Introduction to Machine Learning
Lecture 1

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Pontificia Universidad Javeriana

Introduction to Machine Learning

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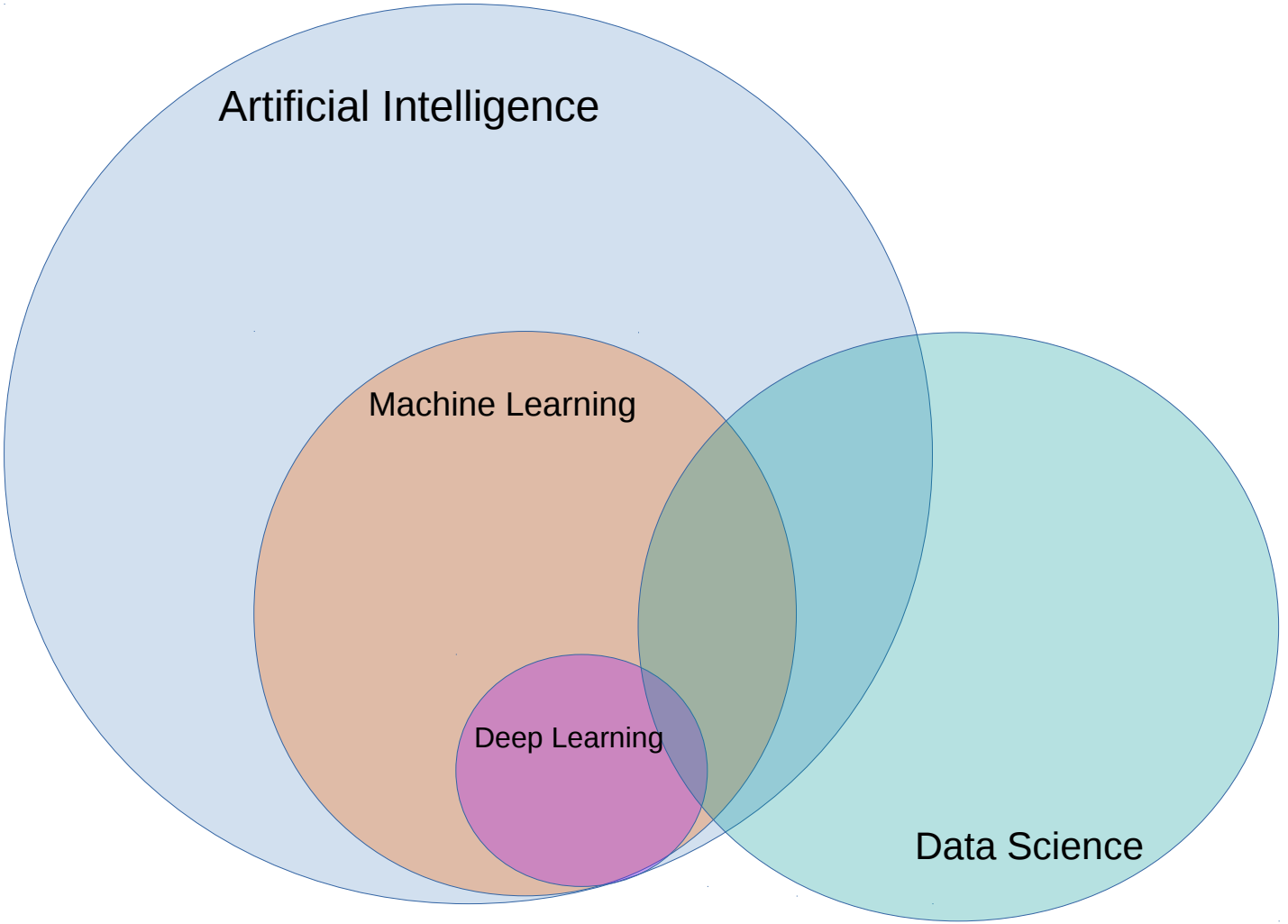
About the course

- An introduction to machine learning with a focus on its applications in economics and business
- 20 hours of lectures with occasional exercises and programming assignments
- Prerequisite: A basic understanding of calculus, probability/statistics, and linear algebra

- This lecture
  - AI vs. ML vs. Data Science vs. Business Analytics
  - Brief history of AI/ML
  - Sample applications
  - Course outline


Artificial Intelligence
Machine Learning
Deep Learning
Data Science

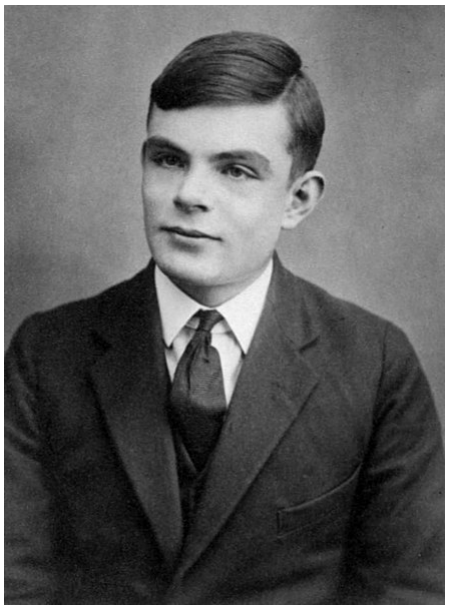
Artificial Intelligence	Machine Learning	Data Science[4]
Aim: Mimicking intelligent behavior[1] Started around 1950s Problems: - Reasoning - Knowledge Representation - Planning - Learning - Natural language processing - Perception/action Approaches: - Symbolic/logic-based - Brain simulation - Statistical learning - ...	Aim: Give computer systems the ability to "learn" from data, without being explicitly programmed[2] As old as AI itself Learning rather than programming to mimic intelligent behavior Focuses more on prediction and performance than interpretability Larger and higher dimensional datasets	Aim: To extract knowledge and insights from data in various forms[3] Relatively modern (2000s) Relies heavily on statistics Focuses more on application Focuses more on understanding and interpretability Generally smaller datasets (with fewer features/attributes)

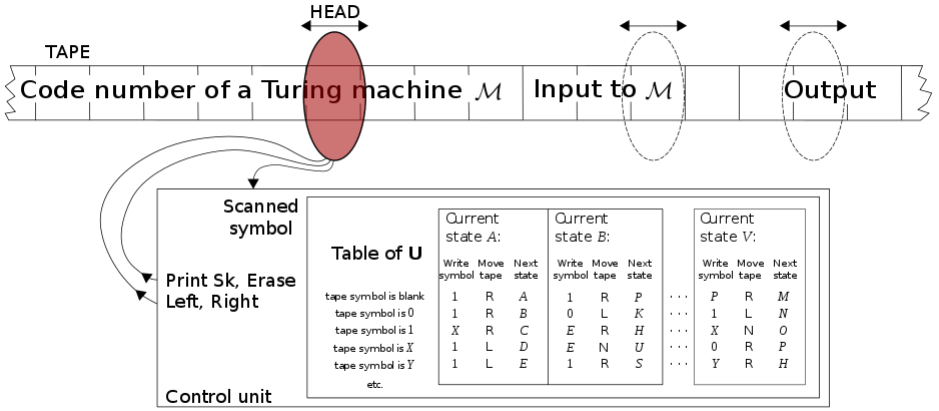
Deep learning: Subset of ML that use artificial neural networks with many layers

Business analytics: More or less synonymous with data science. Focuses on business applications.

Brief history of AI and ML[1,2]

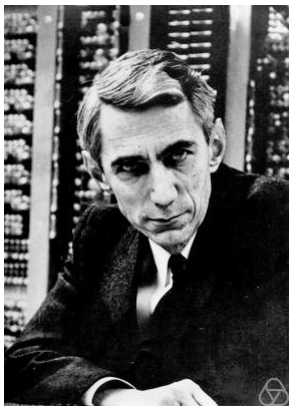
- 1930s: Mathematical logic: Can machines do mathematics?
  - Alan Turing, British mathematician
  - Turing machine
    - Mechanization of logic/mathematics
    - Foundation for modern computers
  - 2014 movie: The Imitation Game
    - https://www.imdb.com/title/tt2084970/





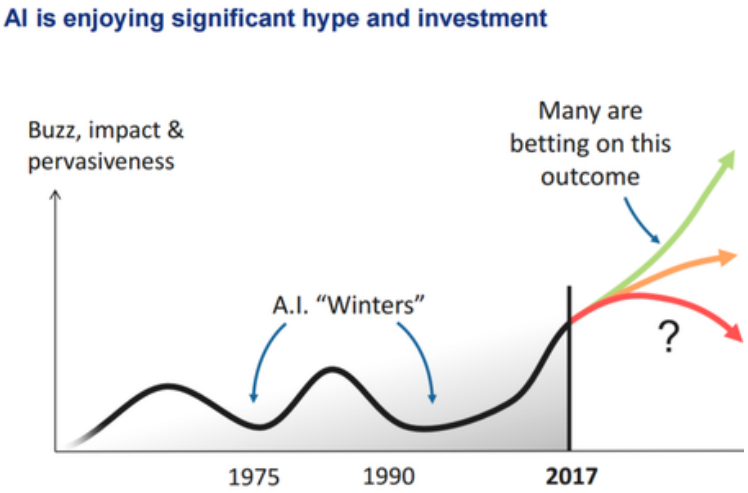
Brief history of AI and ML

- 1956, a workshop at Dartmouth College, New Hampshire
  - Research proposal by McCarthy, Minsky, Shannon
  - Introduced the term artificial intelligence
    - “We propose that a 2-month, 10-man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer. ”



Brief history of AI and ML

- 1960s, first successes
  - Samuel's checkers playing program
  - Solving algebra problems
  - Proving mathematical theorems
- 1970s, first AI winter
- 1980s, resurgence of interest
  - Expert systems (e.g., medical diagnosis)
- 1990s, another AI winter
- From 2000s on forward
  - Deep neural networks
  - Huge interest
  - AI as active as it has never been

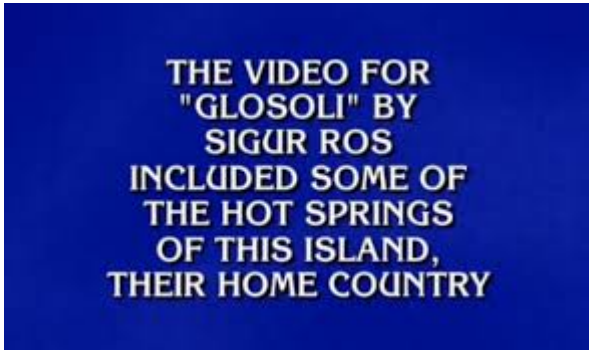


In a 2017 survey, one in five companies reported they had "incorporated AI in some offerings or processes"

Brief history of AI and ML

- 1997: IBM DeepBlue beats Garry Kasparov (score: 3.5 – 2.5)
  - World's 259th most powerful computer
  - Traditional AI, with little machine learning
  - Analyzes 200 million positions per second
  - Today, your laptop can beat a chess grandmaster
  - Improvements both in computational power and chess playing software
    - Pocket Fritz 4 (running on HTC Touch HD) searches fewer than 20,000 positions per second

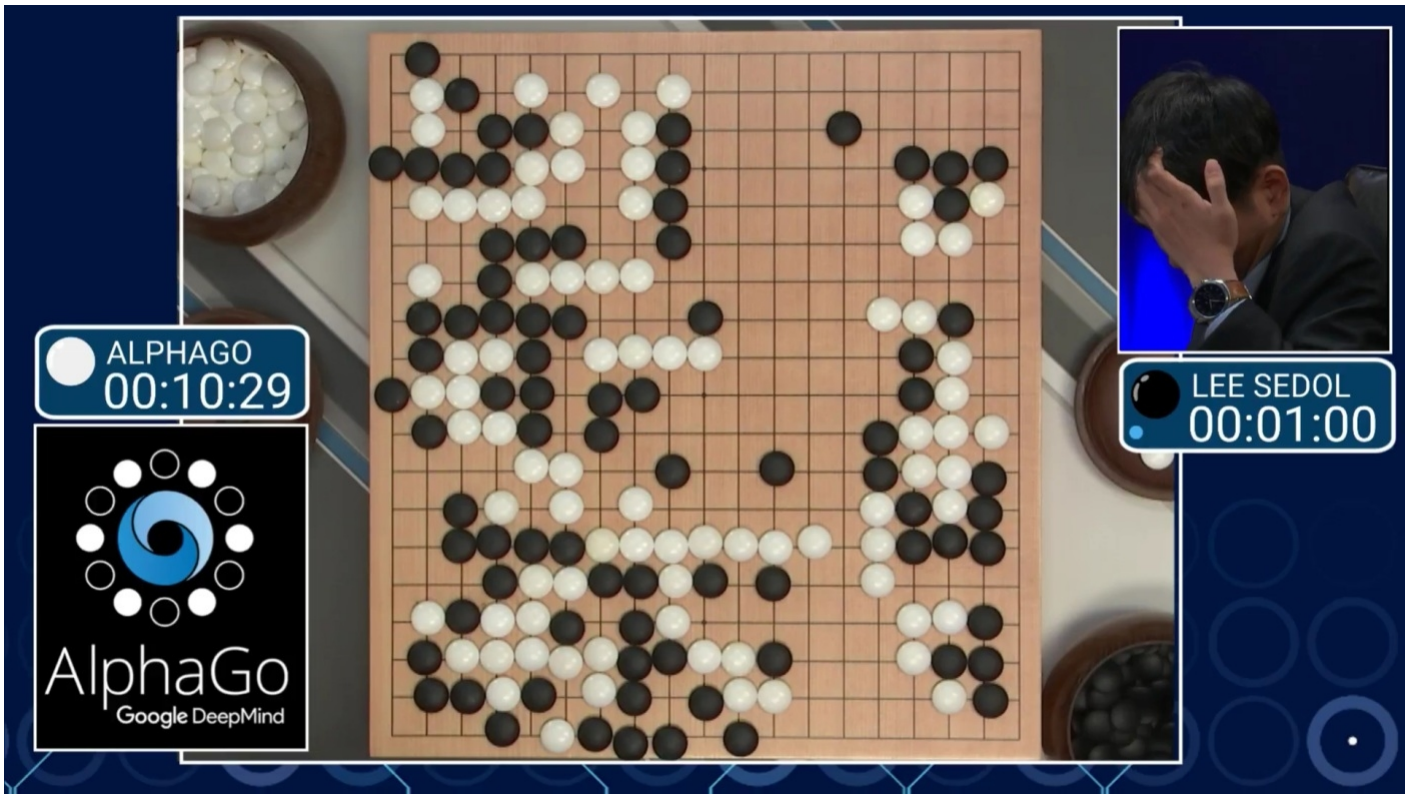
Brief history of AI and ML



- 2011: IBM Watson beats humans at Jeopardy
  - Quiz show
  - Watson
    - https://www.youtube.com/watch?v=P18EdAKuC1U
    - 2,880 POWER7 processor threads and 16 terabytes of RAM
    - Uses a combination of machine learning, natural language processing and information retrieval techniques
    - Access to 200 million pages of documents

Brief history of AI and ML

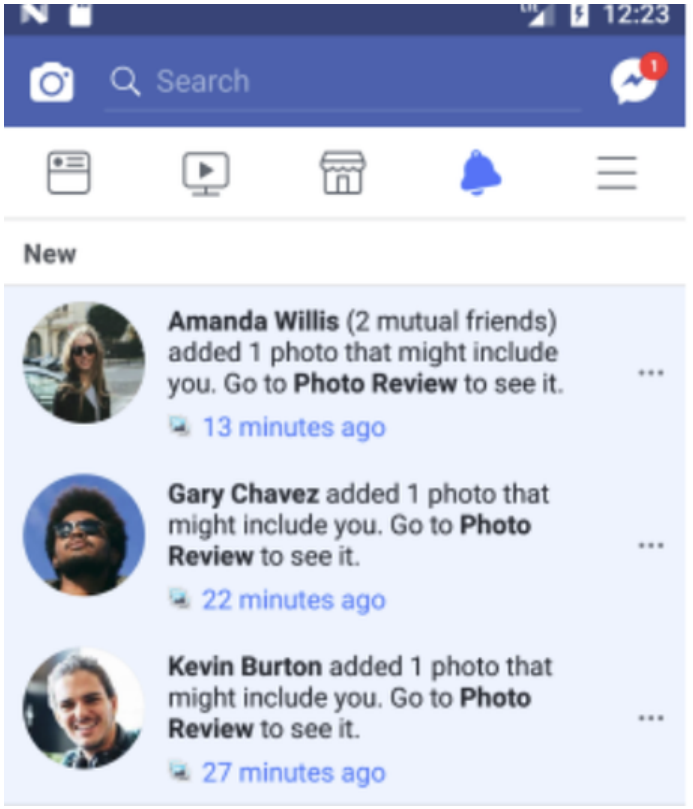
- 2016: Google AlphaGo beats Go world champion
  - Go more difficult than chess
    - 10^{44} vs 10^{170} possible board configurations
  - AlphaGo (https://www.alphagomovie.com/)
    - 1,920 CPUs and 280 GPUs
    - Uses supervised learning and reinforcement learning
    - Learns from human play and self-play
    - AlphaZero: Learned all from self-play. Masters Go, chess, and shogi

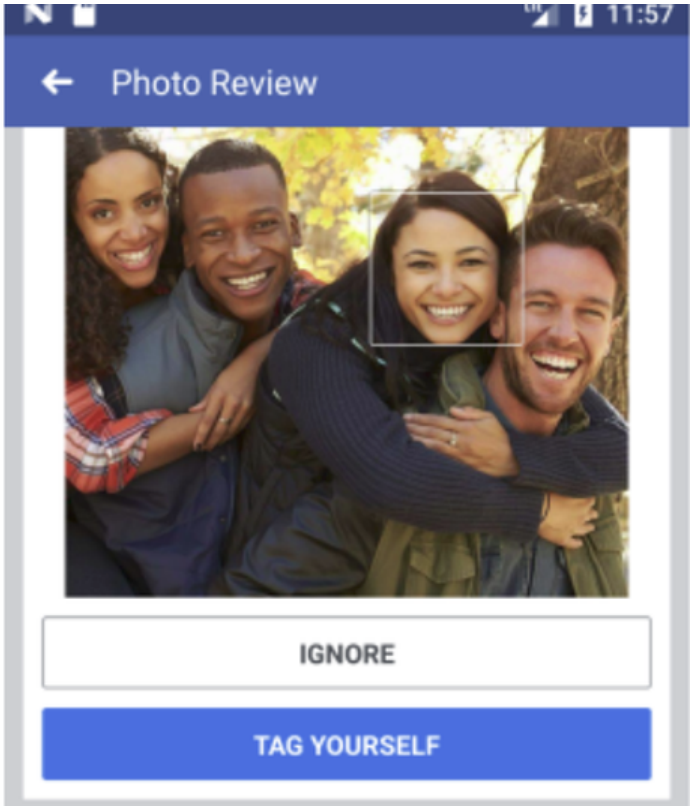


Personal assistants

Face recognition

Facebook's DeepFace, a system that uses neural networks that identifies faces with 97.35% accuracy.[4]

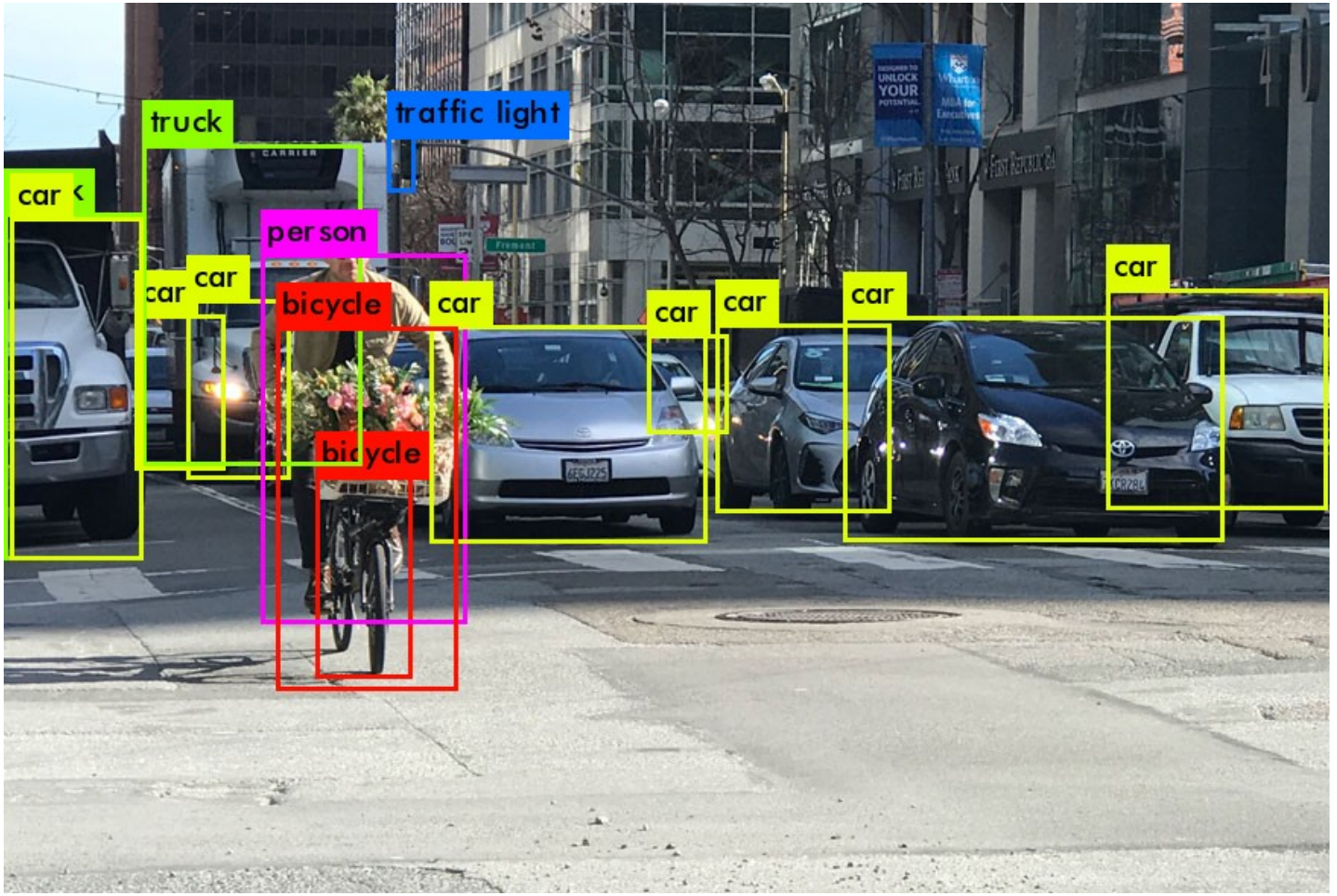




Self-driving cars

Object detection[8]

https://www.youtube.com/watch?v=VOC3huqHrss



Generating captions for images[5]

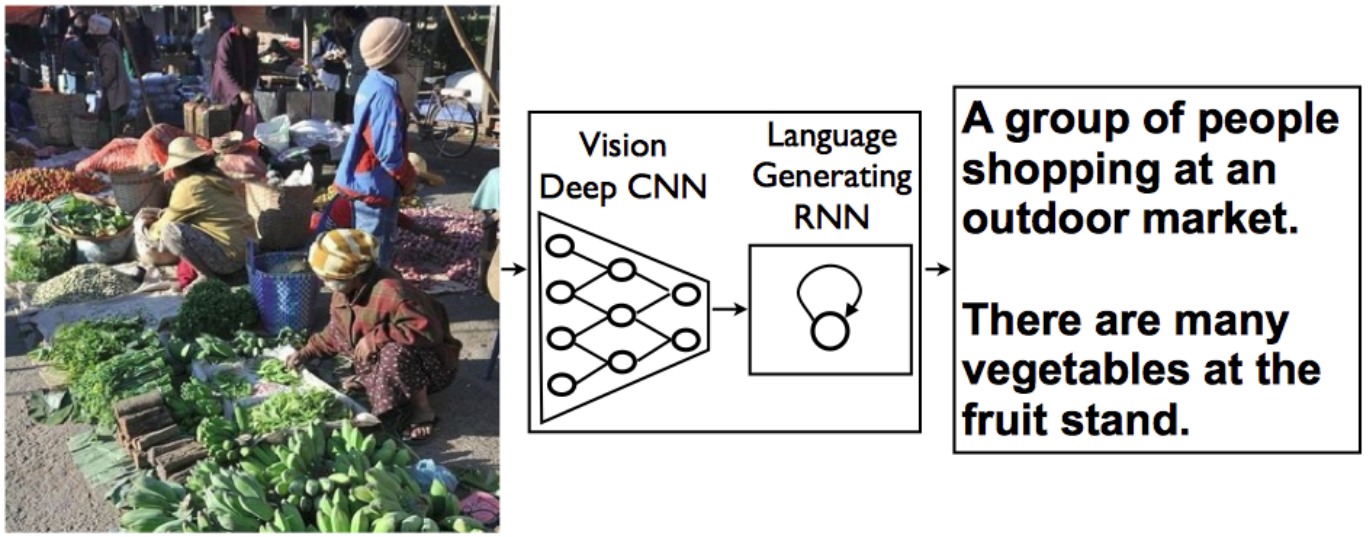


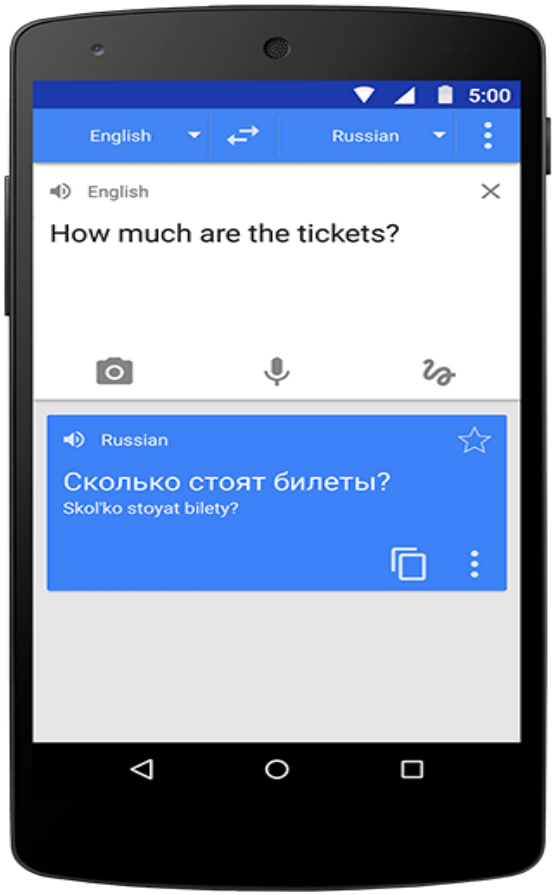
Figure 1. NIC, our model, is based end-to-end on a neural network consisting of a vision CNN followed by a language generating RNN. It generates complete sentences in natural language from an input image, as shown on the example above.

Sample application: Language translation

Youtube automatic captions

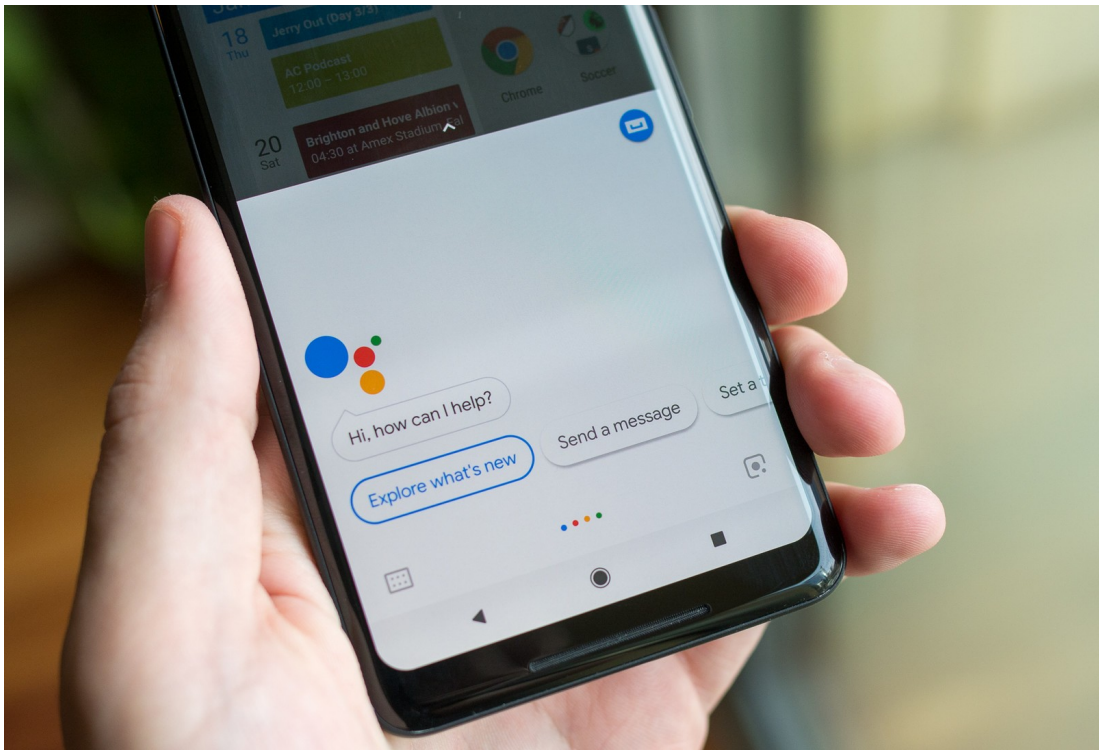
Google translate

https://youtu.be/oQVQVt5H2QM?t=45



Google Assistant making a reservation

https://www.youtube.com/watch?v=-RHG5DFAjp8



Dreaming up celebrities[6]

https://www.youtube.com/watch?v=36lE9tV9vm0

Can computers fool us?

DeepFakes

https://www.youtube.com/watch?v=cQ54GDm1eL0

Robotics

https://www.youtube.com/watch?v=hx_bgoTF7bs

https://www.youtube.com/watch?v=XCLSkFKTWyg

https://youtu.be/jwSbzNHGflM?t=21

Course outline

1. Machine learning fundamentals
   - Overfitting and underfitting
   - Bias variance tradeoff
   - Curse of dimensionality
   - Cross validation
   - No free lunch theorem

2. Supervised learning I (Linear models)
   - Linear regression
   - Regularization
   - Logistic Regression
   - Support vector machines and other supervised learning techniques

3. Supervised learning II (Tree based models)
   - Decision trees
   - Random forests

4. Unsupervised learning
   - Principal components analysis
   - Clustering
   - Rule extraction/Basket analysis

5. Deep learning
   - Neural networks
   - Backpropagation algorithm

6. Putting it all together: Poverty prediction from satellite images
   - Transfer learning
   - Convolutional neural networks

References

[1] https://en.wikipedia.org/wiki/Artificial_intelligence

[2] https://en.wikipedia.org/wiki/Machine_learning

[3] https://en.wikipedia.org/wiki/Data_science

[4] Donoho D. 50 Years of Data Science.
https://www.tandfonline.com/doi/abs/10.1080/10618600.2017.1384734

[5] https://en.wikipedia.org/wiki/Timeline_of_machine_learning

[6] Oriol Vinyals, Alexander Toshev, Samy Bengio, Dumitru Erhan: Show and Tell: A Neural Image Caption Generator.

[7] https://research.nvidia.com/publication/2017-10_Progressive-Growing-of

[8] Redmon J., Farhadi A. YOLO9000: Better, Faster, Stronger.
https://arxiv.org/abs/1612.08242