

# CS 581 – ADVANCED ARTIFICIAL INTELLIGENCE

TOPIC: ARTIFICIAL INTELLIGENCE



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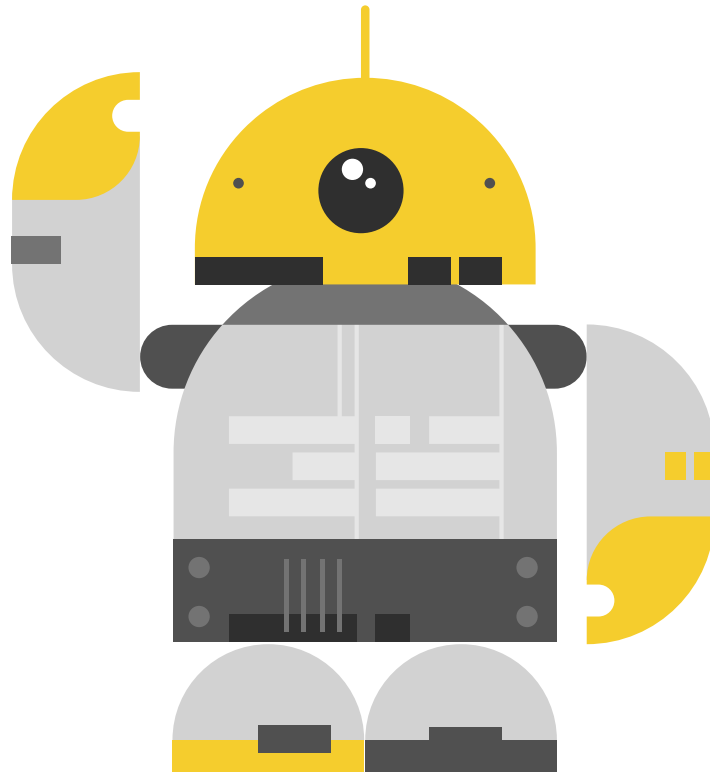


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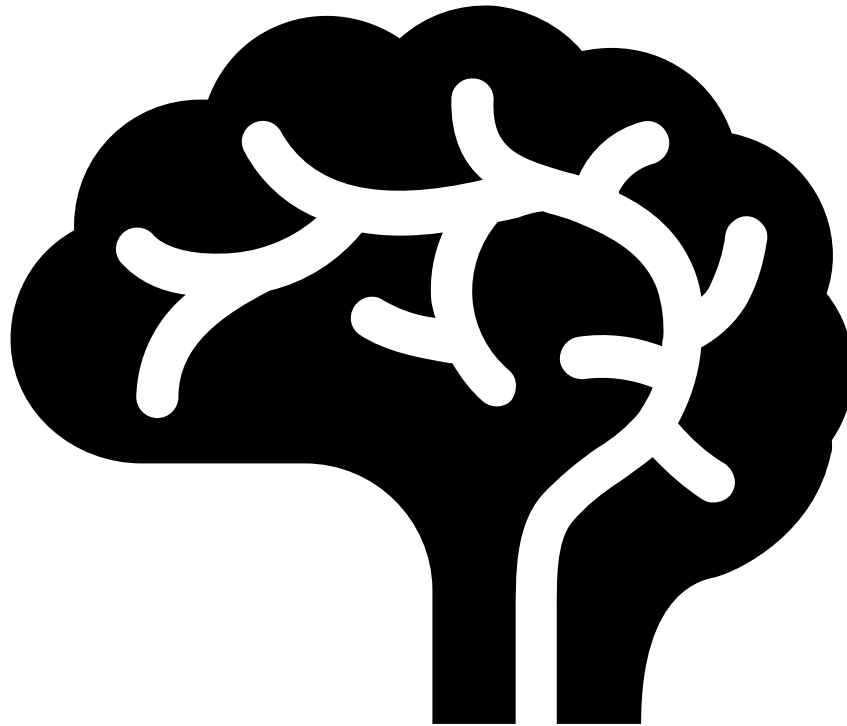


<https://twitter.com/bilgicm>

# WHAT IS ARTIFICIAL INTELLIGENCE?



# WHAT IS INTELLIGENCE?



# LET'S ASK GOOGLE

- Artificial intelligence
  - <https://www.google.com/search?q=define+artificial+intelligence>
- Intelligence
  - <https://www.google.com/search?q=define+intelligence>

# INTELLIGENT?

- Calculators
- Google
- Trees
- Ants
- Humans
- AlphaGo

# INTELLIGENCE & COMPUTATION

- Does algebra require intelligence?
- To be considered intelligent, does an entity need to be good at one thing? Many things? How many?

# HUMAN BRAIN & COMPUTATION

- Can what a brain does be characterized as computation?
- Does a brain perform more than just computation?

# INTELLIGENCE &

- Learning
- Creativity
- Sense of humor
- Emotions
- Consciousness

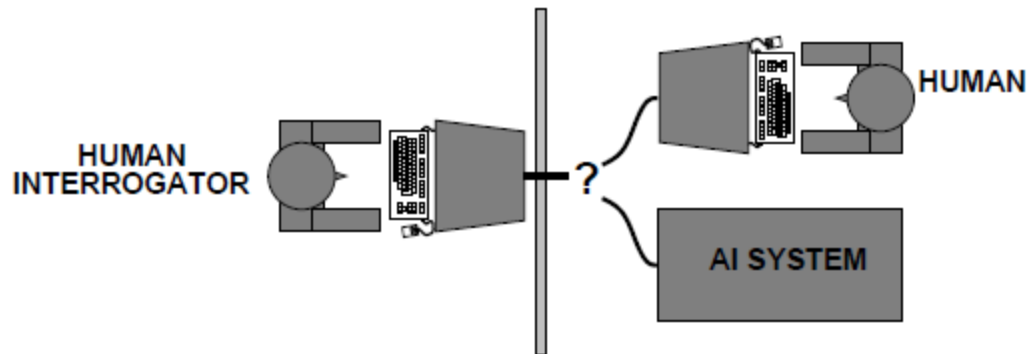


# BEGINNINGS OF AI

- Greek mythology – Talos
- ...
- Initial computational discussions of an artificial brain – 1940s
  - Artificial neurons (Pitts and McCulloch)
- Imitation game – 1950
  - Turing test (Alan Turing)
- The term AI was coined – 1956
  - Dartmouth workshop (John McCarthy)

# THE TURING TEST

- Turing, A. (1950). Computing machinery and intelligence. *Mind*, 59, 433-460.
- The imitation game



- Loebner prize [https://en.wikipedia.org/wiki/Loebner\\_Prize](https://en.wikipedia.org/wiki/Loebner_Prize)

# DARTMOUTH WORKSHOP – 1956

- The workshop where the term Artificial Intelligence was coined
  - [https://en.wikipedia.org/wiki/Dartmouth\\_workshop](https://en.wikipedia.org/wiki/Dartmouth_workshop)
- John McCarthy (1917 – 2011)
  - <http://jmc.stanford.edu/>
- “What is AI?” by McCarthy:  
<http://jmc.stanford.edu/articles/whatisai.html>

# HUMANLY VS. RATIONALLY & THINKING VS. ACTING

	Humanly	Rationally
Think	Thinking humanly	Thinking rationally
Act	Acting humanly	Acting rationally

Turing test      MIT Research  
↑

# CAN MACHINES THINK?

“The question of whether machines can think ... is about as relevant as the question of whether submarines can swim.”

Edsger Dijkstra (1984)

# THE AI EFFECT

- “Every time we figure out a piece of it, it stops being magical; we say, 'Oh, that's just a computation.’”
- “AI is whatever hasn't been done yet.”

Quotes from [https://en.wikipedia.org/wiki/AI\\_effect](https://en.wikipedia.org/wiki/AI_effect)

# WEAK VS STRONG AI

- Weak AI (Narrow AI)
  - Build AI systems that are really good at one task
  - Most, if not all, of the current systems
- Strong AI (Artificial General Intelligence)
  - Build AI systems that are generally intelligent
  - Challenge: the whole is greater than the sum of its parts

# A BIT OF HISTORY

- 1956 – the birth of the term AI
- 1950s/1960s – successes in microworlds
  - GPS, checkers, Lisp, ...
- 1970s – A dose of reality
  - Combinatorial explosion, limitations of perceptrons, ...
- 1980s
  - Expert systems
  - The return of neural networks
  - Probabilistic reasoning; Bayesian networks
- 1990s
  - More computing power; e.g., Deep Blue beats Kasparov
  - Many advances in ML; e.g., support vector machines
- 2000s
  - Data mining; AI on the web
- 2010s
  - Big data
  - Deep learning
- 2020s
  - ?



# AI WINTER

- Hype – Disappointment – Funding Cuts – Renewed interest
  - [https://en.wikipedia.org/wiki/AI\\_winter](https://en.wikipedia.org/wiki/AI_winter)
- 1966
  - National Research Council report: “machine translation was more expensive, less accurate and slower than human translation”
- 1969
  - “Perceptrons” book; showed the limits of perceptrons, the building blocks of neural networks
- 1970s
  - The Lighthill report at UK; the problem of combinatorial explosion and intractability
  - Amendment to DARPA’s funding; required “mission-oriented” research rather than “basic” research
- 1987
  - The beginning of the collapse of the LISP machine and expert systems
- 2020s
  - ?

# WHAT IS DIFFERENT NOW?

## 1. Data

- We generate **so** much data
- We can and do store **all** of it

## 2. Computing power

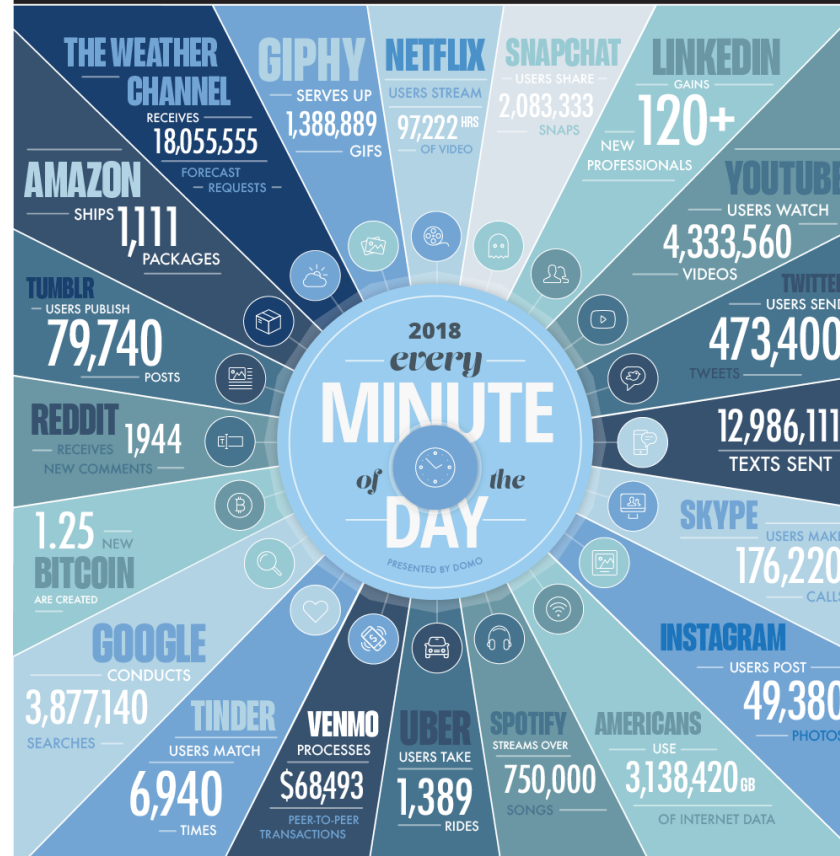
- Moore's law: "the number of transistors in a integrated dense circuit doubles about every two years"
- GPU computation



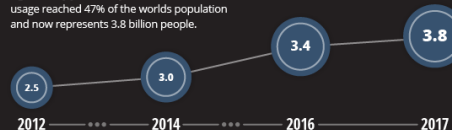
# DATA NEVER SLEEPS 6.0

How much data is generated *every minute*?

There's no way around it: big data just keeps getting bigger. The numbers are staggering, but they're not slowing down. By 2020, it's estimated that for every person on earth, 1.7 MB of data will be created every second. In our 6th edition of Data Never Sleeps, we once again take a look at how much data is being created all around us every single minute of the day—and we have a feeling things are just getting started.



The world's internet population is growing significantly year-over-year. In 2017, internet usage reached 47% of the world's population and now represents 3.8 billion people.



GLOBAL INTERNET POPULATION GROWTH 2012-2017  
(IN BILLIONS)

The ability to make data-driven decisions is crucial to any business. With each click, swipe, share, and like, a world of valuable information is created. Domo puts the power to make those decisions right into the palm of your hand by connecting your data and your people at any moment, on any device, so they can make the kind of decisions that make an impact.

Learn more at [domo.com](http://domo.com)

SOURCES: STATISTA, LINKEDIN, INTERNET WHE STATIS, EXPANDED RAMBLINGS, SLASH FILM, RIAA, BUSINESS OF APPS, INTERNATIONAL TELECOMMUNICATIONS UNION, INTERNATIONAL DATA CORPORATION

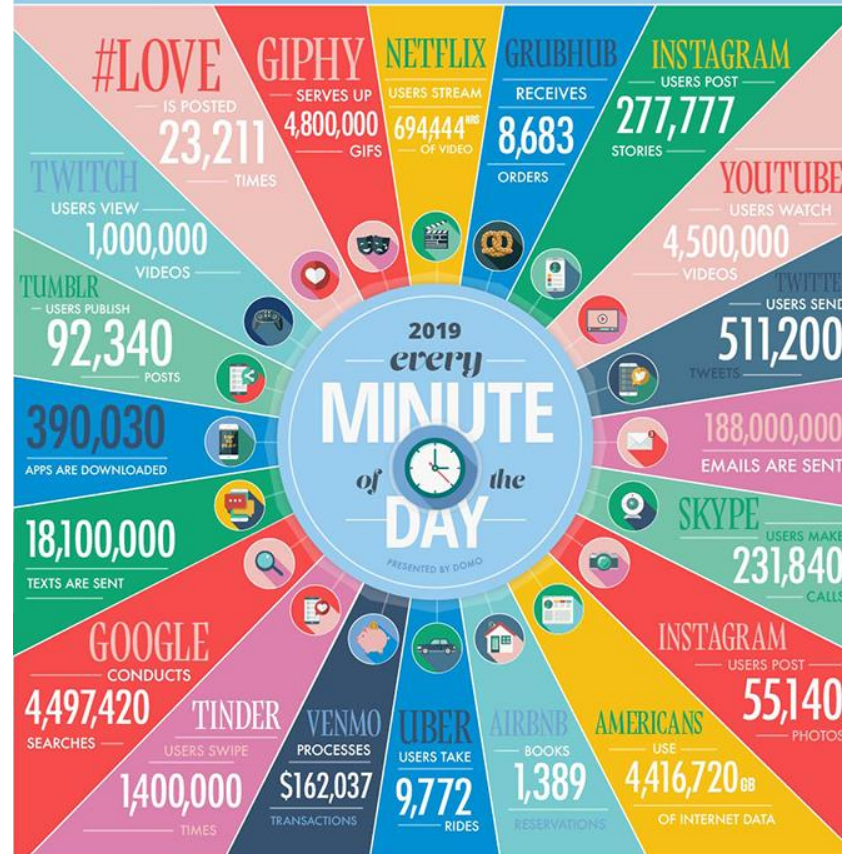




# DATA NEVER SLEEPS 7.0

How much data is generated *every minute*?

There's no way around it: big data just keeps getting bigger. The numbers are staggering, and they're not slowing down. By 2020, there will be 40x more bytes of data than there are stars in the observable universe. In our 7th edition of Data Never Sleeps, we bring you the latest stats on how much data is being created in every digital minute — and the numbers are staggering.



The world's internet population is growing significantly year-over-year. As of January 2019, the internet reaches 56.1% of the world's population and now represents 4.39 billion people — a 9% increase from January 2018.



GLOBAL INTERNET POPULATION GROWTH 2012-2018 (IN BILLIONS)

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SOURCES: STATISTA, INTERNET AND STATE EXPANDED RANKINGS, NATIONAL ASSOCIATION OF

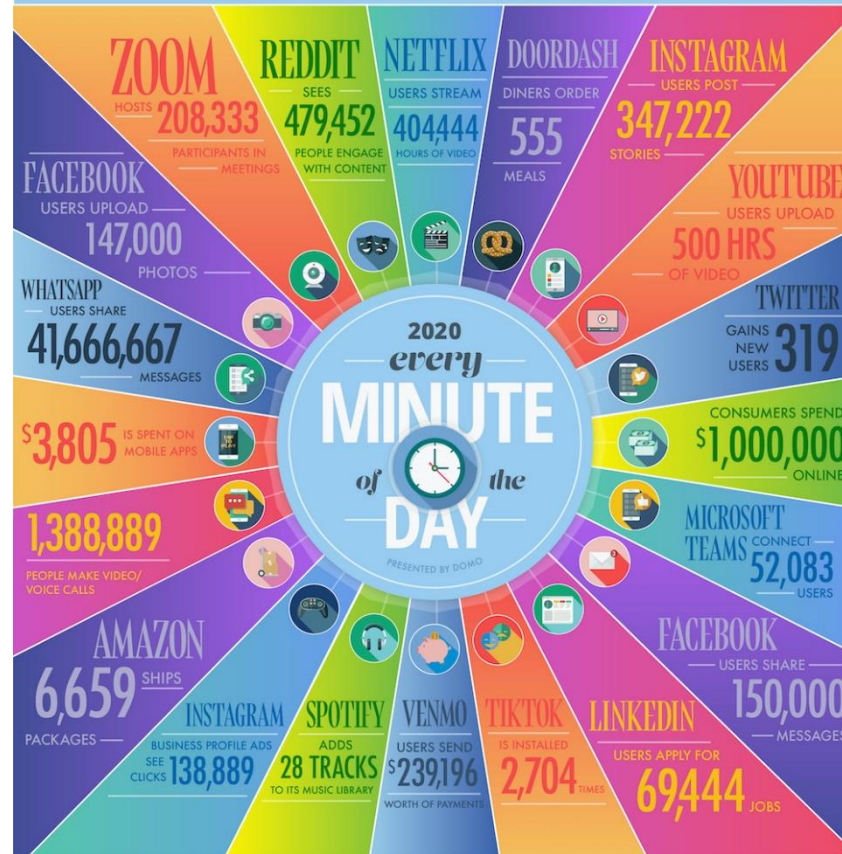




# DATA NEVER SLEEPS 8.0

How much data is generated *every minute*?

In 2020, the world changed fundamentally—and so did the data that makes the world go round. As COVID-19 swept the globe, nearly every aspect of life—from work to working out—moved online, and people depended more and more on apps and the Internet to socialize, educate and entertain ourselves. Before quarantine, just 15% of Americans worked from home. Now over half do. And that's not the only big shift. In our 8th edition of Data Never Sleeps, we bring you the latest stats on how much data is being created in every digital minute—a trend that shows no sign of stopping.



The world's Internet population is growing significantly year over year. As of April 2020, the Internet reaches 59% of the world's population and now represents 4.57 billion people — a 6% increase from January 2019.



GLOBAL INTERNET POPULATION GROWTH 2014–2020  
(IN BILLIONS)

As the world changes, businesses need to change with the times—and that requires data. Every click, swipe, share or like tells you something about your customers and what they want, and Domo is here to help your business make sense of all of it. Domo gives you the power to make data-driven decisions at any moment, on any device, so you can make smart choices in a rapidly changing world.

Learn more at [domo.com](https://domo.com)

SOURCES: STATISTA, VIRAL CAPITALIST, BUSINESS INSIDER, GAME/SPOT, TECHCRUNCH, OMNICORE AGENCY, DOORDASH, BUSINESS OF APPS, NEW VENTURES, ANALOG BUSINESS WORLDWIDE, INC., THE VERGE, INC., HOKUSAI, JUSTIN STOKIT, REDDIT, YOUTUBE, AMAZON, WORK







# Data Never Sleeps 9.0

## How much data is generated every minute?

The 2020 pandemic upended everything, from how we engage with each other to how we engage with brands and the digital world. At the same time, it transformed how we eat, how we work and how we entertain ourselves. Data never sleeps and it shows no signs of slowing down. In our 9th edition of the "Data Never Sleeps" infographic, we bring you a glimpse of how much data is created every digital minute in our increasingly data-driven world.



As of July 2021, the internet reaches 65% of the world's population and now represents 5.17 billion people—a 10% increase from January 2021. Of this total, 92.6 percent accessed the internet via mobile devices. According to Statista, the total amount of data consumed globally in 2021 was 79 zettabytes, an annual number projected to grow to over 180 zettabytes by 2025.

### Global Internet Population Growth (IN BILLIONS)



As the world changes, businesses need to change too—and that requires data. Domo gives you the power to make data-driven decisions at any moment, on any device, so that you can make smart choices in a rapidly changing world. Every click, swipe, share, or like tells you something about your customers and what they want, and Domo is here to help you and your business make sense of all of it.

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SOURCES: LOCAL IQ, BUSINESS OF APPS, DUSTIN STOUT, HOOTSUITE, SPANFORD BANKING, INTERNET WORLD STATS, STATISTA, CBIE, BRANDWATCH, KILL THE CABLE BILL, YOUTUBE, KINISTA, THE VERGE, ADVERTISEMENT COMMUNICATION, A CASE ANALYSIS APPROACH, INTERNET LIVE STATS, SODA, STATISTA.



Our World  
in Data

## Transistor count

10,000,000,000

5 000 000 000

1,000,000,000

500 000 000

100,000,000

50 000 000

10,000,000

5 000 000

1,000,000

500 000

100,000

50 000

10,000

5.000

1,000



Intel 8008 Intel 8080 MOS Technology

Year	Percentage of population aged 65 and over
1970	12.0
1972	12.2
1974	12.4
1976	12.6
1978	12.8
1980	13.0
1982	13.2
1984	13.4
1986	13.6
1988	13.8
1990	14.0
1992	14.2
1994	14.4
1996	14.6
1998	14.8
2000	15.0
2002	15.2
2004	15.4
2006	15.6
2008	15.8
2010	16.0
2012	16.2
2014	16.4
2016	16.6
2018	16.8
2020	17.0

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# RISKS AND BENEFITS

- AI is a tool
- Benefits
  - Solve challenging problems (diseases, climate change, resource shortages, ...)
- Risks
  - Lethal autonomous weapons
  - Surveillance
  - Manipulation
  - Biased decision making (race, gender, religion, ...)
  - Unemployment
  - Safety (driving cars)
  - Cybersecurity
  - ...

Terminator?



# AI ROADMAP

- <https://cra.org/cccvisioning/visioning-activities/2018-activities/artificial-intelligence-roadmap/>

# CS 581

- Search
- Probabilistic reasoning
- Decision making
- Machine learning
- Knowledge representation
- Ethics and safety