CS 480 – Introduction to Artificial Intelligence

Topic: Introduction
Chapter: 1

Mustafa Bilgic

http://www.cs.iit.edu/~mbilgic

https://twitter.com/bilgicm

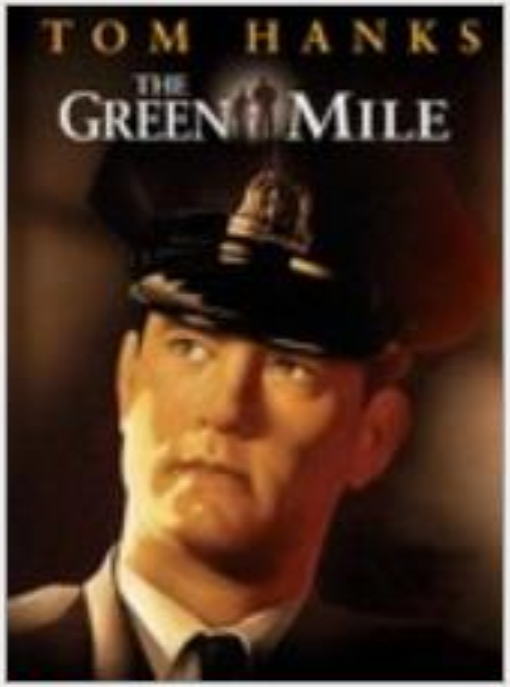
AI is Everywhere Now

Email Filtering

"Wow! I've got one from some

Search Engines

Recommender Systems



Add

The Green Mile

Because you enjoyed:

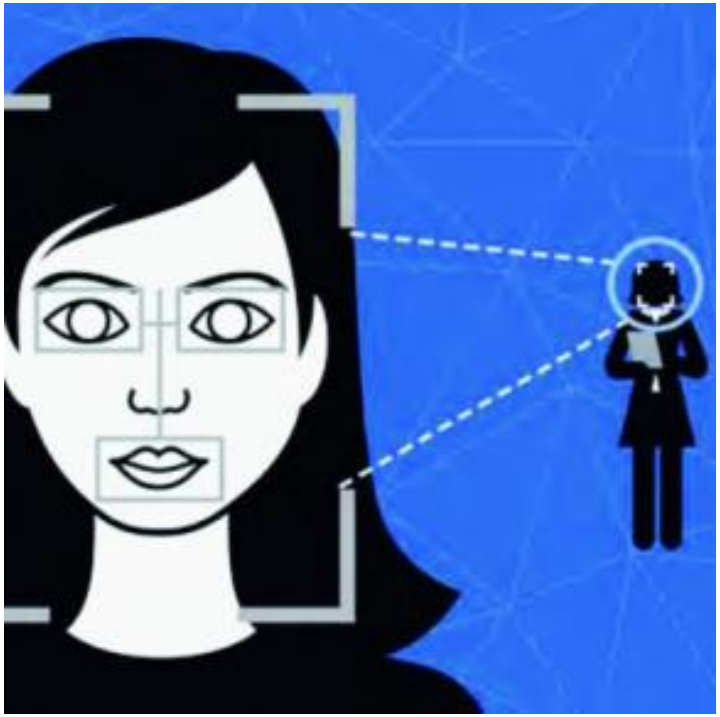
The Shawshank Redemption: Special Edition

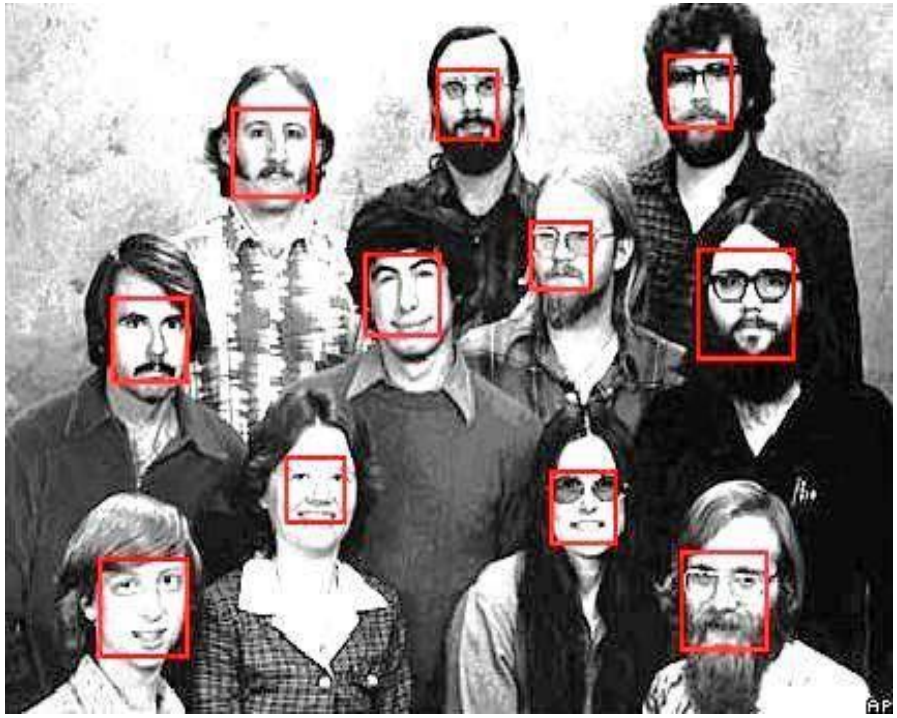
Forrest Gump

Rain Man

Not Interested

Face Detection & Recognition

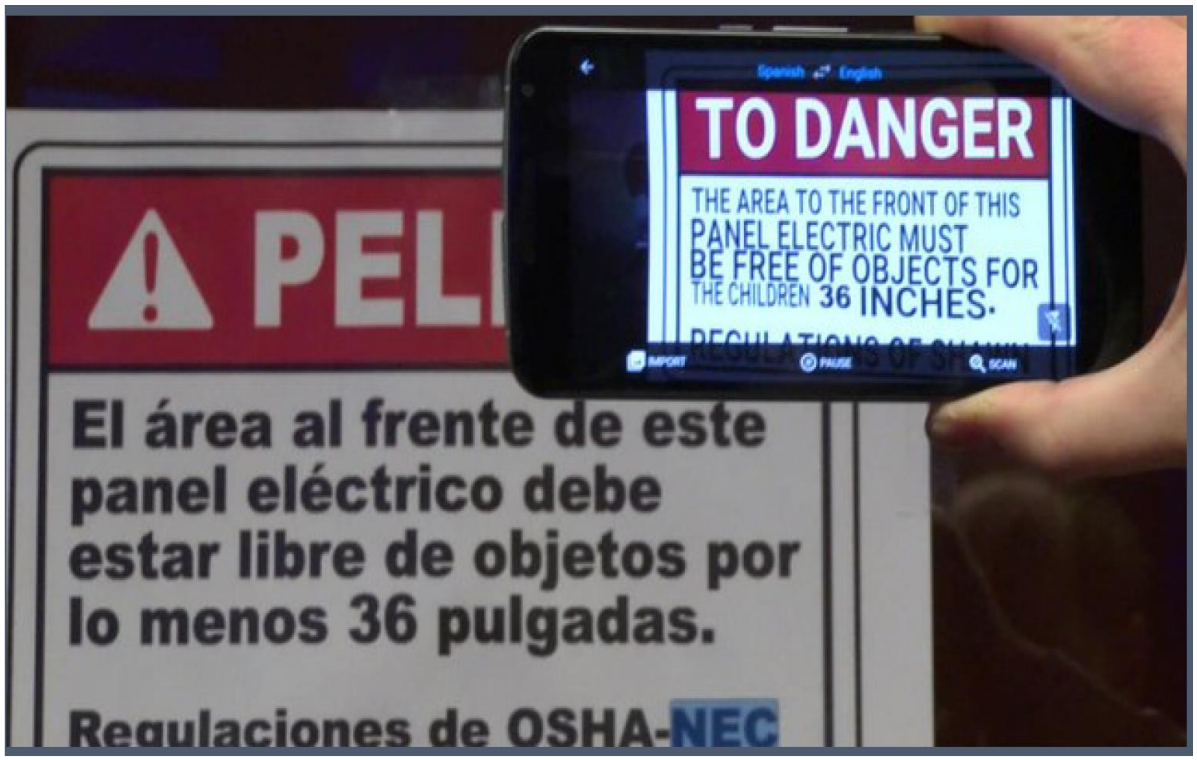




Medical Diagnosis

Intelligent Personal Assistants

Image Recognition + Translation



Self-driving Cars

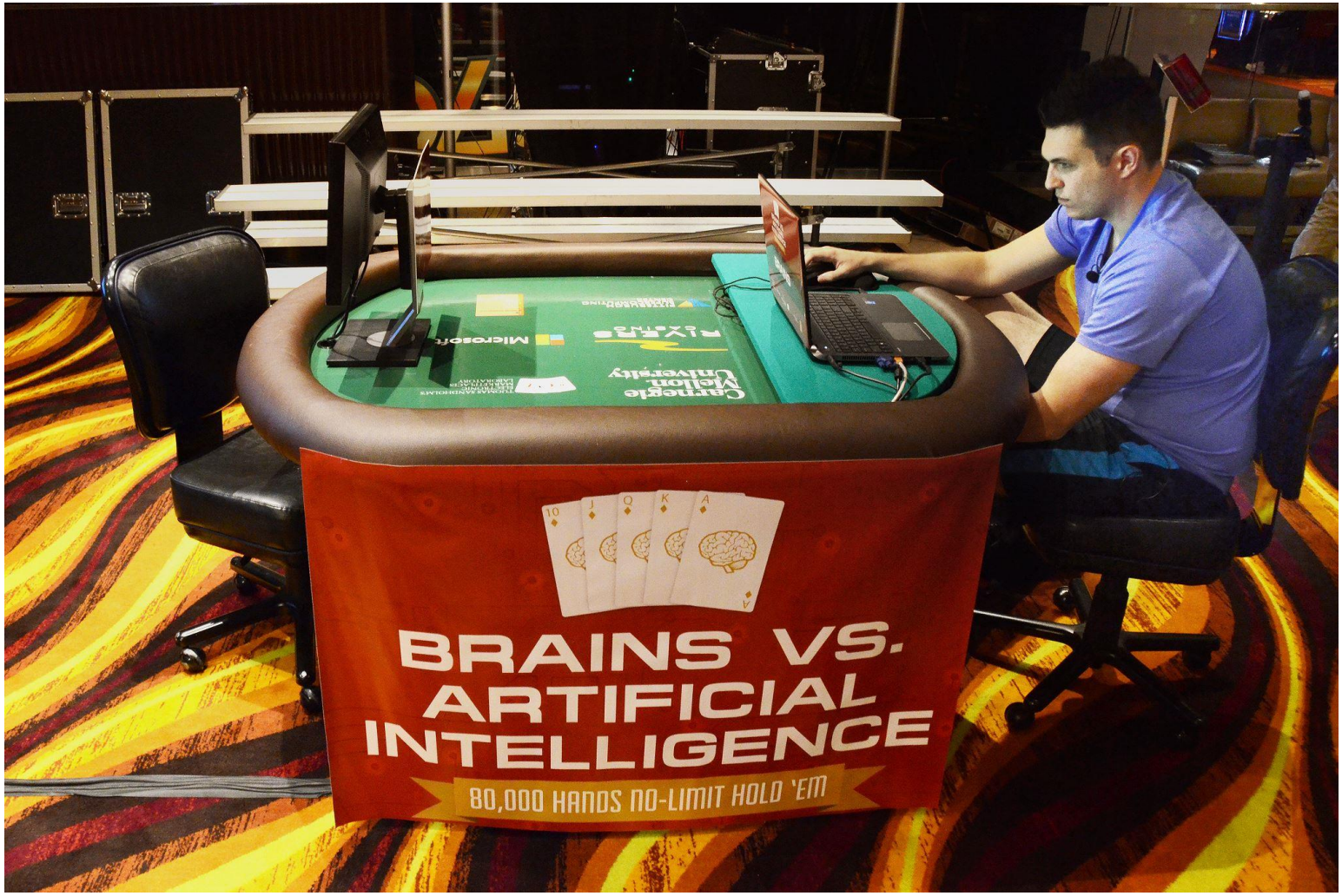
… and of course Games!

Kasparov vs Deep Blue –1997

IBM Watson – Jeopardy – 2011

Google DeepMind – Go – 2016

CMU – Poker – 2017



What's your favorite application of AI? Please share it in the chat.

So, What is Artificial Intelligence?

- First, what is “intelligence”?
- Let’s ask Google

What is AI?

- https://www.lexico.com/en/definition/artificial_intelligence
  - "The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages."
- https://www.merriam-webster.com/dictionary/artificial%20intelligence
  - "a branch of computer science dealing with the simulation of intelligent behavior in computers"
  - "the capability of a machine to imitate intelligent human behavior"
- https://www.britannica.com/technology/artificial-intelligence
  - "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings."
- https://en.wikipedia.org/wiki/Artificial_intelligence
  - "is intelligence demonstrated by machines, unlike the natural intelligence displayed by humans and animals"

Intelligent?

- Calculators?

Intelligent?

- Search engines?

Intelligent?

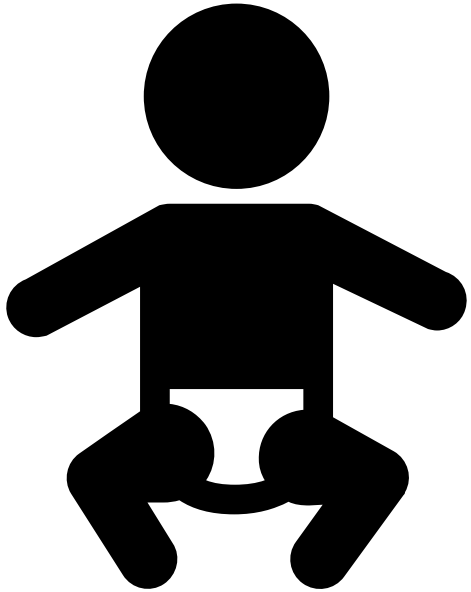
- Trees?

Intelligent?

- Ants?

Intelligent?

- Human babies?



Intelligence and

- Consciousness
- Emotions
- Kindness
- Sense of humor
- Tell right from wrong
- Love
- Creativity
- Learning

A Great Read

- Turing, A. (1950). Computing machinery and intelligence. *Mind,* 59, 433-460.
- Next week's discussion will be about this paper

Imitate Humans?

- Would you call a robot that can perfectly imitate a human *intelligent*?

Would you call a robot that can perfectly imitate a human intelligent?

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.”

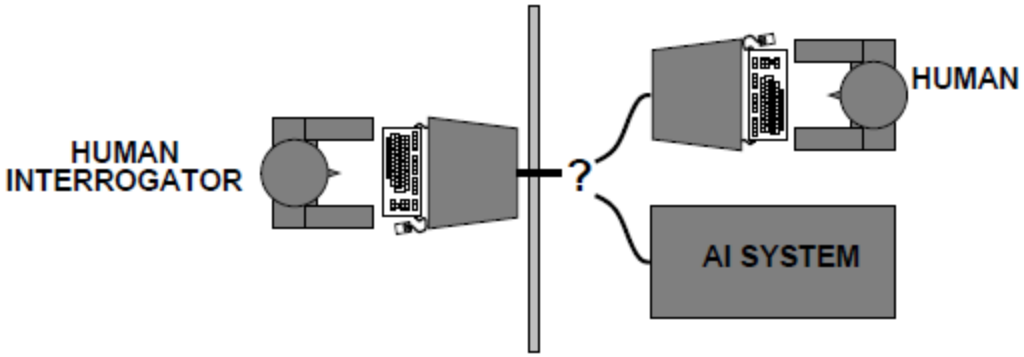
Quotes from https://en.wikipedia.org/wiki/AI_effect

Humanly vs. rationally & thinking vs. acting

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

Acting Humanly – the Turing test

- The imitation game
  - An operational test



- The AI system needs to have:
  - Natural language processing
  - Knowledge representation
  - Automated reasoning
  - Machine learning

Thinking humanly – cognitive modeling

- Need to know how humans think
  - Introspection
  - Psychological experiments
  - Brain imaging
- Cognitive science
  - Based on experimental investigation of humans and animals

Thinking rationally – laws of thought

- Codify "right thinking"
  - Aristotle
- Logic
  - "Socrates is a man; all men are mortal; therefore, Socrates is mortal"
- Two main challenges
  - It is hard to encode esp. uncertain knowledge in formal logic
  - Can be computationally very demanding, unless it is provided some guidance

Acting rationally

- A **rational agent** is an agent that acts so as to achieve the best outcome, or when there is uncertainty, the best expected outcome.
- Two advantages
  - More general than thinking rationally, because acting rationally requires thinking rationally
  - More amenable to scientific development than the approaches based on human

This Course

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

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

The foundations - I

- Philosophy
  - Logic, induction, rationalism, empiricism
- Mathematics
  - Probability, statistics
- Computing
  - Algorithms, data
- Engineering
  - Chips, sensors, robotics

The foundations - II

- Economics
  - Utility, decision theory, game theory
- Neuroscience
  - The study of the brain
- Psychology
  - Behaviorism, cognitive psychology, how humans and animals think and act
- Linguistics
  - Grammar, syntax, how language relates to thinking

Subfields of AI

1. Communication and Perception
   - Language, speech, vision, robotics
2. Knowledge representation and reasoning
   - Logic, probability, planning, decision making
3. Learning
   - Machine learning
4. Problem solving
   - Search, constraint satisfaction, game playing

AI vs ML vs DL

- A common misconception
  - AI = Machine Learning = Deep Learning
- Reality
  - Deep Learning $\subset$ Machine Learning $\subset$ AI

Machine Learning

Developing programs that improve their performance through experience at a given task

Tom Mitchell, Machine Learning

A few ML Examples

- Face recognition
- Speech recognition
- Game playing
- Medical diagnosis
- Scientific data analysis
- Behavior analysis
- Product recommendations
- Ad placements
- Personalization
- Credit scoring
- Fraud detection
- …

History - I

- Gestation:1943 – 1955
  - Based on:
    - Physiology and function of the neurons in the brain
    - Formal analysis of propositional logic
    - Theory of computation
  - First neural network computer – 1950
  - Turing test – 1950
- Birth: 1956
  - Darthmouth workshop: the term AI was coined
  - Logic Theorist – was able to prove most theorems in Chapter 2 of *Principia Mathematica*

History - II

- Early enthusiasm: 1950s – 1960s
  - General Problem Solver (GPS) – imitate human problem-solving protocols – thinking humanly approach
  - Geometry Theorem Prover – was able to prove theorems that many math students found to be tricky
  - Checkers – the program that learned to play checkers using reinforcement learning – disproved the idea that the computers can do only what they are told to do
  - Lisp – the dominant AI programming language for about 30 years
  - Many microworlds – limited domains
    - SAINT – solved closed-form calculus integration problems
    - ANALOGY – solved geometric analogy problems that appear in IQ tests
    - STUDENT – solved algebra story problems
  - Perceptron convergence theorem

History - III

- A dose of reality: 1960s – 1970s
  - There were several predictions that did not come to pass
  - Merely syntactic manipulations
    - "The spirit is willing but the flesh is weak" => "The vodka is good but the meat is rotten"
  - Intractability
    - Tried many possible combinations till worked
    - Worked initially because microworlds contained very few objects and actions
  - Representation limitations of perceptrons
    - Almost killed the neural net research until 80s

History - IV

- Knowledge-based systems: 1970s – 1980s
  - Narrow areas of expertise with domain knowledge integration
  - DENDRAL – inferred molecular structure
    - Integrated domain knowledge to guide and limit the search
  - MYCIN – diagnosed blood infections
    - Was better than junior doctors
    - Was able to handle uncertain knowledge
  - Developments in knowledge representation

History - V

- Return of neural networks: 1980s – present
  - Rediscovery of the backpropagation algorithm
- Probabilistic reasoning: 1980s – present
  - Hidden Markov Models, Bayesian networks, …
- Big data: 2000s – present
  - World Wide Web, …
- Deep learning: 2010s – present
  - Neural networks with multiple layers

The State of The Art

- Whatever I put in this slide has the potential to become stale in a few years
- Check out aiindex.org
- AI has met or exceeded human benchmarks on
  - Chess, Go, Poker, Pac-Man, Jeopardy, ImageNet object detection, speech recognition in limited domains, Chinese to English translation in limited domains, Quake III, Dota 2, Starcraft II, various Atari games, skin cancer detection, prostate cancer detection, protein folding, and diabetic retinopathy diagnosis

AI Winter(s)?

- 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 LIPS machine and expert systems
- 2020s

https://en.wikipedia.org/wiki/AI_winter

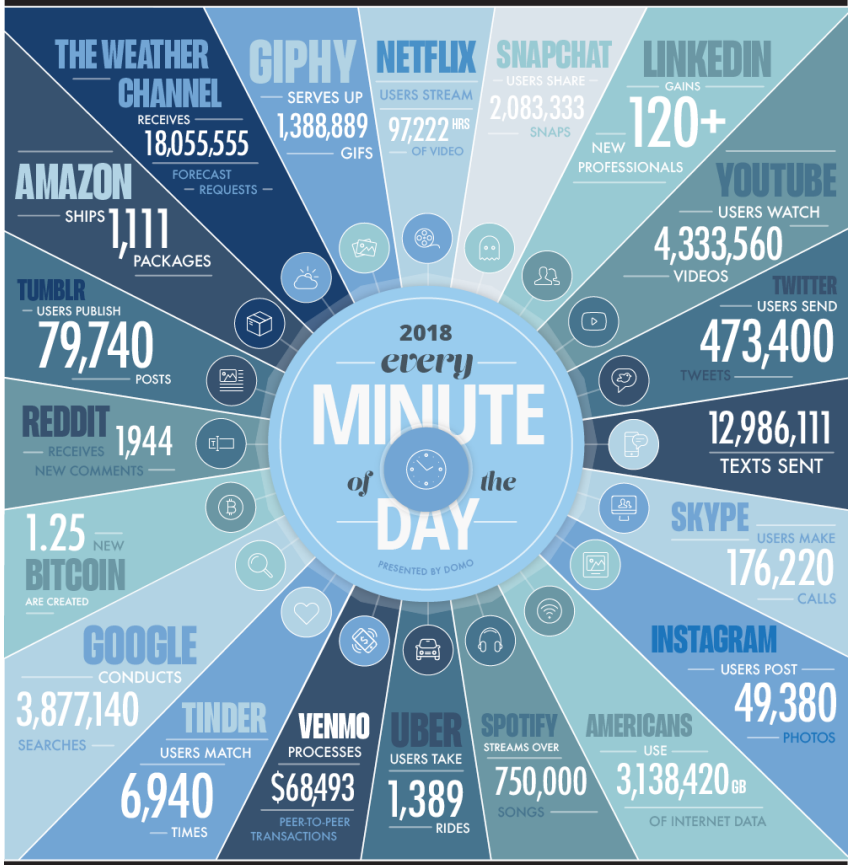
What is new?

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

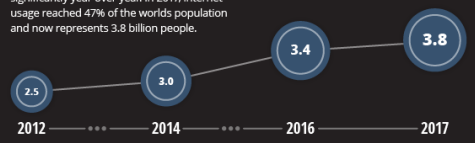
DATA NEVER SLEEPS 6.0

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 worlds 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.

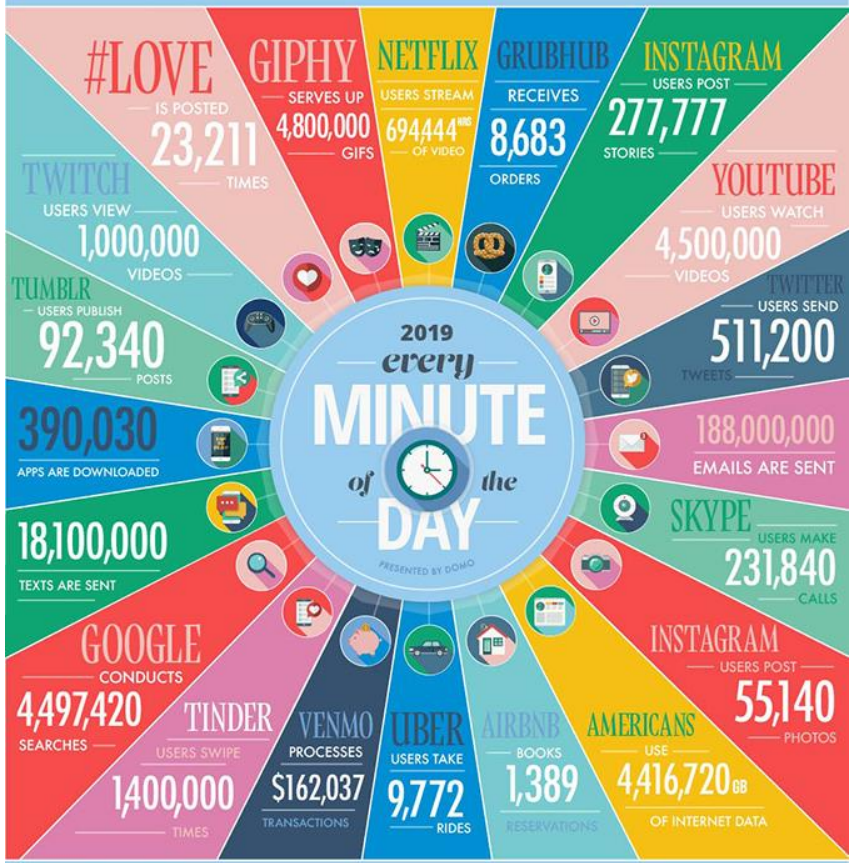
Learn more at domo.com

SOURCES: STATISTA, LINKEDIN, INTERNET LIVE STATS, 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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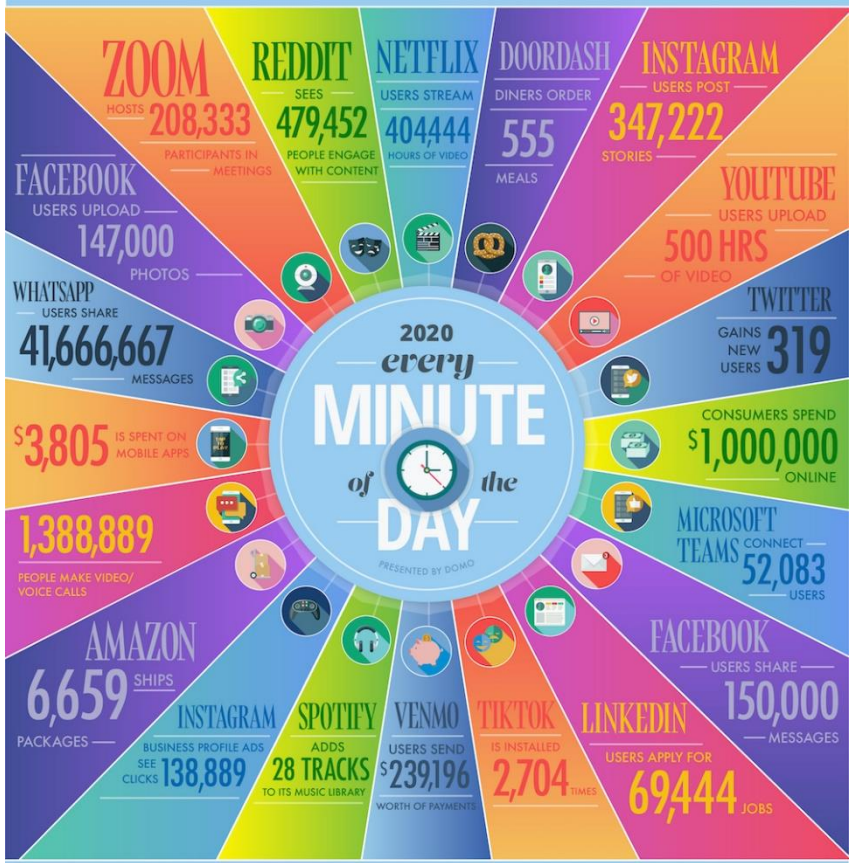
Learn more at domo.com

SOURCES: STATISTA, INTERNET LIVE STATS, EXPANDED RAMBLINGS, NATIONAL ASSOCIATION OF CITY TRANSPORTATION OFFICIALS, WIRED

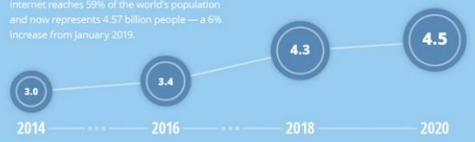
DATA NEVER SLEEPS 8.0

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.

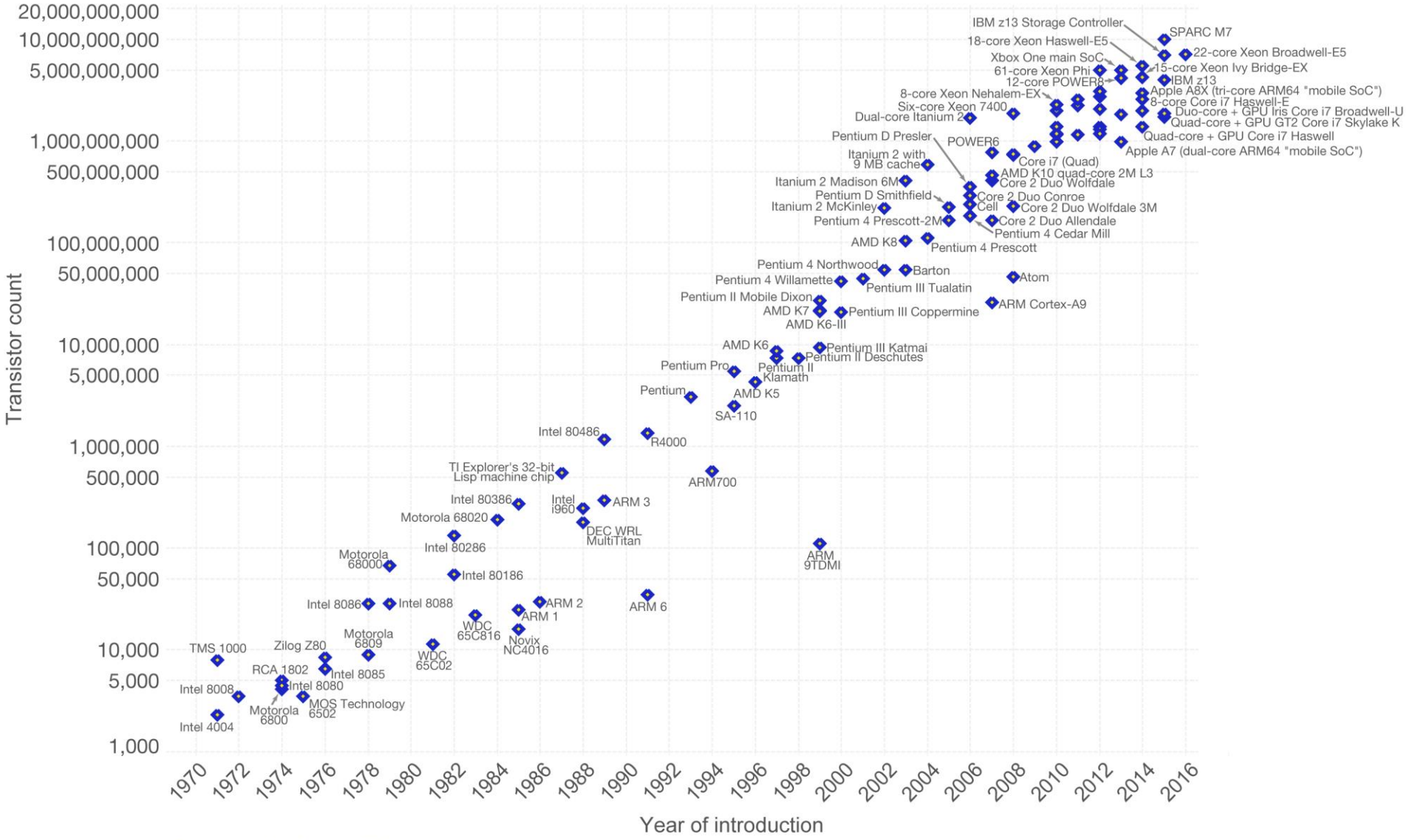
Learn more at domo.com

SOURCES: STATISTA, VISUAL CAPITALIST, BUSINESS INSIDER, GAMESPOT, TECHCRUNCH, OMNICORE AGENCY, DOORDASH, BUSINESS OF APPS, NEW YORK TIMES, MUSIC BUSINESS WORLDWIDE, INC., THE VERGE, INC., HOOTSUITE, DUSTIN STOUT, REDDIT, UBER, AMAZON, VOX

Moore's Law – The number of transistors on integrated circuit chips (1971-2016)

Our World in Data

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are strongly linked to Moore's law.



Data source: Wikipedia (https://en.wikipedia.org/wiki/Transistor_count)

The data visualization is available at OurWorldinData.org. There you find more visualizations and research on this topic.

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
  - …

Rest of the semester - I

- Intelligent agents – Chapter 2
  - Environment, performance, agent programs
- Search – Chapter 3, 5, & 6
  - Problem solving through uninformed and informed search
  - Game playing
  - Constraint satisfaction

Rest of the semester - II

- Knowledge representation and reasoning – Chapters 7, 8, & 9
  - Propositional logic
  - First-order logic
  - Resolution algorithm

Rest of the semester - III

- Uncertainty and Probabilistic Reasoning – Chapter 13
  - Probability theory
  - Bayesian networks
- Decision making – Chapters 16, 17
  - Utility theory
  - Value of information

Rest of the semester - IV

- Learning – Chapters 19, 20, 21, 22
  - Supervised learning
  - Decision trees
  - Naïve Bayes
  - Logistic regression
  - Neural networks
  - Deep learning
  - Reinforcement learning

Rest of the semester - V

- Ethics – Chapter 27
- Future? – Chapter 28