The A.I. Wave Is Here And it's transforming an array of industries.

By STEVE LOHR

The internet is a technology of low-cost communication and connection. Every-thing from email to e-commerce to social networks has hinged on the internet's transformative role in changing the economics of communication. All those connections suddenly became both possible and cheap

Artificial intelligence is a technology of low-cost prediction and discovery. It exvast amounts of data — to identify patterns and make predictions. Much of what A.I. does today can be thought of as a prediction. What product to recommend, what ad to show you, what image is in that picture what move should the robot make next — al show are automated predictions.

This concept of A.I. as an engine of pre-dictive decision-making is the main theme of a new book by three economists at the Rotman School of Management at the Uni-versities of Toronto (Daliant) Machine Machine Machine versity of Toronto, "Prediction Machines: The Simple Economics of Artificial Intelli-gence" (Harvard Business Review Press).

The authors, Ajay Agrawal, Joshua Gans and Avi Goldfarb, argue that A.I.-powered decision-making is poised to alter virtually every industry. To explain, they start with an A.I. leader, Amazon. The online retail giant is constantly learning more and more about its customers' buying habits and tastes, and the data is steadily improving the predictive power of its A.I. algorithms.

Imagine, the authors suggest, that Amazon's A.I. gets good enough that Ahnd-zon's A.I. gets good enough that the com-pany takes the next step — shipping goods before they are ordered. It knows what you want so accurately that returns would be minimal and make Amazon even more efficient.

It would also change the nature of shopping "from an opt-in experience to an opt-out experience," Mr. Agrawal said in an interview

A fanciful thought experiment? Perhaps. But Amazon was granted a patent for "an-ticipatory shipping" in 2013. Just where artificial intelligence is taking

Creating Art

This image was generated by IBM Research to experiment with A.I's creative abilities. IBM used natural language processing tools to analyze about 3,000 A.I.-related articles from the archives of The New York Times, then built a visual recognition model that identified the handshake image from the Times's archives as one that reflected the central concepts. IBM then trained its experimental A.I. system to generate an original version based on the image concept, which it did in about a week. John Smith, of IBM Research, said the image-creation technology was still new but he is confident in the computer's ability to analyze content using natural language pro-cessing and visual recognition. "The hardest part is the generation side of this process," he said. "To have the computer actually draw that was a real learning curve for us. We were delighted by the progress.

us, at what pace and along what trajectory, is uncertain. The technology, of course, raising serious questions about its potential impact on jobs, privacy and politics. Still, A.I. is marching into practically ev-ery field, from agriculture to the arts. Here

are five examples: **MEDICINE** Brendan Frey studied under Geoffrey Hinton, a scientist and pioneer of

so-called deep learning, an A.I. technique that has made remarkable progress in re-cent years on tasks like image recognition and language translation. For years, Mr. Frey has done research that combines

deep-learning and cell biology. Deep Genomics, founded in 2015, is at the forefront of efforts by big companies, start ups and university researchers to trans-form the economics of drug discovery. The problem is apparent. It typically takes sev-eral years and costs billions of dollars for pharmaceutical companies to bring a new drug to market. Much of the money and time is spent on clinical trials on human subjects

A.I. holds the promise of sharply reducing the amount of costly and lengthy trial and error in traditional drug development and testing. Deep Genomics, based in Toronto, is not only using its technology to winnow the number of target compounds to attack a particular disease, but also to predict the biological outcome in humans. "The guesswork is tremendously reduced," Mr.

Frey said. It is still early for Deep Genomics and its approach. The first of its compounds will be tested in clinical trials beginning in 2020.

AGRICULTURE Corporate agriculture deploys an array of high-tech tools including sophisticated weather modeling, soil sen-sors, genetic seed breeding and drones. But there is another side to agriculture: the 500 million small farms — two hectares or less - that produce most of the developing world's food.

PlantVillage, a research and development project, based at Penn State Univer-sity, is beginning to bring artificial intelligence to these smaller farms. Scientists at PlantVillage, in collaboration with international organizations, local farm extension programs and engineers at Google, is work-ing to tailor A.I. technology for farmers in Tanzania who have inexpensive smart-phones. The initial focus is on cassava, a hearty crop that can survive droughts and hearty crop that can survive droughts and barren soil. But plant disease and pests can reduce crop yields by 40 percent or more. PlantVillage and International Institute of Tropical Agriculture have developed a

simple A.I. assistant, called Nuru ("light" in Swahili). Wave the phone over a plant leaf, and the software diagnoses the disease or pest blight and suggests low-tech treat-ments. Once downloaded, the app does not require wireless access to cellular data or remote computing power, which means it works in rural villages.

Works in rural viliages. Programs in Kenya and India are under-way. In the developed nations, people fear A.I. as a job killer. "But in low-income coun-tries that lack human capital in fields like coricol/twol acionae there is on concerturity. agricultural science, there is an opportunity to use A.I. to help break the cycle of pov-erty," said David Hughes, an entomologist at Penn State and the director of PlantVillage

HEAVY EQUIPMENT An estimated billion people in more than 60 countries step onto a KONE elevator or escalator every day. Its big people-lifting machines are a represent-ative example of the A.I. overhaul under-way in businesses that make and service

heavy equipment. The Finland-based multinational is using IBM's Watson software to constantly moni tor the performance of its machines. Lowcost sensors, wireless communications cloud computing and A.I. software are the

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From top, companies like Deep Genomics in Toronto use A.I. to speed up drug development; in Kenya, software identifies pests and disease on cassava plants: a KONE elevator sends streams of data that can indicate that maintenance or a new part is needed; a Root Insurance app uses smartphone sensors to pick up signals of risky driving behavior; Deep Dream uses "neural networks" to digest images, detect patterns and create an aesthetic prediction.

technical ingredients that make the change possible now

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KONE's new equipment is being made with the sensors and wireless links, while its older models are being retrofitted. Data streams off each machine, every second, providing measurements that include vibra tion, leveling, braking, temperature, door openings and cargo weight.

The data is fed into the A.I. software, which looks for telltale signals that a machine is in need of maintenance or a new part, before it fails. "You go from being reac-tive to proactive and predictive," said Larry Wash, an executive vice president of KONE. The results on the elevators deploying the

new technology so far are encouraging. There are 25 percent fewer breakdowns and 60 percent fewer customer reports of problems than on elevators serviced on tradi-tional maintenance schedules.

INSURANCE Root Insurance, a start-up in Co-INSURANCE Root insurance, a start-up in Go-lumbus, Ohio, is using artificial intelligence to more accurately price car insurance. Alex Timm, the chief executive, says good driv-ers pay more than they should, effectively subsidizing the bad-driving culprits — the one third drivers responsible for the major-ity of accidents ity of accidents.

Root is a bet that with modern technology, it can do better, charging good drivers less for auto insurance, up to \$100 a month less — and the start-up can still be quite prof-itable. Since its insurance and use introitable. Since its insurance app was introduced in the fall of 2016, Root has expanded into 20 states to date.

Root uses the sensors in a smartphone to measure location, acceleration, braking and turning. The myriad sensor data is parsed by clever software for signals of risky driv-ing behavior — lane changing, tail gating, even texting (typing generates tiny, but measurable, vibrations).

Potential customers download the Root app and are monitored for a test-drive peri-od, typically two or three weeks. The algorithmically-vetted safe drivers are approved.

"Our models are much more accurately predictive of accidents," Mr. Timm said. Root insists that it collects data only for its own risk analysis. "We've never sold data and never will," he said.

ART In 2015, weirdly morphing images of puppies and celebrity faces appeared in YouTube videos. They immediately became a sensation in the digital art world. Not only was the hallucinogenic imagery remark-able, but it was also the handiwork of

Google's Deep Dream, an A.I. program. Deep Dream used so-called neural networks to digest millions of images, identify visual patterns and then create something new — a kind of aesthetic prediction.

Today, many computer artists are using A.I. tools to create new imagery, design interactive visual experiences and probe ma-chine intelligence. Their work benefits from a wealth of A.I. software that is freely shared

among computer scientists and artists. In his project "Experiments with Deep Generator Networks," Gene Kogan used a machine-learning algorithm that learned from many photos on the web, which were labeled in categories like gazebo or butte, and then produced its own version. "It's a neural network imagining what a gazebo or butte looks like," said Mr. Kogan, a resident scholar at New York University.

Computer art has been around for dec-ades, and Hollywood's digitally animated movies and special effects are marvels of rich, evocative imagery. But that is more comparable to computer-aided design, with the software serving as a supercharged pencil or paintbrush, still firmly controlled by the human artists. Modern A.I. software is different. "Now,

we're playing with tools that, maybe, — are more akin to human perception and intelligence," said Golan Levin, a professor of electronic art at Carnegie Mellon University.

CONSEQUENCES

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By CADE METZ

SAN FRANCISCO – In July, two of the world's top artificial intelligence labs unveiled a system that could read lins.

Designed by researchers from Google Brain and DeepMind - the two big-name labs owned by Google's parent company, Alphabet - the automated setup could at times outperform professional lip readers. When reading lips in videos gathered by the researchers, it identified the wrong word about 40 percent of the time, while the professionals missed about 86 percent.

In a paper that explained the technology, the researchers described it as a way of helping people with speech impairments. In theory, they said, it could allow people to communicate just by moving their lips.

But the researchers did not discuss the other possibility: better surveillance.

A lip-reading system is what policymak-ers call a "dual-use technology," and it reflects many new technologies emerging from top A.I. labs. Systems that automati-cally generate video could improve movie making — or feed the creation of fake news. A self-flying drone could capture video at a football game - or kill on the battlefield.

Now a group of 46 academics and other researchers, called the Future of Computing Academy, is urging the research com-munity to rethink the way it shares new technology. When publishing new research, they say, scientists should explain how it could affect society in negative ways as well as positive.

The computer industry can become like the oil and tobacco industries, where we are just building the next thing, doing what our bosses tell us to do, not thinking about the implications," said Brent Hecht, a Northwestern University professor who leads the group. "Or we can be the generation that starts to think more broadly." When publishing new work, researchers

rarely discuss the negative effects. This is partly because they want to put their work in a positive light — and partly because they are more concerned with building the tech-nology than with using it.

As many of the leading A.I. researchers move into corporate labs like Google Brain and DeepMind, lured by large salaries and stock options, they must also obey the de-mands of their employers. Public companies, particularly consumer giants like Google, rarely discuss the potential downsides of their work.

Mr. Hecht and his colleagues are calling on peer-reviewed journals to reject papers that do not explore those downsides. Even during this rare moment of self-reflection in the tech industry, the proposal may be a hard sell. Many researchers, worried that reviewers will reject papers because of the downsides, balk at the idea.

Still, a growing number of researchers are trying to reveal the potential dangers of A.I. In February, a group of prominent re-



searchers and policymakers from the United States and Britain published a paper dedicated to the malicious uses of A.I. Oth-ers are building technologies as a way of showing how A.I. can go wrong.

And, with more dangerous technologies, the A.I. community may have to reconsider its commitment to open research. Some things, the argument goes, are best kept behind closed doors.

Matt Groh, a researcher at the M.I.T. Media Lab, recently built a system called Deep Angel, which can remove people and objects from photos. A computer science experiment that doubles as a philosophical question, it is meant to spark conversation around the role of A.I. in the age of fake news. "We are well aware of how impactful

Perhaps some things are best kept behind closed doors.

fake news can be" Mr. Groh said. "Now the question is: How do we deal with that?

If machines can generate believable photos and videos, we may have to change the way we view what winds up on the internet.

Can Google's lip-reading system help with surveillance? Maybe not today. While "training" their system, the researchers used videos that captured faces head-on and close-up. Images from overhead street cameras "are in no way sufficient for lip-reading," said Joon Son Chung, a re-searcher at the University of Oxford.

In a statement, a Google spokesman said much the same, before pointing out that the company's "A.I. principles" stated that it would not design or share technology that could be used for surveillance "violating internationally accepted norms."

But cameras are getting better and smaller and cheaper, and researchers are con-stantly refining the A.I. techniques that drive these lip-reading systems. Google's paper is just another in a long line of recent advances. Chinese researchers just unveiled a project that aims to use similar techniques to read lips "in the wild," accommodating varying lighting conditions and image quality.

Stavros Petridis, a research fellow at Imperial College London, acknowledged that this kind of technology could eventually be used for surveillance, even with smart-phone cameras. "It is inevitable," he said. 'Today, no matter what you build, there are good applications and bad applications."

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