The Long View

Investment Insights

April 2017

Artificial Intelligence: It's Not the Future, It's Now

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Artificial Intelligence: It's Not the Future, It's Now

"Today it seems as if we are in the middle of another revolution, and clearly these changes pose significant challenges and opportunities for long-term investors."

Rob Lovelace, Portfolio Manager

Artificial intelligence may be the most transformative and disruptive advancement since the Industrial Revolution. After decades of hype and disappointment, AI is poised to fuel the next wave of innovation, and potentially provide unprecedented opportunities for companies and investors.

Can machines think? That's the question Alan Turing posed in 1950. Turing, an English scientist, is considered by many to be the father of computer science and a key figure in artificial intelligence.

Today, the answer to his question is getting closer to yes, depending on how you define thinking. But during the past few years huge strides have been made toward machines that can figure things out without being told what to do. Machines are using reason, logic and experience – and tons of data – in ways that are remarkably human and, for some, alarming.

These machines are already transforming manufacturing, transportation, health care and hundreds of other elements of daily life on both personal and industrial levels. They are in use in schools, homes, hospitals and cars, and they are changing the way the world works.

For some, machines are a threat, especially to jobs. But AI also has the potential to improve the standard of living around the globe, provide companies with new profit opportunities and reward investors.

"There are periods of fundamental change that can transform the way we live and work," says portfolio manager Rob Lovelace. "Today it seems as if we are in the middle of another revolution, and clearly these changes pose significant challenges and opportunities for long-term investors."

Artificial intelligence has been around as a scientific concept since the 1950s, going through several periods of boom and bust. The term refers to a collection of technologies that enables computers to simulate elements of human thinking. But for years, computers have had to be programmed in painstaking detail.

Things have changed. Through "machine learning," a subset of AI, computers can learn from data without being explicitly programmed. They can teach themselves by analyzing massive amounts of data from the web, smartphones and other internet-connected devices. Also, processing power has soared. Nearly everything online involves machine learning. Netflix, for example, uses it to recommend movies.

Recently, deep learning has taken AI to the next level. Deep learning is a type of machine learning that uses artificial neural networks that loosely mimic how brains work. A machine can now train itself to perform tasks, such as speech or image recognition, without being programmed to do so. Rather than having to be spoon-fed information for every eventuality, machines can analyze vast amounts of data using layers of artificial neural networks.

Whether that's thinking or not, machines can now figure many things out for themselves.

Key Takeaways

We live in a transformational time

- **Artificial intelligence (AI) is on the verge of transforming daily life for millions of people, both at work and at home.**
- **From driverless cars to machines that can converse with humans, advances once considered science fiction are about to become commonplace.**
- **Companies that are poised to take advantage of these changes have the potential to reap new profits, and provide investors with opportunities that few could have imagined a decade ago.**

Cover: Thanks to advances in artificial intelligence, machines can now perform many tasks and play games. Machines, data and people are converging.

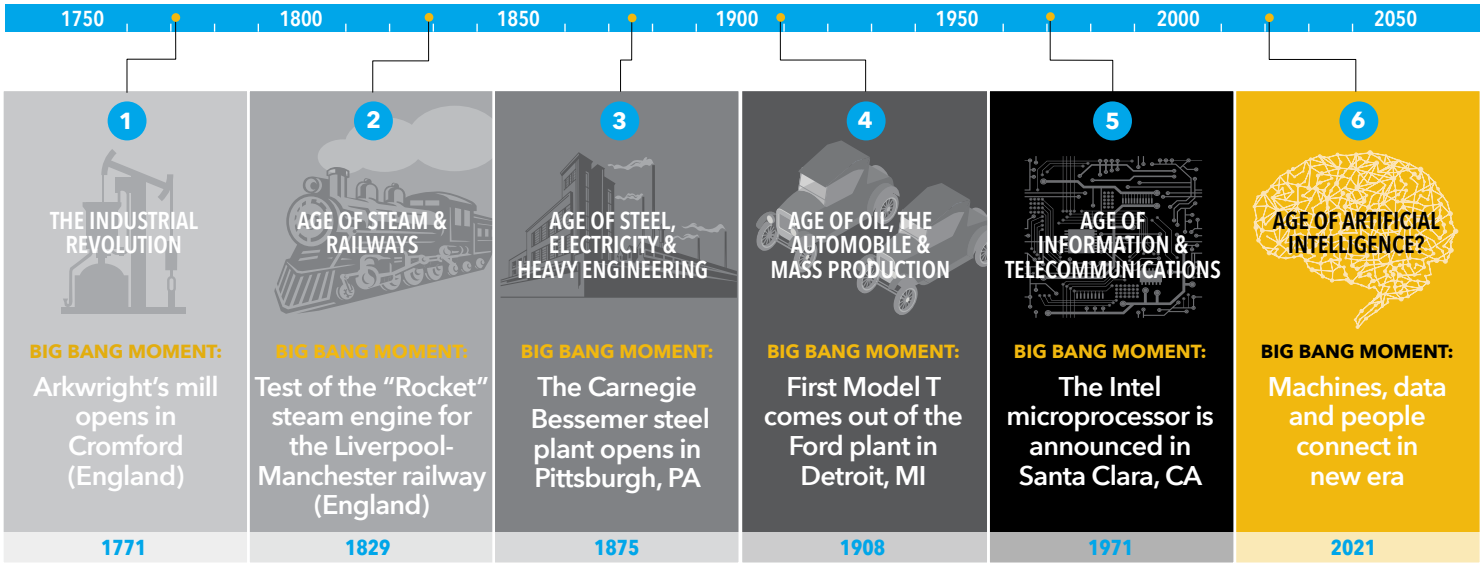
Artificial Intelligence Makes the Next Great Leap

AI May Be the Most Disruptive Change Since the Industrial Revolution

"Technological disruption is afoot. We are in the early innings, but artificial intelligence will be a disruptive economic, social and political force in the years ahead."

Jared Franz, Investment Analyst

Six Successive Technological Revolutions



Source: *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages*, Carlota Perez, 2002.

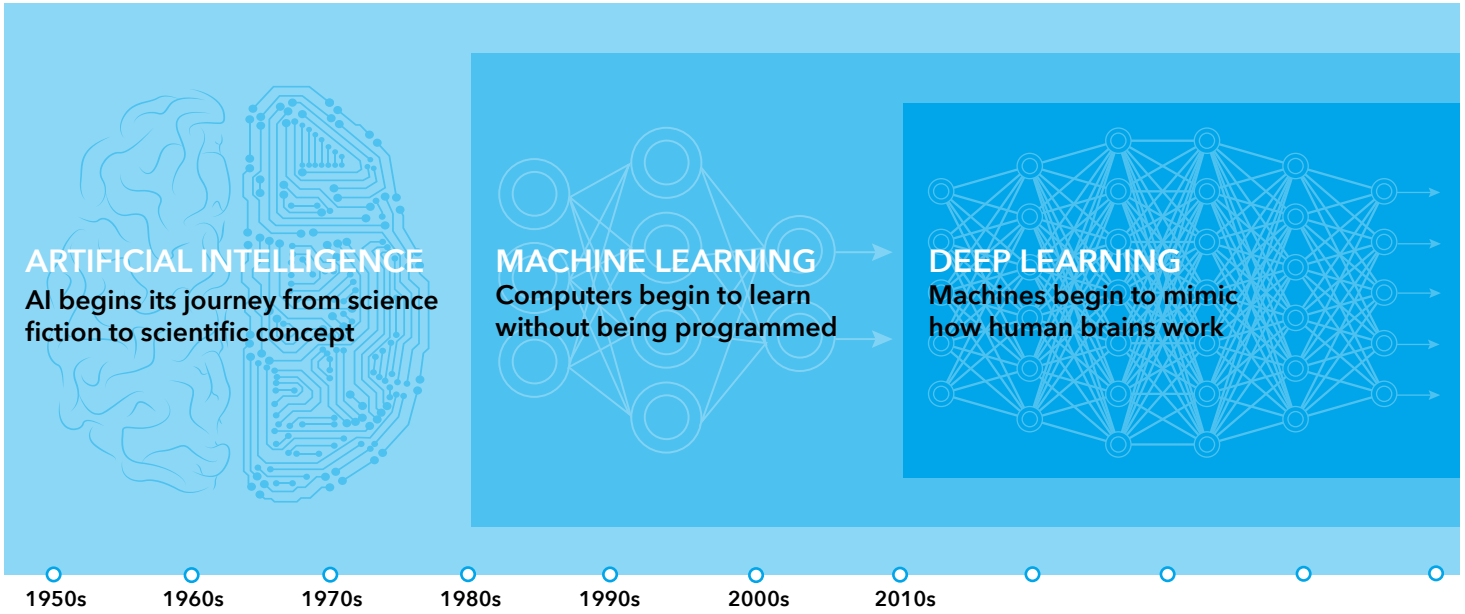
- Mention artificial intelligence and the first thing that comes to mind is probably a movie – *Terminator*, *Westworld*, *2001: A Space Odyssey*. In almost each story, the computer or the robot ends up going haywire. So it's not surprising that many people are ambivalent about AI. But that's fiction. The fact is most people already have a working relationship with a machine that does some thinking and talks to them – their smartphone. Going forward, AI is going to be a bigger part of the way people work, play and learn.
- Instead of the dystopian future that's often depicted in movies, the age of artificial intelligence is more likely to feature advances that were once considered futuristic becoming commonplace, such as driverless cars and machines that can converse with humans. Indeed, there seems to be little cause for concern that AI is an imminent threat to humankind. In many ways, the technology is already part of daily life, and it's reshaping life in schools, homes and hospitals. Actually, AI has been shaping society for years.
- Many AI applications are likely to increase productivity, improve transportation and enhance the quality of life for millions. But this technology will also create profound challenges. While it may increase productivity, it will replace some jobs and impact income. But, in many cases, AI will be critical to people's futures, and employees will be working with AI, not replaced by it. In fact, Hollywood now uses AI technologies to help bring its man-versus-machine movies to the screen.

Artificial Intelligence Comes of Age

AI Moves Beyond Patchy and Unpredictable, Thanks to Machine Learning and Deep Learning

"Machine learning is the automation of discovery – computers learning by themselves by generalizing from data instead of having to be programmed by us."

Pedro Domingos, Author
The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World



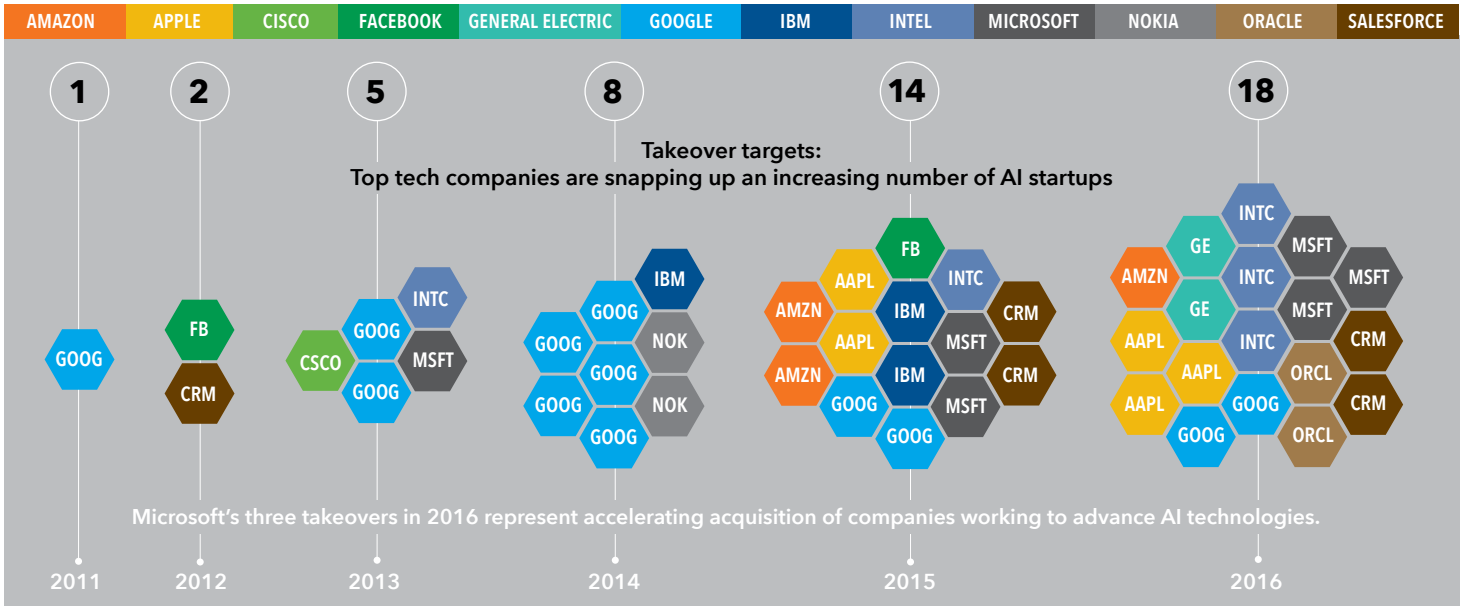
- Artificial intelligence is usually associated with the future, but as a scientific concept, AI dates from about World War II. Since then, artificial intelligence has gone through some booms, but mostly busts. Now, after decades of ups and downs, artificial intelligence is getting smarter. The credit goes to the development of machine learning and deep learning, as well as the increasing capability of microchips, an explosion in the amount of available information, and the ability of supercomputers to analyze data.
- Machine learning is a field of study that gives computers the ability to learn without being explicitly programmed. Machine learning enables such features as Amazon's recommendation algorithm. It's similar to data mining. Machine learning uses data to detect patterns and adjust program actions accordingly – essentially the machine draws an inference from the data. Facebook's News Feed uses machine learning to personalize each member's feed, and make changes when exposed to new data.
- Deep learning is a type of machine learning that uses artificial neural networks that loosely mimic how our brains work. The machine thinks in layers, with each layer capable of analyzing data at a deeper level of complexity and abstraction. Deep learning requires tremendous amounts of data and processing power, neither of which were available until the era of big data and cloud computing. Now, thanks to deep learning, AI is moving closer to delivering human-level capabilities envisioned decades ago.

Tech Giants Go All In on Artificial Intelligence

Google, Intel and Apple Are Among Companies on an AI Buying Spree

"Machine learning is comparable in importance to the personal computer or the internet or cloud computing. It's really going to transform not just computer science but lots and lots of other industries."

Jeff Dean, Senior Fellow, Google



Sources: Capital Group, based on information from CB Insights, Cisco Systems, TechCrunch and The Next Wave websites, and S&P Capital IQ.

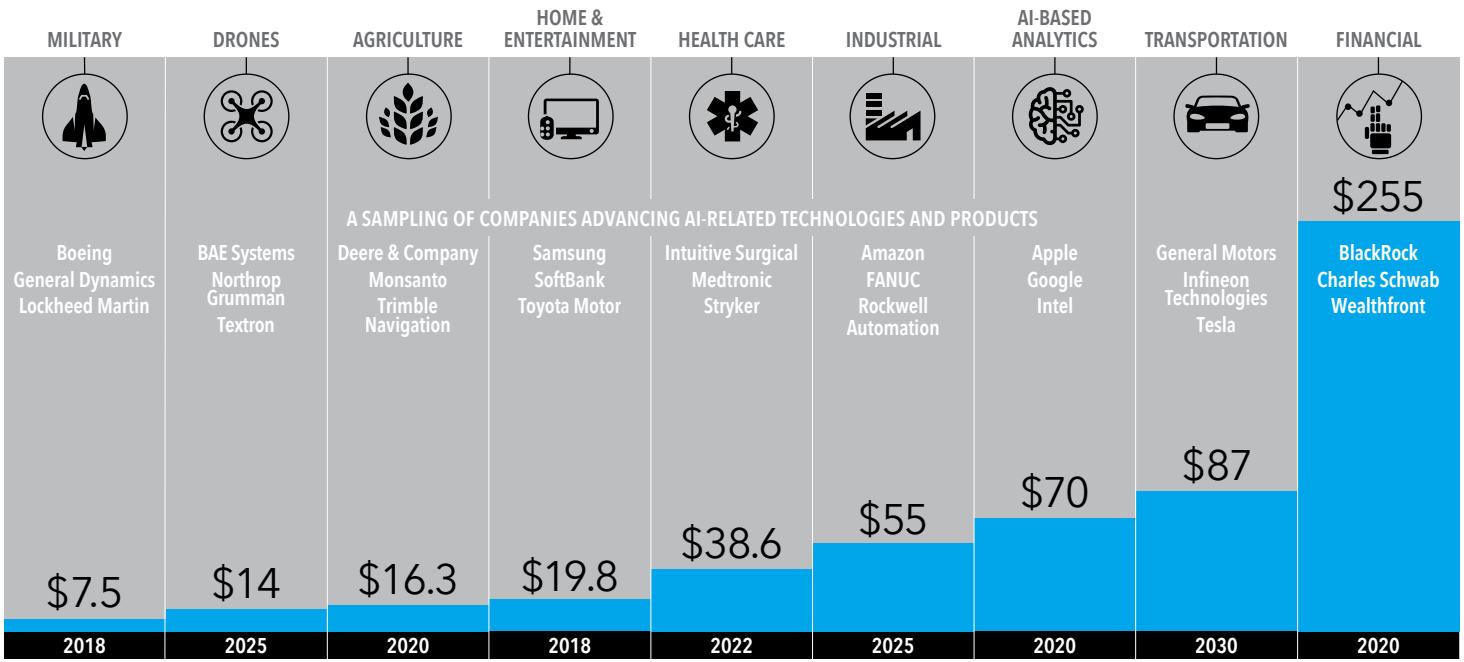
- *Siri, who are the biggest players in the artificial intelligence acquisition binge?* I believe Google, and my creator, Apple, have spent the most money acquiring startups to advance their capabilities in the field of artificial intelligence. Google has been the most active, acquiring 12 different startups, including DeepMind Technologies, a British company, for about $500 million. Apple's acquisition of VocalIQ has allowed me to better understand human speech and speak more naturally, if I say so myself. *Thanks, Siri.*
- Since 2011, about 140 private companies working to advance AI technologies have been acquired, with more than 40 acquisitions taking place in 2016 alone, according to CB Insights. Corporate giants like Google, IBM, Yahoo, Intel, Apple and Salesforce, are competing in the race to acquire private AI companies. Samsung emerged as a new entrant in October 2016 with its acquisition of startup Viv Labs, which is developing a Siri-like AI assistant, and GE made two AI acquisitions in November.
- AI has been largely conceptual for years. The recent acceleration of acquisitions speaks partly to the significant, and relatively recent, advances in the practical uses of AI for consumers and companies. Businesses are now exploring AI's possible applications in big data analysis for marketing, customer relationship management and more. The recent investments hint at the potential for new profits for companies, and also at developments that could reshape the business world and personal lives.

The Age of Automation Has Arrived

From Factory Floors to Financial Services, AI and Robotics Are Redefining How Work Gets Done

"The world is on the cusp of a new revolution in manufacturing."

Dickon Corrado, Investment Analyst



Global AI and robotics market size estimates by segment (financial represents assets under management), based on forecasts between 2018 and 2030 (in billion U.S. dollars)

Source: Capital Group and Statista Inc. Please see back cover for additional information.

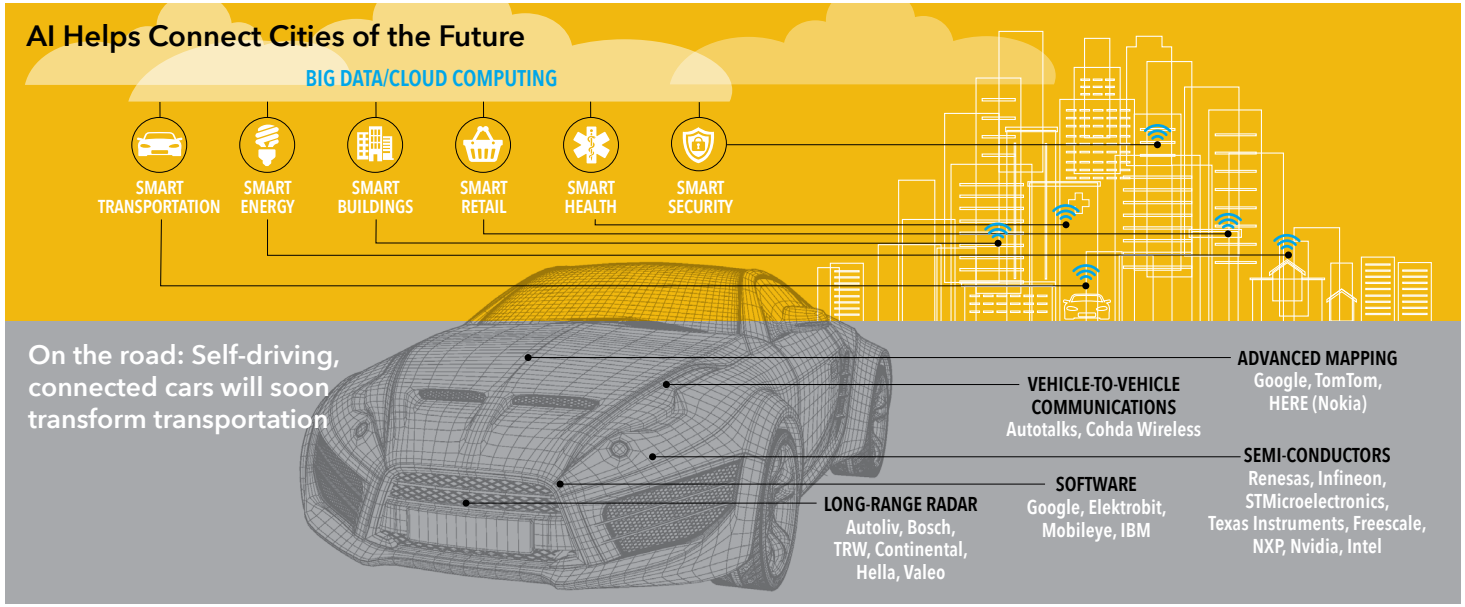
- The robots aren't coming – they're already here. Industrial robots have been around in the thousands for decades. Now, agribots, service robots, robo-advisors and co-bots are becoming part of the landscape. Soon, various forms of automation are likely to roll, or walk, out of laboratories and into the real world. It's been predicted for years, but the coming age of automation is starting to happen now thanks to advances in sensors, hydraulics and artificial intelligence, mostly in the field of machine learning.
- Robo-advisors are an example of technological disruption in wealth management. These machines provide online and automated portfolio management services. This is done through the use of algorithms, meaning human involvement is kept to a minimum. Though new and untested, and clearly lacking in the human touch a financial advisor provides, robo-advisors are becoming increasingly widespread. Assets controlled by robo-advisors could grow to more than $250 billion by 2020.
- The accelerating pace of automation has sent robot sales soaring. Between 2010 and 2015, sales of industrial robots increased 16% a year. In 2015, nearly 254,000 industrial robots were sold worldwide. Still, only about 10% of manufacturing is done by robots. By 2025, robots will account for 25% of manufacturing. This paradigm shift potentially may be among the most disruptive in history, with the possible displacement of human labor presenting a profound challenge for business and society.

The Internet of Things – Connecting Machines, Data and People

The Convergence of Big Data, Machine Learning and Cloud Computing Is Transformative

"We're seeing an explosion of innovation in the auto industry. We'll have self-driving cars on the road in not too long, and a lot of companies are going to benefit from the process it takes to get there."

Kaitlyn Murphy, Investment Analyst



FT FINANCIAL TIMES

Source: Chris Bryant and Andy Charman, "Race Is on to Build World's First Driverless Car," October 13, 2014. Used under license from Financial Times. All rights reserved. Capital Group is solely responsible for providing this abridged version of the original illustration and The Financial Times Limited does not accept any liability for the accuracy or quality of the abridged version.

- How many machines will be connected to the internet by 2020? General Electric puts the number at 50 billion. Industrial equipment, cars, home appliances, even heart monitors – seemingly everything will be tied together via the Internet of Things (IoT). IoT is a network of internet-connected physical objects that contain sensors. The technology allows them to communicate and transfer data over a network. The data can then be used for purposes ranging from monitoring crops to synching traffic signals.
- IoT is another example of a decades-old idea that now has practical applications thanks to big data and the increase in computing power to analyze information. Many businesses have already embraced IoT for cost savings and data collection, and IoT has the potential to transform the lives of individuals as significantly as the spread of mobile internet. IoT now seems on the brink of having a profound impact on industries from manufacturing to health care, and particularly transportation.
- Autonomous vehicles will be rolling examples of IoT. They will use an array of sensors and massive amounts of data to navigate roads without a human driver. The cars represent an opportunity for companies that haven't been part of the auto industry. Companies working on elements of the driverless car include IBM, Intel, Analog Devices, Texas Instruments and Maxim Integrated Products. Many other companies worldwide are developing cameras, radars, sensors and other equipment. They include Delphi, Continental, TRW, DENSO and Autoliv.

The following information pertains to the chart on the page specified below.

Page 4: The following segments reflect aggregated market estimates: home and entertainment – total of $12.2 billion for domestic robots (cleaning) and $7.6 billion for entertainment and leisure robots by 2018; health care – total of $18 billion for surgical robots by 2022, $17.4 billion for personal and care-bots by 2020, and $2.1 billion for medical exoskeletons and $1.1 billion for rehabilitation robots by 2021; industrial – $31 billion for automation of logistics (packaging, material handling, storage) by 2020 and $24 billion for industrial robots by 2025. Drones include unmanned aerial, ground and underwater vehicles (UAVs, UGVs, UUVs); agriculture includes agribots, autonomous vehicles and surveillance drones; financial includes robo-advisors and automated report writing and risk assessments. Transportation represents driverless vehicles and autonomous driving technologies.

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