The Second Machine Age

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Fromm Institute for Lifelong Learning
Spring Session 2018
The Second Machine Age

• **Lecture 8 preview**
  • The current state and the future of AI
  • Selected technologies of the future
    • Robots
    • Autonomous vehicles
    • Medical instruments and applications
    • Brain-computer interfaces
  • Recommended further reading
Impact of AI on employment and work

• **The future of online retailing is bright** -- *The Economist*, Oct. 2017 --
  • the decline in traditional retail jobs in America ... offset by a rise in warehousing work.
  • 2007 to 2017: number of retail jobs shrunk by 140,000
    • e-commerce and warehousing jobs rose by about 400,000
  • ... net gain may be temporary.

• Stores are only now starting to close; those that remain are just testing automation.
• More **robots** will be used in warehouses, too ... workers will need new skills
•
• **Amazon and Alibaba** ... benefit from *network effects*.
  • The more shoppers, the more sellers, attracting yet more shoppers.
• ... which industry will change next?
Impact of AI on employment and work

- *McKinsey Global Institute report on Automation*

  - Physical **robots** have been around for a long time in manufacturing
    - more capable, more flexible, safer, and less expensive robots - in expanding activities
    - combining mechanization with cognitive and learning capabilities—
    - improving over time as they are trained by their human coworkers on the shop floor,
    - or increasingly *learn by themselves*
Impact of AI on employment and work

- *McKinsey Global Institute report on Automation*

- **EMPLOYMENT AND WORK**
  - concerns about the effect on employment and the future of work.
  - For most occupations, partial automation is more likely than full automation
  - Overall, we estimate that about *half of the activities* that people are paid to do
  - have the potential to be automated

- about *30 percent of the activities in 60 percent of all occupations could be automated* (Exhibit 8).
  - This means that many workers will work alongside rapidly evolving machines,
  - worker skills also must evolve.
Exhibit 8: While few occupations are fully automatable, 60 percent of all occupations have at least 30 percent of activities that are technically automatable.

Automation potential based on demonstrated technology of occupation titles in the United States

Example occupations
- Sewing-machine operators
- Assembly line workers
- Stock clerks
- Travel agents
- Dental technicians
- Bus drivers
- Nursing assistants
- Web developers
- Fashion designers
- Chief executives
- Psychiatrists
- Legislators

Share of roles, %
100% = 820 roles

While about 5% of occupations could have close to 100% of tasks automated...

... more occupations will have portions of their tasks automated, e.g. 60% of occupations could have 30% of tasks automated.
Impact of AI on employment and work

- *McKinsey Global Institute report on Automation*
  - **EMPLOYMENT AND WORK**
    - Humans will still be needed in the workforce.
    - Technologies replace some jobs, but *create new work*
      - in industries that most of us cannot even imagine,
      - *new ways to generate income* and match talent to jobs
    - The modern 9-to-5 job dates back to the Industrial Revolution
    - Now challenged by *technology-enabled independent work*

- 15 percent of independent work is on *digital platforms*, growing rapidly
- driven by scale, efficiency, and ease of use for workers and customers
- Such platforms as *Uber, Etsy, Didi*, and others
Exhibit 4: Machine learning has broad potential across industries and use cases
Exhibit 3: The extent of digitization varies by sector

MGI Sector Digitization Index—US example
2015 or latest available US data

Sector

ICT¹
Media
Professional services
Finance and insurance
Wholesale trade
Advanced manufacturing
Oil and gas
Utilities
Chemicals and pharmaceuticals
Basic-goods manufacturing
Mining
Real estate
Transportation and warehousing
Education
Retail trade
Entertainment and recreation
Personal and local services
Government
Healthcare
Hospitality
Construction
Agriculture and hunting

Assets
Overall
digitization
Digital
spending
Digital-
asset
stock
Usage
Transactions
Inter-
actions
Business
processes
Market
making
Labor
Digital
spending
on
workers
Digital
capital
deepening
Digitization
of work

Relatively low
digitization
● Digital leaders within relatively undigitized sectors
Relatively high
digitization
Current state of AI

• “Progress in AI isn’t as impressive as you might think”
  • By Will Knight, MIT Technology Review, Nov., 2017

• “… it’s clear we are a long way from artificial general intelligence”
  • -- Erik Brynjolfsson
Current state of AI

• Cites the **Al Index Report**, Nov. 2017
  • Created and launched as a project of the *One Hundred Year Study on AI*
    • at Stanford University (AI100),
  • **Al Index** is an open, not-for-profit project
    • to *track activity and progress in AI*.
    • *This is the inaugural annual report of the Al Index,*
The number of AI papers produced each year has increased by more than 9x since 1996.
11x

Introductory *AI class enrollment at Stanford has increased 11x since 1996.*

*Note:* The dip in Stanford ML enrollment for the 2016 academic year reflects an administrative quirk that year, not student interest. Details in appendix.

**AI Index Report, Nov. 2017**
The number of active US startups developing AI systems has increased 14x since 2000.
6x Annual VC investment into US startups developing AI systems has increased 6x since 2000.
Sentiment of Articles Referencing AI

<table>
<thead>
<tr>
<th>Date</th>
<th>Positive</th>
<th>Negative</th>
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<tbody>
<tr>
<td>2013</td>
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<td>2016</td>
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</table>

Source: TrendKite

AI Index Report, Nov. 2017
Speech Recognition, Switchboard HUB5'00

Source: Electronic Frontier Foundation, AI Progress Metrics
Current state of AI

• AI in China
  • What about the quality of China's AI products?
  • ... China was nothing but copycats around 15 years ago.
  • Smart and eager Chinese tech giants and entrepreneurs have morphed by western innovations to exceed their overseas counterparts.
  • An example in AI, Chinese face recognition startup Face++ recently won first place in 3 computer vision challenges, ahead of teams from Google, Microsoft, Facebook, and CMU.
Current state of AI

• **AI in China**
  
  • The pro-tech, pro experimentation, and pro speed attributes put China in a position to become a very strong AI power.

  • In this age of AI, I predict that the **United States-China duopoly** is not only inevitable.

  • It has already arrived.
    
    • – Kai-fu Lee, *Sinovation*

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*Al Index Report*, Nov. 2017
Current state of AI

- **AI** -- comments by Andrew Ng -- *Coursera, Stanford*

  - AI is the new electricity, and is transforming multiple industries.
  - AI is now a global phenomenon,
  - The AI Index reminds us to look beyond our own borders to understand progress.
  - The US and China have the greatest investments and the most rapid adoption
  - Canada and UK also making groundbreaking research contributions.

*AI Index Report, Nov. 2017*
Current state of AI

• **AI** -- comments by Andrew Ng -- *Coursera, Stanford*

  • AI changes the foundation of many technology systems
    • *web search, autonomous driving, customer service chatbots*

  • Countries with more sensible AI policies will advance more rapidly, and those with poorly thought out policies will risk being left behind.

*AI Index Report*, Nov. 2017
Current state of AI

• Al – comments by Tim Cook, CEO of Apple, June 2017 (MIT Commencement)

• “I’m not worried about artificial intelligence giving computers the ability to think like humans.
• I’m more concerned about people thinking like computers without values or compassion, without concern for consequences.
• ... if science is a search in the darkness, then the humanities are a candle that shows us where we’ve been and the danger that lies ahead.

• As Steve [Jobs] once said, **technology alone is not enough**.
• It is technology married with the liberal arts married with the humanities that make our hearts sing.
• *keep people at the center of what you do*
Current state of AI

- AI – comments by Sebastian Thrun, Stanford, Udacity

  - I believe that ... AI will be able to free us from repetitive work.
  - AI will be able to watch human experts at work, and gradually acquire the skills of our daily work.
  - more and more repetitive work will be done by the machines, freeing us up to pursue more creative work.
  - ...
  - With this new revolution, I predict we will enter an era of unprecedented human creativity.
  - ...
  - ... As a society, we need to find new ways to help all of us adapt to [these] changes.
Current state of AI

• Comments by Michael Wooldridge, Oxford

• There is, clearly, an AI bubble at present;
  • the question is whether this bubble will burst
    • like the dot com boom of 1996-2001
  • or gently deflate;

• When this happens, what will be left behind?

• I think there is substance underneath the current AI bubble
  • Major companies now understand **how to use AI techniques productively.**
Current state of AI

• Comments by Fei-Fei Li, Stanford & Google

  • “We need to be much more human-centered.
    • the great triumph of pattern recognition.
    • very task-focused,
    • lacks contextual awareness

  • We want technology that makes humans’ lives better, our world safer, our lives more productive and better.

  • bring back contextual understanding. ...  
  • knowledge abstraction and reasoning.
Current state of AI

• Comments by Josh Tenenbaum, Professor, MIT CSAIL,
  • conference on *AI and the Future of Work*—
  • presented by MIT's *Computer Science and Artificial Intelligence Laboratory* (CSAIL)
  • and its *Initiative on the Digital Economy*

• While we have AI technologies, we don't have real AI.

• Instead we have *systems that do just one thing, based on pattern recognition*.

• Real intelligence would instead *model* the world, *explain*, and *understand* what it sees, *imagine, learn*, and *build new models* of the world.

  • We're decades away from an AI that could accomplish this,

  • “3-month-old babies have more commonsense understanding of things in the world”
AI is everywhere

• Selected headlines ...

• European Commission unveils €1.5bn AI funding

• China's State Council, has goals to build an artificial intelligence industry
  • worth nearly $150 billion by 2030

• Building A.I. That Can Build A.I.
  • Google and others, fighting for a small pool of researchers, are looking for automated ways to deal with a shortage of artificial intelligence experts.
  • with AutoML, Google ... is building algorithms that analyze the development of other algorithms, learning which methods are successful and which are not. Eventually, they learn to build more effective machine learning.
  • New York Times  https://nyti.ms/2j1KU0d

• IBM scientists say radical new ‘in-memory’ computing architecture will speed up computers by 200 times
  --- Kurzweil AI (newsletter)
Selected technologies of the future

• Robots
• Autonomous vehicles
• Medical instruments and applications
• Brain-computer interfaces
Robots

• **Robots as co-workers** — KUKA development lab in Augsburg, Germany
  • Robots that help professionals with tedious and dangerous tasks
    • **LBR** for “Leichtbauroboter,” lightweight robot, **iiwa** for “intelligent industrial work assistant.”
  • Has fast-reaction time; can easily find and handle delicate components.
  • Work side-by-side with humans, not behind safety gates.
  • part of what's called Industry 4.0 also known as the **fourth industrial revolution**, tenets:
    • interoperability,
    • information transparency
    • technical assistance
    • decentralized decisions
  • Popular Science, 2018:
Robots

• **Cyclocopter**  
  [https://youtu.be/gbn0Bnt3iDs](https://youtu.be/gbn0Bnt3iDs)

• Cyclocopter aerodynamics is more like that of insects
• **Lift is generated by stirring the air into vortices** rather flow over aerofoils.

• Cyclocopters **get better as they get smaller**; also quieter.
  • “aerodynamic noise is a strong function of the blade- tip speed”
  • better manoeuvrability, and are less disturbed by gusts of wind

• Cyclocopters are about two years away from commercial production.

• Once that happens they could displace polycopters in many roles
Robots

• Robots that hop.
  • One of the most advanced is **Salto**, developed by the Biomimetic Millisystems Laboratory at the University of California, Berkeley.
Robots

• **Robots that hop.**
  • Salto (pictured) is a **monopod weighing 98 grams** that has a rotating tail and side-thrusters.
  • These let it stabilize itself and reorient in mid-leap.
  • That gives it the agility to bounce over uneven surfaces and also to climb staircases.
Robots

• Backflipping robot

• Robo-bee / Robo-fly
  • The team copied nature by equipping their device with a pair of wings which flapped 120 times a second (close to the frequency of a fly’s wing beat).
  • They partly overcame the second hurdle by doing away with conventional motors and driving the wings using a piezoelectric ceramic that flexes in response to electrical currents.
  • added an 8mg solar cell to their device. Focusing a laser on this cell lets them power the robot without wires
    • https://youtu.be/7DXuxGErs9k

• Amazon sorting robot challenge
  • https://youtu.be/yVIRLao1E28
Robots

• **Drones**
  • Today’s drones are mostly flying cameras. They are already being put to a wide range of business uses
    • [https://www.economist.com/technology-quarterly/2017-06-08/civilian-drones](https://www.economist.com/technology-quarterly/2017-06-08/civilian-drones)

  • The FAA’s part 107 rules, providing for **certification of commercial drone operators**, are generally seen as a model by other countries.

  • These rules, a decade in the making, allow operators with a remote-pilot certificate (obtained by passing a test costing $150) to fly a drone for commercial purposes
    • during the day,
    • within line of sight,
    • in uncontrolled airspace, and
    • without flying over people who are not involved in operating the drone.
Robots

Drones

Civilian drones, worldwide

Number, m

FORECAST

Personal

Revenue, $bn

1.1

2.2

6.6

4.6

2015*

16*

17

18

19

20
Autonomous vehicles

- Uber Robocar Kills Pedestrian, Despite Presence of Safety Driver
  - It's the first fatality involving a robocar under the care of a professional human minder
    - IEEE Spectrum, 19 Mar 2018
Autonomous vehicles

• The view from the autonomous car control system
  • [https://youtu.be/MqUbdd7ae54](https://youtu.be/MqUbdd7ae54)
  • [https://youtu.be/nXlqv_k4P8Q](https://youtu.be/nXlqv_k4P8Q)

• 10 million self-driving cars will be on the road by 2020
  • --Business Insider
Autonomous vehicles

• *The success of AVs will depend on sensible regulation*
  • The Economist (special report) Mar 1, 2018

• **Waymo**, Alphabet’s AV effort, is testing a robotaxi service in Chandler, a suburb of Phoenix, and hopes to launch a commercial service later this year.

• **Uber** is operating driverless taxis in parts of Phoenix and Pittsburgh;
  • Users who hail a ride may find themselves being picked up by an autonomous car, supervised by an engineer
  • (Uber gives riders the option to use an ordinary car instead if they prefer).
Autonomous vehicles

• The success of AVs will depend on sensible regulation
  • The Economist (special report) Mar 1, 2018

• Voyage, an AV startup, runs a robotaxi service in The Villages, a retirement community in San Jose, and is expanding to a second location, in Florida.

• Navya, a French startup, is operating an eight-seater autonomous shuttle bus in downtown Las Vegas, with three stops along a 1km (0.6 mile) route.
• It also has shuttles running in several other cities around the world, as does Easymile, a rival French firm.
Autonomous vehicles

• When an AV gets confused and does not know how to respond, or makes the wrong decision, the safety engineer in the driving seat takes over.

• This is known as a “disengagement”, and the number of disengagements per 1,000 miles travelled provides a crude measure of how the companies developing AVs compare (see chart).
## Autonomous vehicles

### I give up

Testing of autonomous vehicles in California*, December 2016-November 2017

<table>
<thead>
<tr>
<th>Company</th>
<th>Disengagement rate† per 1,000 miles</th>
<th>Total number of disengagements†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waymo</td>
<td>0.2</td>
<td>352,544</td>
</tr>
<tr>
<td>Renault-Nissan</td>
<td>4.8</td>
<td>5,007</td>
</tr>
<tr>
<td>Cruise (GM)</td>
<td>5.7</td>
<td>18,517</td>
</tr>
<tr>
<td>Baidu</td>
<td>24</td>
<td>1,971</td>
</tr>
<tr>
<td>Delphi</td>
<td>45</td>
<td>1,810</td>
</tr>
<tr>
<td>Bosch</td>
<td>411</td>
<td>1,454</td>
</tr>
<tr>
<td>Mercedes-Benz</td>
<td>774</td>
<td>1,088</td>
</tr>
</tbody>
</table>

*Source: California Department of Motor Vehicles
†Self-driving mode stopped owing to system error or human intervention

*Ford, Tesla and Uber do not test in California
Autonomous vehicles

• *Disengagements* are best seen not as failures but as learning experiences that help AV systems improve.

• *Sensor data recorded in the lead-up to a disengagement* can reveal what the car got wrong

• Modifications to its software can then be *tested in simulation*.
  • “We can play it back again and again, vary the scenario and see the distribution of outcomes”
  • The improved software is then rolled out in real cars.
Autonomous vehicles

• AVs are **on the cusp of working on public roads**
  • at least *in orderly environments with good weather.*
  • “Once you can crack that nut, it’s incremental,”

• **Intel**, a chipmaking giant, bought Mobileye, a maker of autonomous-driving systems, for $15.3bn in March 2017.

• **GM** bought Cruise, an AV startup, for $1bn in March 2016, set up Maven, a car-sharing service, and invested $500m in Lyft, Uber’s main ride-hailing rival in America.

• **Ford** fired its CEO in May 2017, partly in response to concerns that the firm was falling behind in electric and autonomous vehicles; it is now investing $1bn in Argo, an AV startup, and also has an alliance with Lyft.
Autonomous vehicles

• **Delphi**, a big parts maker, bought nuTonomy, an AV startup, for $450m, and has since reinvented itself as an AV company called Aptiv.

• **Uber** recently agreed to buy 24,000 self-driving cars from **Volvo**, for use in its robotaxi fleet; it also has a partnership with Daimler.

• For its part, **Daimler** has been buying up ride-hailing services across Europe and the Middle East that compete with Uber, also owns a car-sharing service.

• **Volkswagen**, Europe’s biggest carmaker, has struck a deal with Aurora, an AV startup founded by veterans of Google, Uber and Tesla.

• **And so on**. In short, the tectonic plates of technology and carmaking are colliding, heralding a **carquake**.
Autonomous vehicles

• Contrary opinion
  • If the driverless economy is imminent, and the endgame is fleets of fully utilized robot vehicles that create *radical reductions in personal vehicle ownership,*
  • **why would a car company be complicit in undermining its own market?**
  
  • The answer is that it wouldn’t.

• No car company actually expects the futuristic, crash-free utopia of streets packed with Level 5 driverless vehicles to transpire anytime soon, nor for decades.
  
  • *–Car and Driver, Oct., 2017*
Medical instruments and applications

• Robotic labs for high-speed genetic research
  • London DNA Foundry can build and test 15,000 different genetic designs in a day
    • Broad Institute in Cambridge, Massachusetts; Silicon Valley; National University of Singapore

• FDA-approved smartphone apps for treatment (digital therapeutics)
  • opioid addiction, schizophrenia, anxiety, insomnia, PTSD, depression, chronic pain

• "Ultrasound on a Chip" Tool Could Revolutionize Medical Imaging
  • FDA clearance for 13 clinical applications, including cardiac scans, fetal and obstetric exams, and musculoskeletal checks
  • shipping units in 2018 at an initial price of about $2,000 (works with iPhone)
Medical instruments and applications

• **Apple and Amazon’s moves in health** signal a coming transformation

  • **Apple’s Health Records**
    • allow users to view, manage and share their medical records

  • **Amazon** announced a partnership with Berkshire Hathaway and JPMorgan Chase
    • a not-for-profit health-care company for their own employees

• **Alphabet**, Google’s parent, has just launched **Cityblock Health**,
  • alongside **Verily**, a subsidiary in San Francisco,
  • and **DeepMind Health**, an arm of its London-based artificial-intelligence (AI) firm
  • claims to be able to **use AI to predict** possible deaths of hospitalized patients two days earlier

  • -- *The Economist, Feb 3rd 2018*
Brain-computer interfaces

• **BCIs** may redefine what it means to be human.
  - *Thought experiments*  *The Economist, Jan 6th 2018 – Technology Quarterly*
    - In search of Serendipity
    - Turning brain signals into useful information
  - The best route forward for signal processing in a brain-computer interface is likely to be **some combination of machine learning and brain plasticity**

• **Sensory vest** - David Eagleman, neuroscientist
  - [https://www.ted.com/talks/david_eagleman_can_we_create_new_senses_for_humans](https://www.ted.com/talks/david_eagleman_can_we_create_new_senses_for_humans)

• BCIs as a way for humans to **co-exist with AI**
  - rather than be subjugated to it.
  - In 2016 Elon Musk, the boss of SpaceX and Tesla
  - founded a new company called *Neuralink*, which is working to create new forms of implants
Further suggested reading

• Machine, Platform, Crowd: Harnessing Our Digital Future.
• Life 3.0: Being Human in the Age of Artificial Intelligence
• Grave New World: The End of Globalisation, the Return of History
• The Next Era of Human Machine Partnerships
• (SciFi) Snow Crash
Further suggested reading

• **Machine, Platform, Crowd: Harnessing Our Digital Future.**
  - Erik Brynjolfsson, & Andrew McAfee, MIT Sloan School professors
  - Explain how rapid advances in machine learning are presenting new opportunities for businesses.
  - Discuss the potential impact of AI on the economy,
  - How workforces will interact with AI in the future
Further suggested reading

• **Life 3.0: Being Human in the Age of Artificial Intelligence**
  • *Max Tegmark* Knopf 2017 360 pp.
    • Whether it’s reports of a new and wondrous technological accomplishment or of the danger we face in a future filled with unbridled machines, artificial intelligence (AI) has recently been receiving a great deal of attention.
    • If you want to understand what the fuss is all about, Max Tegmark’s original, accessible, and provocative book would be a great place to start.
    • The book’s goal is not to tell us what being human will look like in the years ahead, as the title might seem to suggest, but rather to give us the background necessary to understand where technology might lead the human species.
    • In this it succeeds, bringing well-timed clarity to the sometimes muddled public view of AI that has emerged over the past few years.
Further suggested reading

• Grave New World: The End of Globalisation, the Return of History
  • by Stephen King, Yale University Press; 290 pages, $30

  • Mr. King argues that economic progress that reaches beyond borders is not “an inescapable truth”. ...
  • The result is that ‘co-operative arrangements between nation states will be increasingly hard to come by.
  • Conflict – at least in the economic sphere – will become ever more frequent.”
Further suggested reading

• “The Next Era of Human Machine Partnerships”
  • by Dell & Institute for the Future  http://www.iftf.org/home/

• Forecasts that emerging technologies will reshape lives
• Supported by massive advancements in software, big data and processing power
• Society will enter a new phase in its relationship with machines.
  • The study, released July 12, 2017, examines these changing relationships and how they will manifest themselves in society, business and work during the next 13 years.
Further suggested reading

• **Snow Crash** by [Neal Stephenson](https://en.wikipedia.org/wiki/Neal_Stephenson) 1992/2000

  • In reality, Hiro Protagonist delivers pizza for Uncle Enzo’s CosoNostra Pizza Inc., but in the Metaverse he’s a warrior prince.

  • Plunging headlong into the enigma of a new computer virus that’s striking down hackers everywhere, he races along the neon-lit streets on a search-and-destroy mission for the shadowy virtual villain threatening to bring about infocalypse.

  • Snow Crash is a mind-altering romp through a future America so bizarre, so outrageous...you’ll recognize it immediately.
Further suggested reading

• **Snow Crash** by [Neal Stephenson](https://en.wikipedia.org/wiki/Neal_Stephenson) 1992/2000

  • Quotes

  • “... all information looks like noise until you break the code.”

  • “There's only four things we [Americans] do better than anyone else:
    music
    movies
    microcode (software)
    high-speed pizza delivery”
The Second Machine Age

• See you next year