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December 2017

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Global Equities

AI: THE NEXT BIG THING IS HERE, AND EVERYWHERE

EXECUTIVE SUMMARY

- Artificial intelligence (AI) is developing rapidly, with the potential to disrupt many industries.
 - Industry leaders are making the technology more accessible, spurring increased investment and broader use.
 - Some industry leaders are leveraging AI to strengthen their products and competitive positions.
 - Myriad investment opportunities are emerging, but AI development faces various challenges.
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Artificial intelligence (AI), long the staple of science fiction, is quickly moving into the mainstream of everyday life. It is already disrupting some industries and companies—and forcing investors to become more nimble about how they evaluate new investment opportunities.

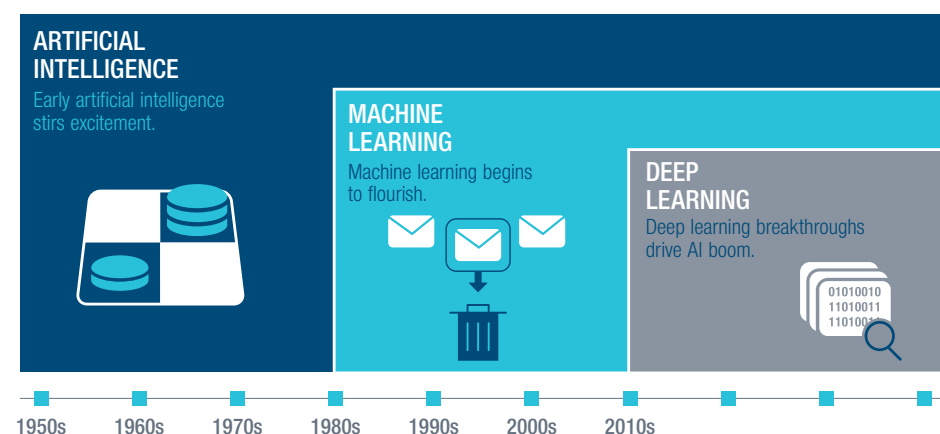
Robots and automated devices will not be taking over the world anytime soon, but computer systems are being trained to analyze more like humans—but with greater speed and accuracy. They are programmed to handle such complex tasks as understanding natural language, visual perception, and speech and text recognition and translation (see Figure 1, page 2).

With its rapid development, artificial intelligence, which involves programming machines to efficiently provide solutions, is permeating a wide range of fields, from health care to financial services to security (see Figure 2, page 3).

AI is embedded in more and more sophisticated mobile devices and digital personal assistants, including Google Assistant; Amazon's Alexa; Apple's Siri; Microsoft's Cortana; and Facebook's M, offered with Facebook Messenger. It also is powering enhanced search functions from Google and Baidu (China's dominant search firm), Tesla's innovation in autonomous driving, and more targeted customer recommendations from Netflix and Amazon, and it is used in advanced image recognition and organization for Google Photos.

In health care, AI is improving illness prevention through diagnostics and is aiding in treatments and surgical procedures. Digital health assistants bridge the gaps between doctors and patients to maintain patient care. IBM's Watson Health analyzes possible cancer treatments, and the company is developing a new platform for evaluating drug safety.

FIGURE 1: Deep Learning: The Newest Driver of Artificial Intelligence



Source: Nvidia Corporation.

As the technology required for AI becomes cheaper and more accessible, corporations seeking greater insights from their data are increasingly investing in AI. According to a Forrester survey last year of more than 600 global business and technology professionals, respondents expected more than a 300% increase in industry investment in cognitive computing (a term often used synonymously with artificial intelligence) in 2017 compared with 2016.¹

Research firm International Development Corporation estimates that widespread adoption of AI will increase worldwide investment in AI and cognitive systems across a broad range of industries from USD \$12 billion in 2017 to more than USD \$57 billion in 2021 (see Figure 3, page 4).

Amazon Web Services, Microsoft, and Google are leading the nascent effort to offer AI capabilities to various industries through their public cloud computing services, in turn spurring more investment and broader use of AI.

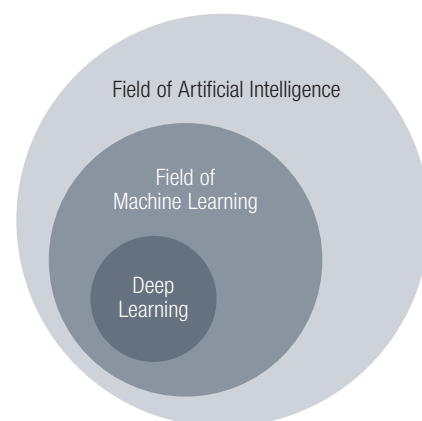
“The artificial intelligence era is going to be a powerful driver for these companies because of their ability to offer these capabilities through cloud services,” says Ken Allen, portfolio manager of the Science & Technology Equity Strategy.

“Companies in a variety of industries will feel compelled to adopt these technologies to better serve their customers and keep up competitively, and those are the three go-to places to get it.”

Paul Greene, portfolio manager of the Media & Telecommunications Equity Strategy, says there is ample evidence that the technology is spreading across corporate America. “I don’t think AI will be this technology that only a couple of companies end up benefiting from and take over the world,” he says. “I think it will be an enabling technology that helps everyone. Small businesses, entrepreneurs, and start-ups are already moving to use these public cloud platforms. But the big companies will benefit disproportionately because others will be using their platforms. Only a handful of companies now truly have the massive amounts of computing capability needed.”

GROWTH SPURT

Broadly speaking, the goal of AI is to train a system with existing data to be able to recognize patterns and make predictions based on future incoming data. Computers essentially are taught how to access and evaluate relevant information to make better decisions.



While the field had progressed in fits and starts for decades, it has more recently been propelled by advances in what are called machine learning and deep learning. With machine learning, systems use algorithms to analyze huge data sets so computers can gather information to solve problems on their own rather than via manual programming for specific functions. Deep learning mimics the brain by constructing artificial neural networks so computers are trained to recognize patterns, images, sounds, and text. Google’s image library utilizes deep learning to enable computers to translate more than 100 languages quickly and accurately.

AI capabilities have been fueled by the development of massive data sets that are used to feed the computers and more powerful, relatively inexpensive computing power—allowing for more complex problems to be solved more economically. “You need cheap, powerful processing because you feed these systems so much data,” says Josh Spencer, portfolio manager of the Global Technology Equity Strategy. “That’s only become available in the last year or two.”

One of the leading developers of this processing power, Nvidia Corporation, reports that more than 19,000

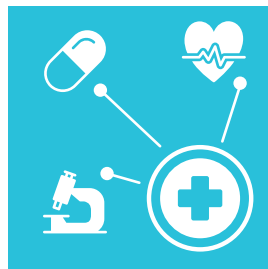
¹Predictions 2017: Artificial Intelligence Will Drive The Insights Revolution, November 2016, Forrester.

FIGURE 2: Uses of Artificial Intelligence Spreading Rapidly and Widely



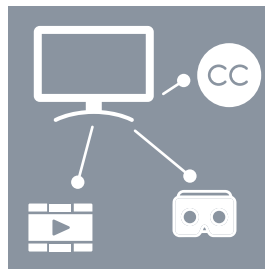
INTERNET AND CLOUD

- Image classification
- Language processing
- E-commerce tagging
- Digital personal assistants (e.g., Amazon Echo, Siri)
- Product recommendations



HEALTH CARE

- Cancer cell detection
- Diabetic grading
- Drug discoveries
- Wearable health data recognition



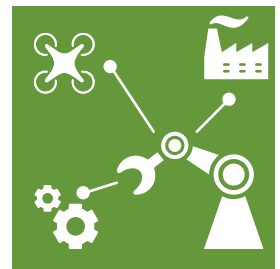
MEDIA

- Video search
- Captioning
- Programming recommendations (e.g., Netflix and Comcast)
- Virtual and augmented reality



SECURITY AND DEFENSE

- Face detection
- Video surveillance
- Geolocation
- Real-time objects and threat detection (e.g., detect explosives and match faces to criminal databases in real time)



AUTOMATION

- Factory automation
- Self-driving automobiles
- Drones
- Store automation (e.g., Amazon's new grab-and-go supermarket)
- Investment and insurance automation

Sources: Nvidia Corporation, Macquarie Research, and T. Rowe Price.

companies are using deep learning to advance their respective industries and that AI is inspiring a new wave of start-ups—more than 1,500 around the world in a wide range of industries.

Indeed, T. Rowe Price portfolio managers say that AI technology has become so impactful that companies that don't recognize the benefits or the threat of potential disruption risk being on the wrong side of change.

Traditional auto companies, for example, are racing to catch up with efforts toward self-driving vehicles led by relative upstart Tesla. Ford recently announced plans to invest USD \$1 billion over five years in Argo AI, an AI start-up, to develop driverless cars by 2021.

INVESTING

Companies dominating the AI research and development include Google, Amazon, Microsoft, Tesla, Facebook, and Alibaba, China's leading e-commerce company. "By and large, AI is making companies with already good products even better and smarter and giving them a competitive advantage, as they have

the scale and technology savvy to invest in it," Mr. Spencer says. In Google's case, for example, AI powers Google Photo, Google Translate, Gmail, and Google Home. Google also is developing self-driving cars.

"Artificial intelligence will further advantage the massive players given a scarce talent pool and the importance of high-scale computing capacity and large proprietary data sets," Mr. Spencer says. "It's a matter of the strong getting stronger. AI is not typically the main reason we invest in these successful companies, but it's becoming more important. AI is maybe 10% of the investment case at Google now, but it's a very important 10%."

Mr. Allen adds, "There aren't really any 100% pure AI plays out there. I consider Google the industry leader in artificial intelligence, computing capabilities, and talent. It has an enormous amount of data because of its dominance in search and its myriad other widely used services like Maps, Gmail, and YouTube. That enables it to innovate fast in making existing services better and developing new ones."

Mr. Allen says Microsoft also could benefit from its acquisition of LinkedIn, which provides access to a trove of professional jobs data that can be used for building customer relationships and making office workers more productive.

And he expects Amazon's Alexa to be a growth driver as more companies seek to integrate this digital assistant to enhance their own products, such as cars and televisions.

Health care is also the source of AI development. Intuitive Surgical, which developed its da Vinci surgical robot 15 years ago to assist surgeons' dexterity in performing operations, is at work on the next generation of robotics. It has also teamed up with Google and Johnson & Johnson on this effort.

"The Intuitive robot has a computer that is integrating images taken preoperatively or even intraoperatively, adding better visualization to assist surgeons on where to cut and how much to cut and to stop them before they make a mistake," says Jon Wood, a T. Rowe Price medical devices analyst.

Looking ahead, Mr. Wood expects AI to play an increasingly important role in genetic sequencing to help diagnose and even predict diseases such as cancer.

SMALL-CAPS

While the goliaths dominate AI, there are increasing opportunities for small companies in traditional businesses that can adapt the technology to lower costs and improve their core services, says Henry Ellenbogen, portfolio manager of the US Small-Cap Growth Equity Strategy.

“We believe we will be able to invest in a handful of durable growth companies that use AI to give themselves a fundamental business advantage and expand their market opportunity,” he says. “It’s going to be across the board, including health care, financial services, and manufacturing.”

Mr. Ellenbogen is tracking several companies investing in AI that “may not drive the portfolio in 2017, but I’m pretty confident [they] are going to make a difference in 2018, 2019, and 2020.”

“I think we will reach a point in several years where, if companies are not using AI to improve products, lower costs, or achieve efficiencies—and their competitors are—then they will be at a big disadvantage,” Mr. Ellenbogen says.

HURDLES

While AI seems to be unstoppable, it does face hurdles. One is a shortage of high-level AI programming experts or “data scientists” to keep pace with rising demand for talent.

Also, government regulation has lagged the technological innovation, and that could become a roadblock given AI’s broad implications for society and the economy. “There’s a lot of uncertainty,” Mr. Spencer says. “How will we deal with the ramifications of self-driving cars? Do we want doctors or computers making the medical diagnosis?”

FIGURE 3: Artificial Intelligence Spending Soaring

Projected Spending by Industry Groups in U.S. Dollars*

Sector	2017 (billions)	2021 (billions)
Financials	USD \$2.7	USD \$12.0
Distribution and Services	2.4	12.4
Public Sector	1.8	8.9
Manufacturing and Resources	2.3	9.5
Other Sectors	2.9	14.8
Total	12.1	57.6

*Financials includes banking, insurance, and securities and investment services. Distribution and services includes retail, wholesale, professional services, personal services, transportation, and media. Public sector includes health care; federal, state, and local governments; and education. Manufacturing and resources includes discrete and process manufacturing and construction and resource industries. Source: International Data Corporation.

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Mr. Wood asks, “How does the Food and Drug Administration review and approve a medical device that has artificial intelligence in it and it’s never been done before? Regulation will probably be the number one barrier to the proliferation of AI in health care. The science is many years ahead of the regulatory process.”

Moreover, accumulating enough data for the systems to learn could inhibit growth in health care and other areas. A problem can’t be solved without enough material to analyze it. “It all starts with the quality of the data,” Mr. Ellenbogen says. “It’s hard for me to imagine that a company without a good data culture is going to be successful at AI.”

In the labor market, AI could also be disruptive. According to a McKinsey & Company report issued in July 2016, “While automation such as machine learning and robotics will eliminate very few occupations entirely in the next decade, it will affect portions of almost all jobs to a greater or lesser degree...Automation could transform the workplace for everyone, including senior management.”²

There also are potential privacy issues. Mr. Allen says such concerns could inhibit the widespread adoption of digital assistant technology as in Amazon’s Alexa. “Putting a device in your home or your car that, when

²McKinsey Quarterly, Where Machines Could Replace Humans—and Where They Can’t (Yet), July 2016.

activated, sends your spoken words to a data center to parse is uncomfortable for a lot of people,” he says. “For AI to be fully maximized on a personal level, it basically needs to know as much as possible about you and have all your information in the data center.”

Despite such obstacles, a report issued in January 2017 by Mizuho Securities USA indicated that investment in AI is “in its infancy with a long road map ahead of it.”³

Mr. Greene notes, “We’re probably overestimating the impact it’s going to have in the next couple of years, but we’re all probably wildly underestimating the impact it’s going to have over the next five to 10 years.”

Even at this relatively early stage, portfolio managers recognize AI’s potentially transformative impact on society. “More than anything, artificial

“AI is already proving to be a transformative technology with broad implications. It is the kind of disruptive technology we are always looking to take advantage of as investors.”

–Josh Spencer, Portfolio Manager, Global Technology Equity Strategy

intelligence and machine learning are enabling computers to do magical things,” Mr. Allen says, demonstrating how Google Translate instantly converts a page of English text to French as he scans it with his phone camera. “That gives you a small insight into the huge potential of AI.”

Mr. Spencer adds, “There has been a lot of hype about the potential of AI and

machine learning, but it is justified. Who would have thought a car could ever be self-driving? AI is already proving to be a transformative technology with broad implications. It is the kind of disruptive technology we are always looking to take advantage of as investors.”

³Mizuho Securities USA Inc., AI & Deep Learning: Primer to a Revolution, January 18, 2017.

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