) (SHRM), 63 percent of human resources professionals indicated that their companies provided undergraduate education assistance for their employees, while 59 percent provided graduate assistance in an effort to develop a more educated workforce for their firm.”

While continuing education is not a State-sponsored right, per se, there do exist many state- and [federally-funded grant programs](#) that assist with the cost of continuing education for qualifying applicants. For example, the established Workforce Investment Act (WIA) “[provides funds to localities for job training and employment services for dislocated workers, youth, and adults](#). The [2009] economic recovery package provides \$3.95 billion for job training and employment services.”

Additionally, many [private companies](#) include [paid continuing education](#) as part of employee benefits packages — attracting new job applicants and retaining the most qualified workers. On-the-job training for new skills development, especially for systems and procedures upgrades, is also integrated into most industrial and office jobs.

## 8. Politics & Society | The size of the underclass is stable

**PREDICTION:** There is continuing concern with an underclass that the skill ladder has left far behind. The size of the underclass appears to be stable, however.

**ACCURACY:** Correct

DISCUSSION: The U.S. [poverty rate](#) and income of the poor are appropriate indicators for defining and measuring the “underclass.”

The percentage of Americans in the U.S. population with income below the poverty level (the poverty rate) has gone down in the most recent decade compared to the prior decade. According to [U.S. Census historic data](#), the average poverty rate for the years 1990 through 1999 was 13.75%. For the years 2000 through 2009 it was 12.52%. This represents a reduction of 1.23% (out of 13.75%).

Looking at five-year periods, it was an average of 14.42% for the period 1990 through 1994, an average of 13.08% for the period 1995 through 1999, an average of 12.06% for the period 2000 through 2004 and an average of 12.98% for the period 2005 through 2009. There has been a gradual downward trend with the exception of the most recent five-year period due to the recession. However, even at the height of the recession in 2009, the rate was only 14.3%, slightly lower than the average for 1990 through 1994.

The income of the poor is another useful metric of stability of the underclass, in the sense that this income has not gone down in the past two decades, as shown by U.S. Census data. According to [U.S. Census historic data](#), the maximum household income (“income limits”) — in adjusted (2009) dollars — in the lowest income quintile of the U.S.

population (the poorest 20%) has gone from an average of \$20,025 in the period of 1990 through 1999 to an average of \$21,188 in the period of 2000 through 2009, an increase of about 6%. The average in adjusted (2009) dollars for the period of 2000 through 2004 was \$21,484 and for the period of 2005 through 2009 was \$20,892. So there was an increase in the most recent ten years compared to the prior decade.

Even in 2009, the year of the recent recession, the figure was \$20,453, slightly higher (in constant dollars) than the average for the period of 1990 through 1999. It is clear that this demographic has remained at least stable even during the recent economic downturn.

**Additional reference**

[Income, Poverty, and Health Insurance Coverage in the United States: 2009](#)

These figures follow a general pattern of a significant reduction in world poverty over the several decades. The global poverty rate has been cut by nearly three quarters since 1970. The percentage of the world population living on less than \$1 a day (in adjusted 2000 dollars) went from 26.8% in 1970 to 5.4% in 2006.

**9. Politics & Society | Underclass neutralized by welfare state**

**PREDICTION:** Although not politically popular, the underclass is politically neutralized through public assistance and the generally high level of affluence.

**ACCURACY:** Correct

**DISCUSSION:** According to [UPI](#), “Violent crime, a key measure of unrest by the underclass, has continued the fall that began in the early 1990s. Overall, violent crime per capita is down 39% from 2000 to 2009, Bureau of Justice Statistics officials say.”

Although we still have poverty in the U.S. and other Western countries, many forms of public assistance cushion to at least some extent the impact of severe poverty. The poor of the United States are actually better off than the median citizen of the world. According to the [U.S. Census Bureau](#), a majority of poor Americans own a car, air conditioner, refrigerator, washer and dryer — goods considered to be luxuries less than a hundred years ago, and still are in many parts of the world today.

## THE ARTS

### Predictions made for 2009 in *The Age of Spiritual Machines*

The following is an analysis of predictions for 2009 made about the future of the arts in the book *The Age of Spiritual Machines*, which was written in the mid to late 1990s.

#### 1. The Arts | Visual artists working digitally

**PREDICTION:** The high quality of computer screens, and the facilities of computer-assisted visual rendering software, have made the computer screen a medium of choice for visual art.

**ACCURACY:** Correct

DISCUSSION: Indeed, visual artists are commonly found behind a computer screen, using a broad variety of computer tools to create graphic arts and other visual expressions. For static pictures, the use of image editing and creation software (such as [Adobe Photoshop](#)) is ubiquitous. According to a Paris photographer quoted in [The New York Times](#), “I have never yet seen, and you probably never will see, a fashion or beauty picture that hasn’t been retouched.” For drawing and painting, there are [devices that allow the artist to create works](#) directly on the computer, using a high-quality touch screen.

In film, the use of computer-generated imagery is equally ubiquitous. *Avatar*, a movie [famous largely for its high-powered computer graphics](#), has now become the [highest-earning film](#) in world history, grossing more than [\\$2 billion](#). And [Pixar](#) Animation Studios, whose films are entirely computer-generated, was described by [The Sunday Times](#) as “one of the most successful studios of all time.”

Computer technology also allows visual artists to use entirely new media. Computer programs written by artists, which [generate custom art](#) for the user on demand, have proven to be [very popular](#).

#### 2. The Arts | Intelligent art software

**PREDICTION:** Most visual art is the result of collaboration between human artists and their intelligent art software.

**ACCURACY:** Correct

DISCUSSION: Nowadays, artificial intelligence in art software is so commonplace that many people forget it exists. Many image editing programs, such as the free program [GIMP](#), offer automatic, intelligent [red-eye reduction](#), and many high-quality digital

cameras come with [face-recognition software](#) built in. Adobe's [latest Photoshop](#) program offers a wide range of intelligent editing technology, including adaptive person recognition, intelligent photo merging, background cleanup, and the Smart Brush. Similarly, [Corel Painter](#) intelligently reproduces the texture of real-life objects and recreates the natural interaction between hand and canvas, and can even turn a photo into a [simulated oil painting](#). [Three-dimensional computer graphics tools](#) are also widely used today for modeling, animation, and rendering.

In motion pictures, intelligent, computer-controlled agents are becoming more and more common as a replacement for expensive human extras. [Massive Software](#), originally used to simulate battles in *The Lord of the Rings* movies, is now [available](#) to the average filmmaker. The software has also greatly expanded in [scope](#), with new applications in the fields of real-world simulation, robotics, and education, in addition to art.

### 3. The Arts | Dynamic virtual art

**PREDICTION:** Virtual paintings — high-resolution, wall-hung displays — have become popular. Rather than always displaying the same work of art, as with a conventional painting or poster, these virtual paintings can change the displayed work at the user's verbal command, or can cycle through collections of art. The displayed artwork can be works by human artists or original art created in real time by cybernetic art software.

**ACCURACY:** Correct

**DISCUSSION:** Computer displays and digital art frames are commonly used to cycle through collections of photos or art. At Kurzweil Technologies, Inc., we have a display on the wall in our reception area of "AARON," a software AI-based artist created by Harold Cohen that paints an original painting, each one different, every two minutes. This program was available for download from [Kurzweil CybertArt](#), and tens of thousands of people downloaded it.

"[Video paintings](#)," which are computer-generated works of video art, have started to make an appearance. A video painting uses computer technology to dynamically render a pleasing image on a screen, but is wall-mounted, like a traditional painting. Many institutions and public buildings feature art installations of dynamic, interactive, digital works that can be programmed to change based on special events, season, time of day, or cues from the audience. Examples include the Los Angeles International Airport's \$6 million permanent [digital art installation](#) (the "Wow Project"), which includes a 25-screen video wall and an undulating curve of 58 video screens that feature digital artwork from 17 visual artists; and the Siebel Center for Computer Science's Digital Art Display at the University of Illinois Urbana-Champaign, where a series of eight video panels called "[the video wall](#)" provide a 15 x 6 foot panorama of information, used for art displays and other purposes.

#### 4. The Arts | Human-computer jam sessions

**PREDICTION:** Human musicians routinely jam with cybernetic musicians.

**ACCURACY:** Correct



**DISCUSSION:** There are many software packages that will accompany you with rhythm tracks that adjust to your playing, walking bass lines, and other accompaniments.

*(Left) Apple's Magic GarageBand Jam (Image courtesy of Apple Inc.)*

Such “auto accompaniment” software is also built into home digital keyboards.

Games such as [Guitar Hero](#) involve computer-generated music tracks in real time. Apple's [GarageBand](#) software includes Magic GarageBand Jam, which lets you jam with a full-screen band.

#### 5. The Arts | Non-musicians composing with smart software

**PREDICTION:** The creation of music has become available to persons who are not musicians.

**ACCURACY:** Correct

**DISCUSSION:** There are multiple software packages that allow you to interact with your computer and create music without requiring music skill and knowledge. An excellent example is Tod Machover's [Music Toys](#), which allows children to create melodies and complex orchestrations without music training. He has extensively used these instruments with disabled children, who have created surprisingly complex and musically pleasing orchestrations.

Machover's work led to the very popular computer game [Guitar Hero](#), which brings this idea to the general public. More recently, Apple has introduced a number of software music-generation apps for the iPhone, iPod, and iPad that can be played by non-musicians. They include [Ocarina](#), [TappyTunes](#), [Guitar](#), and three designed by composer Brian Eno: [Bloom](#), [Trove](#), and [Air](#).

## 6. The Arts | Simpler musical instrument interfaces

**PREDICTION:** Creating music does not necessarily require the fine motor coordination of using traditional controllers.

**ACCURACY:** Correct

DISCUSSION: Tod Machover has created experimental “hyperinstruments,” which are easy-to-use controllers to create music that can be even more complex than would be allowed by traditional controllers, such as keyboards and wind instruments. Today, games such as Guitar Hero, inspired by hyperinstruments, do the same thing. Instruments such as the entire line of current Kurzweil instruments from my company [Kurzweil Music Systems](#) (now a subsidiary of the Korean company Hyundai Development Company) have also allowed players to break the age-old bond between music control and the music that they create. A whole new world of music controllers that are much easier to play than traditional controllers has evolved, such as new types of wind controllers.

For example, the [Kurzweil PC3LE6 Performance Controller](#) allows players to trigger specific programmable sounds, drum or note sequences, chords, and arpeggiations simply by using buttons or pressing different notes on the keyboard. It has 700 onboard effects, such as reverbs and choruses, all selectable without requiring programming or special software. “[Ribbon controllers](#)” allow for a wide variety of MIDI changes, such as changing pitch or volume, by simply sliding the hand across a ribbon. And taking hyperinstruments a step further, [computer scientists have developed](#) a gesture-recognition system that lets musicians simply use gestures to create a wide variety of custom musical instruments and sounds.

## 7. The Arts | Software-assisted composition

**PREDICTION:** Cybernetic music creation systems allow people who appreciate music but who are not knowledgeable about music theory and practice to create music in collaboration with their automatic composition software.

**ACCURACY:** Correct

DISCUSSION: The old “auto play” features on home digital pianos have evolved into intelligent music accompaniment systems that do more than “play along” with the user. They can create rich orchestrations, walking bass lines, intelligently changing rhythmic patterns, and other intelligent automatic composition.



Examples include [Band In A Box](#) (“Type in the chords to any song and Band-in-a-Box automatically generates a complete professional-quality arrangement of piano, bass, drums, guitar, strings and more”), [Inmamusys](#) (a program that automatically creates music in response to the user’s emotions), and David Cope’s [algorithmic composition software](#), which does a credible job of emulating classical music composers.

## 8. The Arts | Brain-generated music

**PREDICTION:** Interactive brain-generated music, which creates a resonance between the user’s brainwaves and the music being listened to, is another popular genre.

**ACCURACY:** Partially correct

**DISCUSSION:** A variety of devices is currently [available to consumers](#), marketed with claims for biofeedback-enabled relaxation, improved cognitive performance, and other purposes, but these devices are not yet popular. I reported on a technology called “Brain Generated Music” (BGM) from NeuroSonics (disclosure: I was on the board of NeuroSonics in the 1990s) in *The Age of Spiritual Machines*.

The technology involves connecting sensors to a person’s head, gathering an EEG, performing a fast Fourier transform to determine the person’s alpha rhythms and then automatically composing music synchronized to those alpha rhythms. Subsequent to the publication of *ASM*, BGM was tested on several hundred individuals (including myself).

I observed some of these tests and the technology did appear to succeed in isolating the user’s alpha rhythms and produced music synchronized with these low frequency (10 to 13 Hz) waves. As a result of this feedback, most users did experience a strengthening of their alpha waves as demonstrated by the computer’s display of the amplitude of the alpha waves. The technology was never commercialized and the company is now inactive.

## 9. The Arts | Virtual acoustic instruments

**PREDICTION:** Musicians commonly use electronic controllers which emulate the playing style of the old acoustic instruments (e.g., piano, guitar, violin, drums).

**ACCURACY:** Correct

DISCUSSION: [MIDI music controllers](#) (piano-like keyboards, sliders, buttons, pads, knobs, ribbons, wheels, and other devices) that allow users to create the playing technique of the piano, guitar, drums, and stringed instruments such as the violin are in very widespread use. The output of these devices drives digital synthesizers, which can emulate the sound and playing style of old (or new) acoustic instruments.

## 10. The Arts | Touchless kinetic musical interfaces

**PREDICTION:** ...but there is a surge of interest in the new “air” controllers in which you create music by moving your hands, feet, mouth and other body parts.

**ACCURACY:** Correct

DISCUSSION: One good example of this is [Guitar Hero](#), a very popular music creating computer game. [Kinect](#), which Microsoft extensively demonstrated in 2009 and introduced in 2010, does not even require a controller, such as with the Wii. The user just waves their hands and other body parts or moves around the room to control games, which include music creation. Another is Smule's Ocarina virtual flute app for the iPhone, which is played by blowing into the iPhone microphone.

## 11. The Arts | Novel musical interfaces

**PREDICTION:** Other music controllers involve interacting with specially designed devices.

**ACCURACY:** Correct

DISCUSSION: In addition to music controllers that emulate the playing technique of traditional acoustic instruments such as the piano, guitar, stringed instruments and wind instruments, there are music controllers that have no counterpart in the acoustic world. Examples include the varied hyperinstruments developed by Tod Machover and his colleagues at the MIT Media Lab, which have inspired a variety of novel music controllers, such as the [sensor chair](#) used in Machover's contemporary [Death and the Powers](#) opera.

Another example is the modification of [friction controllers](#) such as violins to create unusual controllers that would be impossible in an acoustic embodiment.

## 12. The Arts | Writing with voice recognition

**PREDICTION:** Writers use voice-activated word processing...

**ACCURACY:** Correct

DISCUSSION: This was not the case when the prediction was made, but such software is popular (but not ubiquitous) today. More than [3.5 million copies](#) of [Dragon Dictation](#) have been downloaded as of July 2010. It's a speech-recognition iPhone app that, like other [Dragon products](#), has combined the original speech recognition software from Dragon Systems and my company, Kurzweil Applied Intelligence, now available from Nuance Communications (formerly Kurzweil Computer Products).

The PC version, Dragon NaturallySpeaking Version 11, is remarkably accurate on unrestricted vocabulary continuous speech. *The New York Times* [reported](#) an accuracy of 99.5% with Dragon NaturallySpeaking 9.0. That is the accuracy I also achieved using Dragon NaturallySpeaking Version 10 after training on my voice for only ten minutes. Version 11 is reportedly even more accurate.

## 13. The Arts | Grammar-checking software

**PREDICTION:** Grammar checkers are now actually useful.

**ACCURACY:** Correct

DISCUSSION: While a [2005 poll](#) by the *Seattle Post-Intelligencer* found that many Microsoft Word users [did not find](#) the grammar checking feature to be especially useful, grammar-checking technology has continued to improve over the last decade.

A more recent performance chart, from the study "[Evaluating Grammar Checkers: A Comparative Ten-Year Study](#)" on grammar-checking software reliability, conducted by DuPage College on several applications' reliability, found considerable performance improvements in the last 3 years.

Their best-testing product, [Grammarian Pro X](#), found and repaired 50% of the [20 most common English grammar errors](#), compared to a 0% success rate for all versions of Word (Windows) 2000-2007 and 35% for Word (Mac) 2004. It is certainly true that as our understanding of human language evolves — and as our ability to program software for language understanding improves — these tools are becoming useful.

#### 14. The Arts | The rise of e-books and digital distribution

**PREDICTION:** Distribution of written documents from articles to books typically does not involve paper and ink.

**ACCURACY:** Correct

DISCUSSION: Today, a vast distribution number of written documents, ranging from hundreds of millions of blogs to e-books, in addition to text messages and e-mails, are distributed without any paper and ink. [During 2009](#), Internet users worldwide sent a total of 90 trillion e-mails, and published some 47 million new websites, in addition to the content they added to existing websites.

By comparison, the U.S. Postal Service processed fewer than [200 billion](#) pieces of mail in 2009, and only a few hundred thousand [paper books](#) are published each year. Even among titles also published in paper form, [Wired reports](#) that e-book sales now exceed the sales of physical books.

Amazon claims that it sells twice as many e-books as hard cover books, and that it expects e-book sales to exceed paperback book sales in 2011. *The American Journalism Review* also [notes](#) that “many newspaper Web sites now have online audiences that rival or exceed the number of print readers.”

#### 15. The Arts | Software-assisted writing

**PREDICTION:** Style improvement and automatic editing software is widely used to improve the quality of writing.

**ACCURACY:** Partially correct

DISCUSSION: Such software does exist, including the grammar checkers built into Microsoft Word and other word processors. Examples include [ClearEdits](#), Serenity Software’s [Editor](#), and the AutoCrit [Editing Wizard](#). However, whether it is “widely used” is debatable.

#### 16. The Arts | Language translation software

**PREDICTION:** Language translation software is also widely used to translate written works in a variety of languages.

**ACCURACY:** Correct

**DISCUSSION:** Systems that do this for virtually any language pair are available from multiple vendors, in both commercial and free versions. Probably the [most popular](#) is [Google Translate](#), which is available on the Google search engine. It allows the user to translate any text or Web page from any of [57 languages](#) to any of the other languages. The translations themselves are automatically created by applying [AI techniques](#) to vast “Rosetta stone” databases of translated text for each pair of languages that Google has collected.

The \$4.99 Word Lens iPhone app from QuestVisual uses optical character recognition to identify words in an image and translate them, and then draw them back on the screen. It currently offers only English to Spanish and Spanish to English translation. Other languages are planned.

### 17. The Arts | AI-based writing

**PREDICTION:** Nonetheless, the core process of creating written language is less affected by intelligent software technologies than the visual and musical arts. However, “cybernetic” authors are emerging.

**ACCURACY:** Correct

**DISCUSSION:** I have given speeches at conferences of musicians and of artists, and the proceedings of these conferences (or trade shows) look more like computer conferences than music and art conferences. Very sophisticated computerized tools are extensively used in music and art, and less so for written language. This is consistent with Alan Turing’s insight that written language embodies all of our intelligence. He based his “Turing test,” a test to ascertain whether or not an AI is performing at fully human levels, entirely on written text exchanges. One example of a “cybernetic” (that is, artificial-intelligence-based) author is my own “[Ray Kurzweil’s Cybernetic Poet](#).”

The sports website [StatSheet](#) is developing an automated sports journalism program, and Japanese researchers have built a fully functional [robotic journalist](#). However, these programs are still fairly poor writers, and their capabilities are limited in scope.

### 18. The Arts | Virtual experiences

**PREDICTION:** Beyond music recordings, images, and movie videos, the most popular type of digital entertainment object is virtual experience software. These interactive virtual environments allow you to go whitewater rafting on virtual rivers, to hang glide in a virtual Grand Canyon, or to engage in intimate encounters with your favorite movie star.

**ACCURACY:** Correct

**DISCUSSION:** “Interactive virtual environments” can be created with interactive computer games, such as the Wii. In 2009, Microsoft extensively demonstrated Kinect, and introduced it in 2010. It does not require a controller; it picks up the player's movements.

Virtual experience software for each of the three categories I mentioned ([water environments](#), [flight](#), and [erotic experiences](#)) is widely available. Motion simulators for activities like [whitewater rafting](#), [roller coasters](#), [hang gliding](#), [auto racing](#), and [bull riding](#) are also available.

### 19. The Arts | Virtual fantasy worlds

**PREDICTION:** Users also experience fantasy environments with no counterpart in the physical world.

**ACCURACY:** Correct

**DISCUSSION:** Several recent video games explore artificial worlds that would be extremely difficult or impossible to create in physical reality.

One such game is [Super Mario Galaxy](#), released in 2007 for the Nintendo Wii console. Super Mario Galaxy's environment consists largely of 3D obstacle courses with floating platforms, gravity that constantly changes direction, and objects floating in space that one can walk on. There are many other examples.

### 20. The Arts | Haptics still limited

**PREDICTION:** The visual and auditory experience of virtual reality is compelling, but tactile interaction is still limited.

**ACCURACY:** Correct

**DISCUSSION:** This is certainly true. There are haptic and tactile controllers that provide physical interaction, including force-feedback technology, which allows you to feel tactile sensations that are appropriate for a game. Haptics is still in its infancy, but researchers are already working on how to add touch, taste and smell to virtual reality.

For example, in 2007, [Novint](#) released [the Falcon](#), the first consumer 3D touch device with high-resolution, three-dimensional force feedback, allowing haptic simulation of objects, textures, recoil, momentum, and the physical presence of objects in games. The Falcon has tiny motors that are updated approximately 1000 times a second, letting you feel texture, shape, weight, dimension, and dynamics. It lets you control and interact with games in more realistic ways, allowing you to develop real physical skill and muscle memory, which adds a new dimension to gaming.



The [CyberGlove](#) is another Novint product, with uses in many kinds of simulations, including motion capture and industrial training. However, such uses are more limited than the visual and auditory experiences in contemporary computer games.

More realistic tactile interaction is coming, and several other computer interfaces are being developed currently. According to MIT's [Technology Review](#), the keyboard, the mouse and the joystick are gradually being replaced by new technologies like the touchpad, the multitouch screen, gesture sensing, force feedback, voice recognition, augmented reality, spatial interfaces, and brain-computer interfaces.

With interfaces continually improving, we are indeed moving from [virtual reality to real virtuality](#): “The crucial thing for ‘real virtuality’ is that it will hit all five senses in a highly realistic manner,” said Alan Chalmers, a professor at the University of Warwick Digital Lab.

## WARFARE

### Predictions made for 2009 in *The Age of Spiritual Machines*

The following is an analysis of predictions for 2009 made about the future of warfare in the book *The Age of Spiritual Machines*, which was written in the mid to late 1990s.

#### 1. Warfare | Computer and communication security is priority

**PREDICTION:** The security of computation and communication is the primary focus of the U.S. Department of Defense. There is general recognition that the side that can maintain the integrity of its computational resources will dominate the battlefield.

**ACCURACY:** Essentially correct

**DISCUSSION:** In May 2009, U.S. President Barack Obama issued "[\*Cyberspace Policy Review: Assuring a Trusted and Resilient Information and Communications Infrastructure\*](#)." The review was designed to establish a roadmap to a "reliable, resilient, trustworthy digital infrastructure for the future." The following statement supports the prediction: "Ensuring that cyberspace is sufficiently resilient and trustworthy to support U.S. goals of economic growth, civil liberties and privacy protections, national security, and the continued advancement of democratic institutions requires making cyber security a national priority."

On June 15, 2009, Deputy Secretary of Defense William J. Lynn stated at the Center for Strategic and International Studies in Washington, D.C., "The Department of Defense will defend its computer networks. We will protect this domain. Just as the President has called protecting the nation's networks a [national security priority](#), protecting our defense networks is a defense priority."

It is now generally recognized that cyber attacks have the capability of destroying the networks that operate virtually every aspect of modern life, including electrical power creation and distribution, communications, and finance. Creating such systems and defending against them has recently become an increasingly urgent federal priority.

However, it should be recognized that these types of "conventional" cyber attacks are only part of the concern. How secure are our nuclear missiles and our cruise missiles? Could hackers take these over? Clearly, maintaining the integrity of communications control over these systems is becoming increasingly vital. With warfare increasingly waged by automated systems (such as drones), being able to control your own remote weapons and disrupt those of an enemy is an increasingly vital priority area.

## 2. Warfare | Human soldiers replaced with remote weapons, drones

**PREDICTION:** Humans are generally far removed from the scene of battle.

**ACCURACY:** Essentially correct

**DISCUSSION:** There is clearly increasing reliance on remote weapons such as unmanned aerial vehicles (UAVs) and drones, which can be controlled from as far away as the other side of the globe. But the phenomenon of being removed from the scene of battle goes substantially beyond this. American tanks are typically tens or hundreds of miles away from their targets. They initiate computer-guided weapons that travel far distances to their targets. As a result of these and other technologies that detect incoming attacks, American tanks such as the Abrams tank are almost never disrupted — there have only been a handful of casualties of American soldiers operating an Abrams tank over the past decade. The same is true of American planes and helicopters, which generally operate many miles from their targets.

## 3. Warfare | Unmanned intelligent flying drones dominate

**PREDICTION:** Warfare is dominated by unmanned intelligent airborne devices.

**ACCURACY:** Correct

**DISCUSSION:** Today, military technologies such as unmanned air vehicles have allowed soldiers to wage war in Afghanistan from control rooms based in the United States. Soon, these unmanned systems will outnumber manned aircraft.

This also affects the roles of ground soldiers. The [Frontline Documentary](#), “Digital Nation: Life on the Virtual Frontier,” highlighted unmanned systems based overseas, controlled by soldiers based at Creech Air Force Base in Clark County, Nevada.

Technologies such as unmanned aerial systems (UAS’s) are saving lives and removing troops from the battlefield. On October 7, 2009, Lt. Col. Christopher B. Carlile, director of Unmanned Aircraft Systems Center of Excellence, stated, “Unmanned Aircraft Systems are saving lives and keeping troops out of harm’s way.” The story, featured on the United States Strategic Command website, added that, “During the past six years of combat operations, the Department of Defense has experienced unparalleled rapid growth in unmanned systems. From 2002 to 2008, the total number of unmanned aircraft increased from 167 to well over 6,000. UAS’s are proving themselves in key operational roles and are embraced by the warfighters who employ them.”

On March 16, 2009, *The New York Times* [reported that remotely piloted planes](#) have done more than any other weapons system to track down insurgents, while sparing American lives in Iraq and Afghanistan. This success has been credited to the increased number of unmanned intelligent airborne devices in service. These reports offered numbers similar

to what is stated in the previous paragraph: there were 167 military drones available in 2001. By 2009, that number jumped to approximately 5,500.



(Left) The MQ-9 Reaper (Predator B) drone, (Photo courtesy of General Atomics Aeronautical Systems, Inc.)

The number of Predator and Reaper drones, two of the most advanced in the U.S. Air Force's unmanned toolkit, increased over that period to 195 and 28 respectively.

During the same time, the Predator and the Reaper drones were “flying 34 surveillance patrols each day in Iraq and Afghanistan, up from 12 in 2006 [and they were] transmitting 16,000 hours of video each month, some of it directly to troops on the ground.”

Numerous studies focused on military operations and the use of UAVs have been conducted. A [study](#) updated on April 26, 2010 concluded that in support of counterterrorism operations in Pakistan, there have been year-to-year increases in terror suspects killed. From 2004 to 2007, the total number of terror suspects killed in Pakistan was estimated at between 77 and 100. By April 16, 2010, those figures increase to between 130 and 227 killed.

Industry studies confirm that [global spending on UAVs](#) has and will continue to increase significantly. It is important to note that the U.S. military is focused on using unmanned systems to dominate conflicts more than any other nation. The U.S. Department of Defense currently has an estimated 160 unmanned airborne systems in the research and development queue. Globally, there are more than 400 programs in existence.

*Defense Industry Daily* has estimated that the “[total UAV market](#) including air vehicles, ground control equipment, and payloads is expected to be worth \$13.6 billion through 2014. More than 9,000 UAVs are expected to be purchased over the next 10 years by countries in every region of the world.” These figures do not reflect funding for Research Development Test & Evaluation (RDT&E), operations, and maintenance.

Reflecting the success of the Predator series of UAVs, [usage is increasing rapidly](#). Flight hours have increased from 80,000 hours in 2006 to 295,000 hours in 2009. On April 6, 2010, the Predator series hit the 1,000,000 hour mark. It was reported that the “million flight hours milestone came less than a month after the USAF announced that it had surpassed 700,000 flight hours for the MQ-1B Predator.”

#### 4. Warfare | Unmanned drones the size of birds or smaller

**PREDICTION:** Many of these flying weapons are the size of small birds, or smaller.

**ACCURACY:** Essentially correct

**DISCUSSION:** One unmanned aerial vehicle (UAV) that has been deployed by the United States Department of Defense is named the [Raven-B](#), developed by AeroVironment, based in Monrovia, California. The hand-launched Raven-B features a “wingspan of 4.5 feet and a weight of 4.2 pounds. It provides aerial observation, day or night, at line-of-sight ranges up to 10 kilometers, and delivers real-time color or infrared imagery to ground control and remote viewing stations, [with] an endurance of up to 80 minutes.” The Raven-B has been deployed in both Afghanistan and Iraq and by all branches of the military.

Numerous small scale [UAVs are in research and development stages](#), many of which are receiving funding by various entities within the United States Government, such as the Department of Defense’s (DoD) Small Business Innovation Research (SBIR) program and the Small Business Technology Transfer (STTR) program. Some of these systems are nearing deployment. (The prediction does not say that “most” flying weapons would be of this sort, but that “many” would be.)

Examples of such research and development (R&D) programs exist under the umbrella of the Defense Advanced Research Projects Agency’s (DARPA) Defense Sciences Office (DSO), specifically, the [Nano Air Vehicle \(NAV\)](#) program. “The Nano Air Vehicle (NAV) program will develop and demonstrate an extremely small (<15 cm), ultra-lightweight (less than 20 grams) air vehicle system with the potential to perform indoor and outdoor military missions. The program will explore novel, flapping wing, and other configurations to provide the warfighter with unprecedented capability for urban mission operations.”



*(Left, Above) A Nano Air Vehicle (NAV) (Image courtesy of AeroVironment, Inc.)*

Another NAV being developed by AeroVironment, Inc., with DARPA funding, is the [size of a small bird](#), employing biomimicry. The system is designed to provide “reconnaissance and surveillance capabilities in urban environments.”



*(Left, Below) The Switchblade (Image courtesy of AeroVironment, Inc.)*

Another DoD-funded program in development that is comparable to a small-scale UAV (delivering weapons effects) is the Switchblade by AeroVironment.

[The Switchblade](#) “is designed to provide the warfighter with a ‘magic bullet.’ It can rapidly provide a powerful, but expendable miniature flying Intelligence, Surveillance and Reconnaissance (ISR) package on a beyond-line-of-sight (BLOS) target within minutes. This miniature, remotely piloted or autonomous platform can either glide or propel itself via quiet electric propulsion, providing real-time GPS coordinates and video for information gathering, targeting, or feature/object recognition.

“The vehicle’s small size and quiet motor make it difficult to detect, recognize, and track even at very close range. [The Switchblade](#) is fully scalable and can be launched from a variety of air and ground platforms.”

*(Right) The Aeryon Scout (Photo courtesy of Aeryon Labs Inc.)*



Aeryon Labs Inc., located in Waterloo, Canada, has developed the Aeryon Scout, a military off the shelf (MOTS) system that “allows any soldier to become an expert in tactical surveillance gathering.”

[The Aeryon Scout](#) is a “vertical take-off and landing (VTOL) micro unmanned aerial vehicle used for tactical, over-the-hill aerial intelligence. Unlike other systems, the Scout puts the control of aerial intelligence directly into the hands of the people on the ground who require the intelligence while delivering the most sophisticated and highest quality aerial intelligence available today.”

The Scout has also been employed in security operations for Canadian law enforcement and in support of drug raids located within Central America.

## 5. Warfare | **The U.S. remains world’s top military power**

**PREDICTION:** The U.S. continues to be the world’s dominant military power, which is largely accepted by the rest of the world, as most countries concentrate on economic competition.

**ACCURACY:** Correct

The U.S. [FY 2011 Budget](#) provides \$548.9 billion for the Department of Defense base budget. No other country is attempting to compete with the United States in this area.



## 6. Warfare | Armed conflicts are rare

**PREDICTION:** Military conflicts between nations are rare, and most conflicts are between nations and smaller bands of terrorists.

**ACCURACY:** Correct

**DISCUSSION:** Military wars between nation states are rare in the world today. Economic integration and cultural commonalities have also led to this prediction being true. This is also partly due to the great wave of democratization that has occurred in the world and the rise of the Web in the 1990s.

In the past 10 years, terrorist attacks [have greatly increased](#). In fact, the rate of terrorist attacks globally in 2009 was one every 19 days.

As a result of the global war on terrorism, many of the international rivalries between nations have been replaced with partnerships forged in the post-9/11 era. Collective efforts between nations have been established to prevent terrorist attacks, interrupt the finance operations of radical organizations, target terrorist leaders and members, and create international anti-terrorist response teams.

This increased terrorist threat has actually led to deeper global collaborations and, in turn, a reduction in the frequency of nation-versus-nation conflict through cooperative efforts to prevent terrorist organizations from acquiring weapons of mass destruction, such as chemical, biological, radiological and nuclear (CBRN).

The [Proliferation Security Initiative \(PSI\)](#) is “a global effort that aims to stop trafficking of weapons of mass destruction (WMD), their delivery systems, and related materials to and from states and non-state actors of proliferation concern. Launched on May 31, 2003, U.S. involvement in the PSI stems from the U.S. National Strategy to Combat Weapons of Mass Destruction issued in December 2002. That strategy recognizes the need for more robust tools to stop proliferation of WMD around the world, and specifically identifies interdiction as an area where greater focus will be placed.”

In April 2010, U.S. President Barack Obama hosted a Nuclear Security Summit in Washington, D.C. Its mission was “to enhance international cooperation to prevent nuclear terrorism. The goals of the [Nuclear Security Summit](#) are to come to a common understanding of the threat posed by nuclear terrorism, to agree to effective measures to secure nuclear material, and to prevent nuclear smuggling and terrorism.”

Not since 1945 had a President of the United States hosted a gathering that attracted so many world leaders. According to “[White House: Key Facts about the National Security Summit](#),” the President has repeatedly advised that the world come together to “address an unprecedented threat — the threat of nuclear materials in the hands of terrorists or criminals.”

On September 11, 2007, the United States Department of Defense (DoD) issued the Irregular Warfare (IW) [Joint Operating Concept \(JOC\) Version 1.0](#) — a report that outlined the United States’ new era of warfighting: “The IW JOC broadly describes operational-level solutions for how future joint force commanders will conduct protracted IW in combination with other available instruments of national power and in concert with our state and non-state partners to achieve strategic objectives. The term ‘non-state partner’ refers to partnerships with militant groups in an effort to combat an unconventional adversary — international terrorists. First, IW is a form of armed conflict. As such, it replaces the term ‘low-intensity conflict.’ Second, IW is a form of warfare. As such, it encompasses insurgency, counterinsurgency, terrorism, and counterterrorism, raising them above the perception that they are somehow a lesser form of conflict below the threshold of warfare.”

## 7. Warfare | Biological warfare is greatest threat

**PREDICTION:** The greatest threat to national security comes from bioengineered weapons.

**ACCURACY:** Correct

**DISCUSSION:** On December 9, 2009, President Barack Obama issued the [National Strategy for Countering Biological Threats](#). It was described as a “vision for addressing the challenges from proliferation of biological weapons or their use by terrorists. It highlights the beneficial nature of advances in the life sciences and their importance in combating infectious diseases of natural, accidental, and deliberate origin. It also outlines how the risks associated with misuse and potential consequences of a biological attack require tailored actions to prevent biological threats.”

The Strategy placed emphasis on the following areas: (1) Improve global access to the life sciences to combat infectious disease regardless of its cause. (2) Establish and reinforce norms against the misuse of the life sciences. (3) Institute a suite of coordinated activities that collectively will help influence, identify, inhibit, and/or interdict those who seek to misuse the life sciences.

On December 30, 2009, President Barack Obama issued Executive Order 13527, [“Establishing Federal Capability for the Timely Provision of Medical Countermeasures Following a Biological Attack.”](#)

There was significant attention being paid to the threat posed to the United States by the use of biological weapons both in the Senate and in the House of Representatives in the years leading up to 2009. For example, in June 2005, leading arms control advocate and expert U.S. Senator Richard G. Lugar (R-IN) authored the [“The Lugar Survey on Proliferation Threats and Responses.”](#)

This official government document confirmed the prediction when it asked the question: “What non-proliferation goal should receive the highest priority of the United States and the international community?” Based on a survey conducted by Luger, the answer to this question was: “Dismantling, securing and destroying nuclear, biological and chemical weapons and materials in the former Soviet Union and elsewhere should be the world’s top non-proliferation priority,” based on the number of responses in the survey.

More than a quarter of the respondents (27 of 85) either listed by name the Nunn-Lugar Cooperative Threat Reduction Program, saying the top priority should be to implement, strengthen or expand it, or listed as the goal a particular Nunn-Lugar objective, such as securing former Soviet weapons, employing former weapons scientists, or gaining access to Russia’s biological weapons labs.

An unclassified [Report to Congress on the Acquisition of Technology Relating to Weapons of Mass Destruction and Advanced Conventional Munitions](#), authored by the Central Intelligence Agency (CIA), stated that the threat of a biological attack from a terrorist organization was high. The report also outlined instances where adversaries had attempted to acquire a biological agent. Examples of state-sanctioned threats were also given. Examples of such nations were Syria and North Korea.

## HEALTH & MEDICINE

### Predictions made for 2009 in *The Age of Spiritual Machines*

The following is an analysis of predictions for 2009 made about the future of health and medicine in the book *The Age of Spiritual Machines*, which was written in the mid to late 1990s.

#### 1. Health & Medicine | Diseases treated through bioengineering

**PREDICTION:** Bioengineered treatments have reduced the toll from cancer, heart disease, and a variety of other health problems.

**ACCURACY:** Correct

**DISCUSSION:** This is certainly true for heart disease in the United States. The death rate for major cardiovascular diseases has been [reduced](#) by 33% from 1950 to 2000, and then a further 15% from 2000 to 2005. Specifically, the death rates from heart disease have [gone down](#) from 259.9 (deaths per 100,000 population) in 1999 to 211.0 in 2006 (based on the latest publicly available data).

A primary reason for such mortality reductions are advanced techniques, including new medications to lower cholesterol and blood pressure, some of which are early examples of bioengineering. Other reasons include the enormous advances in high-resolution imaging, allowing far better diagnosis.

[Cancer deaths have gone down](#) from 200.7 (deaths per 100,000 population) in 1999 to 178.2 deaths in 2007 (latest publicly available data), according to the National Cancer Institute. Better diagnosis through improved imaging is one major reason. Genetic-based medications (based on specific genetic mutations) have recently been introduced and have shown improved effectiveness (although the results of these treatments will be reflected in statistics after 2007).

Cerebrovascular disease deaths have been reduced from 60.0 (deaths per 100,000 population) in 1999 to 45.8 in 2006, and chronic lower respiratory disease deaths have been decreased from 44.5 (deaths per 100,000 population) in 1999 to 41.6 in 2006. Overall, the mortality rate from all causes of death has gone down from 857.0 (deaths per 100,000 population) in 1999 to 810.4 in 2006 in the United States.

## 2. Health & Medicine | Progress in understanding diseases

**PREDICTION:** Significant progress is being made in understanding the information processing basis of disease.

**ACCURACY:** Correct

**DISCUSSION:** This is true and represents a fundamental revolution in health and medicine and its related field of biology. Until recently, development of new treatments, especially drugs, was hit or miss. As a famous example, Pfizer canceled an ongoing trial for a new blood pressure medication due to disappointing results and asked the test subjects to send back the medication. All of the women complied but many of the men did not. Pfizer found this curious and looked into the reasons — which led to the discovery of Viagra.

Now, drug development is properly considered “drug design,” in which new interventions are designed on computers and tested out on increasingly accurate biological simulators. We now have the software of life (the human genome) and that project was itself a good example of the law of accelerating returns, as discussed in the Introduction above. We currently have the means of changing this outdated “software” with [RNA interference](#), enabling us to turn off selected genes and develop new forms of gene therapy.

I am a board member and advisor to the CEO of [United Therapeutics](#), a leading bioengineering company, where we remove lung cells from patients, add a new gene in vitro (in a Petri dish) so as not to trigger the immune system (which was a downside of earlier attempts at gene therapy), replicate the cell with the additional gene a million fold, and inject it back into the body, where it ends up lodged in the lungs. This has cured pulmonary hypertension, a fatal disease, and is currently undergoing human trials.

There are more than a thousand new drugs and other processes in the development and testing pipeline already that involve direct intervention in changing the information processes that underlie biology, including changing our genes, not just in a newborn, but in a mature individual.

Now that health and medicine has been transformed into an information technology, the power of these methods will grow exponentially, in accord with the law of accelerating returns. These methods will be a million times more powerful for the same cost in 20 years, and it will be a new era in our ability to program our biology away from disease and aging.

According to American biologist [Leroy Hood](#), one of the pioneers of human genome sequencing, “Medicine is going to become an information science. The whole health-care system requires a level of IT that goes beyond mere digitization of medical records, which is what most people are talking about now.

“In ten years or so, we may have billions of data points on each individual, and the real challenge will be to develop information technology that can reduce that to real hypotheses about that individual. I also think it will lead to digitization of medicine, the ability to get relevant data on a patient from a single molecule, a single cell. I think this digitization in the long run will have exactly the same consequences as it has had for the digitization of information technology. In time, the costs of health care will drop to the point where we can export it to the developing world. That concept, which was utterly inconceivable a few years ago, is an exciting one.”

MIT, where I’m on the board, recently [created a new department](#) of Biological Engineering devoted to this idea, the first new department at MIT in 39 years.

### 3. Health & Medicine | Telemedicine widely used

**PREDICTION:** Telemedicine is widely used. Physicians can examine patients using visual, auditory and haptic examination from a distance. Health clinics with relatively inexpensive equipment and a single technician bring health care to remote areas where doctors had previously been scarce.

**ACCURACY:** Correct

DISCUSSION: Telemedicine is now a widespread practice worldwide. Telemedicine is so important today that there is an [American Telemedicine Association](#) (ATA) in the United States, plus similar associations in other countries, and an [International Society for Telemedicine & eHealth](#) (ISfTeH). The ISfTeH has special relations not only with national institutions and the World Health Organization (WHO), but also with the International Telecommunications Union (ITU) and the United Nations Office for Outer Space Affairs (UNOOSA) for specific needs related to telecommunications and space.

[Telemedicine](#) is a fast growing application of clinical medicine. Medical information is transferred through interactive audiovisual media for the purpose of consulting, and sometimes for remote medical procedures or examinations. Telemedicine may be as simple as two health professionals discussing a case over the telephone, or as complex as using satellite technology and videoconferencing equipment to conduct a real-time consultation between medical specialists in two different countries.

For example, the [Cisco HealthPresence Solution](#) helps connect patients with medical providers conveniently and efficiently, regardless of distance. Using the network as a platform for telemedicine, it creates an environment similar to what patients experience when they visit their medical provider. It combines HD video, advanced audio, and network-transmitted medical data.

Another example is [Polycom Telemedicine Solutions](#), which break down distance barriers and facilitate communication between patients, practitioners, specialists, and health-care administrators, using collaborative voice and video solutions.

The Polycom Practitioner Cart HDX mobile health-care solution for the patient side sends live HD video, audio, and PC images to the far-side specialist, who can control the distant patient-side camera, share their PC content, and access browser-based applications and lab reports.

Some advanced telemedicine procedures include robotic surgery and other interactive operations, while some simple applications involve storing and forwarding health information (as with some basic eHealth systems). Remote monitoring and remote diagnosis are common uses of telemedicine as well. Telemedicine was widely used after the January 12, 2010 earthquake in Haiti.

In both developed and developing nations, telemedicine and eHealth are growing fast, thanks to the spread of mobile telecommunications. Telemedicine has been particularly useful for poor areas like Sub-Saharan Africa, where health can be radically [improved](#) by the new technological advances.

Doctors and non-doctors can now download thousands of medical apps for mobile telephones, most of them free or as low as \$0.99 per app. [More than 3 million downloads of 6,000 different apps have been reported](#) (for both consumer/patient and healthcare professional apps) for Android phones, and there are many medical apps for the iPhone and other smartphones.

#### 4. Health & Medicine | Pattern recognition for diagnosis

**PREDICTION:** Computer-based pattern recognition is routinely used to interpret imaging data and other diagnostic procedures.

**ACCURACY:** Correct

**DISCUSSION:** Your electrocardiogram routinely comes back with a reliable computerized diagnosis. The same is true for different types of imaging data. Many forms of medical imaging are currently employed: radiography, magnetic resonance imaging (MRI), nuclear imaging, photoacoustic imaging, thermography, tomography and ultrasound, for example. Additionally, electroencephalography (EEG), magnetoencephalography (MEG), electrocardiography (EKG) and other measuring and recoding techniques produce not only images but also data for medical imaging.

Pattern recognition in medical imaging is an important medical discipline with a growing body of scientific literature. Under its program Health For All, the World Health Organization (WHO) is promoting the international use of such technologies “as modern, high-technology-based diagnostic imaging is moving increasingly into therapeutic medicine, and molecular imaging is becoming daily routine.”

Today, thanks to telemedicine, many computer-based diagnostics are becoming possible for many patients, even in poor countries.



## 5. Health & Medicine | Noninvasive imaging has increased

**PREDICTION:** The use of noninvasive imaging technologies has substantially increased.

**ACCURACY:** Correct

**DISCUSSION:** There has been a revolution in the increased use of noninvasive imaging, not only in the United States, but also in [Japan and many other countries](#). [This is revolutionizing diagnosis in heart disease](#), for example, and there are also [new noninvasive methods](#) for diagnosis and monitoring the progression of diabetes, kidney, urological, hematological and digestive diseases, and hypertensive disorders.

The Society of Noninvasive Imaging in Drug Development (SNIDD) has brought together researchers from the pharmaceutical industry, academic centers, and a wide variety of disciplines to identify ways to facilitate [and optimize the use of noninvasive imaging in drug research and development](#).

Noninvasive diagnosis and therapy have substantially increased, thanks to new technological developments, from scanning techniques to nanosensors. However, in some cases, noninvasive methods will not work for the intended purpose, so medical technology has developed minimally invasive methods, such as hypodermic injection (using the syringe), endoscopy, percutaneous surgery, laparoscopic surgery, coronary catheterization, angioplasty, stereotactic surgery, and many other techniques.

A recent [report](#) by J. Paul Shea, PhD, Director, Molecular Imaging, MPI Research, a noninvasive medical expert, stated that: “Noninvasive imaging technologies are seeing increasing utilization in the drug discovery and development process. Across therapeutic areas, across program timelines, imaging endpoints are showing promise as quantifiable measures of compound efficacy and disease response to treatment. Access to these technologies is increasing.”

## 6. Health & Medicine | Doctors using pattern recognition software

**PREDICTION:** Diagnosis almost always involves collaboration between a human physician and a pattern recognition-based expert system.

**ACCURACY:** Partially correct.

**DISCUSSION:** AI-based expert systems are now included in “[clinical decision support systems](#),” many of which use pattern recognition. However, with the “complexity of clinical workflows and the demands on staff time high,” these systems “[have met with varying amounts of success](#),” so we cannot yet say that diagnosis “almost always involves” such systems, although they are [common](#).

## 7. Health & Medicine | Doctors consult knowledge-based systems

**PREDICTION:** Doctors routinely consult knowledge-based systems (generally through two-way voice communication augmented by visual displays), which provide automated guidance, access to the most recent medical research, and practice guidelines.

**ACCURACY:** Partially correct

**DISCUSSION:** Knowledge-based systems are indeed consulted by doctors. For example, the huge bibliographic databases [PubMed and MEDLINE](#), accounting for close to 20 million records, cover life sciences and biomedical information, including bibliographic information on articles from academic journals on medicine, nursing, pharmacy, dentistry, veterinary medicine, and health care. These [databases](#) are compiled by the U.S. National Library of Medicine (NLM) and are also freely available on the Internet. There are also private services like [WebMD](#) and [DynaMed](#) that [help medical practice, according to recent studies](#). Additionally, there are hundreds of simple and specialized health mobile applications that can be downloaded to smartphones.

According to [mobihealthnews.com](#), there are close to 7,000 medical, health and fitness apps available for smartphones today, from managing diabetes to women's health. [Some of these systems can be driven by voice, like the special Nuance speech recognition systems for the medical market](#). Nuance Healthcare Solutions has a complete series of voice recognition products that range from [Dragon Medical Mobile](#), which provides medical mobile search and real-time mobile documentation, to [SpeechMagic](#), which supports the largest medical capturing platform, with 25 recognition languages and 150 specialized recognition vocabularies. The use of speech recognition is extensive, but we cannot yet say that this is “generally” the case, which is why the prediction is only partially correct.

## 8. Health & Medicine | Patient records are digital

**PREDICTION:** Lifetime patient records are maintained in computer databases.

**ACCURACY:** Correct

**DISCUSSION:** This certainly does happen and there is growing momentum for the electronic medical record (EMR) despite years of resistance. The prediction does not say that this is common or ubiquitous.

According to a [2008 study by the National Center for Health Statistics](#) (NHCS) of the Center for Disease Control and Prevention (CDC), “38.4% of the physicians reported using full or partial EMR systems, not including billing records, in their office-based practices.”

About 20.4% of the physicians reported using a system described as minimally functional, including the following features: orders for prescriptions, orders for tests, viewing laboratory or imaging results, and clinical notes. Comparable figures for the 2006 NAMCS, the latest available for the full survey, were 29.2% and 12.4%, respectively.

There are currently [several competing electronic medical record systems](#) in the market, providing many kinds of medical and accounting capabilities. Beyond the separate electronic medical record systems, there are shared or comprehensive computerized health-care records in enterprise-wide systems called electronic health record (EHR), or electronic patient record, or computerized patient record. This is a systematic collection of electronic health information about individual patients or populations. It is in a digital format that is capable of being shared across different health-care settings, and includes demographics, medical history, medication and allergies, immunization status, laboratory test results, radiology images, and billing information. President Barack Obama has been pushing for the creation of such a [nationwide electronic health record system](#) in the United States by 2014.

Besides EMR and EHR, there are also personal health record (PHR) systems, like the ones popularized by Google Health, Microsoft HealthVault and Dossia. Individuals can also carry some of their medical information on flash drives or in personal microchip implants, like those promoted by [Positive ID](#) (formerly VeriChip Corporation).

## 9. Health & Medicine | Privacy concerns for digital medical records

**PREDICTION:** Privacy issues concerning access to these records (as with many other data bases of personal information) have emerged as a major issue.

**ACCURACY:** Correct

**DISCUSSION:** Indeed a primary issue holding back the electronic medical record (EMR) is the concern about privacy and possible hacking into this type of personal data. In Germany, the United Kingdom and the United States, for example, the concept of a national centralized server model of healthcare data has been poorly received. Issues of privacy and security in such a model have been of great concern, as heralded by German doctors who [are protesting centrally stored patient records](#), as [reported in \*The Los Angeles Times\*](#).

The fact that almost one million records from active personnel and veterans were [stolen from the Ministry of Defense](#) of the United Kingdom was certainly a big problem in 2008, and the Federal Bureau of Investigation (FBI) was also [seeking](#) to recover personal data from 26 million veterans after an apparently random burglary at the home of a computer analyst in 2006.

## 10. Health & Medicine | Doctors train in virtual reality simulations

**PREDICTION:** Doctors routinely train in virtual reality environments, which include a haptic interface. These systems simulate the visual, auditory and tactile experience of medical procedures, including surgery.

**ACCURACY:** Correct

**DISCUSSION:** Virtual reality systems are used for training physicians and also used in actual surgery. Current health-care education systems with virtual-reality environments range from [anatomy instruction](#) to [surgery simulation](#). Various haptic interfaces for medical simulation are especially useful for training in minimally invasive procedures like [laparoscopic surgery](#) and [interventional radiology](#), as well as [remote surgery](#) using teleoperators.

A particular advantage of this type of work is that the surgeon can perform many more operations of a similar type, and with less fatigue. Medical simulations are provided today by [universities](#), [corporations](#) and other institutions to promote “[medical simulation](#) as a way to improve patient safety, reduce medical errors, ensure provider competency, train people to respond to public emergencies and combat situations, and reduce health care costs.”

These technologies are used for both training and real operations for procedures like [eye surgery](#), [colonoscopy](#), [back operations](#), [spine orthopedics](#), and several other procedures, since “surgical [simulation can provide high-fidelity training](#) that increases the diffusion of innovative and less-invasive procedures while decreasing the surgeon’s learning curve.” Robotic surgery is also a growing field, and [86% of all prostate surgeries](#) during 2009 in the United States were robot-assisted.

The [da Vinci surgical system](#) is the current leader in the field, and the company that makes it, Intuitive Surgical Inc., [states](#) that the surgical robotic system provides “superior visualization, enhanced dexterity, greater precision and ergonomic comfort for the optimal performance of MIS (minimally invasive surgery). The da Vinci System enables surgeons to perform even complex procedures such as open-heart surgery through 1-2 cm incisions.”

Additionally, [RoSS](#), a robotic surgical simulator made by Simulated Surgical Systems, uses virtual reality to realistically introduce the user to the operation and feel of a robotic surgical console. RoSS has been called the “[flight simulator](#)” of robotic surgery.

[Virtual-reality simulators](#) are also being developed for brain surgeons to provide better training and safer operations. For teaching anatomy, [A.D.A.M.](#) has popularized interactive online simulation, even though it still has limited capabilities.

[Remote surgery](#) (or telesurgery) allows a doctor to perform surgery on a patient even though they are not physically in the same location, a form of telepresence. Remote surgery combines elements of robotics, cutting-edge communication technology such as high-speed data connections, and other elements of information technology.

While the field of robotic surgery has been fairly well established in the last decade, most of these robots are controlled by surgeons at the location of the surgery. Remote surgery is essentially advanced telecommuting for surgeons, where the physical distance between the surgeon and the patient is immaterial. Since the first major transatlantic remote surgery was [performed in 2001](#), the field of telesurgery has been growing fast.

Now it is even possible to have a complete unassisted heart surgery made by [robots under medical supervision miles away](#). Such an operation was performed in 2006 by a robot in Italy, monitored in Boston by a doctor who claimed that “the robot has gained its immense amplitude of knowledge by experience gathered from over 10,000 patients.... The expertise of several human surgeons was also incorporated into the software to improve efficiency. The robot can even recognize the type of patient and reconfigure the necessary means for operating.”

## 11. Health & Medicine | Doctors train on simulated patients

**PREDICTION:** Simulated patients are available for continuing medical education, for medical students, and for people who just want to play doctor.

**ACCURACY:** Correct

**DISCUSSION:** There are simulated patients used for training, some of which are like computer games, and some of which involve an actual life-size simulated patient that the doctor can examine and perform procedures on.

According to an [online survey](#) performed in 2008 by eVIP (Electronic Virtual Patients), co-founded by the European Union, 55% of the respondents said that they used virtual patients for teaching and learning.

Major universities, like [Harvard in the United States](#), the [Imperial College London in the United Kingdom](#), and the [Karolinska Institutet in Sweden](#), have created virtual patient reference libraries and databases. [Private companies like Entelos](#) and other international efforts like [eVIP](#) and [MedBiquitous](#) are also working on collaborative groups for virtual patients with real cases and examples.

Training exercises can model virtual patient cases, where treatments are designed and tested hypothetically before their real-life implementation. Artificial patients allow for the exploration of millions of [hypothesis-driven experiments](#), leading to better research and development of treatments through predictive simulations.

Even the Second Life (SL) virtual world has [recently been used](#) as way to help teach doctors how to treat patients, and one doctor who has used it says that “we have to recognize our students come equipped with incredible computer skills.... It’s a new way of learning for them,” since the students are moving from lectures and textbooks to virtual patients and almost real simulations.

*(Below) A Second Life/OpenSim-based virtual [patient training simulation](#), from the Imperial College London. (Photo courtesy of the Imperial College London)*



## PHILOSOPHY

### Predictions made for 2009 in *The Age of Spiritual Machines*

The following is an analysis of predictions for 2009 made about the future of philosophy in the book *The Age of Spiritual Machines*, which was written in the mid to late 1990s.

#### 1. Philosophy | Renewed interest in the Turing test

**PREDICTION:** There is renewed interest in the Turing test, first proposed by Alan Turing in 1950 as a means for testing intelligence in a machine. Recall that the Turing test contemplates a situation in which a human judge interviews the computer and a human “foil,” communicating with both over terminal lines. If the human judge is unable to tell which interviewee is human and which is machine, the machine is deemed to possess human-level intelligence.

**ACCURACY:** Correct

**DISCUSSION:** As confidence increases in the artificial-intelligence community that computers will pass the Turing test within a couple of decades (see prediction immediately below), there has been increased interest in the test and what it will mean when a computer passes it. This was a major topic in my book *The Singularity is Near*, published in 2005. Discussion of the Turing test includes the implications for human society and the philosophical issue of whether or not such a computer could be considered “conscious.” Literally, the Turing test is not a test for consciousness; it is a test of a particular objective performance. However, such a computer would certainly seem conscious.

By definition, it would appear just as human in its interactions as a biological human person. After the so-called “AI winter” of the 1970s and 1980s, which I discussed in pages 263-266 of my book *The Singularity is Near*, there has been a renewed interest in AI in the 1990s and 2000s. In 1991, the Annual [Loebner Prize for Artificial Intelligence](#) (also called “The First Alan Turing Test”) was started, and has been growing in prestige during the last two decades.

IBM’s Deep Blue supercomputer [defeated](#) the world’s chess champion, Garry Kasparov, in 1997, one year ahead of my corresponding prediction made in my book *The Age of Intelligent Machines*, which also helped people realize that the expression “thinking machines” is not a contradiction in terms. The year 2012 will be the centenary of the birth of Alan Turing in London, and has been declared the Alan Turing Year, with many celebrations and activities concerning the Turing test.



## 2. Philosophy | People believe a computer will pass the Turing test

**PREDICTION:** Although computers still fail the test, confidence is increasing that they will be in a position to pass it within another one or two decades.

**ACCURACY:** Correct

**DISCUSSION:** At the [AI @ 50 Conference at Dartmouth College in 2006](#), celebrating the fiftieth anniversary of the 1956 Dartmouth Conference that gave artificial intelligence its name, a poll was taken, asking AI experts attending when they thought a computer would pass the Turing test. The most popular choices were a quarter century away and a half century away. A significant portion of the group thought it would happen within a quarter of a century, which is about 20 years from now.

In the 2008 Loebner Prize for Artificial Intelligence contest, mentioned above, a chatbot called [Elbot](#) convinced three of the 12 human interrogators that he was indistinguishable from a human, beating the other contestants and taking the bronze medal. If Elbot had convinced one more judge, it [would have passed the 30% mark](#), the threshold set by Alan Turing in 1950 and used in the Loebner Prize for deciding whether a machine is capable of thinking like a human. The Loebner Prize organizers consider that the silver medal is at risk now, and that one chatbot will eventually take the final gold medal. Note that it is the Loebner Silver medal that represents the Turing test that Alan Turing originally described.

Besides [Elbot](#), there are other prominent chatbots, like the historical [ELIZA](#) of the 1960s, the newer [ALICE](#) (Artificial Linguistic Internet Computer Entity), winner of the 2000, 2001 and 2004 Loebner Prizes, and [my own Ramona avatar, currently on its fourth version](#). There are also examples of narrower Turing tests for specific intelligence at certain tasks, like [the Musical Turing Test, considered by the Sony Computer Science Laboratory Paris](#), the [Financial Turing Test, reviewed by the MIT magazine Technology Review](#), and the current [proposal](#) by Peter Diamandis and myself for an AI Physician X Prize with the X Prize Foundation.

AI keeps improving, but MIT roboticist Rodney Brooks [explained](#) that “every time we figure out a piece of it, it stops being magical; we say, Oh, that’s just a computation.” This is called the “AI effect,” as the Association for the Advancement of Artificial Intelligence (AAAI) [explained](#): “The great practical benefits of AI applications and even the existence of AI in many software products go largely unnoticed by many despite the already widespread use of AI techniques in software.

This is the AI effect. Many marketing people don’t use the term ‘artificial intelligence’ even when their company’s products rely on some AI techniques.”

### 3. Philosophy | Speculation regarding computer consciousness

**PREDICTION:** There is serious speculation on the potential sentience (i.e., consciousness) of computer-based intelligence.

**ACCURACY:** Correct

**DISCUSSION:** As discussed above, with increasing confidence that a computer will pass the Turing test within a small number of decades, there is increasing speculation regarding whether or not such a system could be considered conscious, and therefore sentient. By definition, such a computer system would be indistinguishable from biological humans in its behavior and ability to interact with other humans.

It would mean that human performance is not necessarily dependent on the biological substrate that comprises our brains today. The biological information processing in our brains is, after all, much slower than information processing in conventional electronics today. Information in our brains is transmitted using chemical signals that travel a few hundred feet per second, which is a million times slower than electronics.

Computations take place in the interneuronal connections at a rate of one or two hundred per second, which is about a million times slower than conventional computers running at gigahertz frequencies. The brain is massively parallel, but digital systems are rapidly moving in that direction. As I discussed in *The Singularity is Near*, digital computers will soon be far more powerful than the information processing that takes place in the human brain.

We are also making exponential gains in understanding the basic principles of how the human brain creates intelligent decisions and other aspects of our thinking. The reverse engineering of the human brain is also proceeding at an exponential pace and, already, significant portions of the brain have been modeled, simulated, and tested — including substantial slices of the cerebral cortex.

IBM is leading the [SyNAPSE](#) (Systems of Neuromorphic Adaptive Plastic Scalable Electronics) project, funded by DARPA, with the objective of creating “[cognitive computers](#)” as systems that can simulate the abilities of the human brain.

The [Blue Brain Project](#), at École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland, supported by IBM, expects to simulate the entire human neocortex (the region responsible for our hierarchical thinking) by 2018. In my view, it will take about two decades to fully simulate the human brain, around 2029, but that is still not far away.

The goal of reverse engineering the human brain is not just to simulate an exact copy of it, but to understand its methods and then to leverage those basic methods using engineering, just as we leveraged Bernoulli’s principle to create the entire world of aviation. The point is that our thinking is not dependent on its biological substrate; hence, it can be argued that our consciousness should not be dependent on a biological substrate, either. However, the idea of a nonbiological system being conscious raises intriguing

philosophical issues concerning identity. I discussed these issues in chapter 7 of *The Singularity is Near*.

I am currently writing a new book called *How the Mind Works and How to Build One*, where I discuss several of these issues. Computers might not be humans, but they are increasingly exhibiting some thinking capabilities, just like airplanes are not birds, but they fly, or submarines are not fish, but they navigate under water.

Even British biologist [Richard Dawkins](#) acknowledged the possibility of a fast self-improving artificial intelligence and [wrote](#) that “there is a popular cliché... which says that you cannot get out of computers any more than you have put in... that computers can only do exactly what you tell them to, and that therefore computers are never creative. This cliché is true only in a crashingly trivial sense, the same sense in which Shakespeare never wrote anything except what his first schoolteacher taught him to write — words.”

#### 4. Philosophy | Growing computer intelligence stirs discussion

**PREDICTION:** The increasingly apparent intelligence of computers has spurred an interest in philosophy.

**ACCURACY:** Correct

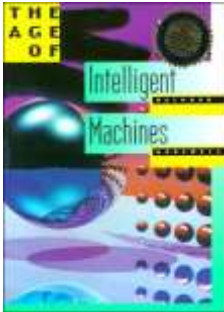
**DISCUSSION:** The very idea that computers might eventually think has motivated many philosophical discussions. The *Stanford Encyclopedia of Philosophy* first included an [article](#) about the Turing test in 2003, largely revised and expanded in 2008. The possibility of “artificial” intelligence has been [traced](#) back to Biblical times, Greek myths, and René Descartes’ *Discourse on the Method*.

The field of philosophy of artificial intelligence has been [growing](#) in order to consider questions like: Can machines have emotions? Can machines be self aware? Can machines have a soul?

Many books have been written pro or con either position, such as the ideas of John Searle and Roger Penrose against, versus the ideas of Rodney Brooks and Marvin Minsky in favor. There is also the nascent field of [ethics of artificial intelligence](#), which considers [how humans should treat AI and how AI could treat humans](#) in the future, and these considerations go much [beyond the basic “Three Laws of Robotics” described by Isaac Asimov in science fiction](#).

It is clear that not all human behavior is intelligent (sometimes comparing human intelligence with human stupidity, and also artificial stupidity with artificial intelligence) and that not all intelligence is human. The intersection domain of non-human intelligence can thus be called [artificial intelligence](#) or, as some prefer today, “synthetic intelligence,” as described by AI experts Peter Norvig and Stuart Russell. Again, some of these philosophical issues are mentioned in my coming book called *How the Mind Works and How to Build One*.

## THE AGE OF INTELLIGENT MACHINES



### Predictions made in *The Age of Intelligent Machines* for the 1990s & 2000s, published in the late 1980s

There are numerous references in *The Age of Intelligent Machines* (written and published in the late 1980s) to future communication technologies which anticipate the nature of the World Wide Web and search engines, which are scattered throughout the book.

#### Here are a few:

Page 428:

...computers will type our letters and reports, intelligently maintain our files and records, and help to organize our work. The areas likely to continue to require significant human involvement, particularly during the first half of the next century, will be communication, teaching, learning, selling, strategic decision making, and innovation. While computers will certainly impact all of these areas, they will continue to be the primary focus of human efforts in the office. As I pointed out above, the office worker of the next century will have sustained contact with both human and machine intelligence.

The concept of a document will undergo substantial change. Extremely high resolution easy-to-view screens will become as common and as easy to read from as paper. As a result, we will routinely create, modify, handle, and read documents without their ever being converted to paper form. Documents will include a variety of types of information beyond mere text and pictures. They will routinely include voice, music, and other sound annotations. Even the graphic part of documents will become more flexible: it may be an animated three-dimensional picture. In addition, documents will be tailored in that they will include the underlying knowledge and flexibility to respond intelligently to the inputs and reactions of the reader. Finally, documents will not necessarily be ordered sequentially as they are in this book: they will be capable of flexible intuitive patterns that reflect the complex Web of relationships among ideas (this is Ted Nelson's "hypertext").

Pages 427-428:

While employing substantially fewer people, the advent of computer controlled manufacturing technologies will permit a degree of individual customization of products not feasible today. Two centuries ago every item was inevitably a little different, since it was made by hand. During the First Industrial Revolution the innovation of mass production substantially reduced the individualization of products. During the Second

Industrial Revolution the innovation of extremely flexible manufacturing will increase it. For example, consumers will be able to sit down at their home computers and design their own clothes to their own precise measurements and style requirements using friendly, computer-assisted design software. When the user issues the command “Make clothes,” the design parameters and measurements will be transmitted to a remote manufacturing facility, where the clothes will be made and shipped within hours.

Pages 429-430:

This situation will, in my view, include the following eight developments:

Every child has a computer. Computers are as ubiquitous as pencils and books.

They are portable laptop devices about the size of a large book.

They include very high resolution screens that are as easy to read as books.

They include a variety of devices for entering information, including a keyboard and a track ball (or possibly a mouse).

They support high quality two-way voice communication, including natural-language understanding.

They are extremely easy and intuitive to use.

A great variety of high-quality interactive intelligent and entertaining courseware is available.

Computers are integrated into wireless networks.

.....

Wireless networks will allow easy sharing of courseware, submissions by students of papers, exams, courseware responses, and other creations, electronic mail and other communications (e.g., love notes). By being plugged into international networks of information, children will have immediate access to the great libraries of the world right from their school bags. In addition to being able quickly to access virtually all books, magazines, data bases, and other research materials, there will exist intelligent software assistants to help students quickly find the information they are looking for.

The above vision of an optimal educational workstation will obviously not come forth suddenly. Some aspects of it are becoming available now; others will emerge over the next decade. A personal computer with the necessary attributes should become available around the end of this century. With the historical ten-year lag of the educational field in adopting new computer technology, we can expect a critical mass level of ubiquitous utilization of such technology by the end of the first decade of the next century.

Page 414:

Adoption of the advanced media technologies described here will begin in the late 1990s and mature over the first half of the next century. Applications include entertainment, education, conducting business transactions, even companionship.

Pages 432-434:

Our portable computers will be gateways to international networks of libraries, data bases, and information services.

We can expect the personal computers of 2010 to have considerable knowledge of where to find knowledge. They will be familiar with the types of information contained in our own personal data bases, in the data bases of companies and organizations to which we have access, as well as to all subscription and public information services available through (wireless) telecommunications. As described earlier, we shall be able to ask our personal computers to find, organize, and present diverse types of information. The computer will have the intelligence to engage us in dialog to clarify our requests and needs, to access knowledge from other machines and people, and to make organized and even entertaining presentations.

.....

One major impact of advanced communications technology will be on the nature of our cities. Cities first developed to facilitate manufacturing and transportation and thus tended to be located near ports and rivers. With highways and railways providing greater flexibility in transporting goods and people, a primary purpose of the city shifted to communication. Congregating people in one place facilitated their ability to meet and conduct business. But if we can “meet” with anyone regardless of where we are and our computers can easily share information through wireless telecommunications networks, the need for cities will diminish. Already our cities are spreading out, and this trend will accelerate as the communication technologies described above become available. Ultimately, we will be able to live anywhere and still work, learn, and play with people anywhere else on the globe. The world will become one city, the ultimate realization of McLuhan’s vision of the global village.

Page 439:

Lifetime patient records and histories will be maintained in nationally (or internationally) coordinated data banks in place of today’s disorganized system of partial, fragmented, and often illegible records. These records will include all imaging data, the complete readouts of our home blood tests and wristwatch monitoring systems. Intelligent software will be available to enable this extensive data bank to be analyzed and accessed quickly by both human and machine experts.

Page 441:

For the blind, reading machines will be pocket-sized devices that can instantly scan not only pages of text but also signs and symbols found in the real world. These machines will be able to read with essentially perfect intonation and with a broad variety of voice styles. They will also be able to describe pictures and graphics, translate from one language to another, and provide access to online knowledge bases and libraries through wireless networks.

Pages 445-447:

As I have pointed out throughout this book, wealth and power in the age of intelligent machines is increasingly becoming a function of innovation and skill. The cornerstones of power during the First Industrial Revolution — geography, natural resources, and manual labor — are rapidly diminishing in importance and relevance. We are entering a world in which wealth can be beamed across the world by satellite, smart weapons can reach their destinations from thousands of miles away, and some of the most powerful technologies in history require only tiny amounts of material resources and electricity. We can only conclude that the strategic variables controlling our future are becoming technology and, in particular, the human intellectual resources to advance technology.

For thousands of years governments have demonstrated the possibility of forcing people to perform manual labor (although even here productivity is certainly diminished by coercion). It is a fortunate truth of human nature that creativity and innovation cannot be forced. To create knowledge, people need the free exchange of information and ideas. They need free access to the world's accumulated knowledge bases. A society that restricts access to copiers and mimeograph machines for fear of the dissemination of uncontrolled knowledge will certainly fear the much more powerful communication technologies of personal computers, local area networks, telecommunication data bases, electronic bulletin boards, and all of the multifarious methods of instantaneous electronic communication.

Controlled societies like the Soviet Union are faced with a fundamental dilemma. If they provide their engineers and professionals in all disciplines with advanced workstation technology, they are opening the floodgates to free communication by methods far more powerful than the copiers they have traditionally banned. On the other hand, if they fail to do so, they will increasingly become an ineffectual third-rate power. Russia is already on a par with many third-world countries economically. Russia is a superpower only in the military sphere. If it continues to stagnate economically and fails to develop advanced computer technologies, this type of power will dissipate as well.



Innovation requires more than just computer workstations and electronic communication technologies. It also requires an atmosphere of tolerance for new and unorthodox ideas, the encouragement of risk taking, and the ability to share ideas and knowledge. A society run entirely by government bureaucracies is not in a position to provide the incentives and environment needed for entrepreneurship and the rapid development of new skills and technologies.

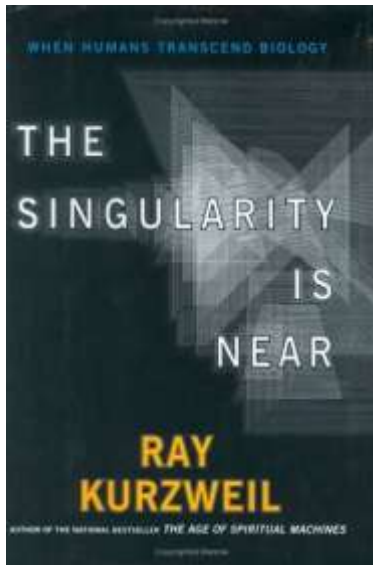
From all appearances, some of the leaders of the Communist world have had similar thoughts. Mikhail Gorbachev's much-heralded campaigns of glasnost (openness) and perestroika (restructuring) have taken some initial steps to open communication and provide market incentives. Important steps have been taken in many of these societies toward achieving individual liberty. But these are only the first steps in what will need to be a long journey to complete a full transformation. Already the forces of reaction in China have taken a major step backward. What is not yet clear is the ability of these societies to succeed in moving deeply entrenched bureaucracies. What is clear, however, is that the pressures for such change will not go away.

Should these societies opt instead for a continuation of the controlled society, they will also find computers to be of value. Computers today play an indispensable role in legitimate law enforcement; there is no reason why they would not be equally useful in enforcing any form of state control. With the advanced vision and networking technologies of the early twenty-first century, the potential will exist to realize George Orwell's chilling vision in 1984.

Computer technology may lead to a flowering of individual expression, creativity, and communication or to an era of efficient and effective totalitarian control. It will all depend on who controls the technology. A hopeful note is that the nature of wealth and power in the age of intelligent machines will encourage the open society. Oppressive societies will find it hard to provide the economic incentives needed to pay for computers and their development.

## PREDICTIONS FOR 2010

### Predictions made in *The Singularity is Near* for 2010



There is one page of predictions for 2010 in Chapter 6 (“The Impact...”) of *The Singularity is Near*. It should be pointed out that as this section of this essay is written, 2010 is not yet over, and perspectives change quickly.

For example, as of October 2009, the idea of large-vocabulary, speaker-independent, continuous speech recognition from a cell phone as well as speech-to-speech language translation from a cell phone still seemed like distant dreams to many observers, yet only a month later both of these application types were among the most popular phone apps for the iPhone, and now for Android-based phones. Once these things happen, it seems like they’ve been around for a long time. Both prospects and realities change very quickly.

Also, these predictions are organized by decades (actually in 20-year increments: there is a page on 2010 and it then jumps to 2030), so if a prediction comes true in 2011 or even 2012 or 2013 it is still “essentially correct.” In these predictions I was trying to give a sense for what life will be like around these particular times.

#### 1. For 2010 | Invisible, embedded computing

**PREDICTION:** Computers arriving at the beginning of the next decade will become essentially invisible: woven into our clothing, embedded in our furniture and environment.

**ACCURACY:** Correct

**DISCUSSION:** Note that this prediction refers to computers arriving early in the current decade (2010 – 2020). When I wrote this prediction in the early ’00 years, computers were still relatively bulky devices carried under your arm. Today, they are commonly found in shirt pockets and jacket pockets, and hung from belt loops. Colorful iPod nano models are worn on blouses or on sleeves while running; health monitors can be [woven into undergarments](#). There are now computers in hearing aids, and there are many other examples.

According to [VDC Research](#), about 500 million processors in 2009 went to the “wearable market segment,” with about 25 million of these embedded in clothing. My prediction also alludes to the great profusion of embedded computers that are indeed built into

scores of everyday devices. Computers are ubiquitous in today's household; "98 percent of computing devices are embedded in all kinds of electronic equipment and machines, such as credit cards, mobile phones, cars, and planes and are being used throughout our lives in places such as homes, offices, and factories," according to a [Microsoft executive](#).

According to VDC Research, 3.8 billion embedded microprocessors were shipped in 2009, with 30 to 100 per home, not including cars. In addition, according to [Bruce Emaus](#), chairman of SAE International's Embedded Software Standards Committee, a typical car today has 30 or more computers (luxury cars have as many as 100). This was not the case when this prediction was written in the early '00 years.

## 2. For 2010 | Tapping the Mesh

**PREDICTION:** [Computers] will tap into the worldwide mesh (what the World Wide Web will become once all of its linked devices become communicating Web servers, thereby forming vast supercomputers and memory banks) of high-speed communications and computational resources.

**ACCURACY:** Correct

**DISCUSSION:** The "worldwide mesh," which we now call the cloud, is indeed harnessing computers on the net to form supercomputers, providing vast memory banks and computing resources to anyone who wants to access them. People are increasingly moving their file storage and computing needs to the cloud.

## 3. For 2010 | Always online

**PREDICTION:** We'll have very high-bandwidth wireless communication to the Internet at all times.

**ACCURACY:** Correct

**DISCUSSION:** People do indeed walk around with their "cell phones" (in quotes because they are computers first and phones second) and other mobile devices online all of the time.

#### 4. For 2010 | Heads-up display

**PREDICTION:** Displays will be built into our eyeglasses and contact lenses and images projected directly onto our retinas.

**ACCURACY:** Essentially correct

**DISCUSSION:** The wording of the prediction here is unclear as to whether it implies that this technology merely exists or is common or ubiquitous. The wording was clear in *The Age of Spiritual Machines (ASM)* that the technology would exist but not necessarily be common, and so the *ASM* prediction is correct (see prediction 17 in “The Computer Itself” section).

In *The Singularity is Near*, the wording could be interpreted to mean that it is commonly used, which is not yet the case, but this is likely to become the case over the next couple of years as computer gaming moves in the direction of 3D full-immersion environments (as leaders of that industry have indicated that it will).

#### 5. For 2010 | Projected audio

**PREDICTION:** Similar tiny devices will project auditory environments.

**ACCURACY:** Correct

**DISCUSSION:** A technology created by a small company called Audience (disclosure: I am on its scientific advisory board) has created a cell phone audio technology that indeed blocks out background sounds based on reverse-engineering of the brain mechanism that allows humans to do this. Major Asian cell phone manufacturers have recently licensed it and these phones should show up later this year.

Regarding projecting sound from a distance to specific locations in 3D space, the technology does indeed exist. The prediction does not say that the technology would be ubiquitous.

This prediction is based on the principle that ultrasonic sound modulated by audible audio signals can generate audible sounds at any location in nearby 3D space. “It works by using harmless ultrasonic tones that we can’t hear. These tones use the property of air to create new tones that are within the range of human hearing. The result is audible sound. The acoustical sound wave is created directly in the air molecules by down-converting ultrasonic energy to the frequency spectrum we can hear,” according to inventor Elwood G. Norris.

HyperSonic Sound (HSS) from [LRAD Corporation](#) (formerly American Technology Corporation) is based on this principle. “The HSS H450 offers display-point audio that is so focused that only the intended listener will hear your audio message.” Through the combination of an ultrasonic-powered emitter and a signal processor/amplifier, LRAD’s HSS focuses sound into a tight beam for optimal directionality and intelligibility.

While this technology is not yet incorporated in consumer products, “this ability to direct or focus sound into a tight beam has a wealth of [consumer-related] applications. Museums, aquariums, zoos, monuments and other self-guided or tour-led facilities can enhance the visitor experience through targeted communication about artistic displays, historical documents, artifacts, animal and marine life, without the need for headphones.”

“In high ambient noise environments such as airports, rail lines, buses, commuter train stations, or port terminals, HSS can intelligibly target traveling information and local area tourist information to a specific area. Retailers of all types can provide targeted, unobtrusive advertising directly at the point of purchase.”

## 6. For 2010 | Complete virtuality

**PREDICTION:** These resources will provide high-resolution, full-immersion, visual-auditory virtual reality at any time.

**ACCURACY:** Essentially correct

**DISCUSSION:** The computer game industry is rapidly moving in this direction. Technologies such as Microsoft’s [Kinect](#) allows players to control a videogame without requiring controllers by detecting the player's body motions. Three-dimensional high-definition television is now available and will be used by a new generation of games that put the user in a full-immersion, high-definition, visual-auditory virtual reality environment.

## 7. For 2010 | Augmented reality

**PREDICTION:** We will also have augmented reality with displays overlaying the real world to provide real-time guidance and explanations.

**ACCURACY:** Correct

**DISCUSSION:** Augmented reality (AR) is a system in which data is overlaid on a screen or displayed on glasses. The data explains what is inside a building or [recognizes a person](#). This has indeed just recently emerged as a popular new class of mobile phone-based app for iPhone and Android platforms. This is another prediction that seemed far off in Fall 2009, but is now considered an important category of existing applications.

## 8. For 2010 | Real-time translation

**PREDICTION:** We'll have real-time translation of foreign languages, essentially subtitles on the world.

**ACCURACY:** Correct

**DISCUSSION:** Indeed text-to-text, speech-to-text, and speech-to-speech language translation are popular applications on cell phone platforms such as the iPhone and Android. Language translation for virtually all popular language pairs is also built into Google's search engine and website.

The \$4.99 Word Lens iPhone app from [QuestVisual](#) uses optical character recognition to identify words in an image and translate them, and then draw them back on the screen. It currently offers only English to Spanish and Spanish to English translation. Other languages are planned.

## 9. For 2010 | Information at-hand

**PREDICTION:** We'll have access to many forms of online information in our daily activities.

**ACCURACY:** Correct

**DISCUSSION:** This was not the case when the prediction was written in the early '00 years, since computer applications were desktop- or notebook-based and represented an activity separate from our daily routine.

Now, with hundreds of thousands of applications, popular mobile platforms such as the iPhone and Android do indeed integrate intelligent knowledge-based capabilities into every aspect of our daily routine. These include, for example, navigating, locating friends, finding stores and other resources, shopping and conducting transactions of every sort, reading magazines and newspapers, and buying music, books, movies, and other media.

## 10. For 2010 | Virtual assistants

**PREDICTION:** Virtual personalities that overlay the real world will help us with information retrieval and our chores and transactions. These virtual assistants won't always wait for questions and directives but will step forward if they see us struggling to find a piece of information."

**ACCURACY:** Partially correct

**DISCUSSION:** Virtual assistants do indeed help us with information retrieval and our chores and transactions. Information assistance applications integrated with virtual personalities have been developed but are experimental and not yet in common usage.

The next major phase of search engines will attempt to determine what information we want and need and not necessarily require us to unambiguously specify what we are looking for. This is a major focus of research at Google and Microsoft. Google's new "Instant" search service provides search results before you finish typing your query, based on past searches by you and others, and represents one step in this direction.

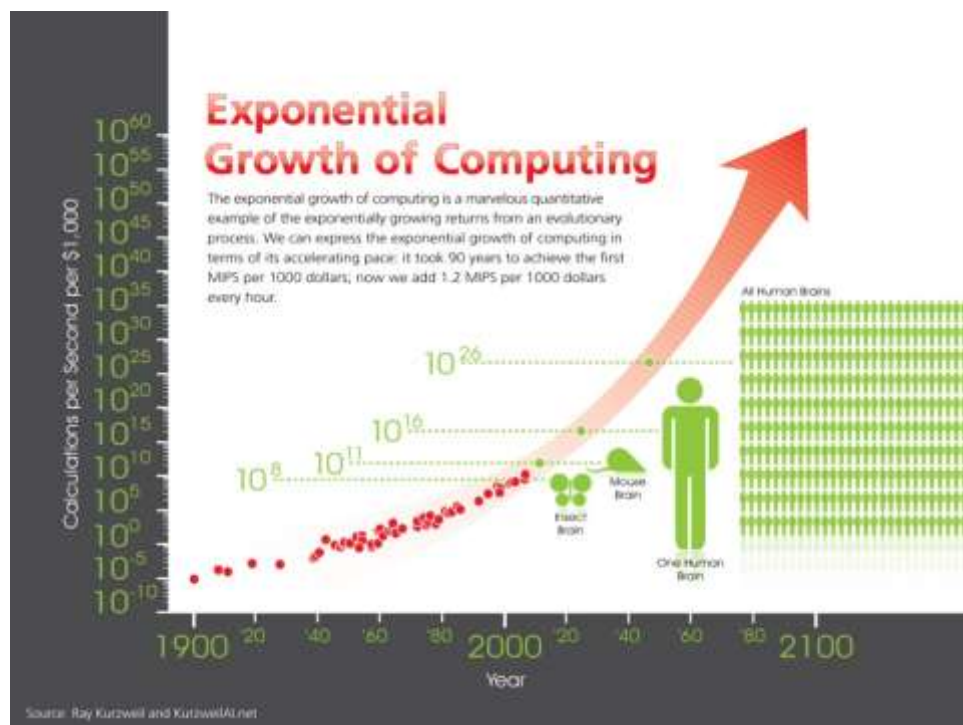


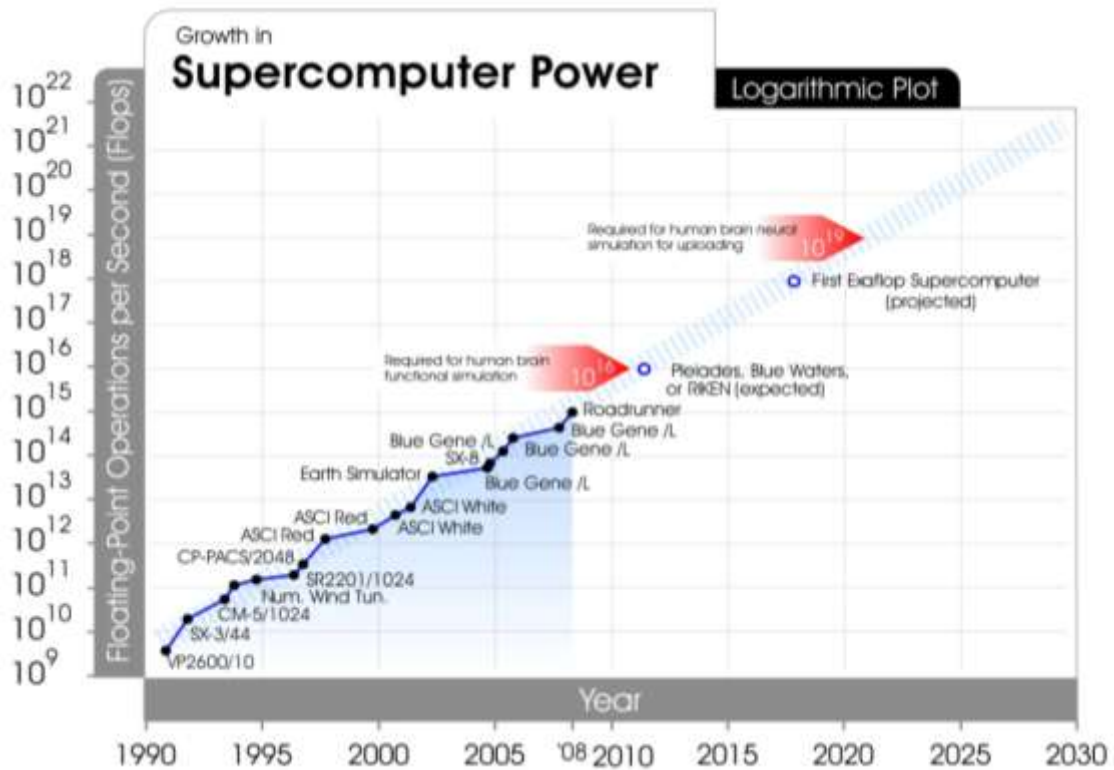
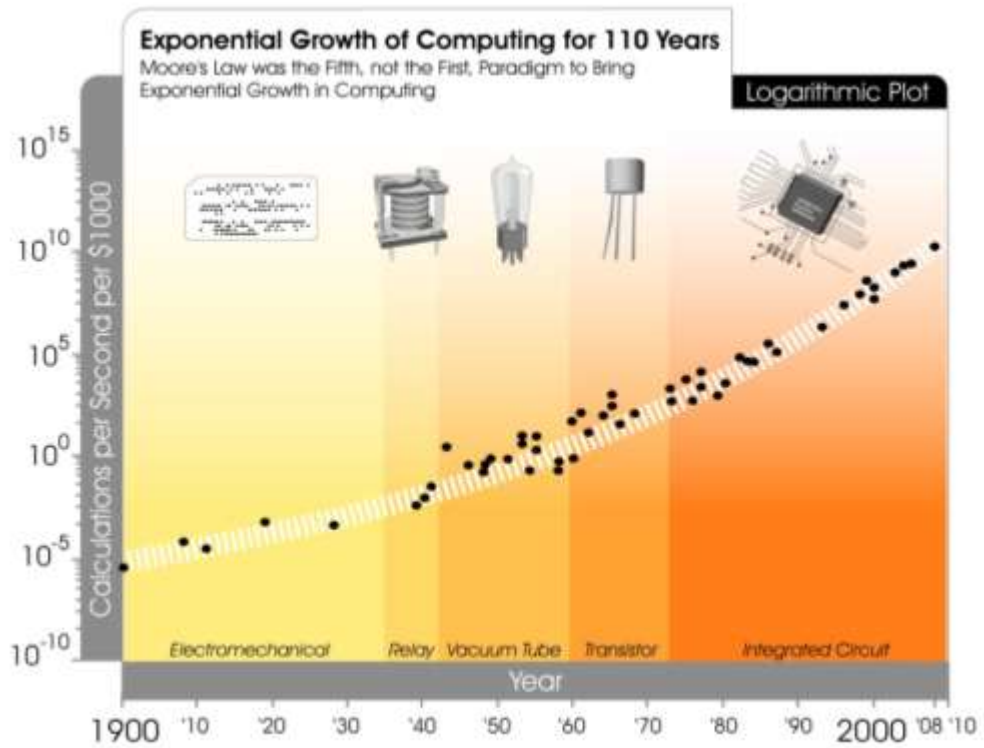
## THE SINGULARITY IS NEAR | GRAPHS

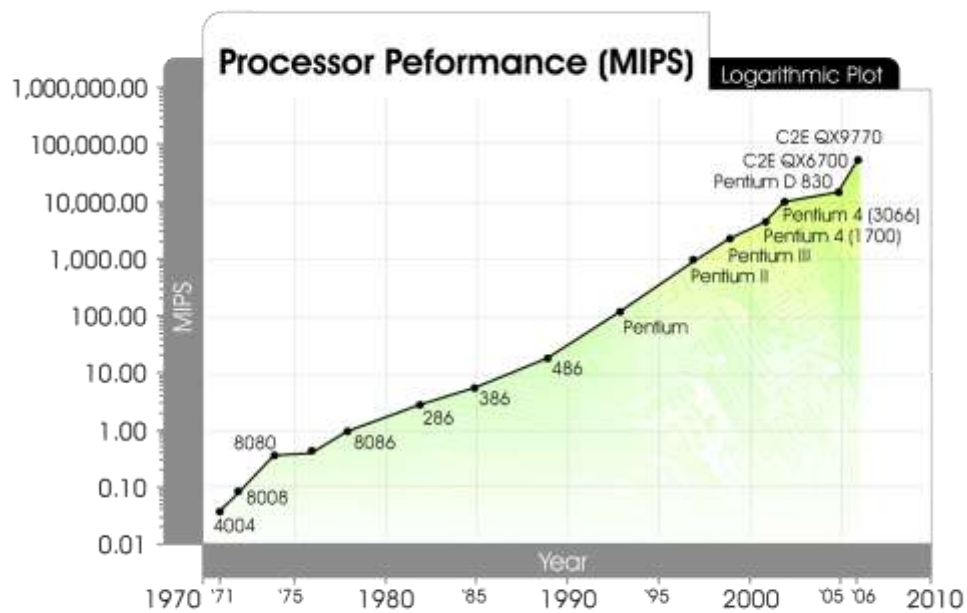
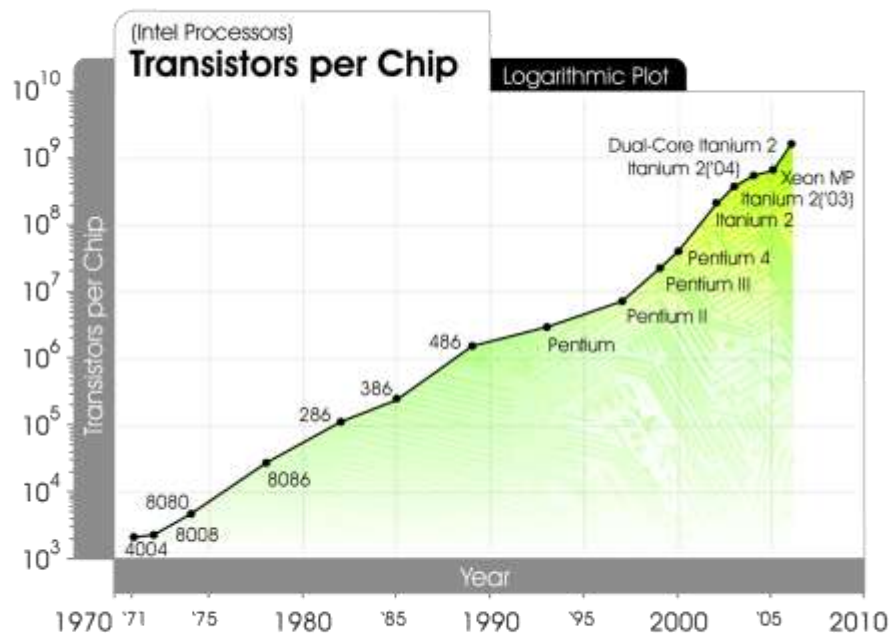
The ongoing exponential progressions of information technology cited in *The Singularity is Near* — written in the early 2000s, published in 2004

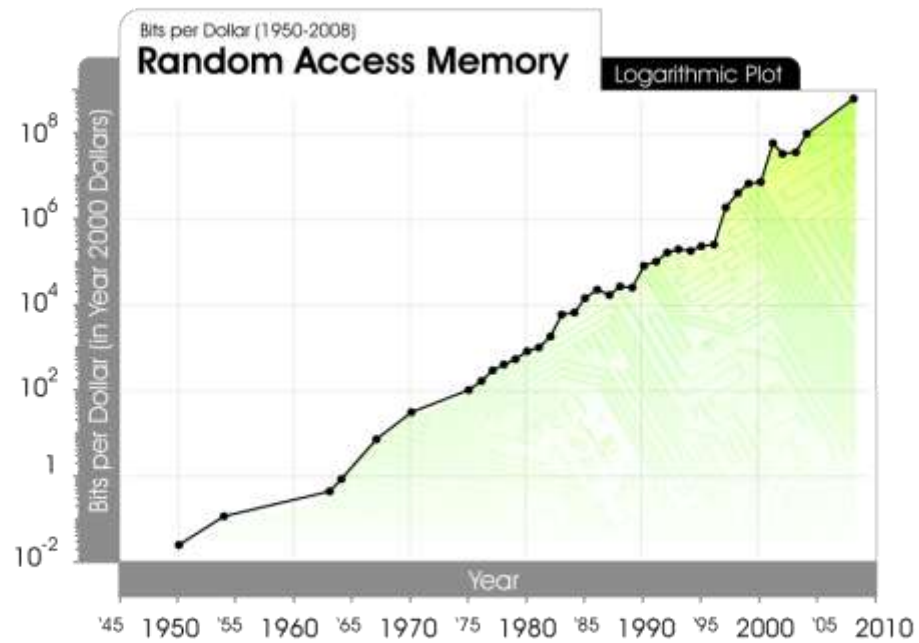
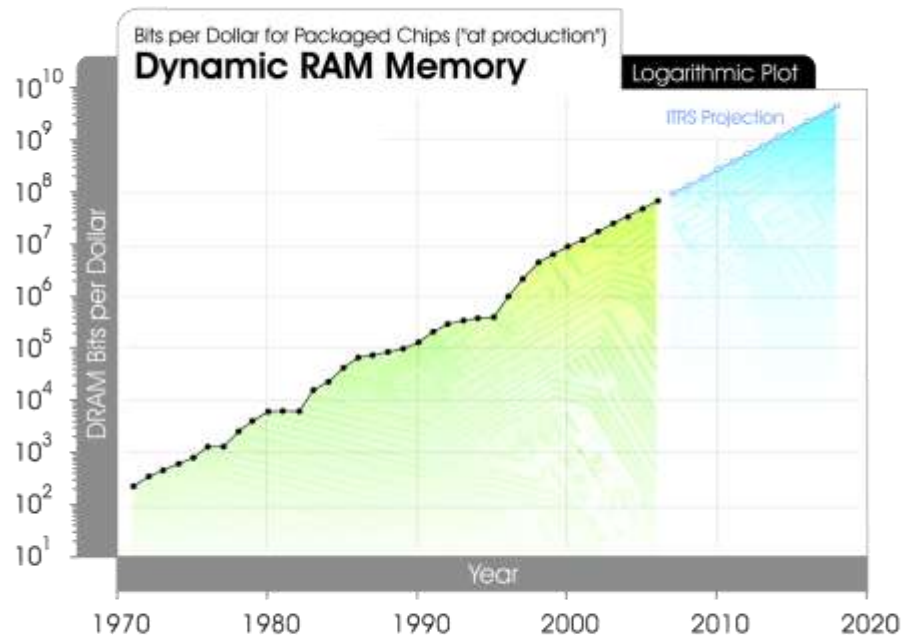
With regard to *The Singularity is Near (SIN)*, the graphs in this book are themselves predictions. The point of these graphs is not just to show what has happened in the past but to implicitly predict that these trends will continue.

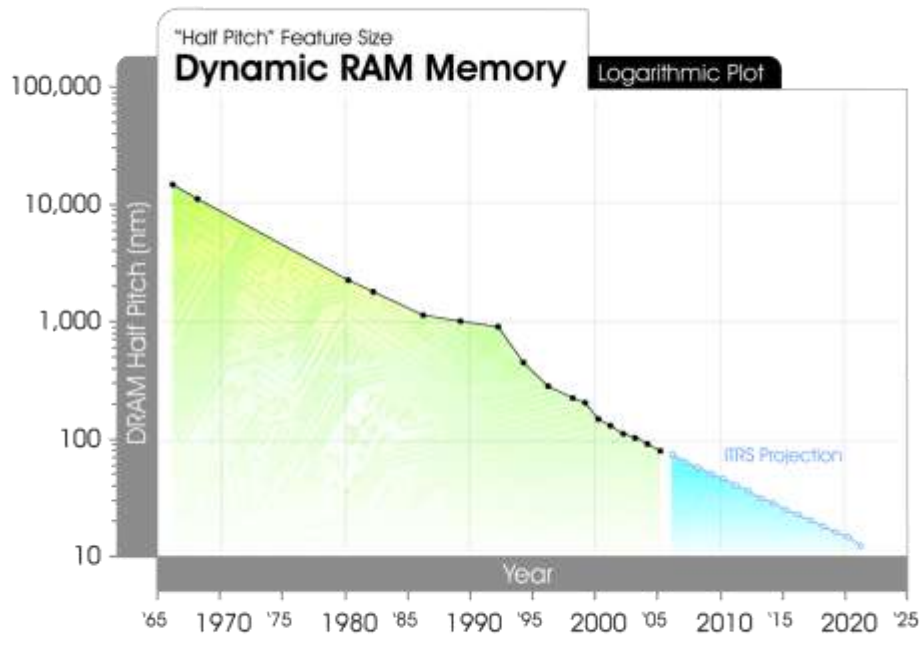
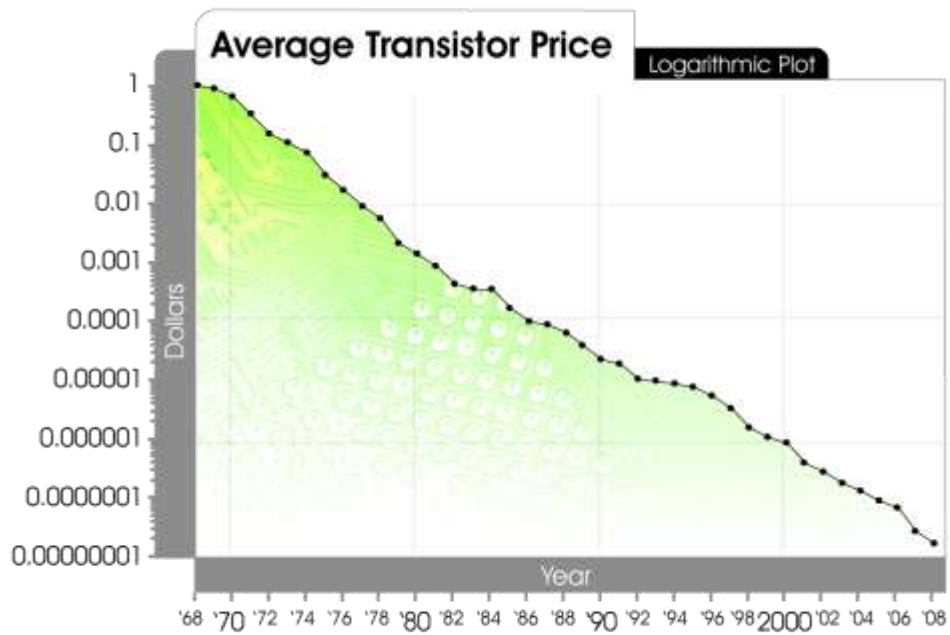
Below are the same graphs as I included in *SIN* updated to 2008. Indeed the exponential trends for a broad variety of information technology measures have continued right on track.

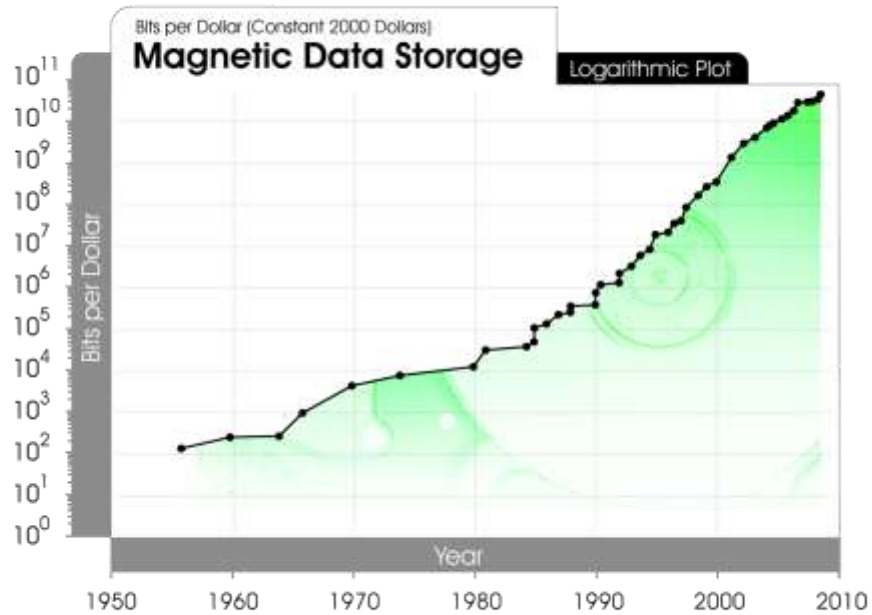
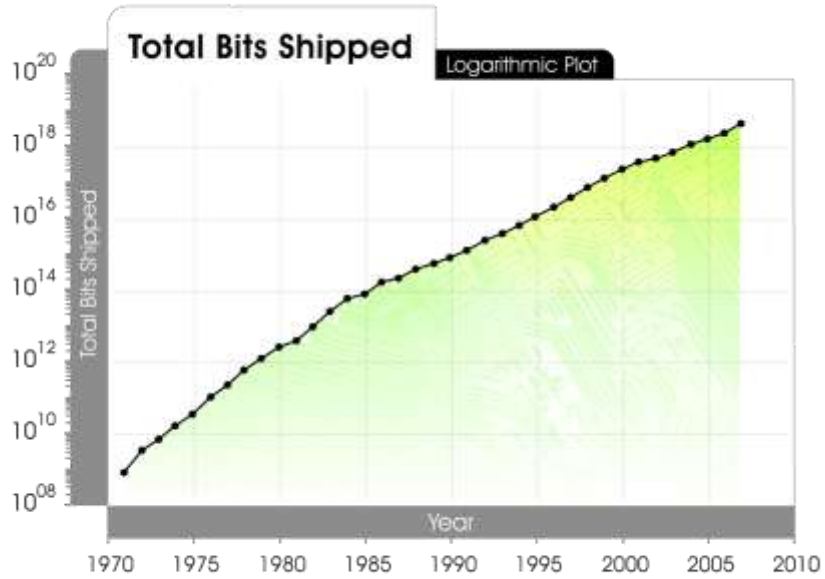


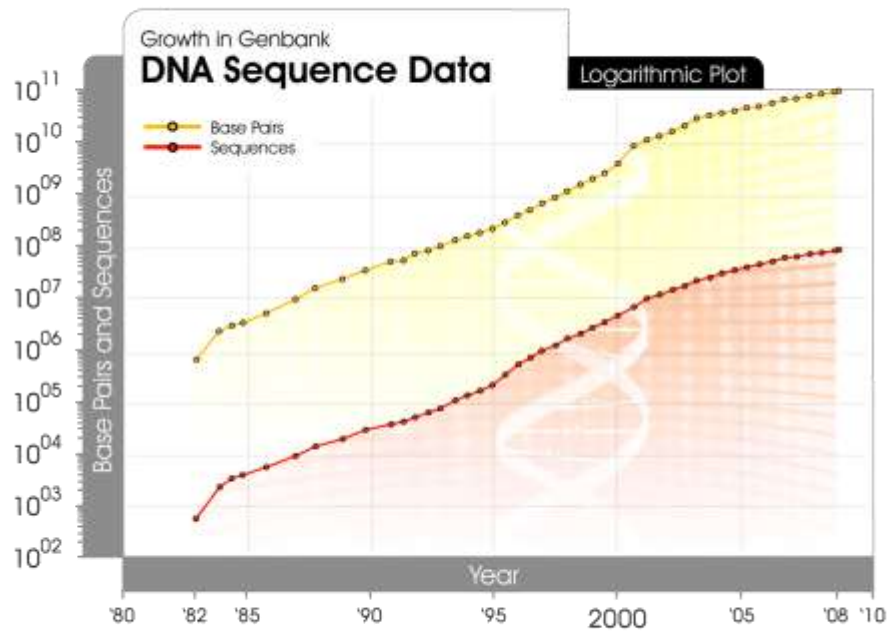
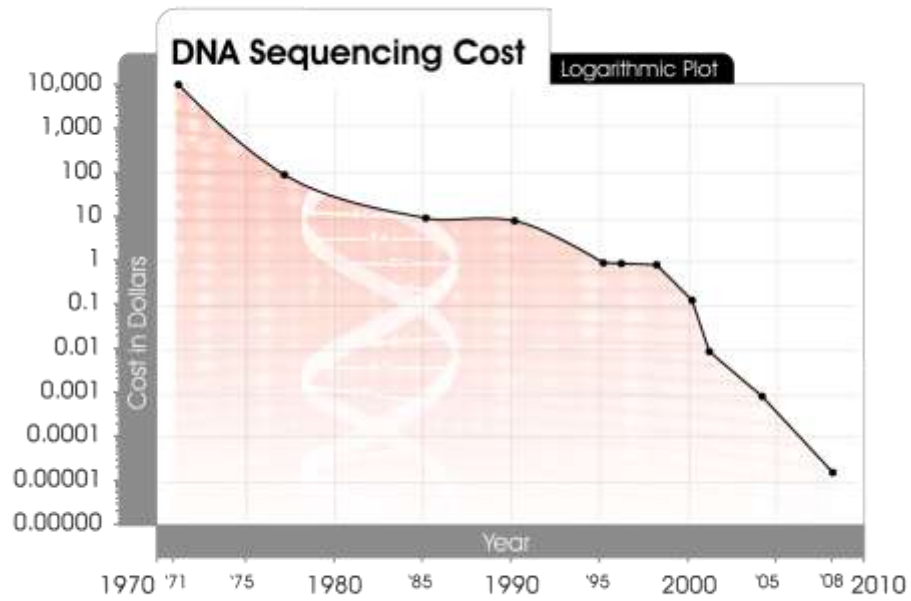




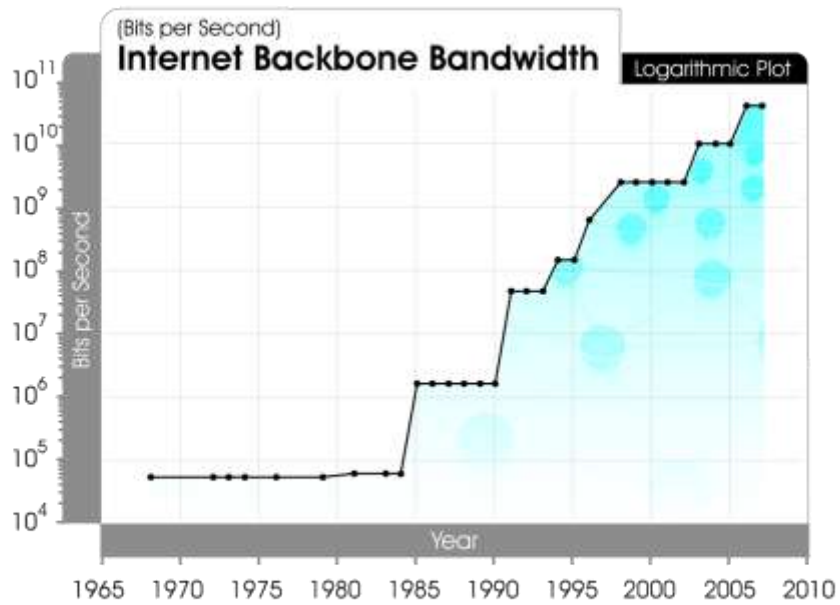
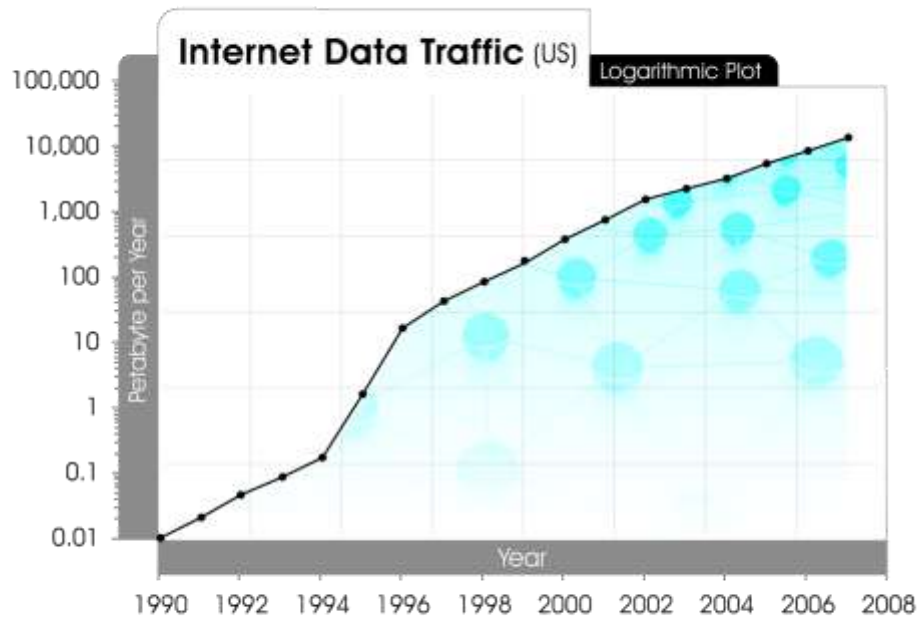


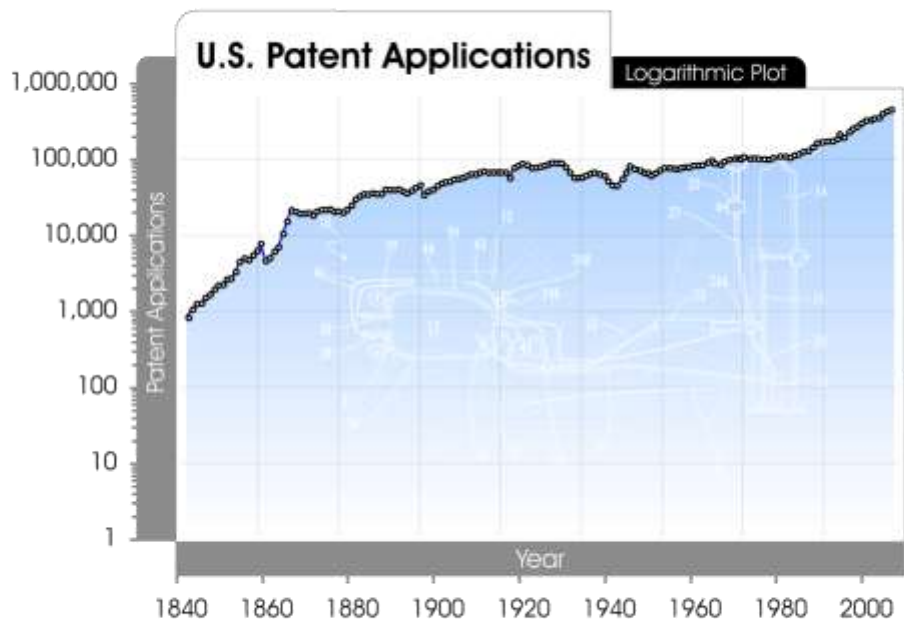


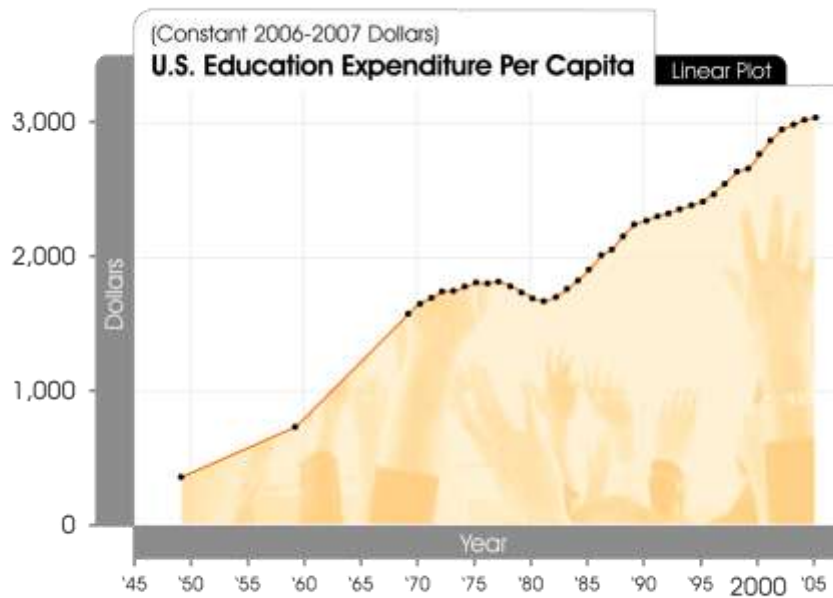
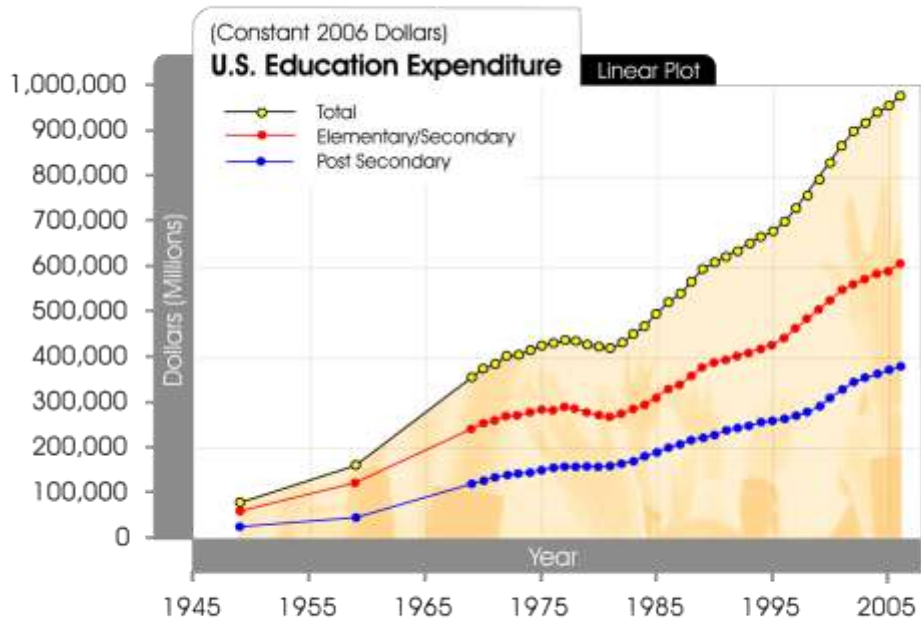


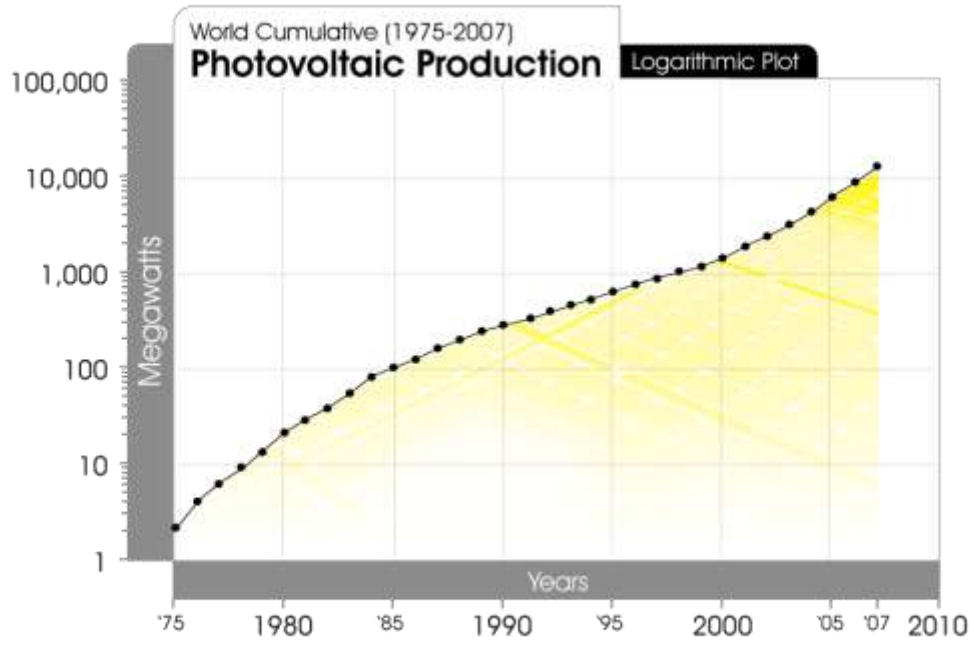












## LIBRARY JOURNAL PREDICTIONS

### Predictions on the emergence of the e-book and e-readers in the *Library Journal* written in 1992-1993

In 1992 and 1993, I wrote a series of 19 articles for the *Library Journal* (the leading journal for library professionals), five of which dealt with my predictions for virtual books and libraries. This is interesting to read now in light of the very rapid current growth in popularity of e-readers and e-books.



One leading product in this category is our own Blio e-reader, which is a free multi-platform software e-reader that comes with a million free books ([www.Blio.com](http://www.Blio.com)). Blio is a joint venture between my company K-NFB Reading Technology, Inc. and Baker & Taylor, the world's leading book distributor.

#### Here are the hyperlinks to these articles:

[The Future of Libraries, Part 1: The Technology of the Book](#) | Originally published January 1992

[The Future of Libraries, Part 2: The End of Books](#) | Originally published February 1992

[The Future of Libraries, Part 3: The Virtual Library](#) | Originally published March 1992

[The Virtual Book Revisited](#) | Originally published February 1993

[The Virtual Library](#) | Originally published March 1993

[The Virtual Village](#) | Originally published June 1993

You can see all 19 articles I wrote for the *Library Journal* between 1991 and 1993 on <http://www.kurzweilai.net/>