TECHNOLOGY TRENDS TO WATCH 2015

A Special Supplement to

i3

IT IS INNOVATION

CEA Consumer Electronics Association

PRODUCER OF International CES

TECHNOLOGY TRENDS TO WATCH 2015

i3

IT IS INNOVATION

Consumer Electronics Association (CEA)®

CEA PRESIDENT AND CEO
Gary Shapiro

SENIOR VICE PRESIDENT
Jeff Joseph

SENIOR DIRECTOR, PUBLICATIONS
Cindy Loffler Stevens

MANAGER, PUBLICATIONS
Mark Chisholm

COORDINATOR, PUBLICATIONS
Justin Siraj

GRAPHIC DESIGNER, CREATIVE SERVICES
Collin King

PRODUCTION COORDINATOR
Mark Zacepilo

CEA MARKET RESEARCH AND LIBRARY

CONTRIBUTING WRITERS:
Mike Bergman
Mark Chisholm
Jack Cutts
Shawn DuBravac
Brian Markwalter
Sean Murphy

TECHNOLOGY TRENDS TO WATCH

The Leading Edge of Innovation

By Gary Shapiro

Ideas are the juice that powers our economy with innovation happening fast on multiple technology fronts. Rapid developments are in play in areas as diverse as 3D printing, Ultra HD, sensors, health care, automotive electronics, agriculture, transportation, biotech and genetic mapping.

The $211 billion consumer electronics (CE) industry is at the vanguard of innovation. Just last year, the U.S. Patent Office issued a record 277,835 patents. We are at the beginning of a surge of technology advances that we will all benefit from.

Welcome to the latest edition of *Five Technology Trends to Watch*. This annual Consumer Electronics Association (CEA)® publication looks at technologies that will shape both our professional and personal lives. CEA represents more than 2,000 companies that are investing in innovation every day. While difficult to select just five sectors to focus on, CEA analysts use the latest consumer research and market forecasts to choose areas with significant industry potential.

We look at the opportunities with Big Data, efficiencies with robots and drones, lives improved by digital health, astounding new entertainment experiences, and disruptive opportunities and business models in the new innovation economy. We also take a quick look at a few technologies that we previously reviewed, but still remain essential in the CE industry: 3D printing, the Internet of Things and privacy.

Surely the best place to see new technologies in action is the 2015 International CES® to be held in Las Vegas on January 6-9. CES is the heartbeat of innovation. With 3,500 exhibitors and more than 150,000 attendees coming from 140 countries, CES is the worldwide showcase for new products, the unrivaled event to learn about new tech advances and the best place to network with colleagues.

CES is also the opportunity for countless startups and entrepreneurs in Eureka Park and Eureka Park Next to get noticed by the media. Come see what game-changers will be shown in more than 20 Marketplaces as well as in the Innovations Awards Showcase. We are also proud to announce that we are hosting the inaugural CES Asia in Shanghai on May 25-27. For the latest show updates, visit CESweb.org.

I am passionate that innovation will empower opportunity, bolster the global economy and improve the quality of life for people across the world. ■

GARY SHAPIRO
President and CEO
Consumer Electronics Asssociation (CEA)

Looking Forward

By Sean Murphy

As a technology association on the front lines of innovation, we at CEA like to think we have a handle on what's to come when considering the future of technology. It may seem naïve given the speed of our industry, but some technologies are hard to miss and even harder to ignore. *Five Technology Trends to Watch* strives to put the focus on the technologies – in our pockets, in our cars, in our homes or otherwise – that will shape tomorrow. Whether emerging or present, these are technologies to watch.

3D Printers

One of the most talked about new technologies is 3D printers, and CEA expects consumers to embrace these products. There will be double-digit percentage growth in unit shipments through 2018, and 3D printers will bring in $76 million in total revenue in 2014, up 44 percent over 2013. By 2018, CEA expects 3D printers to generate $175 million in total revenue.

Impacting everything from car parts, classrooms, food (!), to internal organs (!!), we're hearing of experiments constructing entire cars and living rooms. Suffice it to say, 3D printers are an emerging – and exciting – addition to the CE landscape. As always, seeing is believing and it's safe to assume that once people see these products in action, the only questions will involve what 3D printers can't do and of course, cost. The 3D Printing Marketplace at the 2015 International CES will be double the size of what we saw in 2014, growing to more than 14,000 net square feet of exhibit space.

The challenge over the next few years will be informing consumers of the myriad possibilities, while managing both expectations and price points. For example, 3D printers will first be used in business environments, as tools for use, with cost less of an obstacle. Eventually, as awareness grows so will enthusiasm in the public sphere. As is typically the case with consumer electronics, innovation ensures that tantalizing new products become more efficient and cost-effective as time goes by.

Internet of Things

The "Internet of Things" (IoT) is arguably the hottest topic in technology right now, even if universal consensus has not been reached in terms of defining exactly what "it" is. Key words such as embedded technology, connectivity, convergence and notions like efficiency and activity lend insight into this mostly invisible – but very powerful – technology. Simply put, the Internet of Things enables household or more "traditional" products to connect with portable, networked devices, like PCs and smartphones. The Internet of Things is making it possible to connect anything and everything to the Internet.

Name a product or device and chances are it's already part of the IoT, or soon to be connected. At the 2014 International CES we saw toothbrushes, cookware and clothing using sensors to be "smart", safe and efficient. If this sounds like space age innovation, it is, but the impetus behind this technology is efficiency and productivity. With this technology, old-fashioned and/or analog devices increasingly can connect, via sensors, over a network and share data (think: household appliances, cars and toys).

The numbers are mind-boggling. Every day, new reports are being released discussing whether the IoT market will be measured in billions or even trillions by the end of this decade. IoT sensors are becoming commonplace, and before long will be expected components of virtually any device or product. Of course, as the IoT makes ceaseless connectivity a steadily ubiquitous proposition, we will need to deal with the idea of spectrum, and how it is controlled and paid for.

Gary Shapiro, CEA's president and CEO, has put matters in perspective: "We're seeing an explosion of connected devices that rely almost exclusively on unlicensed spectrum. The Internet of Things is proof of the skyrocketing value of unlicensed spectrum. As we continue to use smarter, connected devices, we need enough unlicensed spectrum for them to communicate with their surroundings and one other. Innovators can then harness the power of the network to give devices more utility than they could ever have in isolation."

Tech/Privacy

We took a detailed look at this issue in 2011, and the intersection of technology and privacy – as predicted – has become more intricate and pervasive. Put bluntly, for every opportunity the Internet affords us personally and professionally, there are trade-offs in terms of the information we share, willingly or not.

Few consumers would deny that an optimized online shopping experience, or being able to digitally manage banking or health records, or customizing content streams, are anything but welcome and worthwhile developments. Of course, the issue of control is nothing if not complicated. To enhance how we interact and exist online, we sacrifice aspects of our privacy and individuality. Most of us accept that the places we shop, socialize and work require our personal information. Understanding the trade-offs is what we give up and how the data is used so online companies can serve us remains a challenge. And then there are pros and cons, particularly the unanticipated ones, of effectively living our lives online. Facebook has been the best-known real time case study of the good, the bad and the ugly repercussions of where personal space meets modern world reality.

In an interesting turn of events, the continuing controversy involving Edward Snowden illustrates that literally anyone can be affected by the ways valuable – even top secret – information is accessed and divulged. Where previous focus has been directed at how corporations can, or should, handle consumers' data, Snowden proves that even matters of national security can become compromised. In this regard, technology and privacy transcends consumer electronics and even politics. It's unlikely that we'll arrive at any definitive agreement on how we can, or should, negotiate this terrain. We live in a world that even George Orwell could not have foreseen, and he would likely appreciate the ways innovation has helped democratize (for better or worse) how information is received and disseminated. ■

TECHNOLOGY TRENDS TO WATCH

Ghost in the Machine: The Predictive Power of Big Data Analytics

By Jack Cutts

Let's get one thing straight: There is no single correct definition of the term "Big Data." As a concept, Big Data has been thrown around by practitioners, pundits and poseurs for years and is now a term exhausted by overuse. But that does not make it any less important for understanding how the world around you really works, and how services and goods you use every day have been shaped and delivered using Big Data technologies.

Did you know that the food you eat was grown with the aid of Big Data? Or that the car you drive can navigate thanks to the decision-making power afforded by Big Data? Your actions can be analyzed and anticipated because Big Data knows so much about you that even you might not know. To some, this is a scary revelation. To others, it is a gee-whiz-what-will-they-think-of-next kind of phenomenon. Most people, however, fall somewhere in the middle.

They realize that they have, and will continue, to benefit from Big Data. They are complicit to some degree in its collection and analysis, and yet conflicted about whether they think it is a good thing or a bad thing. If you understand one thing about Big Data, understand that the mere collection of huge volumes of information is not Big Data any more than collecting postcards from exotic locales makes you well-traveled. The "magic" of Big Data is in the use of analytics to gain new insight.

Big Data is used for analytical purposes, pattern recognition, machine learning and predictive analytics both for your benefit and, possibly, to your detriment.

The Big Data Analytics Continuum

Unless you slept through high school, you likely understand that correlation does not equal causation. I drink water every day and also happen to sleep every day. Of course, although there is a strong correlation between those two activities (r = 1.0, in my case), drinking water does not cause sleep and vice versa. Therefore, there is no causal link between the two.

Much of what makes Big Data so powerful is that it is built upon the analysis of data sets that, on their face, may be peripherally related to one another or completely unrelated. A second attribute that makes Big Data a true game changer is that the analytical methods used often can be performed without even understanding what type of data is being analyzed. Before diving into specific examples of Big Data analytics in use, however, it is helpful to understand the common type of analytics and how they are used.

Descriptive Analytics

If we describe the evolution of data analytics within an organization, descriptive analytics would come first on the continuum as the most simple. Think of descriptive data analytics as the adjectives and adverbs of data. Which one? What kind? How many? These are the types of questions answered by descriptive analytics.

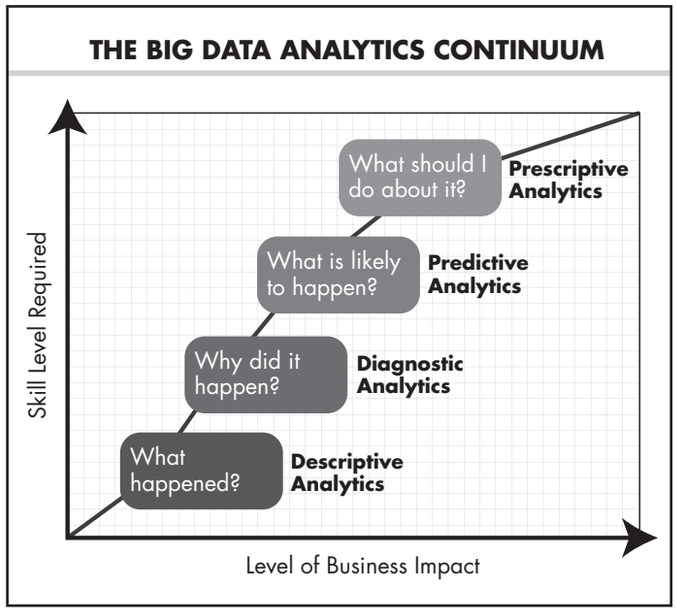


Figure 1: The Big Data analytics continuum
Image source: *"Agenda Overview for Analytics, Business Intelligence and Performance Management,"* Gartner, 2013

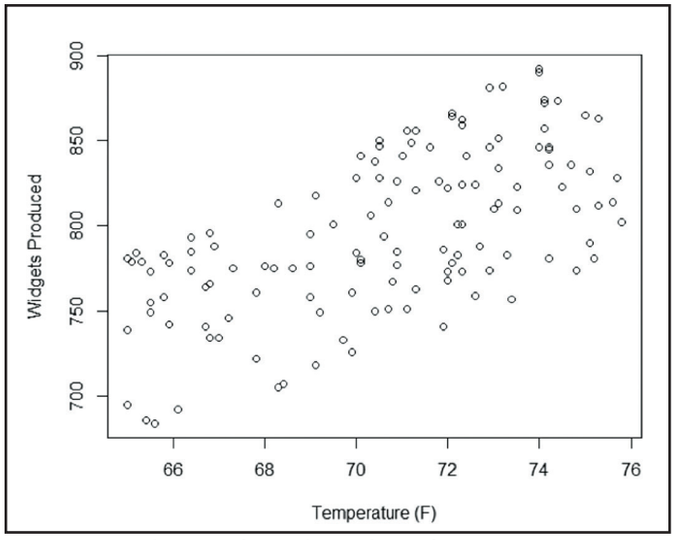


Figure 2: Scatter plot output from R data analysis software

In a manufacturing environment, for example, certain data fields like [number of widgets] might be combined with other data fields like [production time] to calculate new fields like [widgets per hour]. With its fancy new [widgets per hour] metric, an organization can embark upon creating and analyzing a whole raft of new efficiency metrics like [widgets per employee], [widgets per shift], and so forth. In the full scope of Big Data analytics, however, these calculations are table stakes.

Predictive Analytics

Implementing predictive analytics – even at a rudimentary level – is where Big Data really begins in earnest. Borrowing from the earlier widgets-based example, what if the factory manager could begin to predict the number of widgets produced per hour? Even the most efficient factory cannot produce a consistent number of widgets per hour. There are a variety of known factors that play into how well a factory performs on a given day, during a given shift, or in a given hour such as which employees (or how many) are staffed during a given shift or how labor-intensive the production process is.

Where Big Data analytics is helpful is in understanding other variables that are not directly related to widget production, but that through analysis are revealed to have a tighter-than-normal correlation (positive or negative) with production levels. For example, if the factory floor manager were to consider factors that might make employees work more efficiently, the floor manager might turn his or her attention to the physical work environment. If the floor manager were to take temperature readings from the factory floor every hour for an entire year, those readings could then be entered into a spreadsheet alongside the number of widgets produced per hour for the full year. From there, a simple Pearson correlation test could determine whether there was any correlation between temperature and widget production. Performing a correlation test in R, a favorite statistical analysis tool of Big Data practitioners, indicates high confidence ($7.994x10^{-15}$) in a fairly strong correlation (.618) between observed temperature on the factory floor and hourly production levels. Figure 2 shows a scatter plot of the same data where a general overall correlation between the two variables is evident.

Having established some correlation between temperature and production, the floor manager might look to other, less obvious variables to add to the dataset. Suppose this particular factory floor was located in Pittsburgh, Pennsylvania and happened to employ a number of Pittsburgh Steelers fans. Through some cursory analysis, the floor manager noticed that production rates were often lowest on Monday morning and improved throughout the week. Occasionally, dips were noted on Tuesday morning and, even more rarely, Friday morning.

Using information about the dates and times of Pittsburgh Steelers games (which typically occur on Sundays but occasionally are played on Monday or Thursday nights), the floor manager might find that the lowest production rates occur most often on the morning following a Steelers night game. The floor manager would likely come to the conclusion that low production is correlated (and likely caused) by employees staying up late to catch a Steelers game and, perhaps, over-imbibing. Now armed with evidence of a likely causal relationship between production and employees' off-the-clock activities, the floor manager may opt to employ prescriptive analytics to improve production.

Prescriptive Analytics

The most advanced level of Big Data analytics involves not only predicting the probability of future outcomes, but also automatically taking action based upon predicted outcomes. Prescriptive analytics also requires a continuous feedback loop in order to iteratively refine its predictive prowess. The predictive model can train itself by taking in certain variables and parameters, making a guess as to the predicted outcome, and then comparing the prediction to the actual outcome (known, of course, only after the event in question has occurred). After examining test cases where the actual outcome of a particular event diverged from the initially predicted outcome, the model can refine itself and improve accuracy.

In the factory example, the floor manager may opt to develop an application that uses historical production and staffing information to predict and generate an optimal staffing schedule for the coming week. Because the predictive model was fed valuable information about the Pittsburgh Steelers schedule, the

model has learned to assume that certain employees are more apt to call in sick on the day after a Steelers game while others may show up but work more slowly than on other days of the week. The model correctly predicts that the factory will run more smoothly and efficiently if certain employees are proactively given Monday off or are scheduled to start a shift beginning at 3 p.m. rather than 8 a.m. Over time, those predictions are tested by comparing expected optimal production levels to actual results and the model becomes more predictive over time. The hopeful end result is a more efficient production environment, better staff utilization and a happy floor manager.

Big Data in Real Life

Whether you realize it or not, you are surrounded by Big Data nearly everywhere you go. Big Data analysis is used in many ways to improve our lives and – as is more often the case – to learn how to better sell products and services to us. In other, rarer cases, Big Data can be used to monitor or predict our behavior or establish linkages between us and friends, family or associates.

Whether you realize it or not, you are surrounded by Big Data nearly everywhere you go.

Fraud Detection

One of the most common and helpful uses of prescriptive Big Data analytics is in the field of fraud detection in the credit card industry. If you have used a credit card for any length of time, you have likely been on the receiving end of an automated telephone call alerting you of a suspicious pattern of charges to your account. The phone call will ask you to verify or decline the charges and will often link you directly to a live human to complete the fraud mitigation process.

What you may not realize is that the phone call was the first prescriptive action taken in a Big Data program that analyzes not only your established charge pattern, but also red flags that have been identified by analyzing the charge patterns of millions of other consumers. The learning algorithm of the credit company's fraud detection machine is constantly refining how it understands what patterns are mostly likely to be markers of fraud.

For example, a hypothetical customer with a home ZIP code of 22202 will be allowed to make point of sale purchases in a fairly large geographic region around his or her home ZIP code. If the customer frequently travels to Cleveland, Ohio, the machine learning algorithm will pick up on this pattern and allow such charges to pass through.

Conversely, there are certain charge patterns known to be red flags that will almost certainly result in a call from the credit card company. A common use of stolen credit cards is at big box retailers. The thief will often purchase big ticket items that are easy to re-sell on the private market. Because of this relatively common practice, if a card is used in Washington, D.C. (the customer's home ZIP code) and then used 30 minutes later at a big box retailer in Chicago, Illinois, a fraud alert will usually be generated since it is impossible for a card to be in Washington, D.C. one minute then in Chicago 30 minutes later.

Predictive Maintenance

The failure of parts and components in large, complicated industrial machinery is an ever-present problem in the manufacturing world. What if a factory manager could be forewarned against failures of certain parts before they happened, minimizing down time? The U.S. Department of Energy cites surveys estimating the cost savings of a functioning predictive maintenance program to be 8-12 percent of total maintenance spending. In a world where margins are being squeezed from all sides, this can mean significant savings, especially when manufacturing on a large scale.

Imagine a machine that contains a hose of some sort, perhaps used to supply lubricant to a moving part in an industrial machine. Hoses commonly wear out, but it can be hard to predict when a hose failure will occur. Using a machine learning algorithm, one can monitor the operating condition of the hose in real-time to help establish normal operating parameters. For example, the plant manager could attach a vibrometer and thermometer to the hose and sample output from those sensors once per minute for several years and through several hose failures.

Over time, the plant will build up a comprehensive dataset that will help predict hose failures. For the sake of simplicity, assume that hose failures are caused by a combination of heat and vibration. The large dataset will show which combinations of heat and vibration tend to coincide with or precede hose failures. Through data analysis the plant manager may find that when heat is more than three standard deviations above the mean hose temperature and when vibration is more than one standard deviation above the mean, hose failure is expected within one week in 95 percent of cases.

The next time the machinery exhibits those two conditions simultaneously, the machine learning algorithm may trigger an alert to the plant manager and also automatically place orders with suppliers for new hoses in anticipation of imminent failure.

This way, the plant saves money either by mitigating the failure conditions (reducing temperature/vibration) or avoiding machine downtime by replacing the hose proactively.

Disease Prevention

For years, the medical industry has struggled to move patient records and information into electronic medical records (EMRs) and away from antiquated paper records. While the primary benefit of such a transition is for doctors and patients to have convenient, instant access to medical information, there are other potential Big Data benefits as well.

If you have ever had your blood drawn and had a blood panel performed, the results provided to your doctor are comprehensive and may include counts of more than two dozen different blood parameters such as hemoglobin levels, red blood cell distribution and white blood cell count. The blood panel results for you, and millions of other patients like you, are stored in a machine-readable format inside of your electronic medical record.

What if the power of Big Data could be deployed and anonymously analyze the data inside those millions (if not billions) of medical records to better predict disease? Without needing to know the identities of the patients whose data is being examined, a properly trained machine learning algorithm can comb datasets like blood panel results and patient diagnoses to determine if there is any linkage between certain blood measurements or characteristics and the incidence of blood-related diseases like leukemia or diabetes.

In fact, Google X (the arm of the company responsible for undertaking "moonshot" projects) has recently begun a new program called "Baseline Study" to tackle just such an analytical problem. In enumerating the challenges to such analysis, Google cites privacy issues as being a chief roadblock to undertaking EMR analysis. Interestingly, it is these privacy concerns and the differences in opinion among generations that will shape the future of Big Data.

Privacy

People of all ages are being tracked in a wide variety of ways. Your Web browsing habits are being aggregated in order to refine search results and feed machine learning algorithms information about the linkages between Web pages, topics and personal interests. Your television watching habits are being monitored by the set-top boxes in millions of American households. That viewing data is used to help set advertising rates, demographically profile viewers and measure overall engagement with content.

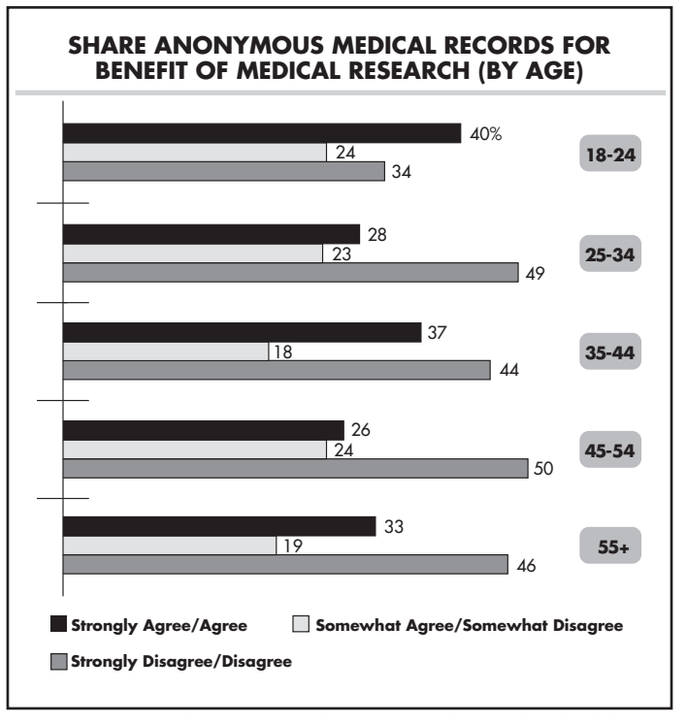


Figure 3: Generational attitudes towards anonymous sharing of medical data
Source: CEA Market Research

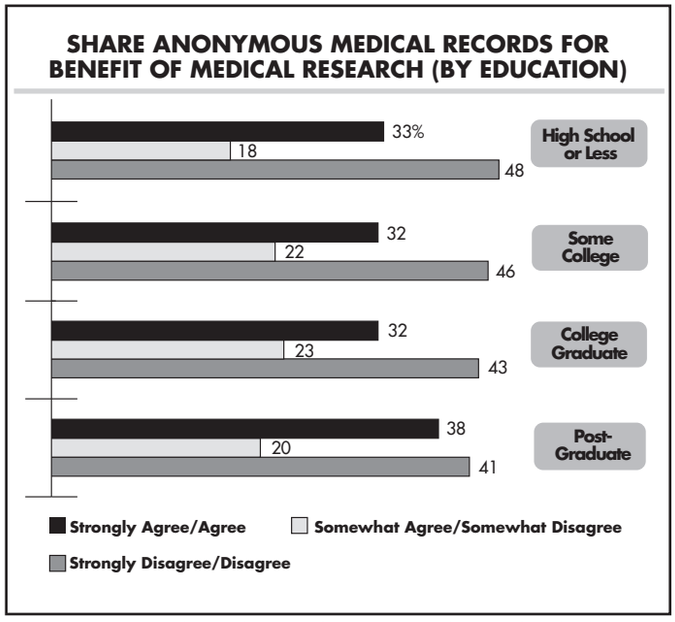


Figure 4: Generational attitudes towards anonymous sharing of medical data
Source: CEA Market Research

For the most part, the average American has tacitly agreed to allow this sort of passive tracking. There is a general sense that everything done online is logged and scrutinized in some way.

However, medical data stands apart. Only just now exiting the back offices of medical facilities around the country, medical data is moving to the electronic world and, increasingly, into the cloud. CEA consumer research suggests that attitudes towards the anonymous sharing of medical information may

be a generational shift. In a July 2014 survey of more than 1,000 consumers, 40 percent of respondents between 18-24 years of age were willing to share anonymously, versus just 31 percent for those over age 25.
On the flip side, older generations are very strong in their distaste for sharing medical data anonymously. Among the youngest cohort, 34 percent did not like the idea of sharing, versus more than 47 percent of respondents in the older age groups.

These findings are not surprising given the fact that millennials have grown up online and are relatively used to having their data "out there." There also seems to be a tendency for more educated respondents to be more amenable to anonymous usage of their medical data for the good of medical science. In the CEA survey, those that have completed at least some post-graduate work more likely agree (38 percent) with sharing data anonymously and the least likely to disagree (41 percent) with the practice.

Based upon recent history, it is a virtual certainty that a major breach of medical data will occur in the not-too-distant future. The outcome of such a breach, and society's reaction to the fallout, will go a long way towards determining how enthusiastically we embrace the digitization of one of the most private forms of personal data. Health data is the ultimate test case for the value of privacy when weighed against societal benefit.

Health data is the ultimate test case for the value of privacy when weighed against societal benefit.

The Future of Big Data

In many ways, the future of Big Data is now. So much of what we use now in Big Data – machine learning, pattern recognition and predictive maintenance – will continue to be used in the future. The two innovations that will continue to feed the Big Data machine are more data sources and more computing power.

As new data sources are added to the Big Data arsenal, additional valuable context is enhanced in existing models. As additional computing power is thrown at computing associations between all of this Big Data, insights will be generated faster and some in real time.

A big part of what makes us human is our ability to reason, discern and react. A human might approach a problem as follows:

- Identify problem
- Survey surroundings
- Seek additional information about the problem
- Develop hypothesis of causation
- Test and refine hypothesis
- Solve problem

Conversely, an algorithm or computer program can only approach a problem with the inputs with which it is supplied and interpret those inputs in the manner prescribed in its operating code. In other words, it can only do what it is told to do. The single biggest trend on the horizon for Big Data is an explosion in the number and variety of data sources available – thanks mostly to the Internet of Things (IoT) movement. In a world where a wide variety of sensors are connected to the Internet and report data about all sorts of things (altitude, temperature, location, sound, video, etc.), the IoT promises to add more detailed context to decisions made by Big Data technologies.

Imagine a scenario in which an electronic front door lock could also request data on your location and unlock your door just as you arrive home. Now imagine this scenario with the added context of weight sensors in your vehicle informing your front door lock that you have a heavy load of items in your vehicle's trunk. Using this additional contextual information, perhaps the front door not only unlocks, but opens in anticipation of the homeowner arriving with arms full of shopping bags. The more one considers this scenario, the more contextual inputs come to mind as being valuable in making an informed decision and taking some helpful action. That is the power of Big Data.

Another frontier for Big Data is scalable cloud computing. When most people think of "the cloud," they think of file storage. The cloud is so much more than that. The real promise of the cloud is in allowing demanding computer programs and Web applications to leverage Internet-connected sources of computing power in real time. Scalable computing is already a common practice in the Web world where companies running highly trafficked websites can light up new servers in the cloud almost instantly when traffic spikes and decommission them just as quickly.

In the world of Big Data, scalable computing means that more of the heavy number crunching required of say, a machine learning algorithm, can be transmitted to a server bank in the cloud and processed by 30 servers running virtual machines rather than struggling along on a single multi-core desktop or server processor.

Such a concept is already in play for relatively small-scale computing tasks. In fact, Amazon, a giant in the world of scalable cloud computing, offers a cloud-enabled version of Google's famous MapReduce algorithm – called Elastic MapReduce – that allows Big Data practitioners to send their heaviest computing tasks into the cloud. From there, Electronic

MapReduce's proprietary code divides up the computational task into units of work and distributes them among a handful of servers. Those servers then perform their tasks and return the results back to the coordinating server for delivery back to the original application. With pricing as low as $.01 per hour per server instance, it is possible for Big Data results to be delivered in seconds versus hours or days on a stand-alone system.

In Amazon's case, it uses heavy computational power to deliver product recommendations to you constantly. Think about the power of being able to recommend sunscreen to a person who is about to purchase a round of golf in July at a local golf course using Amazon local deals. To the computer comparing the two products, there is no obvious connection between a round of golf and sunscreen, but using its existing database of user reviews and shopping cart analysis, Amazon's machine learning algorithm can use Electronic MapReduce services to determine that a relatively high percentage of customers who purchase golfing equipment also purchase sunscreen, thereby establishing some linkage between products. By being able to generate and display this recommendation to the user before the transaction is complete means Amazon has a chance at convincing the customer to add sunscreen to their cart before checkout.

In the coming years, computing and Internet bandwidth will progress to the point where services like Electronic MapReduce can take in and process video clips, sound clips and images and perform real-time analytics on them. These types of data, known in Big Data circles as "unstructured data," are extremely difficult to process programmatically because it is difficult to describe the relationship between data observations.

In one famous example, Google is working to train an algorithm to recognize images (frames of video) containing human faces without doing so much as describing the characteristics of a human face or even telling the algorithm whether or not a given frame contains a face at all. Early results are promising as the algorithm has achieved a remarkable 17 percent success rate in identifying human faces while also distinguishing from cats' faces it has found and silhouettes of the human body. While the output of the Google face study is seemingly trivial, the ability to train a computer to learn about similarities between pieces of unstructured data holds enormous promise for the future of Big Data.

The ability to train a computer to learn about similarities between pieces of unstructured data holds enormous promise for the future of Big Data.

Big Data Marches On

"Big Data" is a bit of an oversimplification. Big Data is a big deal not only because of its size, but its scope. The quantity of data observations is becoming secondary to the breadth of inputs available and the ability to process it in an efficient manner to deliver results that can be acted upon and learned from. It is not difficult to envision the many opportunities for data mining to be abused, especially when applied to all of the audio and video traveling across the Internet at any given time.

For better or worse, that genie will never go back in the bottle and technology will march inexorably forward as it always does. When Big Data technologies become refined enough to achieve even higher levels of accuracy and predictive power, the only bottlenecks to a massive explosion in Big Data insights are bandwidth, computing power and our imagination. ■

TECHNOLOGY TRENDS TO WATCH

The Rise of the Machines

By Mike Bergman

Since the invention of the first machine, humans have been the managers and overseers of our creations. We are directly involved in the work being done or we set our devices to a task and walk away. But now, the traditional roles are being supplemented by a new relationship. Technologies we have been developing for years are not just bearing fruit – they are working with each other to accomplish tasks without our direct supervision.

Wireless computing, robotics and artificial intelligence (AI) have been in development for years. Taken alone, there have been numerous incremental improvements. But a disruptive trend is emerging that is larger than just individual developments. It is the combination of these technologies that is creating a new paradigm. This paradigm is Big Data plus wireless plus AI plus drones and robots – it is an autonomous Internet of Things (IoT) with hands.

The rise of these technologies is powered by a combination of three core developments coming together. These synergies are not new, but they are increasingly bearing the kind of fruit that has long been predicted by futurists and sci-fi writers.

Smarter Computers

The first foundational technology is improved AI. The term, artificial intelligence, may call to mind images of sentient robots and androids from a long history of television and movie depictions. AI occasionally becomes newsworthy as researchers make new breakthroughs, but we still do not have *Star Trek's* Data or *Star Wars'* C3PO. Instead, recent advances in AI include powerful algorithms to emulate basic human skills like vision or the ability to learn from data or experience.

This evolution in machine intelligence is not so much a breakthrough event as it is like a rising tide. AI and related developments are raising the capabilities of many systems. And like a tide, the changes are coming gradually and incrementally as contributions from many small breakthroughs rather than a few big ones.

These core capabilities, by themselves, are bearing fruit. Perhaps the best example is IBM's Watson, the AI famous for winning the *Jeopardy*! game show in 2011. According to *Forbes*, in 2013 IBM began offering Watson's expert advice in determining treatment for patients. Even without the life-and-death issues involved in caring for humans, this is a high-stakes game. On one side is the skyrocketing cost of medical care in the U.S. On the other side is a pizza-box-sized IBM server running the Watson AI, helping doctors and hospitals pick the right tests and care, thus bringing down costs and raising healthcare quality.

In January 2014, IBM launched the Watson Business Group division. Watson is now a commercial tool for other applications as diverse as legal analysis and online retail recommendation. IBM is investing $1 billion in the group, including $100 million earmarked to invest in startup companies building applications that run on the Watson Developer cloud.

AI has actually been migrating into products and services for some time. Last year, *Business Insider* valued the global AI-based solution market at $900 million. The introduction of Deep Learning, a layered approach that makes more effective use of large data sets, has brought significant advances in the effectiveness of AI.

AI technologies are especially fueling growth in areas that pertain to better human-computer interactions: computer vision and facial recognition, natural language processing, and speech and voice recognition.

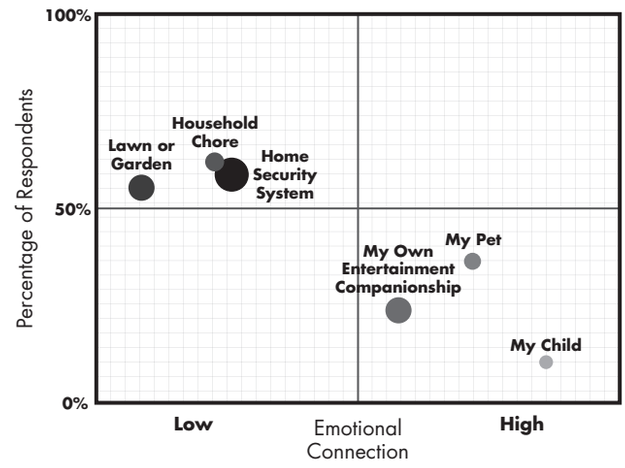
Robotics

The second technology in the Rise of the Machines is autonomous devices. According to *Business Insider*, there will be a $1.5 billion market for consumer and business robots by 2019. Autonomous drones are finding applications in surveying and monitoring around the world, and the industry has been applying autonomous technology to factory and warehouse automation for years. In the past decade, autonomous vacuum

cleaners have brought robotics into the consumer space. Robotics is becoming real to consumers, so it is worth considering how robots are perceived. Consumers have seen fictional robots portrayed in film and television as sometimes helpful, sometimes terrifying. Unsurprisingly, consumer attitudes about getting up close and personal with real robots are mixed.

CEA consumer surveys conducted in 2013 and 2014 show that an increasing majority of consumers are interested in robotic assistance, as long as it is for relatively impersonal services. As the service becomes more personal or critical, consumers are less accepting, and not many are ready for most demanding task, child care.

ROBOTS' VARIOUS TASKS VS THE EMOTIONAL CONNECTION TO THE OBJECT OF THE TASK



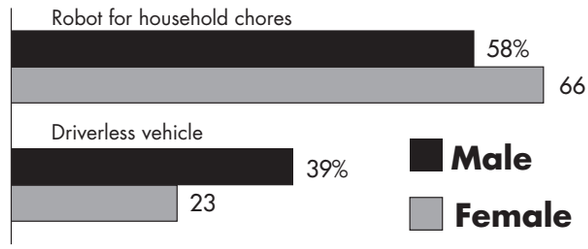
Source: CEA Market Research

The chart above shows consumer interest in having a robot take care of various tasks, versus. the emotional connection to the object of the task. Bubble size indicates relative growth in interest, from 2013 to 2014.

Interest in automated pet care was measured at 28 percent in 2013 and rose slightly to 30 percent in 2014. For personal entertainment or companionship, the results were similar, at 21 percent and 24 percent for the two years. Robotic child care, however, stimulates little interest. Desire for this kind of service was slightly under eight percent in 2013 and only slightly higher in 2014.

On the other hand, more than half of consumers report interest in having a robot help with the relatively impersonal tasks of household chores, gardening and home security. Automated home security interest rose to 59 percent in 2014. Interest in lawn and garden was high at 46 percent in 2013 and rose to 56

MEN AND WOMEN'S INTEREST IN ROBOTICS



Source: CEA Market Research

percent this year. This brought robotic gardening more in line with indoor household chores, which rose three percent to 62 percent in 2014.

Interestingly, men were significantly more willing to trust a driverless car, with 39 percent of men interested in letting a car drive itself at speeds over 55 mph, as compared to 23 percent of women. Men and women showed interest in robotic help with the home or yard, although women showed a greater interest at 66 percent versus 58 percent for men. But without exception, all categories showed growth in interest from 2013 to 2014. Men and women showed different levels of interest in robotic assistance, depending on the task at hand.

This increase in consumer acceptance comes from ongoing efforts by many companies. One standout contributor started back in 1990, when three researchers from the MIT Artificial Intelligence Lab founded iRobot. This company brought robotics into consumers' homes in a mass market way with the Roomba autonomous floor vacuum. The company has added floor scrubbing, pool cleaning and gutter cleaning robots as well. According to iRobot, sales in 2013 were more than 1.9 million home robots.

Amazon and Google certainly agree with the importance of robotics in the future. Google's 2013 acquisitions of Redwood Robotics (robotic arms), Meka Robotics (robots), Holomni (robotic wheels), Bot & Dolly (robotic camera systems) and Boston Dynamics (DARPA robotics challenge winner) are clear indications of this interest.

Amazon recently acquired Kiva Systems, a robotics and logistics company that develops and deploys intelligent automated warehouse systems. Amazon has also been in the news promoting the idea of drone package delivery. With a cloud-based ordering process, an automated warehouse and a drone delivering the package, the customer could ultimately be the only human directly involved in the purchase.

Increased acceptance of robotics in consumers' lives is coming from the efforts of companies like these, and from the increased

capability that makes an autonomous product or service successful. As autonomous devices become more intelligent they will be more useful and efficient, and find more applications in consumer lives.

The Cloud is Everywhere

Last in this trio of key developments is the growth of the "Pervasive Cloud", which combines the growth in ubiquitous connectivity with the rise of cloud computing. The Internet of Things (IoT) is a broad universe of applications that involve connecting devices to Internet resources without constant human intervention. Fundamental to the IoT is the massive cloud computing and data resources that are now available everywhere, thanks to the growth of ubiquitous connectivity. But the cloud can also stand alone as a significant data and compute resource for remote use and for corporate business practices.

Devices almost anywhere and in any environment can be connected to cloud resources. Such connections make available racks of servers for compute-intensive tasks. Remote devices with tiny memory resources get connected to search engines and enormous databases. Access to this level of power allows a device to offer orders of magnitude greater capability than its internal CPU and memory could allow.

This power from the cloud is widely available. Global mobile devices and connections will reach 10.2 billion by 2018, of which 19.7 percent will be machine-to-machine connections, according to the Cisco Visual Networking Index. Wireless access to the Internet is available in most places in the U.S. in one form or another.

Innovative companies are taking advantage of the ubiquitous cloud by adding Internet connectivity to stand-alone devices and linking them to remote resources. Berg recently announced a prototype washing machine that is integrated with a cloud API. The appliance provides a suite of new features such as the ability to order detergent from the front-panel and smartphone reminders for wet clothes waiting to go into the dryer. Simple Living Technology offers CloudCam, a security camera that can stream HD video directly to the cloud.

A number of players now offer cloud storage and hosting services. This group includes Amazon S3, Apple iCloud, Microsoft Skydrive, Rackspace, IBM Storage Solutions and Dropbox. The cloud has clearly become big business, whether it is supplementing remote devices in the IoT or as a deep pool of resources for business. IHS estimates that cloud-related business spending in 2014 will reach $174.2 billion globally, and triple by 2017. When the cloud is combined with nearly ubiquitous mobile broadband, the result is a powerful and pervasive element.

Thinking Machines

Increasingly, the pervasive cloud is being enhanced with artificial intelligence. The result is reaching consumers through virtual personal assistants (VPA). A VPA is a software tool that responds to natural language and can fetch information, read your texts and emails to you, and otherwise act on your behalf with the electronic world around you.

VPAs are possible because the pervasive cloud can host huge data sets and massive processing. These resources are required for a smartphone to pull off a trick like Apple's Siri telling you that the jet passing overhead is a Boeing 777. Siri needs to receive your request at the remote server location, pull your own location from your phone, compare that to a data stream of flights, pick the most likely one based on the flight's updated location, and then extract the airplane type and return the answer to you.

When the cloud is combined with nearly ubiquitous mobile broadband, the result is a powerful and pervasive element.

Apple Siri, Google Now and Microsoft Cortana development teams are pulling multiple tools from the artificial intelligence toolbox to enable and enhance these virtual assistants. According to Microsoft Research, Satori is the intelligence behind Cortana and Bing. The platform uses AI tools including advanced machine learning, speech recognition, inference systems and entity understanding. Cortana leverages the massive Satori database and AI tools to answer natural language questions.

Tools like Siri, Now and Cortana are relatively new. Siri came out in 2011, followed by Now (2012) and Cortana (2014). Because these systems build on years of breakthroughs and incremental improvements in AI, the results are sometimes startlingly effective. As more databases are added or created for these systems, they will gain new capabilities seemingly overnight.

Cloud Robotics

Merging AI and the pervasive cloud with smartphones makes a lot of sense, but the cloud also offers massive computing power to less "smart" gadgets. As Google's Ken Goldberg put it, "What if robots and automation systems were not limited by onboard computation, memory or programming?"

Certainly, robots need to be able to operate without the Internet, at least some of the time. But when the cloud is available, the

(Image source: Aldebaran)

Aldebaran Robotics' Nao

capabilities soar. Robotics can take advantage of massive off-line processing and data, of software and capabilities upgrades, of collective learning as many nodes collect data, and yet rely on remote human intervention and control as needed. Researchers are interested in which tasks should be done locally, such as balance and quick movement control, and which tasks can be done in the cloud, such as route determination and object recognition.

Robotics enhanced with cloud processing and data is "cloud robotics", a term coined by Google's James Kuffner in 2010. Cloud robotics is new enough that researchers have only scratched the surface. An EU research project called RoboEarth is combining cloud storage and computing with robotics. RoboEarth curates a database of information, including human-provided software and data, plus data collected by robots. The result is a variety of software and data elements that increase robotic abilities: maps, action recipes, manipulation strategies and object recognition models.

By connecting robots to the pervasive cloud, RoboEarth enables both sides to grow—robots gain abilities as they become available in the cloud, and the cloud grows with data collected from robots. By collaborating via the cloud, robots can even work together to accomplish a task. In a simulated hospital in Eindhoven, RoboEarth demoed four robots using the cloud as a knowledge base, communication medium, and computational resource to offload some of their heavy computation.

As an example of cloud robotics, Aldebaran Robotics' Nao can operate independently, but gains new capabilities via the cloud, including speech and facial recognition, and the ability to answer questions via access to databases like Wikipedia.

Back in the U.S., development has been underway for years to link cars and enhance safety. Vehicle-To-Infrastructure, or V2I, is the wireless connection of cars to a roadway infrastructure. Linking vehicles in this way gives on-board processors access to critical data on traffic, weather and road conditions. With V2I, a car can receive advance warning of traffic light status, black ice conditions and unexpected traffic pile-ups.

Elsewhere, researchers are enabling robots to build 3D maps of their surroundings by off-loading the processing to the cloud (A-Star Social Robotics Laboratory in Singapore); and enabling humanoid robots with cloud-based speech recognition and facial detection in tests of interaction with human patients (Aldebaran Robotics in Italy).

Robotics, AI and the pervasive cloud are three technologies that are growing into success stories, alone and in pairs. The greatest potential for disruption arises when companies start putting these technologies together. Combining these technologies opens up new realms of possibilities. These possibilities are becoming applications, and these applications are beginning to impact business in a number of industry segments.

AI Plus Robotics Plus Cloud Equals Your Future Car

Current robotic vacuum cleaners are primarily stand-alone robotics devices. Vacuum maker Dyson actually designed a robotic vacuum in 2001, but the product was not launched. Dyson never gave up on the research, and recently announced that they are investing in a joint robotics lab at Imperial College London. The goal is to increase robotic vision capabilities through application of artificial intelligence.

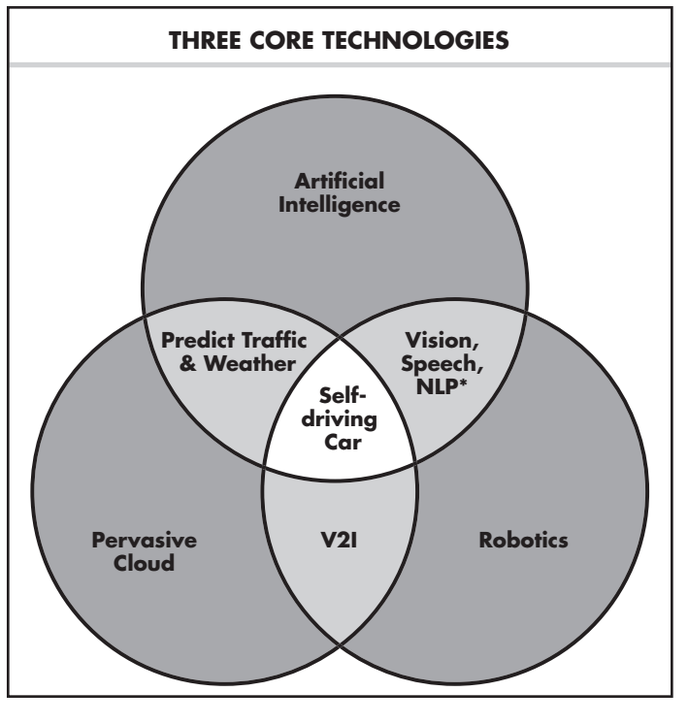
But these appliances depend on battery power for mobility, for suction and any computing they do. AI vision algorithms will reduce battery life. However, a vacuum cleaner doesn't need quick reactions, and can rely on the cloud for help. Imagine a vacuum cleaner faced with a forest of chair legs, pausing to send images to the cloud for processing and route determination.

Even a cost-sensitive robotic home appliance can have significantly more capability thanks to AI and the pervasive cloud. This power will make it possible for autonomous devices to do more with less human intervention, or ultimately with none at all.

One of the most visible milestones for autonomous devices is the self-driving car, a fully autonomous vehicle where the passengers need never take control. Nissan has a plan for vehicles with "Autonomous Drive" available by 2020; meaning a car that is able to do more things automatically, rather than a fully autonomous vehicle. Nissan is working towards the self-driving car, but in phases. In November, Morgan Stanley echoed this incremental approach in a research note on car company Tesla. The analysis listed phases of autonomous driving from the passive systems that we have now, to complete autonomous capability in 2022. Some experts put the self-driving car further out than that, but in the meantime we will be seeing steps towards fully robotic vehicles.

Putting true autonomy into car electronics will require a balanced approach. Automotive electronics are extremely cost-sensitive, which implies putting as many self-driving tasks as possible in the cloud. On the other hand, a vehicle simply cannot rely on the Internet for steering, braking or pedestrian detection. Artificial intelligence in the cloud will predict traffic patterns, weather and determine routing based on expected road conditions.

Vehicle-to-infrastructure connections will tie the cars to an intelligent roadway to keep on-board processors up to date on things like traffic light phases and lane blockages. Advanced UI tools like speech recognition and natural language processing will make it easier for humans to interact with the vehicle, and AI will make the autonomous car better at recognizing the world around it. All of these capabilities will be necessary to enable a truly autonomous vehicle, but they are coming.



* Natural Language Processing
Source: CEA Market Research

To Wrap it Up

The rise of the machines is not about individual robots, but about the systems around us gaining capabilities through artificial intelligence combined with robotics and linked with the power of the pervasive cloud. Like any disruptive trend, barriers must be overcome, such as intellectual property battles, consumer perceptions of robotics and cost issues. But the immediate picture is one of opportunities that will enhance existing business.

Robotics is already in use in the factory and warehouse, and may find its way into the distribution chain or other points of presence in the business cycle. Artificial intelligence will enhance these applications, and where a business is using the cloud, one might consider how artificial intelligence can help.

The rise of the machines is the trend of systems gaining tremendous capability to take on physical tasks, find information and make recommendations. This rise comes from the combination of technologies that have been developing separately, but are beginning to enhance each other with remarkable results. Expect to see more of these eye-opening capabilities, from intelligent personal assistants to clever appliances to robotic chauffeurs, as researchers and engineers discover new ways to leverage these individual achievements. ■

Digital Health and the Quantified Self

By Mark Chisholm

By this point, most of us have been thankful to have a smartphone, tablet or e-reader while sitting in a physician's waiting room. But every day, the ubiquity of technology is playing a bigger and bigger role in easing the pain of a visit to the doctor's office. While once our phones and our wrist watches only helped us to track the minutes or hours since our scheduled appointment time had come and gone, every day our devices are enabling us to track a growing amount of health-related information. Whether through a sensor embedded in a smartphone or in the smart watch on our wrist, our devices can collect vast amounts of information about our bodies and our health.

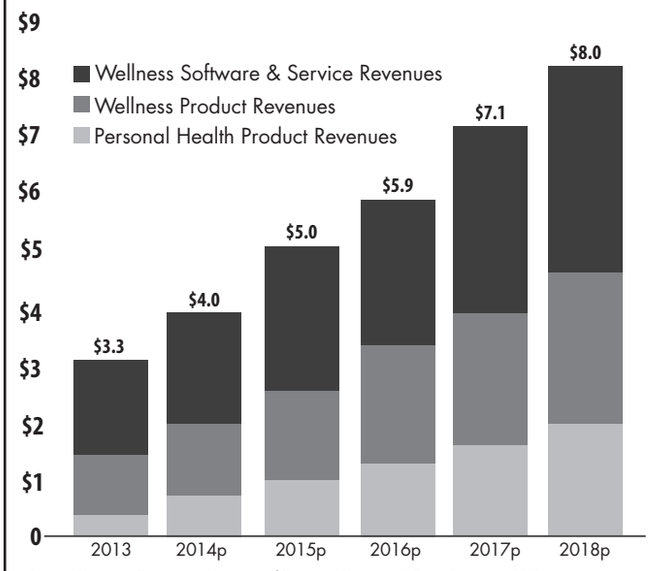
This ability to track and measure health and fitness information on our own has become known as the 'quantified self.' The concept of the quantified self revolves around the collection of data – specifically information related to a user's health and daily activities such as calories consumed and/or burned, heart rate, blood oxygen levels and other metrics that have become easier to collect and analyze thanks to advances in embedded and wearable sensors.

Gary Wolf of *Wired Magazine* – who coined the phrase 'quantified self' along with coworker Kevin Kelly in 2007 – spoke about the concept at the TED conference. "A few years ago Kevin Kelly, my partner, and I noticed that people were subjecting themselves to regimes of quantitative measurement and self-tracking that went far beyond the ordinary familiar habits such as stepping on a scale every day," Wolf said. On stage, Wolf presented the Fitbit Tracker as an example. The original Fitbit employed a single accelerometer sensor to track such metrics as steps taken, distance traveled, calories burned and the quality of a user's sleep.

"We know that new tools are changing our sense of self in the world," Wolf noted. "But we think of these tools as pointing outwards, and I'd just like you to invite you to think of them as turning inward and becoming mirrors."

Health and wellness technology has not only proliferated, but has become more capable, removing the need for antiquated

CONNECTED PERSONAL HEALTH & WELLNESS PRODUCTS: U.S. MARKET REVENUES (BILLIONS)
2013 - 2018



Source: Consumer Electronics Association | Research Copyright © Parks Associates 2013

healthcare processes. Soon, if not already, we'll feel nostalgic when we remember measuring our blood pressure at a machine in the grocery store. In time, we may find ourselves in a "world where the physician might very well prescribe an app instead of a pill," as Sue Schreiner imagined in a recent issue of CEA's *It Is Innovation* magazine.

The empowering aspect of connected health and wellness devices promises to transform the healthcare industry. "Regulators, insurers and care providers are shifting to a patient-centered approach that engages patients as active participants in their own care management," CEA notes in its recent white paper, *Connected Health and Wellness* Market. "Concurrently, design breakthroughs, technology advances and mass adoption of mobile consumer devices have made consumer-centric care possible in ways previously impossible." From wearable accelerometers to skin patches and smart

contact lenses, inward-focused technology applications – or as Wolf described them, "mirrors" – are becoming less intrusive and increasingly popular. Sales of personal health and wellness products are predicted to top $8 billion by 2018, according to CEA and Parks Associates. Hopefully, such technology will take some of the pain out of visiting the doctor's office, and if we're lucky, in some cases it may relieve us of the need to sit in the waiting room at all.

Digital Measurements

In its white paper, CEA outlines 15 markets within the health and wellness technology industry. These markets include devices and software ranging from blood pressure monitors, glucose meters and insulin pumps to heart rate monitors, digital pedometers, and health and wellness apps. CEA differentiates between 'personal health products' – including electrocardiograms (ECGs) and insulin pumps – and 'wellness products' such as digital pedometers and heart rate monitors.

Within the 'connected' personal health category, devices such as blood pressure monitors and glucometers currently dominate, just as digital pedometers and digital weight scales reign over the connected wellness category. When looking at CEA's forecast for the next five years, however, we see how digital health products will transform the healthcare industry.

In the connected personal health products market, the largest compound annual growth rates (CAGR) from 2013 to 2018 (by units sales) are predicted to be in the pulse oximeters to measure users' blood oxygen levels and pulse rate (90 percent) and ECGs for personal use (73 percent) categories. Meanwhile, in the connected wellness products market, sleep quality, diet and stress monitoring products will see the largest CAGR (75 percent).

This shift from simple pedometers and digital scales to connected devices that address health and wellness is what makes the digital health sector such an important area to watch going forward.

Perhaps the most important aspect of the expansion of digital health products lies in their connectivity. Whether through a wired or wireless connection, the connectivity of digital health devices transfers both convenience and concerns. After all, the collection of complex health data doesn't do much good if we need to go to medical school to analyze it ourselves.

CONNECTED PERSONAL HEALTH PRODUCTS: U.S. MARKET UNIT SALES (#M)							
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2013-2018 CAGR**
ECG for Personal Use	0.004	0.008	0.011	0.015	0.029	0.067	**73%**
Insulin Pump	0.071	0.076	0.086	0.097	0.117	0.134	**13%**
Personal Emergency Response System	0.092	0.135	0.249	0.374	0.451	0.567	**44%**
Pulse Oximeter	0.040	0.119	0.219	0.266	0.557	1.004	**90%**
Pill box/dispenser	0.091	0.151	0.220	0.294	0.531	1.077	**64%**
Glucometer	0.190	0.315	0.488	0.714	0.955	1.256	**46%**
Blood Pressure Monitor	0.411	0.631	0.862	1.178	1.512	1.942	**36%**
Total	**0.900**	**1.434**	**2.134**	**2.938**	**4.153**	**6.047**	**46%**

Source: Consumer Electronics Association | Research Copyright © Parks Associates 2013

CONNECTED WELLNESS PRODUCTS: U.S. MARKET UNIT SALES (#M)							
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2013-2018 CAGR**
Digital Pedometer/ Activity Tracker	4.0	5.6	7.9	11.2	14.5	16.6	**33%**
Heart Rate Monitor	0.5	0.6	0.9	1.3	1.8	2.1	**36%**
GPS Sport Watch	0.5	0.6	0.9	1.4	2.2	2.7	**41%**
Digital Weight Scale	2.7	4.0	5.8	7.0	8.1	9.2	**28%**
Sleep Quality/Diet Monitoring/ Stress Management Products	0.1	0.3	0.5	1.0	1.8	2.4	**75%**
Total	**7.8**	**11.1**	**16.0**	**21.9**	**28.4**	**33.0**	**34%**

Source: Consumer Electronics Association | Research Copyright © Parks Associates 2013

By enabling us to measure data at home and remotely share with medical professionals, either through direct transmission or through storing it in the cloud, connected digital products will – hopefully – save us the time and hassle of being physically present in the doctor's office for every medical issue.

As the portfolio of digital health products we choose to connect expands, these devices will communicate not just with us, but with each other and in many cases medical professionals. This will create a network similar to the Internet of Things that exists between our devices. This connectivity, however, also presents challenges and risks due to the personal nature of our medical records. This network will require more security due to its sensitive nature.

The Internet of Us

Understandably, when it comes to the adoption of connected health devices there appears to be a precarious balance between the convenience offered by medical technology and the privacy concerns presented by it. In other words, consumers may be more willing to adopt digital health technology if the convenience outweighs the perceived privacy risks.

Encouragingly, a recent CEA survey of more than 1,000 consumers conducted in July, 2014, shows that when it comes to the storage and transmission of personal health data, consumers may not be as apprehensive as one would expect. Not surprising was that consumers were most comfortable with devices that collect digital information and send medical alerts to only the user, with 44 percent responding that they were either very comfortable or comfortable.

When asked if they were comfortable with sharing digital health information – collected from devices like heart rate monitors and blood glucose meters – with a medical professional through a virtual doctor's appointment, the number of respondents who described themselves as comfortable or very comfortable fell to 37 percent. While there is still work to be done in building consumers' trust in the storage and transmission of sensitive medical data, this came in second as the scenario in which consumers felt most comfortable.

In an encouraging finding for medical professionals, consumers were least comfortable using the collected health data to self-diagnose an illness or injury, with only 31 percent responding that they would be very comfortable doing so. Though many of us have been working on our WebMD medical degrees for years, the importance of having a trained medical professional analyze such data has not been lost in the digital age.

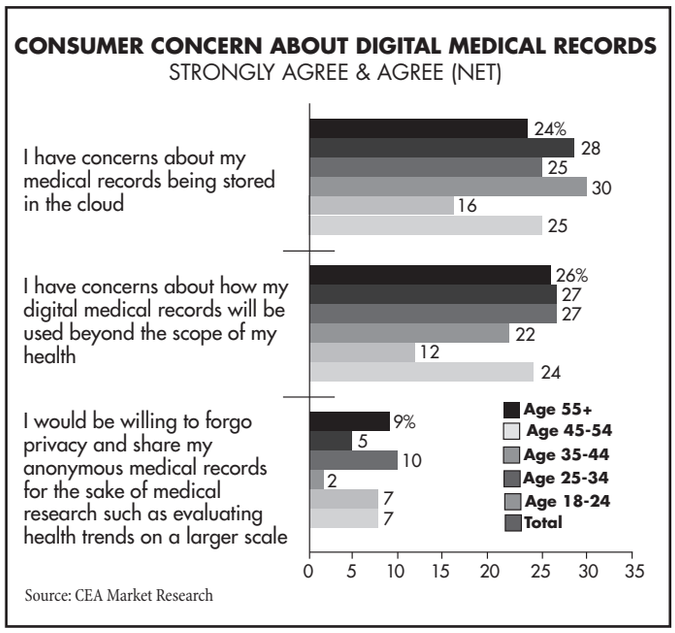
In his section on Big Data, "Ghost in the Machine: The Predictive Power of Big Data Analytics," Jack Cutts examined how the collection and storage of patient records has immense implications for the medical industry and privacy. Cutts examined how much of an effect age and education had on how comfortable survey respondents were with anonymously sharing their medical records for analysis. As Cutts explains, the survey suggested that younger age groups and those who have completed a higher level of education were more willing to share their medical data anonymously.

Those trends continue when asking respondents about their concerns with digital medical records and storing such information in the cloud. Older survey respondents were more likely to agree or strongly agree that they had concerns about how their digital medical records would be used beyond the scope of their health, and that they were concerned about their medical records being stored in the cloud.

LEVEL OF COMFORT SHARING SELF-COLLECTED DIGITAL INFORMATION AND FORGOING AN INITIAL IN-PERSON APPOINTMENT

	Total	Male	Female	Age 18-24	Age 25-34	Age 35-44	Age 45-54	Age 55+
Very Comfortable + Comfortable (Net)	34%	38%	30%	38%	34%	41%	33%	29%
Very Comfortable	11	12	10	9	9	14	8	12
Comfortable	23	26	20	29	25	27	26	16
Some Comfortable / Somewhat Not Comfortable	21	24	19	27	19	26	18	20
Not Comfortable (Net)	42	35	49	33	47	31	46	47
Not Very Comfortable	14	12	16	15	16	7	18	15
Not At All Comfortable	28	23	33	18	31	23	28	32
Don't Know	3	3	2	2	N/A	2	3	4

Source: CEA Market Research



The younger demographic's comparative lack of concern about medical privacy issues could be due to a number of factors including their familiarity with technology, lower expectations of privacy or the comparative lack of serious medical issues for that age group. It will be important to pay attention to the public's attitude towards medical privacy going forward. Will consumers become more comfortable with sharing such information or could a data breach in the future shake confidence in the collection and storage of such data?

The survey indicates consumers are less concerned with their medical records being stored in the cloud than they are about how they will be used by those with access. This will be an important consideration as our ability to analyze such data for self-improvement grows. There is major potential for future medical advances through Big Data analysis of medical datasets such as blood measurements for disease prediction. The completed transition to electronic medical records (EMRs) has been a desirable goal for some time. While consumers have concerns about digital medical records, transparency – accomplished through EMRs themselves – may in fact be the key to assuaging those fears.

Digital Transparency

In the *Connected Health and Wellness Market* report, CEA outlines both the work done to entice health care providers to transition to EMRs, and the benefits they offer to both providers and patients. "The [Affordable Care Act] establishes a new coordinated care payment model that rewards care providers for the outcome of care instead of the volume of services provided." One of the features of coordinated care models is rewards offered for costs savings, something that can be accomplished via remote monitoring and the connectivity offered by health and wellness products. Such digital health offerings go hand in hand with EMRs, and The Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009 that offers financial incentives to health care providers who adopt EMRs. According to Parks Associates, 90 percent of urban hospitals and 60 percent of physicians in the U.S. had adopted EMRs by the end of 2013.

Some may remember a classic episode of the TV show *Seinfeld*, where after angering her physician, Elaine Benes tried in vain to see what he had written in her chart that had made her the black sheep of medical patients. Had that episode been set in 2014, we may not have been as entertained. EMRs offer consumers the ability to more easily access their own information. According to CEA, the Blue Button initiative "provides patients with secure access to their health records by clicking a simple and highly visible 'Blue Button' on insurer and care provider websites." According to the white paper, more than 80 million U.S. consumers have access to their information thanks to the initiative.

By knowing what is in their records, consumers may be more trusting of how they are used. Thanks to the fast-emerging health and wellness technology sector, consumers may feel more comfortable about their own health because they're reporting it themselves. In the years ahead, technology may offer the best solution to the problems that have plagued the health care industry for decades, such as cost, transparency and convenience. Soon, we'll not only collect and control our own health data as our quantified selves take shape, but we will have access to this data as well. And, such advances in health and wellness technologies, products and services may save us all a few trips to the doctor's office and improve our lives dramatically. ■

Entertainment and Immersive Content

By Brian Markwalter

Christian Huygens is credited with inventing the magic lantern back in the 17th century. With what amounts to a candle-powered slide projector, people managed to entertain crowds for several centuries. Conjuring up the supernatural and calling dead spirits were mainstays of 18th and 19th century magic lantern shows. Étienne-Gaspard Robert perfected the "phantasmagoria" ghostly show in 1798 with moving slide images, rear projection, and literally "smoke and mirrors." Robertson, as he was known in the business, was investigated by Paris authorities for scaring his audience witless, which proves two things: sometimes we want a good scare more than we want art, and authorities have always intruded into our leisure time activities.

I am only satisfied if my spectators, shivering and shuddering, raise their hands or cover their eyes out of fear of ghosts and devils dashing towards them…
- Étienne-Gaspard Robert

Within the next three years technology advancements will come together that result in entertainment experiences so vivid and immersive, movies and games will completely engulf our senses. Here's what's in store.

Feeling is Believing

We experience entertainment primarily by what we see, hear and feel. Huge innovations are around the corner for all three senses. Let's look first at the one we read about the least – touch or tactile sensing – and how we will finally get to feel like we are part of the event we are watching.

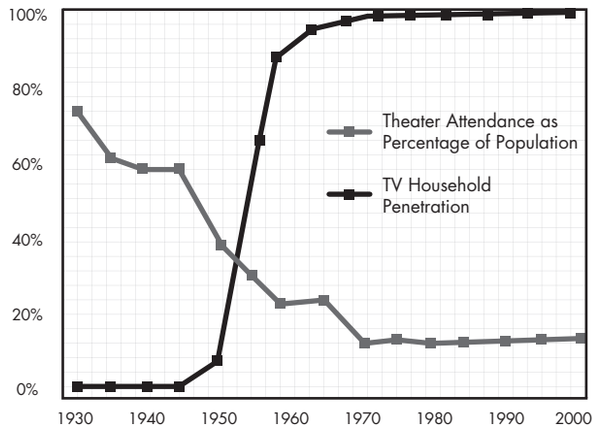
If you have been to a stock car or drag race or sat up front at a hockey game, you know there is something visceral missing in watching the same event on TV. Is it possible to send that same thunderous feeling, along with the video and audio, and recreate that sensation of "being there" for the viewer at home?

You bet, and work going on in the Society of Motion Pictures and Television Engineers standards group provides a glimpse of what's entailed. Sensors capture the motion or vibration from a person (driver or hockey player) or object (car seat) in the event. That tactile or motion data is encoded and broadcast along with the compressed audio and video. In engineering speak the sensor reports amplitude along an axis. Translation: how much movement and in which direction?

The cool part is the system doesn't care what the data is or how it's recreated at home. One obvious choice is a chair that imparts the same X, Y, Z vibration the driver feels. But the data could just as well map to hands, chest and seat. According to Mark Luden, CEO of Guitammer which developed the ButtKicker brand hardware product line, "We see the market for haptic, tactile and motion (immersive) broadcasting exploding in the next two to five years. Literally everything and everyone – from your family pet to NFL players – will have some kind of sensor on them transmitting all types of information, including location, motion and force for further use. We believe standardizing the 'pipe' – the path from the live event to the end user without regard to what brand or type of end user hardware is used – will help drive the multi-billion dollar over-the-top market. Imagine watching the next Olympics on the 'Immersive Channel' (whether broadcast or IPTV delivered) and being able to ski or snowboard with your favorite athlete. See what they see and feel what they feel. Combined with a heads up display, say Oculus Rift for example, and some new type of tactile or motion platform and you'll literally be in the mountains or in the half pipe."

You won't have to imagine it for very long. *The Silicon Valley Business Journal* reports that Comcast SportsNet is embarking on a partnership with the San Jose Sharks and Guitammer to evaluate a system that transmits signals from arena sensors to in-stadium seats or at-home adapters that vibrate fan seats.

CONVENIENCE RULES - PERCENTAGE OF U.S. POPULATION ATTENDING MOVIES AND OWNING TVS



Source: *Communication Technology Update*, Grant & Meadows (Theater attendance data)
Source: Nielsen (TV ownership data)

The Disruptors

In the first half of the 20th century, movie theaters captured our imagination and money in a way we can scarcely relate to today. In 1930, the first year for which we have reliable records, an astounding 73 percent of the U.S. population went to the cinema each week. After a swoon in attendance during the Great Depression, attendance bounced back to 60 percent during World War II, and Americans spent 23 percent of their recreation dollars at the movie theater. Then television happened.

As TVs showed up in more homes, movie theater attendance sank. We have seen this cycle in the tech industry many times. Convenience trumps quality in the short run, until the tools catch up to deliver the other thing consumers always demand – the highest quality experience possible. In 1950, consumers were steadily handing over a noticeable slice of their $3,800 average annual salary for a 10-inch television to watch *The Texaco Star Theater*. Spring forward five years, during which time household TV penetration jumped from nine to 65 percent, and enduring shows like *I Love Lucy* and *The Ed Sullivan Show* topped the rankings.

Television disrupted the movie theater business but created a hugely successful industry of its own. TV has had amazing staying power. CEA research shows that TV is by far the most commonly owned viewing device at 97 percent of households. Further, 93 percent of households indicate having watched video on a TV in the previous year. No other viewing device – among laptops, desktops, smartphones and tablets – has crossed the 50 percent mark.

In terms of quality and immersion, analog TV was a step backwards from the resolution and widescreen presentation found in theaters. That deficit was mostly rectified with the introduction of HDTV, which brought 1920x1080 resolution and multichannel surround sound to viewers. Today, we are on the leading edge of dramatic change in visual entertainment in three fields: Ultra HDTV, digital actors and virtual reality (VR).

Picture This

Despite the slight downturn in U.S. TV sales in recent years – a product of previous banner years as consumers bought flat-panel HDTVs in droves – the industry still sells nearly 40 million units annually. Consumers are getting bigger and better screens for less money. CEA forecasts sales of Ultra HDTVs to ramp quickly from 800,000 units this year to three million units next year. Not bad considering that 2014 is the first full calendar year with a range of Ultra HDTV models from multiple brands.

What makes an Ultra HDTV today and what's in the realm of possibility for the next generation of displays? CEA worked with industry affiliates to document minimum performance attributes that Ultra HD displays now provide light:

- **Display Resolution:** At least eight million active pixels, with at least 3840 horizontally and 2160 vertically.
- **Aspect Ratio:** The width to height ratio of the display's native resolution is 16:9 or wider.
- **Upconversion:** The display can upscale HD video and display it at Ultra High-Definition display resolution.
- **Digital Input:** Has one or more HDMI inputs supporting at least 3840x2160 native content resolution at 24p, 30p, & 60p frames per second. At least one of the 3840x2160 HDMI inputs can support HDCP v2.2 or equivalent content protection.
- **Colorimetry:** Processes 2160p video inputs encoded according to ITU-R BT.709 color space, and may support wider colorimetry standards.
- **Bit Depth:** Has a minimum bit depth of 8 bits.

TOTAL ULTRA HIGH-DEFINITION TV SHIPMENTS
Sales to Dealers

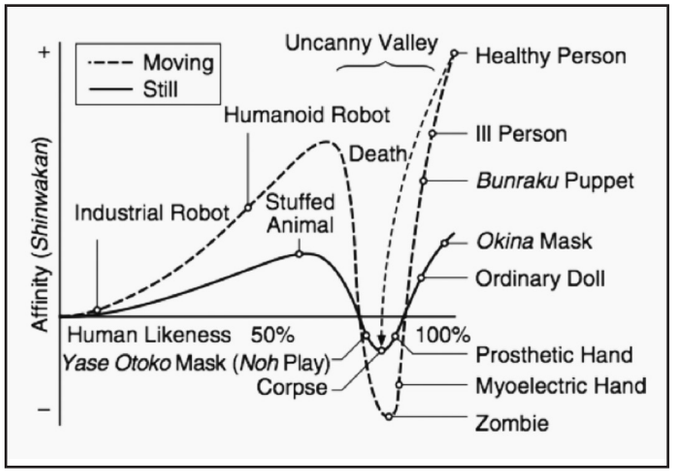
	Unit Sales (Thousands)	**Dollar Sales** (Millions)
2012	1	$22
2013	77	310
2014e	800	1,913
2015p	3,000	5,022

Source: CEA Market Research

There are five important ways to improve picture quality: resolution, frame rate, colorimetry, bit depth and dynamic range. Resolution is easy. Double HDTV's 1920 pixels in the horizontal direction and double the 1080 pixels vertically to get four times the "spatial" resolution and arrive at Ultra HD's 3840x2160 minimum resolution.

But video is moving pictures, which brings us to frame rate or what we might call temporal resolution. It's convenient to think about video as still pictures captured at 24, 30 or 60 frames per second, but nothing is really still. The shutter opens for a moment, during which time parts of the scene move around, especially with sports. Resolution won't save the day. It can make it worse in some cases. The still parts are super-sharp, which accentuates the blurred motion. The BBC has been at the forefront of testing the interaction between Ultra HD resolution and frame rate. Preliminary results of perceived quality under different frame rates suggest that most ill effects from judder and blurring are cleaned up in the 100 to 120 frame per second range. Today, HDMI can handle Ultra HD resolution up to 60 frames per second, which makes for stunning movies and TV shows. Soon, consumers will be able to dial the knob between more pixels and faster pixels.

Here is the oversimplified version of what colorimetry is and how displays are doing a better job showing what our eyes see in the real world. Color television uses a blend of red, green and blue primaries to generate the palette of colors you see. A flesh-tone pixel from your favorite actor's face is really a mix of red sub-pixel, green sub-pixel and blue sub-pixel, each turned to a specified brightness. International standards, like BT.709, define exactly what the red, green and blue colors are and how to represent their brightness numerically, among other things. The goal is this: the television needs to produce the same mix of red, green and blue that the studio intended when the program was created.



Source: Masahiro Mori's Uncanny Valley – *IEEE Robotics & Automation Magazine*

It might seem a little anachronistic to reference BT.709, originally developed for HDTV in 1990, in the latest Ultra HDTV definition when there is an equivalent standard, BT.2020, for Ultra HD. The TV industry is using the resolution and frame rates from BT.2020, while relying on the existing colorimetry of BT.709. Ultra HDTVs are not precluded from using BT.2020 or other wider color spaces, but to guarantee interoperability with existing content and workflows, BT.709 must be supported.

The last area of display improvement comes from extending the dynamic range by increasing the maximum white level while decreasing the minimum black, as well as making all available colors brighter and adding more of the colors that the human eye can see. Research has shown consumers would prefer images that are up to 200 times brighter with 4000 times more contrast than today's broadcast and Blu-ray standards, so there is plenty of opportunity for improvement. Dolby has been working hard on such improvements and calls this combination of higher dynamic range in luminance and greater color pallet "extended dynamic range." Dolby has developed an end-to-end solution that starts with better content at the source and preserves artistic intent all the way to the consumer.

Tom Hanks versus Digital Ira

Many people consider Tom Hanks' character in *The Polar Express* (2004) to be solidly in the "uncanny valley," that creepy no man's land where cartoons or robots look close to human but not quite right. Robotics professor Masahiro Mori coined the term "uncanny valley" in 1970, referring to human comfort level or familiarity as people interact with robots which appear more and more like natural humans. Comfort level rises to a point where the robot approaches a human likeness, then falls into the "uncanny valley" of a negative emotional response.

Motion amplifies the response as shown in Mori's depiction of affinity versus human likeness. It makes intuitive sense that we have a heightened response to something animate when it triggers a negative reaction. Of course, motion is what's needed in the movie business. Our acute visual perception and steep wall of the uncanny valley combine to make creating digital actors extremely challenging.

Now compare Digital Ira to Hanks in *The Polar Express.* Digital Ira is an active project at the USC Institute for Creative Technologies in collaboration with Activision that aims to create a photo-realistic digital actor. The important distinction between Digital Ira and USC ICT's previous Digital Emily project is the goal of generating a digital actor in *real-time* that could be used in tight closeups. Imagine video games in which characters are indistinguishable from filmed actors and you can understand why Activision is partnering on the project.

Digital Ira started with a real actor being scanned with high-resolution cameras on a special light stage as the actor goes through 30 facial expressions. The team selected eight expressions that would be the real-time rendering output. A big part of the hard computation is done offline to generate a topographical mesh that captures how expressions "flow" from neutral to a smile, for example. The game engine, the real-time part, has to deal with all the optical nuances that make for convincing video, like ambient shading and eye-refraction. Search for "Digital Ira" and watch the short demonstration video at the ict.usc.edu page then decide for yourself how close we are to having real-time digital actors.

The importance of digital actors goes beyond stunning games and better action movies. Movies already blend digital doubles with real actors and plenty of motion capture computer-generated imagery (CGI). In *Iron Man 3,* some scenes with Robert Downey Jr. used a digital double after he hurt his leg and the same for Guy Pearce's Aldrich Killian villain after Pearce grew a beard for his next movie. Instead of filling in a few CGI scenes, storytelling can fundamentally change with digital actors. Stories don't have to have a fixed plotline from start to finish. The boundary between games and movies will vanish.

Presence Accounted For

What differences this time around, suggest that virtual reality (VR) can succeed with consumers? Many experts believe that hardware and software are advanced enough to finally achieve what experts call "presence" on platforms that are cost effective for consumers. Well executed VR should convince your brain you are present in the experience and not viewing that world from the outside. It's the difference between looking through a portal and being teleported. Suspension of disbelief isn't needed when motion and vision are integrated. Turn your head in a movie theater, and you break the connection. Turn your head wearing a VR headset, and the immersive experience is reinforced.

Sony's Project Morpheus

Four big name players are in the news with announced or expected plans for VR products. After showing prototypes at the International CES, Sony Computer Entertainment (SCE) announced in March Project Morpheus, a VR system that leverages the PlayStation 4's phenomenal graphics computing power. Morpheus uses a visor-style display with inertial sensors and the PlayStation Camera to track head movement. Morpheus aims to completely change the gaming experience. Sony says, "… the player can use a PlayStation®Move (PS Move) Motion Controller as an object, such as a sword. Morpheus will reproduce the player's hands and sword within the game so the player feels like they are physically fighting off enemies with their sword in the virtual world." Morpheus also integrates 3D audio, so that as the player's head moves, sounds move in an immersive 360-degree environment.

At the other extreme is Google Cardboard – literally a folded up cardboard holder for your Android phone. Drop your phone in, hold it up to your eyes like a Fisher-Price View-Master, and voila – virtual reality. The phone's hardware handles motion tracking. The Google Cardboard app provides integration so you can fly around in Google Earth or watch YouTube videos. There are third party apps available in the Google Play store. Few would argue that Cardboard provides real presence to the user, but it goes a long way to demonstrate how much computing power we carry around.

From its initial Kickstarter campaign to the subsequent $2 billion purchase by Facebook, Oculus has become synonymous with the future of consumer VR. It has done so by tackling head-on everything that leads to "sim sickness" or what Brendan Iribe, Oculus CEO, calls "the uncomfortable valley" that results when a VR display does not match what the brain expects. Here's the timeline that brings us to Oculus' Development Kit 2 (DK2):

- November 2010 – Palmer Luckey, 18-year-old video gamer and VR enthusiast announces his first VR headset prototype, called PR1, through the *Meant to Be Seen* online forum.
- September 2011 – Luckey announces his third generation prototype to an insider online group.
- April 2012 – Working on his sixth generation headset, to be called Rift, Palmer Luckey announces he will run a Kickstarter campaign to produce DIY Rift kits. Connects with John Carmack, legendary game creator, who touts Rift in conjunction with *Doom 3 BFG Edition.*
- September 2012 – Oculus blows past $250,000 Kickstarter goal to raise $2.4 million.
- March 2013 – Development Kit 1 starts shipping.

- August 2013 – John Carmack leaves id Software to join Oculus.
- March 2014 – Oculus announces Rift Development Kit 2 and purchase by Facebook.

What does it take to tame "sim sickness?" Michael Abrash, who headed Valve's VR work before becoming chief scientist at Oculus, suggested this level of performance at Steam Dev Days in January: 20ms latency from head motion to picture, 95 Hz refresh, 3ms pixel persistence, 110-degree field of view, and tracking accuracy down to the millimeter. It's not surprising that the Oculus DK2 specs hew closely to Abrash's earlier statement on what it takes to achieve sickness-free presence.

The last big company expected to make a VR splash is Samsung. Rumors suggest Samsung will release a headset called Gear VR around the time this publication goes to print. Gear VR will work in conjunction with Samsung phones and be driven by software from Oculus VR.

Gaming dominates VR news, but the immersive experience does not have to be computer generated graphics. At the 2014 International CES this year, Kolor, a French company specializing in image stitching and virtual tour software, combined 360-degree camera footage shot from a hot air balloon with the Oculus Rift. Put on the headset and you are transported to the air above France. Look up and see the balloon. Look to the left and there's another balloon nearby. Look over the edge of the basket and down to experience that jolt of vertigo that only comes with real presence.

When it Hits You

"One good thing about music, when it hits you, you feel no pain," sang musician Bob Marley. Some would argue that listening to compressed songs ten years ago was quite painful. Music listening has gone through the most obvious and profound quality/convenience tradeoff and is poised to regain all the quality lost in our rush to pack songs onto portable devices. Back in 1998, the MPMan launched in Asia and the Diamond Rio sold in the U.S., each with just 32 megabytes of memory, able to hold about SIX compressed songs. As a result, music files were crushed as small as possible to fit on the limited space of available flash memory, or once the iPod hit in 2001, the 5 GBs on Toshiba's one-inch hard drive. While storage and broadband speeds marched ahead at the pace of Moore's law, music and CE companies together built out a robust digital distribution system for music, which sets the stage for finally putting the quality back in music with high-resolution audio.

High-resolution audio is defined as lossless audio that can reproduce the full range of sound from recordings that have been mastered from better-than-CD quality sources. Hi-res audio equipment and music files are expected to support 96 kHz/24 bit sampling or higher quality, beating even CD audio spec'd at 44.1 kHz/16 bit. Why such a high bar? Why is the focus on getting master quality files all the way to consumers? In part it is because storage and devices can now readily handle the files, but more importantly because consumers want quality. Nine in ten consumers say sound quality is the most important component of a quality audio experience according to CEA's study, *Notions of Quality: Audio Expectations of Consumers.*

A host of companies, including Sony, Onkyo and Pioneer, are already backing hi-res audio. In fact, more than 50 companies displayed hi-res audio products at the 2014 International CES. About a dozen digital music stores, like HDTracks and Blue Coast Records, sell compatible recordings.

Improvements in such areas as display technology, virtual reality and haptic feedback accompanying high-resolution audio are making our favorite forms of content more immersive every day. In addition, motion-capture technology is moving us closer to photorealistic digital actors that will lead us out of Masahiro Mori's 'uncanny valley'. Just as the audiences of Étienne-Gaspard Robert's phantasmagoria shows found themselves scared witless, we too are entering an era of content that will more immersive and believable than anything we've previously encountered. ■

Business Models in the Innovation Economy

By Shawn DuBravac

In the summer of 2014, Harvard historian Jill Lepore attacked the very essence of disruption by methodically deconstructing and challenging the theory put forth by Clayton Christensen in his seminal book, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. In so doing, Lepore sought to reign in the often misguided and excessive use of disruption theory by examining its origins and true characteristics. "Disruptive innovation" she wrote, "is a theory about why businesses fail. It's not more than that. It doesn't explain change. It's not a law of nature. It's an artifact of history, an idea, forged in time. It's the manufacture of a moment of upsetting and edgy uncertainty. Transfixed by change, it's blind to continuity. It makes a very poor prophet."

While theory of disruption could certainly benefit from a return to reason, disruption is a process and the technology industry still benefits enormously from a reasoned embrace of Christensen's insight because the business environment has never before been so conducive to disruption. *The Innovator's Dilemma* explains that market dominating companies, often large and entrenched, are prone to disruption by upstarts precisely because incumbents are lulled by the comfort of their entrenched positions and fail to sufficiently heed encroaching risk from new market entrants. Instead, he says, they focus on protecting their market leads from existing, similar competitors.

While serving their core customers, market leaders slowly cede segments of their market until there are no pieces left to relinquish. Upstarts gain a foothold in these well-served markets with solutions that are simpler and less costly, and at least initially, not as good – the key to why incumbent players fail to immediately worry about newcomers. Rather than compete in low-margin segments of their industry, they focus on higher margin segments with great profitability.

Eventually, what begins as a small segment of their market grows larger as the upstart matures and gains a greater and broader industry hold. This slowly moves the upstart into segments of higher margins until they become the dominant player. John Hagel put it best when he recalled Joseph Schumpeter's idea of "creative destruction" and explained, "markets are a powerful engine for 'creative destruction' – they invite competitors with a better idea or a better approach to come in and challenge incumbents."

In the last 20 years, a tremendous amount of attention has been given to the understanding of how disruption occurs, but we benefit most from a contextual understanding of disruption. The original intent of disruption analysis was to shift attitudes away from avoidance and reluctant response, but what actually happened was disruption became an infallible protagonist, a disruptor itself. In the narrative we've now created, Drake Bennet of *BusinessWeek* explains, "the upstarts are the heroes. Their eventual victory over the established order is foreordained, and they are the force that moves society – or at least technology – forward, disruption by disruption. Starting a company holds the potential to be not only lucrative, but also revolutionary."

Many indications suggest disruption is accelerating. For example, John Hagel, co-leader of the Center of the Edge at Deloitte, points to the topple rate, or a measure of how fast companies lose their lead positions in their respective industries. The topple rate has increased by almost 40 percent since 1965 and the tenure of companies on the S&P 500 (a rough list of the largest 500 publicly traded companies in the U.S.) has fallen from 75 years in 1937 to 18 years today.

Disruption in the Second Digital Era

We are entering a second digital era with profound implications for the future of disruption. The first digital era began when analog devices were replaced by their superior digital equivalents, but this second digital era is driven by the broader digitization of our physical space. In the second digital era, not only are more of the objects around us digitized, but we systematically digitize the information the objects gather. It is this digitization of data that fully opens the floodgates of disruption.
As Hagel explains, the difference between the major technology

disruptions of the past (the steam engine, electricity and telephony) and today's disruption patterns lies in digital technology's demonstration of "sustained exponential improvement in price/performance over an extended period of time and continuing into the foreseeable future…there's no stabilization in the core technology components of computing, storage and bandwidth." Contemporary disruption's stunning acceleration is, in part, explained by our entrance into this second digital era.

The Reality of Startups

While instinct tells us to credit the leadership of successful upstarts for being disruptive, some of the credit actually should fall to the environment in which the upstart found its footing. Disruption is, after all, a process and upstarts owe some of their success to their position within the process. In the beginning, the inherently lower cost structure of upstarts allows them the latitude to experiment. While many of these experiments fail, some experience tremendous success.

Another key to disruption is that startups often build their industrial structure and operating procedures on a foundation of new technologies. This enables the production of services and products on the cutting-edge of value and application in the current business environment. Startups often are disruptive vis-à-vis giant incumbents, but more accurately, can differentiate partly by the structure and approach surrounding their genesis. According to Hagel, "disruption turns the assets of incumbents into potentially life-threatening liabilities" and upstarts, because of their liberated origins, are not saddled with these liabilities – at first.

The (Basic) Economics of Disruption

In competitive markets, disruption will always drive an industry's net growth as a function of simple economics. New companies typically have lower cost structure born of differences in their labor force or the deployment of new, more productive capital. The entrant with a lower cost structure will drive down the marginal cost in the industry which, in a competitive market, means a shifting out of the supply curve, as the diagram illustrates.

In a competitive marketplace, demand is equal to price. So even without changes in preferences, the industry's new cost structure means increased demand for a greater quantity and as a result the total market grows. While we often recognize some intrinsic acumen on the part of the disruptors, a significant portion of their success is derived from basic economic principles at play.

Characters of Disruption in the Second Digital Era

If measures of disruption are accurate and disruption is in fact accelerating, it is worth considering the face of disruption in the digital era before us. The second digital era's attributes will have a pronounced impact on innovation and subsequently, disruption. Factors that help to drive disruptors include the ability to scale innovations, the network effects inherent in digital environments, compressing diffusion cycles, the shifts toward services, the development of platforms and the corresponding characteristics of platforms.

Scale

Scaling businesses is a key element of growth, but the character, cost, linear nature and magnitude of scaling businesses changes significantly in the second digital era. Switching costs are lower in a digital marketplace. In an analog world, consumers face real costs when choosing to find and travel to a new store or engage a new service provider. But in a digital marketplace, both search costs and switching costs are lower meaning consumers can more readily find and switch to new businesses without major disturbance to themselves. Lower switching costs enable businesses to scale (and fail) quickly. The lack of real-world tangibility also accelerates scale. Moreover, digital businesses can scale their core business without scaling tangible assets in tandem, meaning digital businesses face increasing returns to scale. In other words, they can grow revenue faster than the costs required to capture incremental revenue.

Digital technology has also changed the magnitude associated with scaling a business. In an analog setting, selling the first 50,000 units may be the threshold that the marketplace is viable. However, the scaling of Internet businesses is gauged on a completely different tier. Today we might say anyone can get their app downloaded a million times, it's the next 10 million times that matter. One reason behind this shift in scale is that digital technology enables hyper-speed that fuels not only rapid scaling, but also wide scaling.

Network Effects

In economics, network effects are the impact users have on the value of a good or service to other users and potential users. Network effects are a powerful force in technology and help explain how the value of devices like telephones or fax machines increase (and decrease) over time. For example, the value of the first fax machine was close to zero without a second fax machine from which to send and receive documents. But as the number of fax machines began to increase, the value of the network increased as more users joined the network. The same is true as users of fax

EXAMPLES OF DIGITAL MULTI-SIDED PLATFORM BUSINESSES	BUSINESS MODEL
Airbnb	Rent homes, apartments or rooms directly from owners
Bla Bla Car	Europe's largest car share
Boatbound	Rent boats directly from owners
Cargomatic	Connects local shippers with carrier companies who have extra space in their trucks
Circle Up	Online marketplace that links accredited investors with consumer product and retail companies
Deliv	Crowdsourced same-day delivery service for large national multichannel retailers
Elance	Online platform for connecting freelancers and businesses
Hailo	Connects taxis and passengers
Instacart	Same-day delivery for grocery and home essentials from a variety of local stores
Lending Club	Direct peer-to-peer lending network
Lyft	Peer-to-peer ridesharing, matching passengers looking for a ride with those offering a ride
MakeSpace	Storage service that provides pick-up, redelivery and online cataloging of what you've stored
Our Crowd	Equity-based crowdfunding platform, built exclusively for a select group of accredited investors to provide venture capital funding for startups
Pivotdesk	Matches companies together to share office space
Pley	Rents Lego sets to customers for a monthly subscription
Postmates	Phone app that delivers anything to your door in under an hour
Prosper	Service enabling individuals to either invest in personal loans or request to borrow money
Relay Ride	Carsharing service enabling private car-owners to rent out their vehicles
Sidecar	Platform to match riders with drivers
Soundcloud	An audio platform enabling music creators to upload, record, promote and share directly
Skill Shar	An online learning community
Storefront	Provides short-term retail spaces for rent to companies for pop-up stores
Traity	Verifies the online profiles and reputations of individuals
Uber	Connects passengers with drivers of vehicles for hire and ridesharing services
Wattpad	A writing community in which users can post articles, stories and poems
Yerdle	Provides daily list of things people are giving away
Zopa	UK's largest peer-to-peer lending service – matching individual borrowers and lenders

machines began to leave the network. Positive network effects are usually a defining attribute of disruptive businesses in the second digital era. Today, platforms like Instagram, Pinterest and Snapchat all benefit from positive network effects.

Compressing Diffusion Cycles

One of the properties of the second digital era is the ability to quickly ascertain a marketplace. Historically, companies could innovate slowly around core businesses and both create and capture value. This innovation would take place linearly with time. It could be slow and methodical, but that is no longer the case. Upstarts are creating value around existing business from all sides. Digital technology compresses diffusion cycles which also compress adoption cycles, meaning startups can create businesses as well as entire industries nearly instantaneously.

In the second digital era, we are moving from a world of incremental innovation to one where value is created and organized quickly. In the analog world to enter a given market – even a service market – businesses had to organize capital. Expansion would require capital because these businesses didn't generally have increasing return to scale. In other words, they had to grow costs in order to grow revenue. But in the second digital era businesses have increasing returns to scale which means they can expand quickly.

At the same time, perspective adopters of the service face lower search costs and lower switching costs. These forces combine to compress diffusion of the new business, and ultimately, adoption of the service.

A Shift to Services

Over the last 50 years, there has been a broad shift towards services. In the 1960s, U.S. consumers spent about 45 percent of total spending on services. Today, that figure has increased to 66 percent and it is likely to move higher due to the larger number of devices that rely on accompanying services to ascertain their value to end users. The products and devices launched in today's digital environment look increasingly more like services.

Further, the design cycle and subsequent product cycle of digital products are undergoing tremendous change. Because software is a large component of a device, manufacturers can update, upgrade and change the primary functionality of a product after the point of purchase. Before, if consumers wanted to upgrade their devices to new applications, they had to buy new hardware. Now, because hardware is a smaller portion of the service experience, manufacturers increasingly can push upgrades to devices. In some cases, software upgrades are changing what was the primary use case scenario for the device.

Multi-sided Platforms

Disruption was the lead theory on change over the last decade and a half. But economics of multi-sided platforms are set to replace disruptive theory as the key theory on business organization and industry dynamics over the decade ahead of us.

Multi-sided platform businesses are best thought of as marketplaces that allow participants to have direct interaction with each other. The scaling and network effects of digital environments create an atmosphere well-suited for multi-sided platforms, or what economists call two-sided marketplaces. These marketplaces have two distinct groups that each benefit from interaction with the other side.

Generally the two distinct groups in these marketplaces provide each other with network benefits. Examples include temporary staffing agencies (workers and employers), search engines (advertisers and users), credit card networks (merchants and cardholders) and even shopping malls (shoppers and merchants). Multi-sided platforms enable direct interaction between individuals within the two distinct groups and the interaction improves opportunities to trade with the other side of the market through network effects. The number of successful digital multi-sided platforms is growing daily. Examples include Uber, Airbnb, Square, Craigslist, and sites like Tinder or Wechat.

Final Thoughts

The literature since Christensen's seminal work constructs a framework to identify and explain patterns of disruption – for both the disruptor and the disrupted. Changing business environments present new patterns and paths of disruption and the next decade will bring new challenges as well as new pathways to success. As Hagel wrote, incumbent players must "find ways to expand the horizons of their leadership team beyond the next quarter or next year and to challenge on a sustained basis the key assumptions, often unstated, that they bring to the table regarding what is required for business success."

The second digital era brings an environment extremely conducive for disruption and change. Multi-sided platforms are developing and disrupting incumbent business models. In turn, the seeds of disruption that are planted today will exert pressure on multi-sided businesses. The attributes and characteristics of digital technology suggest disruption, in all its varied forms, will continue to accelerate. ■

See Technology Advances at the 2015 International CES

The International CES is *the* place to see innovation in action. More than 20 CES Marketplaces will showcase game-changing technology in Las Vegas on January 6-9. Marketplaces are unique exhibit areas that group new technology markets together and feature up-and-coming products, services and companies. CES is the unrivaled event to learn about tech advances and the best place to network. Following are just some of the targeted areas featured at the 2015 International CES.

Health and Wellness

Fitness & Technology
The Fitness & Technology Marketplace features the latest developments and discoveries across the digital fitness category. View the products, services and solutions using technology to make workouts and outdoor activities fun, safe and effective.

Lifelong Tech
Technology for seniors can help people live in comfort, safety and engagement. Lifelong Tech explores this population, from scientific longevity advancements to new ways to stay in touch, monitor aging in place, create memories and even develop financial plans. The Lifelong Tech Marketplace, presented by Living in Digital Times, showcases the best products for this market.

Wearables
The Wearables Marketplace focuses on the collaboration between sensors, low energy Bluetooth, cloud computing, 3D printing and flexible membranes that are transforming fashion. Discover everything from high-tech fashion and smart jewelry to wearables that track your mood, activity, health, and even pets, as well as the newest augmented reality devices.

Innovation Taking Shape: 3D Printing

3D Printing Marketplace
Additive manufacturing is one of the fastest-growing printing processes in the 21st century – virtually making an object appear out of thin air by generating successive layers of material to create a three-dimensional product. Most 3D printers are used for building prototypes for the medical, aerospace, engineering and automotive industries, but with the advancement of the digital technology supporting it, these machines are becoming compact units with affordable price points for consumers. Showcasing the leaders in the 3D printing industry and jaw-dropping demos, see the future of printing on the show floor in the 3D Printing Marketplace.

2015 International CES®
THE GLOBAL STAGE FOR INNOVATION

PRODUCED BY CEA®

Business Models in the Innovation Economy

Entrepreneurs and Startups at Eureka Park and Eureka Park Next
Returning for its fourth year, Eureka Park will feature new technologies from more than 300 startups. With 59 percent more exhibit space than at the 2014 CES, Eureka Park is where companies with new business models, products and services debut fresh ideas. At Eureka Park startups can connect with other companies to secure funding, form partnerships with distributors and advance to their first full production cycle.

Content at the International CES

Entertainment Matters and Brand Matters
The Entertainment Matters Program helps entertainment professionals navigate CES with a focus on exhibits, keynotes, panels and events that are critical to the Hollywood community. In 2014, Entertainment Matters (EM) attracted more than 29,000 content and entertainment professionals including executives from 20th Century Fox, Disney/ABC, ESPN, Lionsgate, Miramax, Paramount, Universal Studios, Viacom and YouTube to see the newest devices, technologies and platforms that will broadcast content.

The Brand Matters Program provides the marketing and advertising community with a customized CES experience including keynotes, events and conference tracks. More than 5,000 executives from leading brands like Twitter, Facebook, MillerCoors, Ford and AOL came to the 2014 CES for insights into the changing technologies, platforms and critical touch points shaping the future of advertising and media.

CES Introduces C Space
Located at ARIA, C Space is the official headquarters for senior executives from the marketing, advertising, content and creative communities. ARIA is the networking hub and "ideas" center that will host conferences, meeting rooms, exhibits, receptions and parties. CEA is partnering with the Association of National Advertisers (ANA) to develop conference programming. C Space is the gathering place for Brand Matters and Entertainment Matters participants and professionals from the creative industries.

For more information on CES Marketplaces, visit CESweb.org.


FOR FOUR DAYS,
WHAT'S NEXT IS
HERE NOW.
The 2015 International CES. With the who's who of innovation, business and technology, it's the one show on Earth that promises the future. And delivers it in ways you never imagined. Register today at CESweb.org.
2015 International CES®
THE GLOBAL STAGE FOR INNOVATION
PRODUCED BY CEA
JAN. 6-9, 2015
LAS VEGAS, NEVADA
CESWEB.ORG
#CES2015

1919 South Eads Street | Arlington, VA 22202
Toll free 866-858-1555 | Main 703-907-7600 | Fax 703-907-7601 | CE.org

2015