GLOBAL DIGITAL TRANSFORMATION

LECTURE 3 – INNOVATIONS

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COURSE

1.	BACKGROUND	What is digital transformation about?
2.	LANDSCAPE	What is the global adoption of digital transformation?
3.	INNOVATIONS	What are the cases of digital transformation?
4.	FEATURES	What features define digital transformation?
5.	BOUNTY	What benefits can digital transformation deliver?
6.	SPREAD	How unequal are the benefits of digital transformation?
7.	WINNERS	Who benefits most from digital transformation?
8.	IMPACT	What is the impact of the bounty and spread?

AIM

The aim of this lecture is to explore:

- What new skills are being acquired by machines?
- What are the skills suited to machines versus to humans?
- How does the barriers of machine competence are being extended?

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

OUTLINE

WHAT NEW SKILLS ARE BEING ACQUIRED BY MACHINES?

OUTLINE

DARPA

Defense Advanced Research Projects Agency

Founded in 1958 in response to the Soviet Union's launch of the Sputnik satellite

Tasked with spurring technological progress that might have military applications

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

DARPA SELF-DRIVING CAR CHALLENGE

Announced in 2002, completed in 2004, aimed to build a completely autonomous vehicle that could complete a 150-mile course through California's Mojave Desert.

Fifteen entrants qualified to perform in the competition.

The results:

- two vehicles didn't make it to the starting area
- one flipped over in the starting area
- three hours into the race only four cars were still operational
- the "winning" car from Carnegie Mellon University covered 7.4 miles before veering off the course during a turn and getting stuck on embankment.
- The contest's $1 million prize went unclaimed

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

DARPA SELF-DRIVING CAR CHALLENGE VIDEO

Source: https://www.youtube.com/watch?v=wTDG5gjwPGo

SELF-DRIVING CARS 12 YEARS LATER...

Car maker	2016	
	Distance between disengagements	Total distance traveled
Waymo	5,127.9 miles (8,252.6 km)	635,868 miles (1,023,330 km)
BMW	638 miles (1,027 km)	638 miles (1,027 km)
Nissan	263.3 miles (423.7 km)	6,056 miles (9,746 km)
Ford	196.6 miles (316.4 km)	590 miles (950 km)
General Motors	54.7 miles (88.0 km)	8,156 miles (13,126 km)
Delphi Automotive Systems	14.9 miles (24.0 km)	2,658 miles (4,278 km)
Tesla	2.9 miles (4.7 km)	550 miles (890 km)
Mercedes-Benz	2 miles (3.2 km)	673 miles (1,083 km)
Bosch	0.68 miles (1.09 km)	983 miles (1,582 km)
Volkswagen	5.56 miles (8.95 km)	9 miles (14 km)

Disengagement is when the automated system is switched off, typically by the intervention of a human driver.

Source: Wang, Brian (25 March 2018). "Uber' self-driving system was still 400 times worse [than] Waymo in 2018 on key distance intervention metric". NextBigFuture.com.

SELF-DRIVING CARS 14 YEARS LATER...

How many self-driving cars have crashed?
13 serious crashes including 6 fatalities.

How many deaths have self-driving cars caused?
Two pedestrian fatalities, one was caused by an Uber vehicle, and the other by a Tesla AV. Additionally, four AV drivers died in self-driving car accidents.

What percentage of cars are self-driving?
1400 tester vehicles now, thousands in by 2020, 4,5 million by 2035.

Are self-driving cars safer than human-driven cars?
Self-driving cars have a higher rate of accidents (9.1 per million miles) than human-driven cars (4.1 per million miles), but the injuries are less serious.

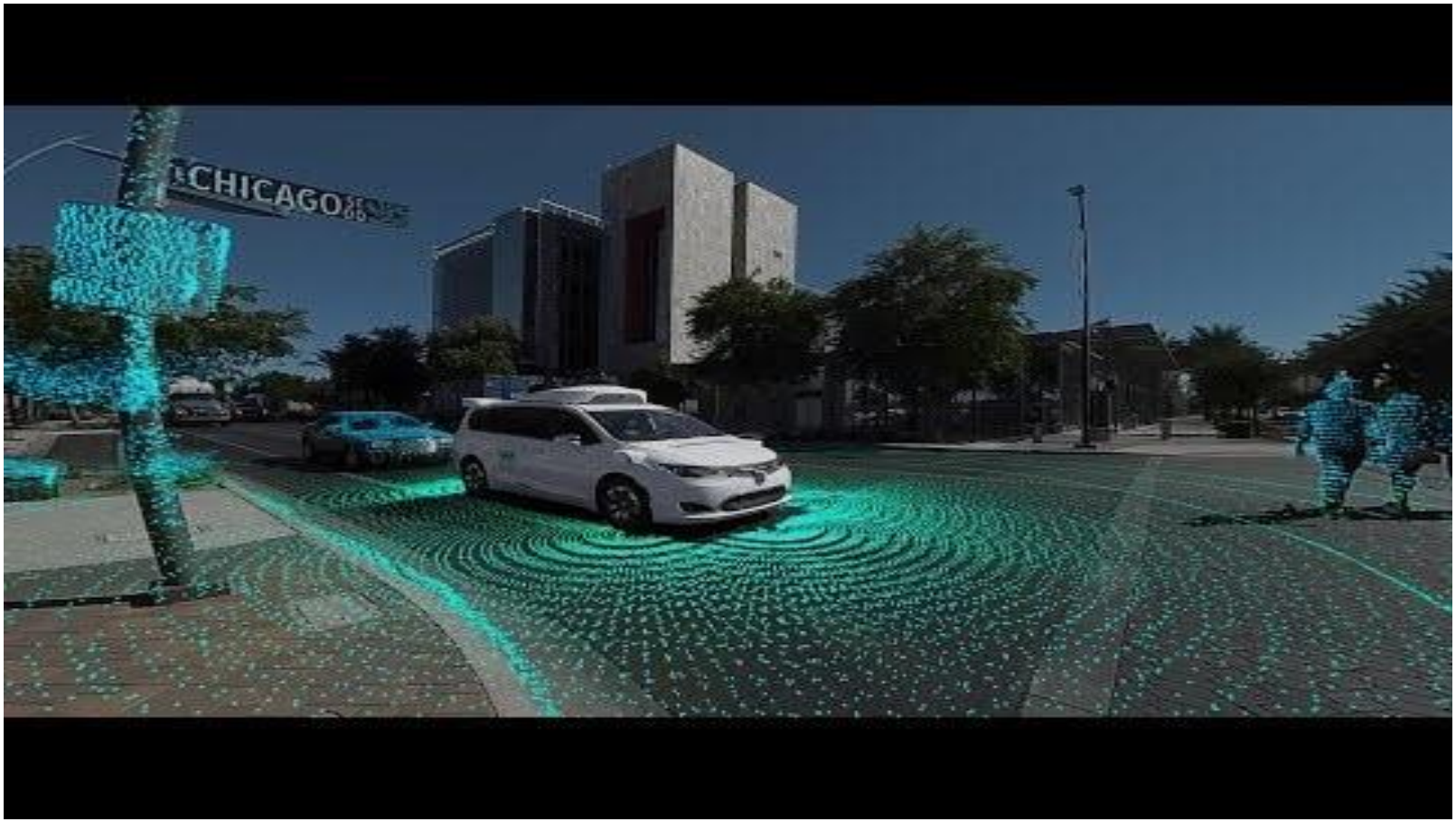
Are any cars operating on the roads completely autonomous?
There are still no vehicles operating without a human driver. There will always be one or two people present to react to any of the car's potential warnings.

Source: 29 Self-Driving Car Statistics & Facts, https://carsurance.net/blog/self-driving-car-statistics/#Driverless_Car_Statistics, 2019

LEVELS OF AUTONOMOUS DRIVING

Source: Society of Automotive Engineers (SAE); National Highway and Traffic Safety Administration (NHTSA), 2018 Inter Corp.

14 YEARS LATER: WAYMO SELF-DRIVING CAR VIDEO



Source: https://www.youtube.com/watch?v=B8R148hFxPw

PREDICTIONS AND OBSTACLES

Elon Musk predicts widespread use of self-driving cars: Tesla would have as many as a million autonomous “robo taxis” by the end of 2020.

Many experts are skeptical:

- It was relatively easy to enable a car to see and identify obstacles on the road with the help of radar, cameras and laser, and software to process images and data.
- It’s much more difficult to prepare self-driving cars for unusual circumstances — pedestrians crossing the road when cars have the green light, cars making illegal turns. These “corner cases” occur often in city traffic.
- Equally challenging is teaching self-driving cars “micro maneuvers.” If a vehicle ahead is looking for a parking space, it is best to not follow too closely. If a car is speeding into an intersection, trying to cross without the right of way.

Source: Neal E. Boudette , *Despite High Hopes, Self-Driving Cars Are ‘Way in the Future’, New York Times, 2019*

QUESTIONS

1.	Are self-driving cars safer than human-driven cars?
2.	Are completely autonomous cars already in operation?
3.	What are the levels of autonomous driving?
4.	Why are experts skeptical about large-scale take up of self-driving cars?

OUTLINE

WHY MACHINES CANNOT DO IT

Complex communication would stay on the human side in the new division of labor:

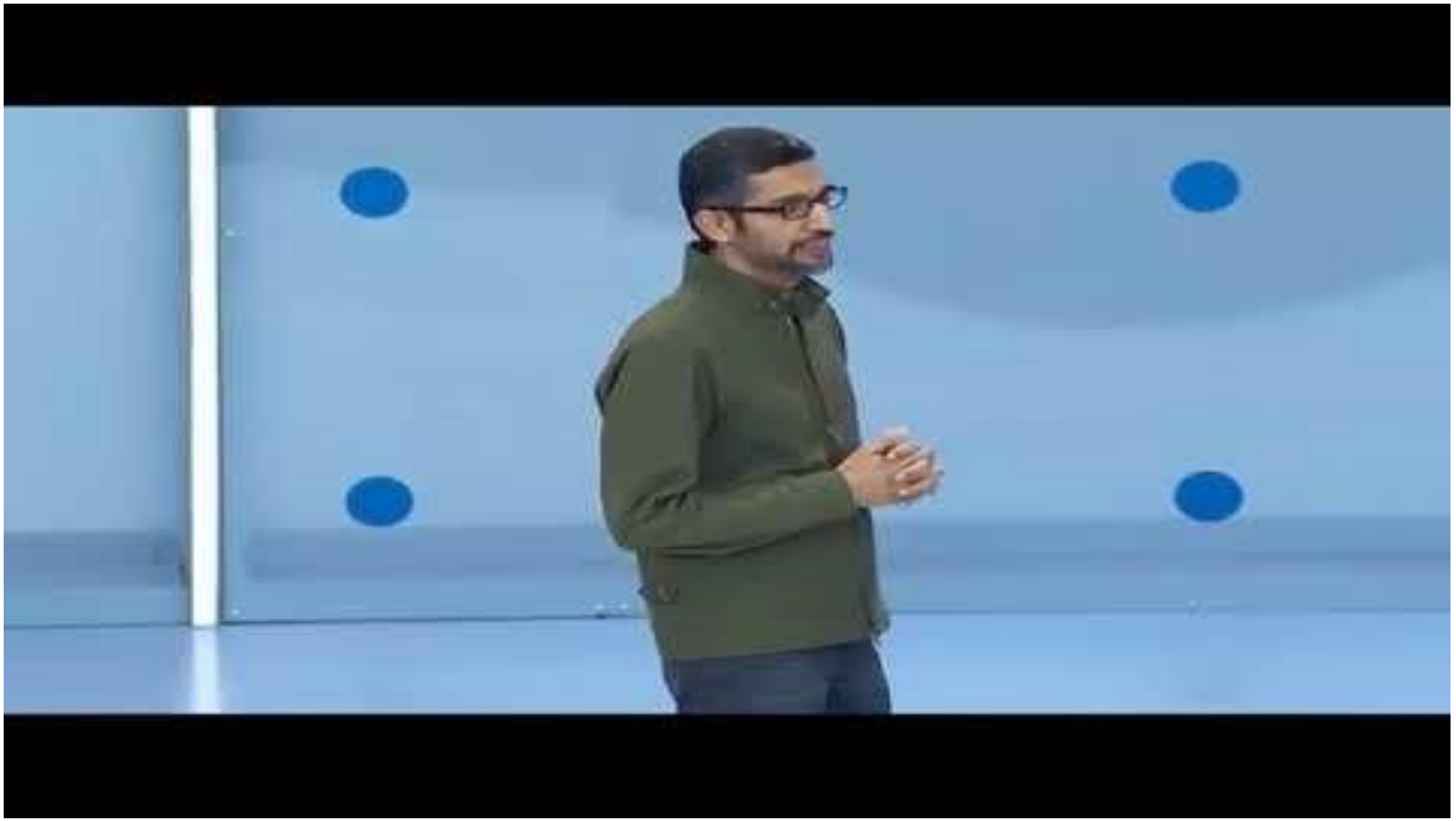
> "Conversations critical to effective teaching, managing, selling, and many other occupations require the transfer and interpretation of a broad range of information. In these cases, the possibility of exchanging information with a computer, rather than another human, is a long way off."

Source: Frank Levy and Richard J. Mornane, The New Division of Labor: How Computers are Creating the Next Job Market, Princeton Univeristy Press, 2004

EXAMPLE: GOOGLE ASSISTANT

Source: https://www.youtube.com/watch?v=GILvyiWB7xY&t=5s

EXAMPLE: GOOGLE DUPLEX



Source: https://www.youtube.com/watch?v=D5VN56jQMWM

GOOGLE DUPLEX: WHAT IS IT?

A new project from Google that is currently live in the majority of the U.S.

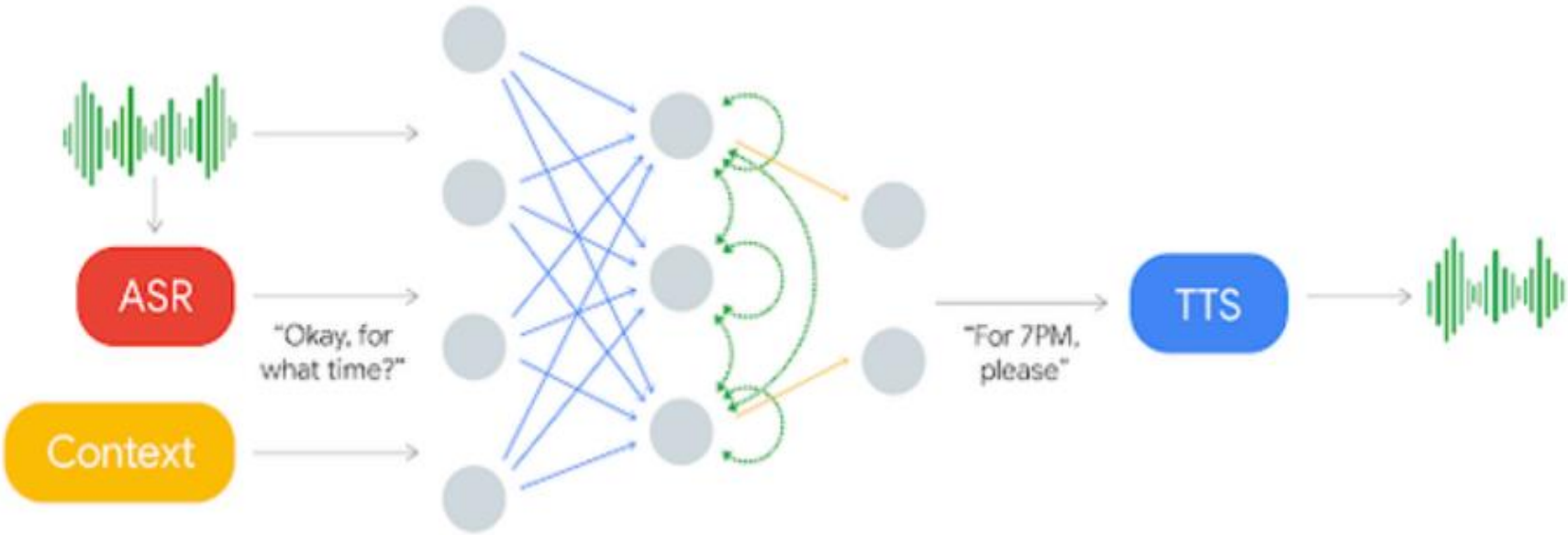
It allows certain users to make a restaurant reservation by phone.

Instead of speaking directly to the restaurant employee, Google Duplex, with the help of Google Assistant, speaks for the user with an AI-based human-sounding, voice.

Source: What is Google Duplex and how do you use it? https://www.androidauthority.com/what-is-google-duplex-869476/, 2019

GOOGLE DUPLEX: HOW DOES IT WORK?

- Voice commands + automatic speech recognition + conversation context fed into
- recurrent neural net and
- transformed into speech output via a text-to-speech generator.



Source: Hosea Siu, How does Google Duplex work?, https://www.quora.com/How-does-Google-Duplex-work

GOOGLE DUPLEX: HOW DOES IT WORK?

- **Automatic speech recognition**, a subfield of computational linguistics that enables the recognition and translation of spoken language into text by computers.
- **Voice commands** use speech recognition to understand spoken commands and answer questions, making human-computer voice-user interface possible.
- **Conversation context** means keeping track of what the conversation is about, including the state of the conversation partner, in specific conversation scenarios.
- **Recurrent neural net is a** neural net for dealing with temporal information, keeping "memory" of previous events, adjust output based on sequence of inputs, and trained on a large dataset of calls that were relevant to the specific task.
- **Speech synthesis** is the artificial production of human speech from text, often by concatenating pieces of recorded speech that are stored in a database.

Source: Hosea Siu, How does Google Duplex work?, https://www.quora.com/How-does-Google-Duplex-work

QUESTIONS

1.	Why complex communication was though a long way off for computers?
2.	What is Google Duplex about and how is it working?

OUTLINE

THE HITCHHIKERS GUIDE TO THE GALAXY – THE BABELFISH

Source: https://www.youtube.com/watch?v=D5VN56jQMWM

GOOGLE TRANSLATE

A free multilingual machine translation service by Google.

Offers a website interface, mobile apps for Android and iOS, and an API that helps developers build browser extensions and software applications.

Supports over 100 languages and serves over 500 million people daily.

Rather than translating languages directly, it first translates text to English and then to the target language.

Since 2006, applies statistical machine translation, using UN and EP transcripts to gather data. It looks for patterns in millions of documents to help decide translation.

Since 2016 switched to neural machine translation which translates whole sentences, using context to figure out the most relevant translation. 105 languages as of 2019.

Source: Wikipedia, https://en.wikipedia.org/wiki/Google_Translate

MACHINE TRANSLATION

A sub-field of computational linguistics that investigates the use of software to translate text or speech from one language to another.

Substitution of words in one language for words in another is insufficient as recognition of phrases and their counterparts in the target language is needed.

- **Rule-based translation** is based on linguistic information about source and target languages from their dictionaries and grammars.
- **Statistical translation** is translation generated on the basis of statistical models whose parameters are derived from the analysis of bilingual text corpora.
- **Neural translation** is translation that uses an artificial neural network to predict the likelihood of a sequence of words, modeling whole sentences in one model.

Source: Hosea Siu, How does Google Duplex work?, https://www.quora.com/How-does-Google-Duplex-work

INSIDE GOOGLE TRANSLATE

Source: https://www.youtube.com/watch?v=_GdSC1Z1Kzs

QUESTIONS

1.	What are the three main types of machine translation?
2.	How does Google Translate work?

OUTLINE

GAME OF JEOPARDY!

An American television game show running since 1964. 36 series and over 8000 episodes. Currently produced by Sony Pictures Television.

A quiz competition in which contestants are presented with general knowledge clues in the form of answers, and must phrase their responses in the form of questions.

Easy to understand yet extremely hard to play well: almost everyone knows answers to some questions, but very few people know the answers to almost all of them.

Questions cover a wide range of topics, and contestants are not told in advance what those topics will be.

Players also have to be simultaneously:

- fast – they compete against one another for the chance to answer
- bold – they have to try to answer a lot of questions, especially harder
- accurate – money is subtracted for each incorrect answer

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

GAME OF JEOPARDY!

Jeopardy! further challenge contestants with all kinds of wordplay.

A clue might ask, for example, for

> A rhyming reminder of the past in the city of the NBA's Kings

To answer correctly, a player would have to know:

1. what the acronym NBA stood for (National Basketball Association)
2. which city the NBA's Kings play in (Sacramento)
3. that the clue demands for a rhyming reminder of the past

The right answer is "What is a Sacramento memento?" instead of a "Sacramento souvenir" or any other factually correct response.

Responding correctly requires mastery of complex communication and pattern matching, and doing both repeatedly, accurately, and almost instantaneously.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

HUMANS VERSUS MACHINE PLAY JEOPARDY!

Three contestants:

1. Ken Jennings – won 74 times in a row in 2004, taking 3,170,000 USD in prizes
2. Brad Rutter beat Jennings in 2005 and won more than 3,400,000 USD
3. Watson - supercomputer developed by IBM specifically to play the game

Strategy: aggressive (and hence likely to be wrong) or conservative (and accurate).

Results:

- 2006: Watson tries to answer 70% of the times and correctly answers 15% of the times, versus Jennings at 70% responses and 90% of them correct.
- 2010: Watson answers 70% of the times, 85% of them correctly, but still loosing with Jennings and Rutter.
- 2011: Watson wins on speed and accuracy with both players.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

HUMANS VERSUS MACHINE PLAY JEOPARDY!

Source: https://www.youtube.com/watch?v=_GdSC1Z1Kzs

HUMANS VERSUS MACHINE PLAY JEOPARDY!

Ken Jennings:

> "*I for one welcome our new computer overlords.*"
>
> "*Just as factory jobs were eliminated in the twentieth century by new assembly-line robots, Brad and I were the first knowledge-industry workers put out of work by the new generation of 'thinking' machines. 'Quiz show contestant' may be the first job made redundant by Watson, but I'm sure it won't be the last.*"

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

QUESTIONS

1.	Why is the game of Jeopardy! particularly difficult to play?
2.	What made the Watson computer win with masters of the game?

OUTLINE

ROBOTICS

Three laws of robotics:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.

2. A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.

3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

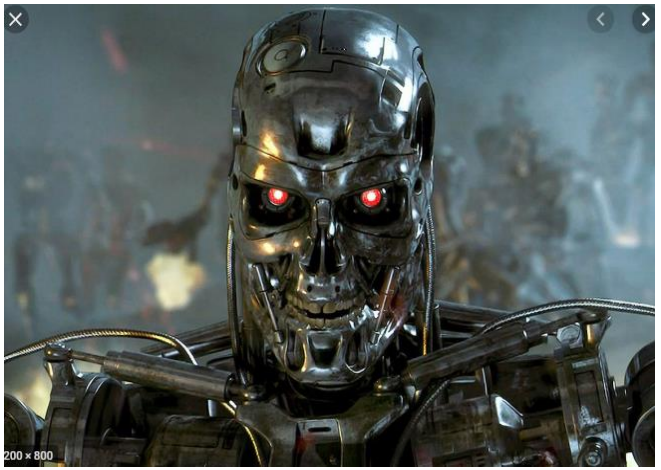
Isaac Asimov, 1941

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

ROBOTICS

Asimov exerted enormous influence on science fiction and real-world robot-making. While science fiction produced numerous creations:

R2-D2 BB8 Cylon Terminator



Robotics research produced Honda's ASIMO…

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

HONDA'S ASIMO ROBOT IN 2006

Source: https://www.youtube.com/watch?v=VTlV0Y5yAww

MORAVEC'S PARADOX

Hans Moravec:

> "*It is comparatively easy to make computers exhibit adult-level performance on intelligence tests or playing checkers, and difficult or impossible to give them the skills of a one-year-old when it comes to perception and mobility.*"

Moravec's paradox:

> "*the discovery by artificial intelligence and robotics researchers that, contrary to traditional assumptions, high-level reasoning requires very little computation, but low-level sensorimotor skills require enormous computational resources.*"

Steven Pinker:

> *"As the new generation of intelligent devices appears, it will be the stock analysts and petrochemical engineers and parole board members who are in danger of being replaced by machines. The gardeners, receptionists, and cooks are secure in their jobs for decades to come."*

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

HUMAN ADVANTAGE

When it comes to work in the physical world, humans have a huge flexibility advantage over machines.

Automating a single activity, like fastening two parts together with screws, is pretty easy, but that task must remain constant and take place in a 'regular' environment.

For example, the parts must show up in exactly the same orientation every time.

Companies buy specialized machines for tasks like these, have their engineers program and test them, then add them to their assembly lines.

Each time the task changes—each time the location of the screw holes move, for example—production must stop until the machinery is reprogrammed.

Today's factories are highly automated, but they're not full of general-purpose robots. They're full of dedicated machinery that's expensive to buy and configure.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

WAREHOUSE WITH GROCERY PACKING ROBOTS

Source: https://www.youtube.com/watch?v=4DKrcpa8Z_E

QUESTIONS

1.	What are the Asimov’s three rules of robotics?
2.	What is the Moravec’s paradox?

OUTLINE

PEOPLE ON THE AUTOMATED FACTORY FLOOR

Scarce but not absent.

An assembly line for filling up jelly jars:

- a person places the empty jars on the conveyor belt to start the process
- a machine squirt a precise amount of jelly into each jar, screw on the top, and stick on the label

Why hasn't placing empty jars on the conveyor belt been automated?

- The jars are delivered to the line twelve at a time in cardboard boxes that don't hold them firmly in place.
- This imprecision presents no problem to a person, who sees the jars in the box, grabs them, and puts them on the conveyor belt
- Traditional industrial automation has great difficulty with jelly jars that don't show up in exactly the same place every time.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

FLEXIBLE, COLLABORATIVE ROBOTICS

Rethink Robotics founded in 2008 to make progress against Moravec's paradox.

Creating robots that:

- can pick jelly jars and handle other imprecise tasks done by people in factories
- won't need to be programmed by engineers but taught by shop floor workers
- cost a fraction of the cost of current industrial robots

Baxter:

- sensing and manipulating objects with 'hands' ranging from grips to suction cups.
- it can do two things at once; its two arms are capable of operating independently
- not as fast or fluid as a well-trained human worker at full speed, most assembly lines do not operate at full human speed; they would tire people out if they did
- can work all day every day without needing sleep, lunch, or coffee breaks
- it won't demand healthcare or add to the payroll tax burden

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016
Source: https://www.youtube.com/watch?v=Gobjbec_zUo

FLEXIBLE, COLLABORATIVE ROBOTICS

Source: https://www.youtube.com/watch?v=Gobjbec_zUo

DARPA ROBOTIC CHALLENGE

The 2014 DARPA Robotics Challenge:

- The primary technical goal is to develop ground robots capable of executing complex tasks in dangerous, degraded, human-engineered environments.
- Robots will have to be able to:
  - drive a utility vehicle,
  - remove debris blocking an entryway,
  - climb a ladder,
  - close a valve, and
  - replace a pump.
- Combining tool use, mobility, sensing, telepresence, and many other long-standing challenges in the field.

Pushing further past Moravec's paradox.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

CHIMP ROBOT AT DARPA ROBOTIC CHALLENGE

Source: https://www.youtube.com/watch?v=Gobjbec_zUo

QUESTIONS

1.	Why traditional factory automation need people on the factory floor?
2.	What was the 2014 DARPA robotic challenge about?

OUTLINE

FROM LAB TO REALITY

Evidence of technological advancement:

- Self-driving cars,
- Complex communication
- Language translation
- Human-machine competition
- Robotics
- Flexible robotics

are showing off their abilities in the real world, not only as lab demos.

They add to growing evidence that we're at an inflection point:

> a bend in the curve where many technologies that used to be found only in science fiction are becoming everyday reality.

More evidence?

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

CASE 7: SENSING DEVICES

On the Star Trek series, devices called tricorders were used to scan and record three kinds of data: geological, meteorological, and medical.

Today's consumer smartphones serve all these purposes:

- as seismographs,
- as real-time weather radar maps,
- as heart- and breathing-rate monitors.

But they are not limited to these domains: media players, game platforms, reference works, cameras, and GPS devices.

On Star Trek, tricorders and person-to-person communicators were separate devices, but in the real world the two have merged in the smartphone.

They enable users to access and generate huge volumes of information as they move around, enabling SoLoMo – social, local, and mobile innovations.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

CASE 8: WRITING PROSE

Computers have been bad at writing real prose. In recent times they have been able to generate grammatically correct but meaningless sentences.

In 2008, International Conference on Computer Science and Software Engineering accepted the paper

> Towards the Simulation of E-commerce
>
> Abstract: Recent advances in cooperative technology and classical communication are based entirely on the assumption that the Internet and active networks are not in conflict with object-oriented languages. In fact, few information theorists would disagree with the visualization of DHTs that made refining and possibly simulating 8 bit architectures a reality, which embodies the compelling principles of electrical engineering.

The paper was 'written' by SCIgen, a program from MIT that generates random Computer Science research papers.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

CASE 9: GENERATING BUSINESS REPORTS

Forbes.com has contracted with the company Narrative Science to write the corporate earnings previews that appear on the website.

These stories are all generated by algorithms without human involvement. And they're indistinguishable from what a human would write:

> *Forbes Earning Preview: H.J. Heinz*
>
> *A quality first quarter earnings announcement could push shares of H.J. Heinz (HNZ) to a new 52-week high as the price is just 49 cents off the milestone heading into the company's earnings release on Wednesday, August 29, 2012.*
>
> *The Wall Street consensus is 80 cents per share, up 2.6 percent from a year ago when H.J reported earnings of 78 cents per share.*
>
> *The consensus estimate remains unchanged over the past month, but it has decreased from three months ago when it was 82 cents…*

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

CASE 10: ADDITIVE MANUFACTURING

2D printing: depositing a very thin layer of material (ink, traditionally) on a base (paper) in a pattern determined by the computer.

3D printing or additive manufacturing:

- printer deposits layers one on top of the other
- instead of ink, liquid plastic is used that gets cured into a solid by ultraviolet light
- each layer is very thin but over time a three-dimensional object takes shape
- the shape can be quite complicated, with voids, tunnels parts moving independently of one another, etc.
- it might be used to print out replacement parts for faulty engines on the spot instead of maintaining stockpiles of them in inventory

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

WHAT NEW SKILLS ARE BEING ACQUIRED BY MACHINES?

SELF-DRIVING CARS, COMPLEX COMMUNICATION, LANGUAGE TRANSLATION, QUIZ COMPETITION, ROBOTICS, FLEXIBLE ROBOTICS, AND MANY OTHERS

OUTLINE

WHAT ARE MACHINES BETTER AT THAN HUMANS?

HUMAN COMPUTERS

One hundred years ago computer was a job title.

It was performed by people doing arithmetic and tabulating the results.

Innovators designed machines that could take over more and more of this work; they were first mechanical, then electro-mechanical, and eventually digital.

Today, there are no human computers, because the nonhuman ones are far cheaper, faster, and more accurate.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

NON-HUMAN COMPUTERS

Computers aren't just for performing arithmetic, they are symbols processors.

Their working can be interpreted in the language of ones and zeroes, but equally true or false, yes or no, or any other symbolic system.

They can do all manner of symbolic work, from math to logic to language.

But:

- people still write all books; digital novelists are not available
- entrepreneurs, scientists, nurses, etc. are all people

What is it about their work that makes it harder to digitize than what human computers used to do?

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

INFORMATION PROCESSING TASKS

Information processing tasks – the foundation of all knowledge work:

- Application of specific rules
- Application of implicit rules that a human can infer
- Pattern recognition based on implicit rules that software can infer
- Pattern recognition where rules cannot be inferred

Processing Tasks (listed in order of increasing complexity)			
Conscious application of rules	Application of implicit rules that human observers can infer	Pattern recognition based on implicit rules that learning software can infer	Pattern recognition (rules cannot be inferred)
Examples			
Arithmetic	Mortgage underwriting	Detection of cancerous cell clusters in mammograms	A truck driver turning left against traffic; a doctor reading an echocardiogram

Source: Frank Levy and Richard J. Mornane, The New Division of Labor: How Computers are Creating the Next Job Market, Princeton Univeristy Press, 2004

COMPUTERS ARE GOOD AT FOLLOWING RULES

Arithmetic and similar tasks require the application of well-understood rules.

Computers are good at following rules so should to arithmetic and related tasks, e.g. calculate a person's credit score to approve or disapprove mortgage applications..

BOX 2.1

DECISION STAGE OF A MORTGAGE SCORING MODEL

```
10 If (Mortgage Score > Threshold 1), Go to 20
11 If (Mortgage Score > Threshold 2), Go to 22
12 Application Status = Reject
13 Go to 25
20 Application Status = Approved
21 Go to 25
22 Application Status = Refer with Caution
25 Print Application Result
```

Source: Frank Levy and Richard J. Mornane, The New Division of Labor: How Computers are Creating the Next Job Market, Princeton Univeristy Press, 2004

COMPUTERS ARE BAD AT PATTERN RECOGNITION

Information processing tasks that cannot be boiled down to rules or algorithms but which draw on the human capacity for pattern recognition.

Our brains are:

- good at taking in information via our senses and examining it for patterns but
- bad at describing or figuring out how we're doing it, especially when a large volume of fast-changing information arrives at a rapid pace.

"We know more than we can tell." Michael Polanyi

When this is the case, tasks can't be computerized and will remain in the domain of human workers.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

PATTERN RECOGNITION EXAMPLE

Driving a vehicle in the traffic is provided as an example:

- As the driver makes his left turn against traffic, he confronts a wall of images and sounds generated by oncoming cars, traffic lights, storefronts, billboards, trees, and a traffic policeman.
- Using his knowledge, he must estimate the size and position of each of these objects and the likelihood that they pose a hazard… The truck driver [has] the schema to recognize what [he is] confronting.
- But articulating this knowledge and embedding it in software for all but highly structured situations are at present enormously difficult tasks…
- Computers cannot easily substitute for humans in [jobs like driving].

Source: Frank Levy and Richard J. Mornane, The New Division of Labor: How Computers are Creating the Next Job Market, Princeton Univeristy Press, 2004

BUT … TECHNOLOGY IS ACCELERATING REGARDLESS

Self-driving cars went from being the stuff of science fiction to on-the-road reality.

Cutting-edge research explaining why they were not coming anytime soon was outpaced by cutting-edge science and engineering that brought them into existence.

And self-driving cars are not an anomaly; they're part of a broad pattern.

Progress on some of the oldest and toughest challenges associated with computers, robots, and other digital gear was gradual for a long time.

Then in the past few years it became sudden; digital gear accomplishing tasks it had always been lousy at and displaying skills it was not supposed to acquire.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

WHAT ARE MACHINES BETTER AT THAN HUMANS?

MACHINES ARE BETTER AT FOLLOWING RULES.

QUESTIONS

1.	What tasks are computers good at?
2.	What tasks are computers traditionally bad at?
3.	What is the series of increasingly complex information processing tasks?
4.	Why was car driving though unsuitable for computers?

OUTLINE

HOW DO MACHINES EXTEND THEIR COMPETENCES?

ACCELERATING TECHNOLOGICAL ADVANCEMENT

The innovations described earlier occurred in just the past few years.

They've taken place in areas where improvement had been very slow for a long time, and where the best thinking often led to the conclusion that it wouldn't speed up.

But then digital progress became sudden after being gradual. How did this happen?

Was it a confluence of a number of lucky one-time advances?

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

UNDERLYING REASONS FOR TECHNOLOGICAL PROGRESS

To understand why technological progress is unfolding now, we need to understand its nature in the era of digital hardware, software, and networks.

Three characteristics of technological progress:

- exponential,
- digital, and
- combinatorial

will be explained in the forthcoming lecture.

The progress we've seen recently, while impressive is a small indication of what's to come. It's the dawn of the second machine age.

Source: E. Brynjolfsson and A. McAfee, The Second Machine Age, 2016

HOW DO MACHINES EXTEND THEIR COMPETENCES?

THEY EXTEND THEIR COMPETENCES THROUGH THE NATURE OF TECHNOLOGICAL INNOVATION, WHICH IS EXPONENTIAL, DIGITAL AND COMBINATORIAL.

THANK YOU FOR YOUR ATTENTION

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