September 2019
VOL. XXXV, NO. 9

Daniel Burrus'

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TECHNOTRENDS® NEWSLETTER

The biggest ideas that are changing everything

IN THIS ISSUE

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Understanding Artificial Intelligence, Machine Learning, and Deep Learning

By Daniel Burrus, CEO of Burrus Research

Technological advancements and change are running rampant in today's business world, disrupting not only large organizations but even the smallest startups left and right. Whether you run a Fortune 500 company or a mom-and-pop shop, you and your organization are not immune to digital disruption.

> *Will you be the disruptor or the disrupted? There is no middle ground anymore!*

The inquiry I always present is as follows: Will you be the disruptor or the disrupted? There is no middle ground anymore! In order to be the former of the two, you need to pay close attention to the Hard Trends that are shaping the future of your industry, your business, and the world outside of your industry, and identify the related opportunities you can use to innovate, grow rapidly, and become the new disruptor.

In addition, you must use those Hard Trends to pre-solve any problems your organization or your customers might have before they occur, thus putting you far ahead of agile organizations that are focused on reacting quickly after a disruption occurs or after a problem occurs.

The Power of Shared Understandings and Definitions

There has become a noticeable issue in the world today: having a shared definition and understanding of the words we use. While several companies are on course to use Artificial Intelligence (AI), Machine Learning (ML), and even Deep Learning (DL) to become a positive disruptor in their industry, back at the starting line, many hardly understand the fundamental differences among these powerful technologies.

How can one be successful, much less disruptive, when they themselves do not have a handle on what AI, Machine Learning, or Deep Learning can do for their companies, let alone what each is? They can't!

Recently, a technology and software company known as Sage conducted surveys pertaining to AI and individuals' understanding of the ever-growing technology. Surprisingly and unfortunately, 43% of respondents in a US survey and 47% of respondents in a UK survey claimed they had no idea what AI is about, or any of its capabilities or applications in business, let alone their own.

Now, this is not solely an issue of under-education in the worlds of those individuals. General observations in today's market reveal that many vendors rush a myriad of AI solutions to market before the ultimate decision-makers and buyers are up to speed on what they need, or what the technology could actually do for their companies. This leads to dramatic confusion both within organizations and in the minds of observers from the outside and internal employees.

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TECHNOLOGY NEWS HIGHLIGHTS

Giant Computer Chip

Artificial intelligence (AI) requires a level of computing power that many processors simply aren't capable of handling. Analyzing vast amounts of data and graphics using complex algorithms typically takes multiple processor chips working together. But moving information between chips can be slow, limiting how fast these systems can operate.

Some hardware manufacturers have been looking at broadening the conndections between chips in order to speed up the data transfer rates. But a relatively new tech startup recently unveiled a different approach. In a world where we generally think of computer chips becoming smaller and smaller, they've created the world's largest – 56 times larger than any chip available. Known as the Wafer Scale Engine (WSE), it contains 1.2 trillion transistors and 400,000 AI-optimized cores. The idea is to keep all of the processing power on a single chip so the system can operate faster.

From a quality standpoint, it's not as simple as it sounds. One of the reasons chip makers keep them small is that the process of etching circuits into silicon is complex, and keeping the size down offers less room for error (i.e., higher yields). The developers have gotten around this problem by dividing the approximately 12-inch-by-12-inch chip into smaller cores with the assumption that some may not work. These areas can be bypassed by routing information around them.

The result is a chip that's between 100 and 1,000 times faster than existing hardware technology. The new chips would be installed in large data processing centers to promote the use of AI for a variety of applications including self-driving vehicles, surveillance systems, and autonomous weapons.

For information: Cerebras Systems, 175 South San Antonio Road, Los Altos, CA 94022; Web site: https://www.cerebras.net/

Hydrogen-Powered Airplane

As more and more companies step up to the plate to address the need for zero-emissions aircraft, several approaches have been proposed. Most rely on batteries as either their primary source of power or as secondary backup to provide short bursts of power; for example, during takeoff. But at least one startup has developed a system based exclusively on hydrogen fuel cells.

It's been estimated that aviation accounts for more than 12 percent of global emissions – that's more than 900 million metric tons of carbon dioxide every year. Furthermore, because these emissions are released at higher altitudes, their impact is two to four times greater than those released on the ground. With four times the energy density of even the best batteries available today, hydrogen is an obvious alternative for short flights using smaller planes. The current powertrain design has a range of 300 to 500 miles and operates at about half the cost of a typical fossil fuel engine. Designed for carrying 10 to 20 passengers, the smaller planes can bypass large, congested hubs; make better use of underutilized regional airports; and effectively reduce the total number of miles that passengers need to travel.

The proposed system uses compressed hydrogen stored in carbon fiber cylinders, which adds weight and limits the usable range. And while a shift to liquid hydrogen for use in larger aircraft is feasible, it will require additional safety testing. But nearly half of flights globally range 500 miles or less, which is well within the limits of the current technology.

For information: ZeroAvia, Inc., 90 Skylane Drive, Hollister, CA 95023; Web site: https://www.zeroavia.com/

Iron Ion Battery

Researchers have developed a stable, low-cost alternative to lithium-ion batteries using iron. In addition to being more cost-effective, the new batteries have the potential for slightly more storage capacity and are less likely to overheat than their lithium-based counterparts.

Lithium reserves are in short supply around the world due to the high demand for rechargeable batteries in everything from cell phones to automobiles. The process for mining lithium requires huge amounts of water (up to 500,000 gallons per ton of mineral) and toxic chemicals, both of which undermine efforts toward sustainability and protecting the environment. In addition, fabrication of lithium-ion batteries requires a controlled environment, further increasing production costs.

The new battery is composed of an anode made of low-carbon steel, a cathode of vanadium pentoxide, and an iron chloride electrolyte. Iron is not only less expensive than lithium, it also has a higher redox potential – meaning that it more readily loses and gains electrons, a necessary property for charging and recharging. Because the iron ion is less reactive, it can be fabricated in ambient conditions, and iron's inability to produce

dendrites prevents the batteries from short-circuiting during discharge.

The capacity of the proof-of-concept batteries is about 70 percent that of lithium-ion, and they have been demonstrated to withstand up to 150 charge-discharge cycles, with about 54 percent capacity remaining after 50 cycles. Further research will focus on improving stability and energy density.

For information: Ramaprabhu Sundara, Indian Institute of Technology, Department of Physics, Chennai, Tamil Nadu 600036, India; Web site: https://www.iitm.ac.in/

Farm Drones

An autonomous network of unmanned aerial vehicles (UAVs) could help farmers more effectively monitor their cattle herds. Although the system is still in the development stage, the hope is that it will reduce the more than 2.5 million cattle deaths that occur every year from health issues by detecting the signs of disease earlier.

The first step is to create a 3D image database of each animal in the herd. This is done in a pen, equipped with 40 or more cameras, to capture 360-degree images that will eventually feed into a "facial recognition" software system. Each cow is also fitted with a heart rate monitoring strap similar to those used by human athletes.

Out in the field, the UAVs will work in teams of four to triangulate the location of a specific animal. A machine learning system will then be programmed to autonomously measure weight, size, physical activity, and other vital information.

Before being fully deployed, the researchers must assess what effect, if any, the drones will have on the cattle themselves, both behaviorally and physiologically. Changes in heart rate will provide a measure of how stressful the process might be and how close the drones can maneuver without adverse effects.

The project is funded by a grant from the United States Department of Agriculture and is slated to continue through February 2021.

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Flat Lenses

We typically think of a lens as having two curved surfaces, the shape of which (also known as the angle of incidence) determines how light passing through it changes direction. A convex shape results in a converging lens, while a concave surface causes the light to diverge. The other factor that determines how the light will behave is the material from which the lens is made. When light slows down (by passing through glass, for example), it also changes direction – a process called refraction.

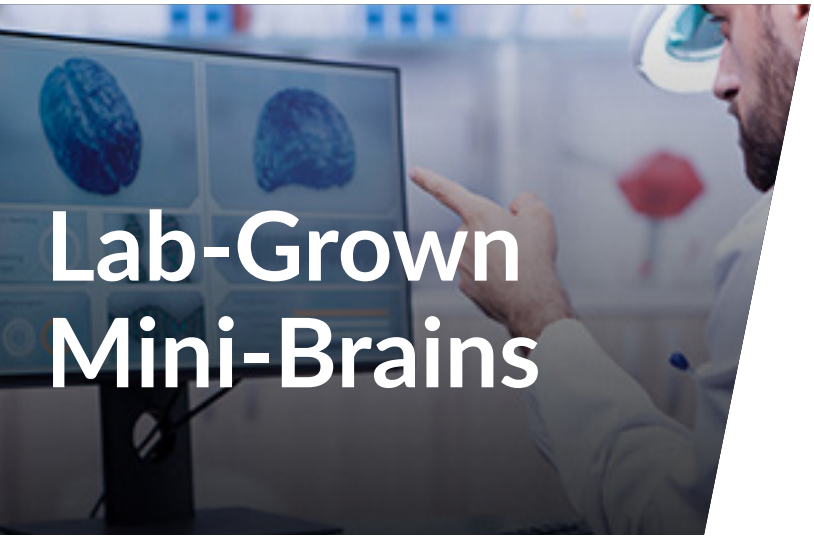
Now a new class of magnifying lenses has

been developed that are flat and thinner than a human hair. They consist of millions of tiny antennae arranged in concentric circles on a substrate using nanolithographic manufacturing techniques. When light falls on them, it is scattered in a way that effectively changes its speed and direction without needing to vary the angle of incidence.

The thin, flat lenses can also be stacked to achieve nearly the same level of control as conventional glass lenses, which are bigger, heavier, and more costly to manufacture. The only drawback is that only about 50 percent of the light traveling through a triplet (three flat lenses sandwiched together) passes through, compared with 90 percent for glass lenses. The researchers are confident, however, that this can be improved by adjusting the shape and position of the antennae.

The new technology will have application in many fields, from eyeglasses to optical radar systems.

For information: Nanfang Yu, Columbia University, School of Engineering and Applied Science, 500 West 120th Street #510, New York, NY 10027; phone: 212-854-2993; email: ny2214@columbia.edu; Web site: https://engineering.columbia.edu/



Lab-Grown Mini-Brains

Organoids are miniature versions of human organs that are grown under strict laboratory conditions. While they are not fully functional, they are useful for modeling diseases and tracking any structural changes that may occur as a result of drugs and/or gene therapy. Organoids are grown by harvesting cells from adult skin or blood, reprogramming them into stem cells, and placing them into a "cocktail" of molecules that turn specific gene factors on and off to regulate their development.

Recently, a team of researchers used this process to grow cortical neurons – cells from the part of the brain that controls thought and behavior. They also further refined the growth cocktail to allow the mini-brains to develop for longer periods of time. After two months, using tiny electrodes that measure brain activity, they detected scattered wave as might be seen in an immature human brain. After nine months, the electrical impulses were analyzed using a machine learning algorithm that had been trained on data from premature infants. The algorithm could not distinguish brain activity in the mini-brains from that of preemies.

The clinical implications of this research could be far-reaching for studying disorders of neural circuitry, such as autism, epilepsy, and schizophrenia. Eventually, organoids may even be able to replace areas of damaged tissue in the brain.

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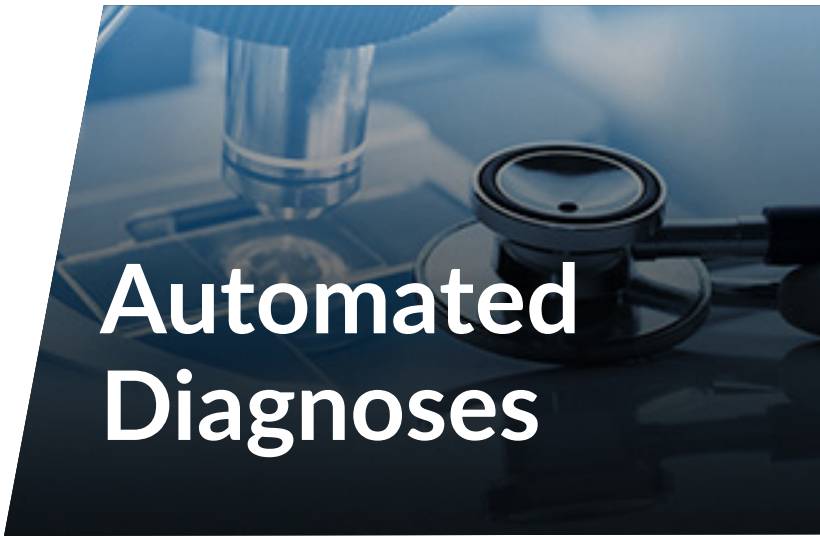

Automated Diagnoses

A new machine learning algorithm known as DeepGestalt has been developed that

can identify genetic syndromes better than doctors, simply by analyzing a person's face.

By adding this automated capability to a clinician's tool kit, earlier diagnosis and treatment could lead to improved quality of life for many children.

The DeepGestalt algorithm was "trained" on a dataset of more than 150,000 patients. The first step it takes is to identify facial landmarks such as eyes, nose, and mouth.

The patient's image is then cropped into small segments of 100 by 100 pixels, each of which is analyzed using "deep convolutional neural networks" – a well-known model for automated image classification.

A probability for potential syndromes is assigned to each segment and the data from the entire image is then compiled to return a prediction. In one test on 600 images of patients with Cornelia de Lange syndrome, the algorithm was 97 percent accurate as compared with a cohort of 65 experts who achieved only 75 percent accuracy.

About 6 percent of children worldwide are born with severe genetic syndromes, but many of these syndromes are rare. In addition, with hundreds of possible diagnoses, proper detection often depends on whether a doctor has encountered a specific condition before.

For that reason alone, this is truly a field where artificial intelligence (AI) could move practice forward in ways that would otherwise be impossible.

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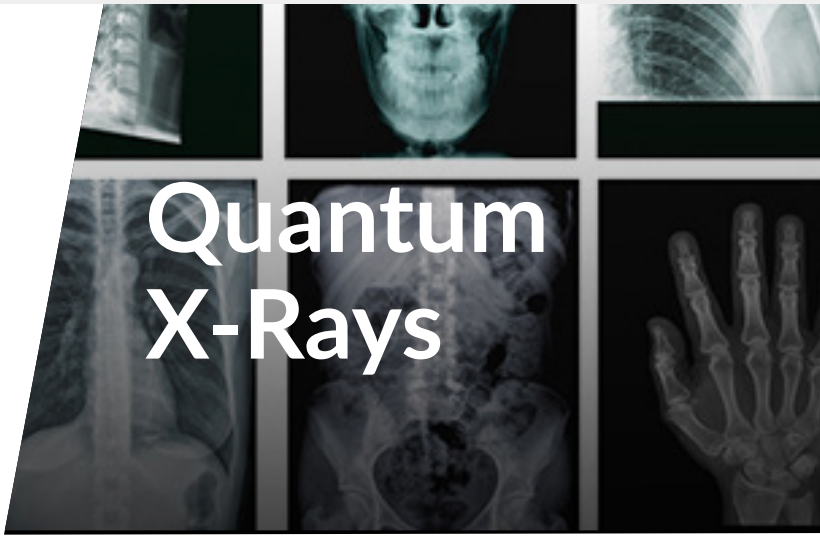

Quantum X-Rays

X-rays are notorious for being highly affected by ambient noise. Traditionally, this has been dealt with by shielding the area from outside radiation. An even simpler solution is to just turn up the dosage of x-rays to drown out the "noise." But that's not ideal for a lot of reasons.

A team of Israeli researchers recently discovered a new imaging method that uses quantum x-rays to make sharper images with less radiation exposure. Quantum x-rays are formed by passing a beam of radiation through a diamond to split it in two. The first beam (called the idler) serves to track background noise and is sent directly to a detector. The second beam (called the signal) passes through the object being imaged before hitting a detector. By comparing the two, background noise can be filtered out to create an extremely sharp image. At the same time, the number of photons needed to acquire an image is substantially reduced, so there is less exposure.

Although not yet ready for hospital use, that is the long-range goal. For the time being, however, scientists will be able to learn much about quantum mechanics from researching these kinds of particle pairs.

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Understanding Artificial Intelligence, Machine Learning, and Deep Learning

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Add to the mix the subcategories of AI such as Machine Learning and Deep Learning, and this situation gets even more convoluted. When CIOs and other technology leaders are asked by the CEO about the specifics of what AI can accomplish or, better yet, how AI differs from its counterparts mentioned above, they often draw a blank.

As I advise the leadership of many leading companies, governments, and institutions around the world, I have found that we all have different definitions of and understandings about AI, Machine Learning, Deep Learning, and other related topics.

For example, several months ago, I was asked to participate in a high-level strategy meeting regarding AI in Washington, DC. In the meeting were AI experts from the Department of Defense, DARPA, and several major defense contractors.

Before the meeting began, I could hear several people talking about what they were doing with Deep Learning, and another group talking about the results they were getting from Machine Learning.

I started the meeting by saying that everyone at the meeting was from different large organizations focusing on applying different elements of AI, and before the meeting began, all were excited about the future possibilities as they were sharing their interest in the various topics. But do we know what everyone else is talking about? So, I asked one of the experts to give their definition of Machine Learning. Then I asked another expert for their definition. By the third person, it was clear we all had different definitions for the same thing – or were we sure we were even talking about the same thing?

I asked for the definition of Deep Learning from several other individuals and once again got different definitions. I then asked how they would define Artificial Intelligence. Once again, many different definitions emerged.

My point is, if we are sharing how we are applying a technology, but we have different definitions and therefore understandings for what it actually is that we are talking about, we are not truly communicating with each other, much less collaborating with each other.

In addition, it's likely we will create an increasing number of problems going forward. As you might guess, we spent the next part of the meeting crafting definitions that everyone agreed on.

What Exactly Is AI? · Machine Learning? · Deep Learning?

Artificial Intelligence applies to computing systems designed to perform tasks usually reserved for human intelligence using logic, if-then rules, and decision trees to recognize patterns from vast amounts of data, provide insights, predict outcomes, and make complex decisions.

AI can be applied to pattern recognition, object classification, language translation, data translation, logistical modeling, and predictive modeling, to name a few. It's important to understand that all AI relies on vast amounts of quality data and advanced analytics technology. It's critical to understand that the

quality of the data used will determine the reliability of the AI output.

Machine Learning is a subset of AI that utilizes advanced statistical techniques to enable computing systems to improve at tasks with experience over time. Chatbots like Amazon's Alexa, Apple's Siri, or any of the others from companies like Google and Microsoft all get better every year thanks to all of the use we give them and the Machine Learning that takes place in the background.

Deep Learning is a subset of machine learning that uses advanced algorithms to enable an AI system to train itself to perform tasks by exposing multilayered neural networks to vast amounts of data, then using what has been learned to recognize new patterns contained in the data.

Learning can be Human Supervised Learning, Unsupervised Learning, and/or Reinforcement Learning like Google used with DeepMind to learn how to beat humans at the complex game Go. Reinforcement learning will drive some of the biggest breakthroughs.

Autonomous Computing uses advanced AI tools such as deep learning to enable systems to be self-governing and capable of acting according to situational data without human command.

AI autonomy includes perception, high-speed analytics, machine-to-machine communications, and movement. For example, autonomous vehicles use all of these in real time to successfully pilot a vehicle without a human driver.

Augmented Thinking: Over the next five years and beyond, AI will become increasingly embedded at the chip level into objects, processes, products, and services, and humans will augment their personal problem-solving and decision-making abilities with the insights AI provides to get to a better answer faster.

It is critical for leaders and employees alike to develop a firm understanding of the fundamental differences among AI, Machine Learning, and Deep Learning.

The increasing levels of business insights that can be gained from a shared understanding of the different elements of AI become more evident when understanding exactly how these ever-growing, disruptive technologies can be harnessed by your organization and, by applying them strategically, set you on a path to being a positive disruptor as opposed to becoming the disrupted.

Of course, it will always be imperative for organizations and leaders to go beyond reacting quickly and becoming anticipatory by paying attention to the Hard Trends that will happen and work to have solutions to problems before they occur.

Understanding the above AI technologies and how they build upon one another is a great start, and will ultimately help you and your organization move swiftly into the future.

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