

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

Books

- **An Introduction to Statistical Learning with Applications in R.**
 - Available free online: <http://www-bcf.usc.edu/~gareth/ISL/>
 - Great introduction book

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[About this Book](#)

[R Code for Labs](#)

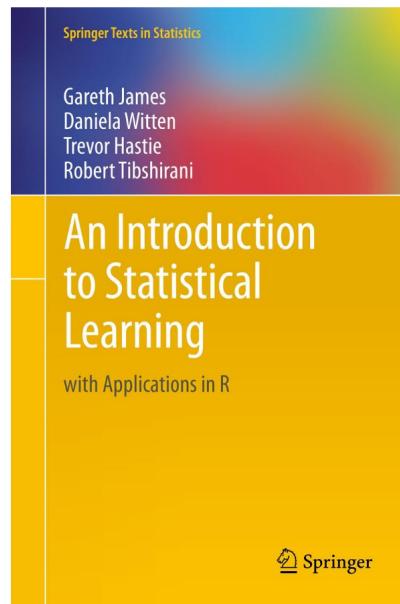
[Data Sets and Figures](#)

[ISLR Package](#)

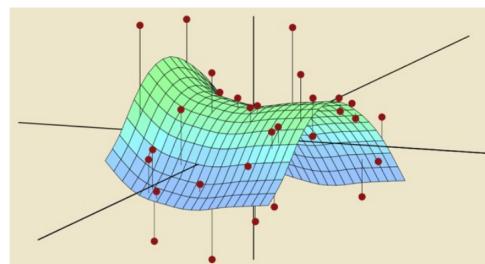
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[Download the book PDF
\(corrected 7th printing\)](#)

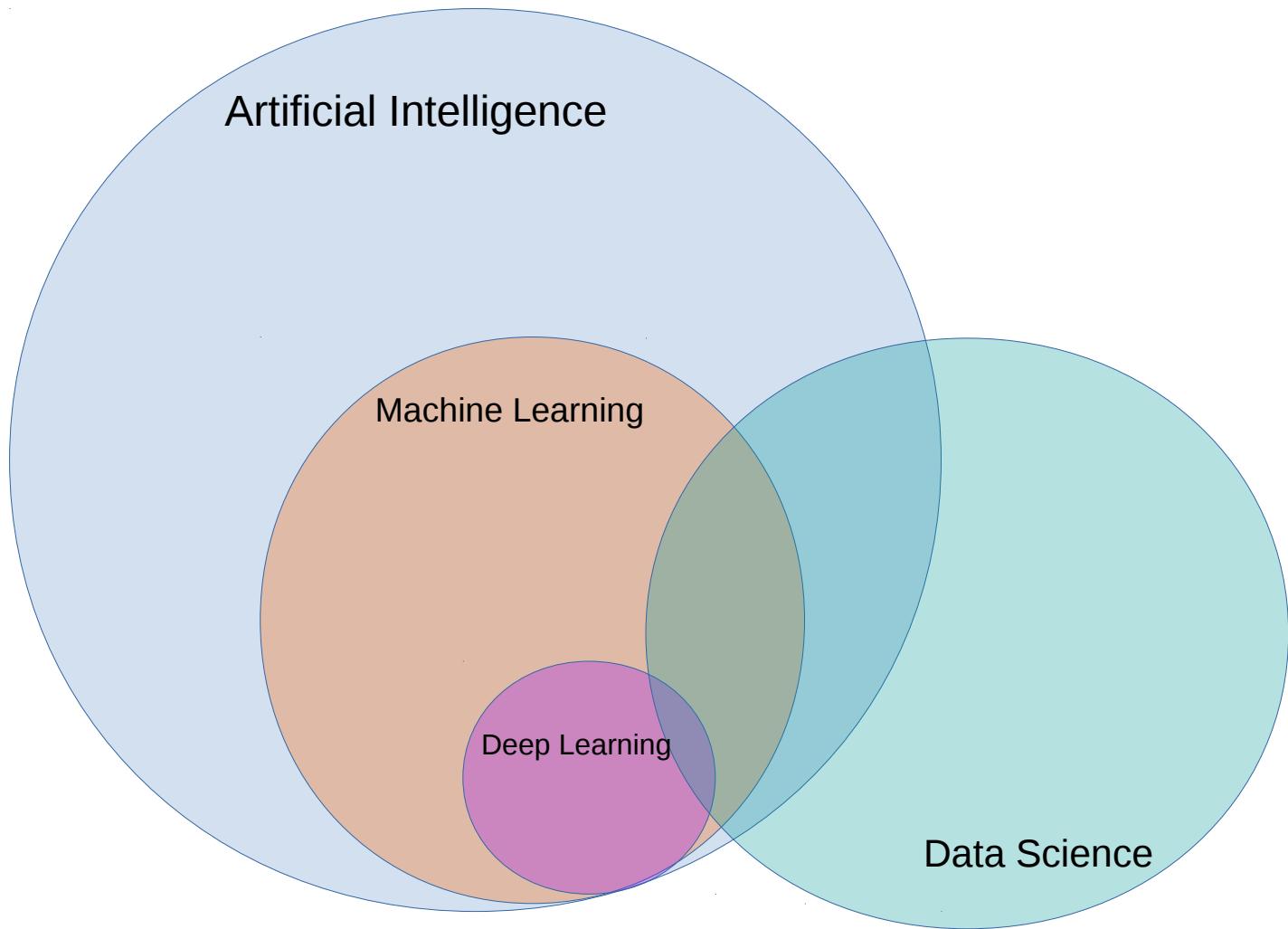


*Statistical Learning MOOC
covering the entire ISL book
offered by Trevor Hastie and Rob
Tibshirani. Start anytime in self-
paced mode.*

This book provides an introduction to statistical learning methods. It is aimed for upper level undergraduate students, masters students and Ph.D. students in the non-mathematical sciences. The book also contains a number of R labs with detailed explanations on how to implement the various methods in real life settings, and should be a valuable resource for a practicing data scientist.

Books

- **The Elements of Statistical Learning.**
 - by Hastie, Tibshirani, and Friedman.
 - Available free online: <https://web.stanford.edu/~hastie/ElemStatLearn/>
- **Pattern Recognition and Machine Learning.**
 - by C. Bishop.
 - <https://www.springer.com/gp/book/9780387310732>
- **Deep Learning.**
 - by Goodfellow, Bengio, Courville.
 - Available free online: <https://www.deeplearningbook.org/>



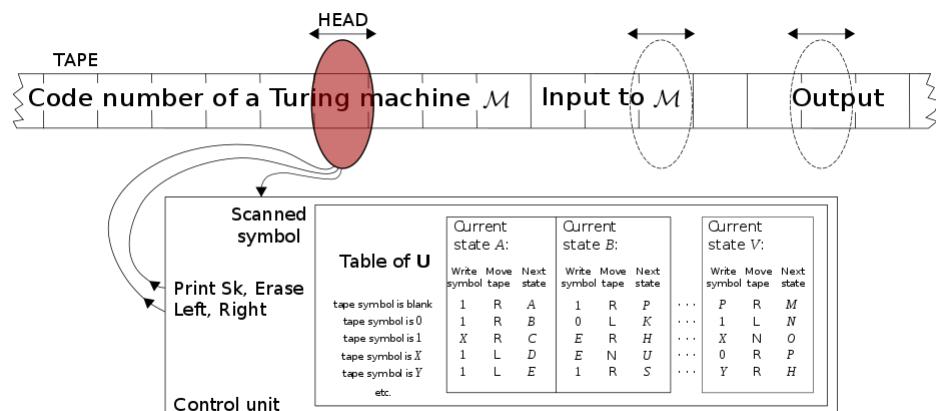
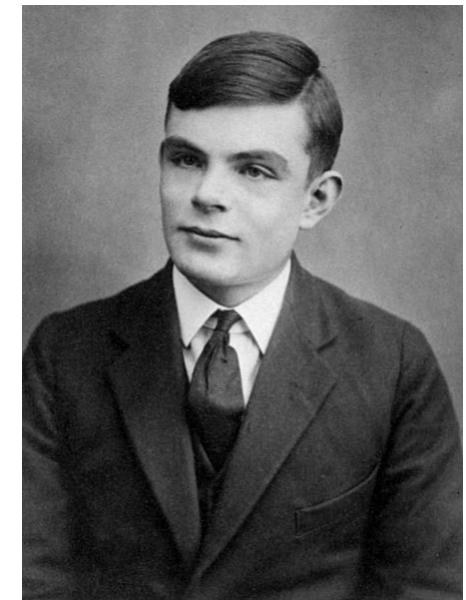
Artificial Intelligence	Machine Learning	Data Science ^[4]
Aim: Mimicking intelligent behavior ^[1]	Aim: Give computer systems the ability to "learn" from data, without being explicitly programmed ^[2]	Aim: To extract knowledge and insights from data in various forms ^[3]
Started around 1950s		Relatively modern (2000s)
Problems:	As old as AI itself	Relies heavily on statistics
<ul style="list-style-type: none"> - Reasoning - Knowledge Representation - Planning - Learning - Natural language processing - Perception/action 	Learning rather than programming to mimic intelligent behavior	Focuses more on application
Approaches:	Focuses more on prediction and performance than interpretability	Focuses more on understanding and interpretability
<ul style="list-style-type: none"> - Symbolic/logic-based - Brain simulation - Statistical learning - ... 	Larger and higher dimensional datasets	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.

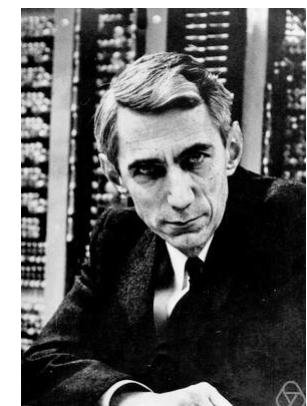
Brief history of AI and ML^[1,2]

- 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. "

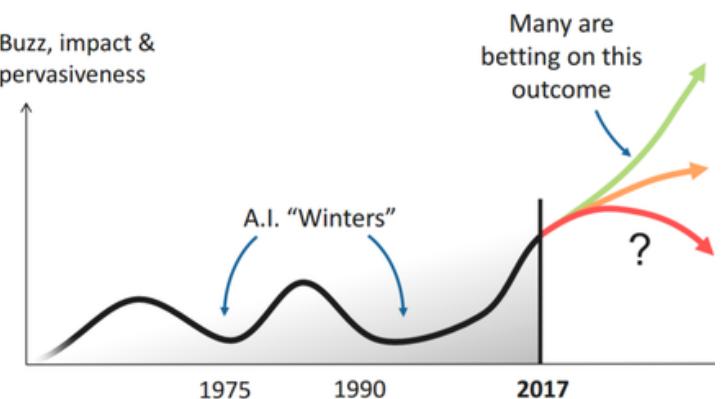


Brief history of AI and ML

- 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



AI is enjoying significant hype and investment



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

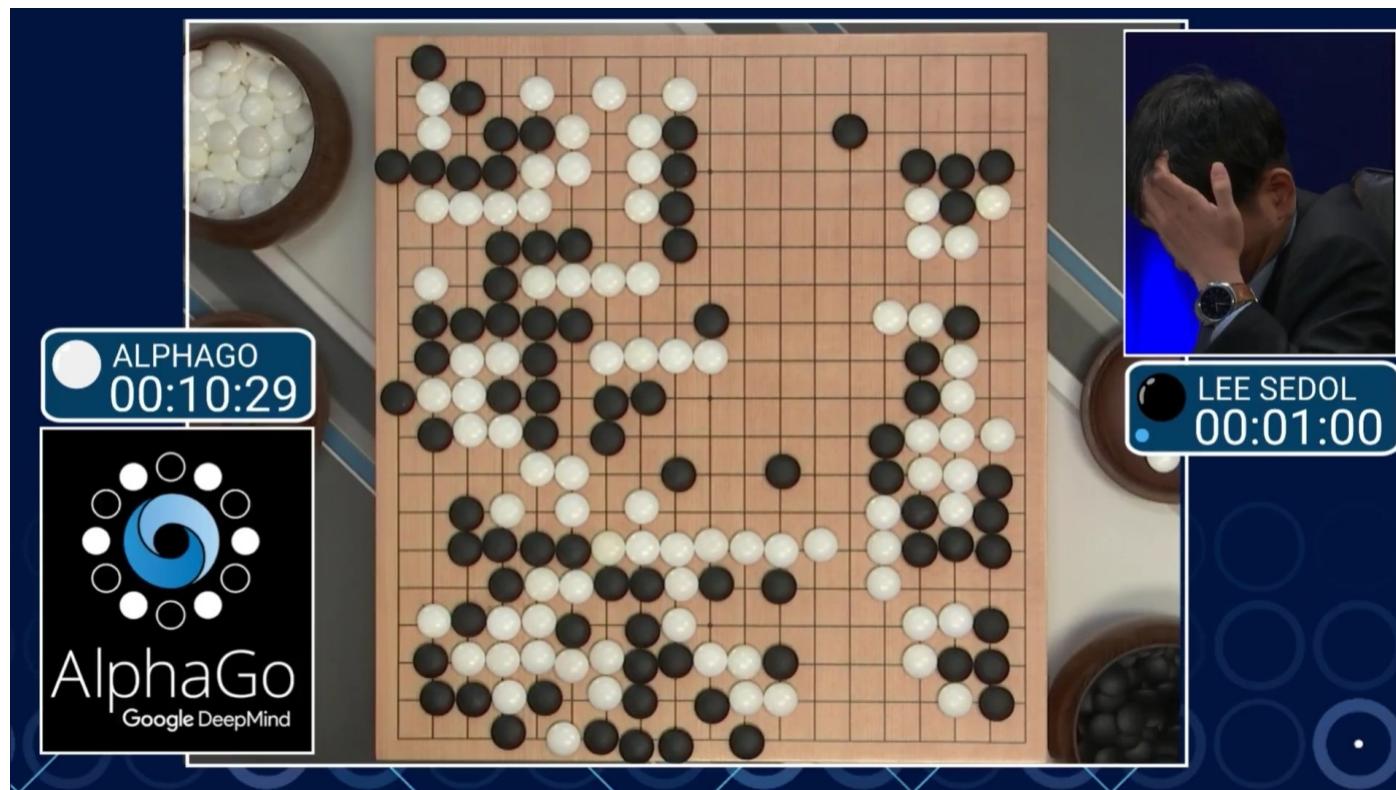
- 2011: IBM Watson beats humans at Jeopardy
 - Quiz show
 - Watson
 - <https://www.youtube.com/watch?v=P18EdAKuC1U>
 - 2,880 POWER7 processor threads and 16 terabytes of RAM
 - Uses a combination of machine learning, natural language processing and information retrieval techniques
 - Access to 200 million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

THE VIDEO FOR
"GLOSOLI" BY
SIGUR ROS
INCLUDED SOME OF
THE HOT SPRINGS
OF THIS ISLAND,
THEIR HOME COUNTRY



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

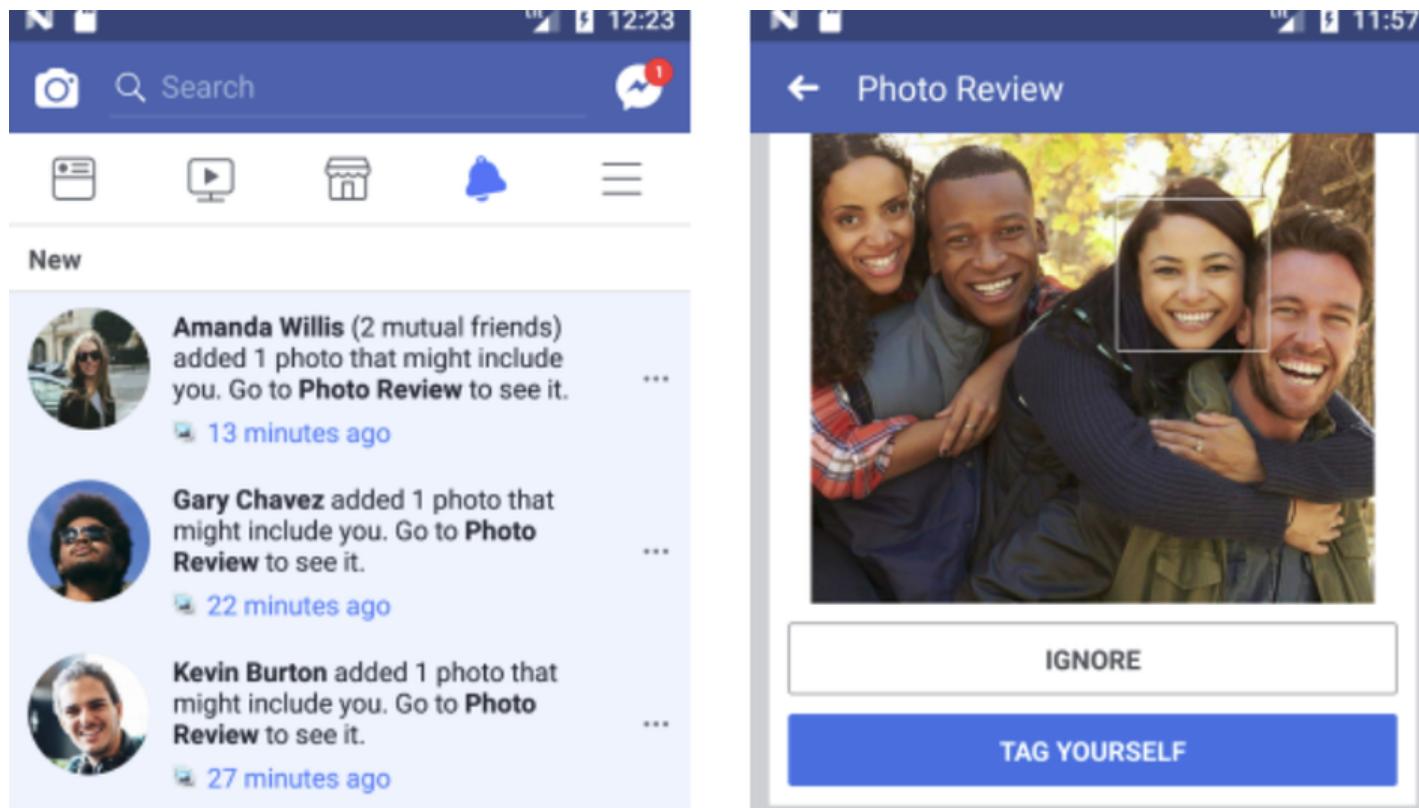


Personal assistants



Face recognition

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

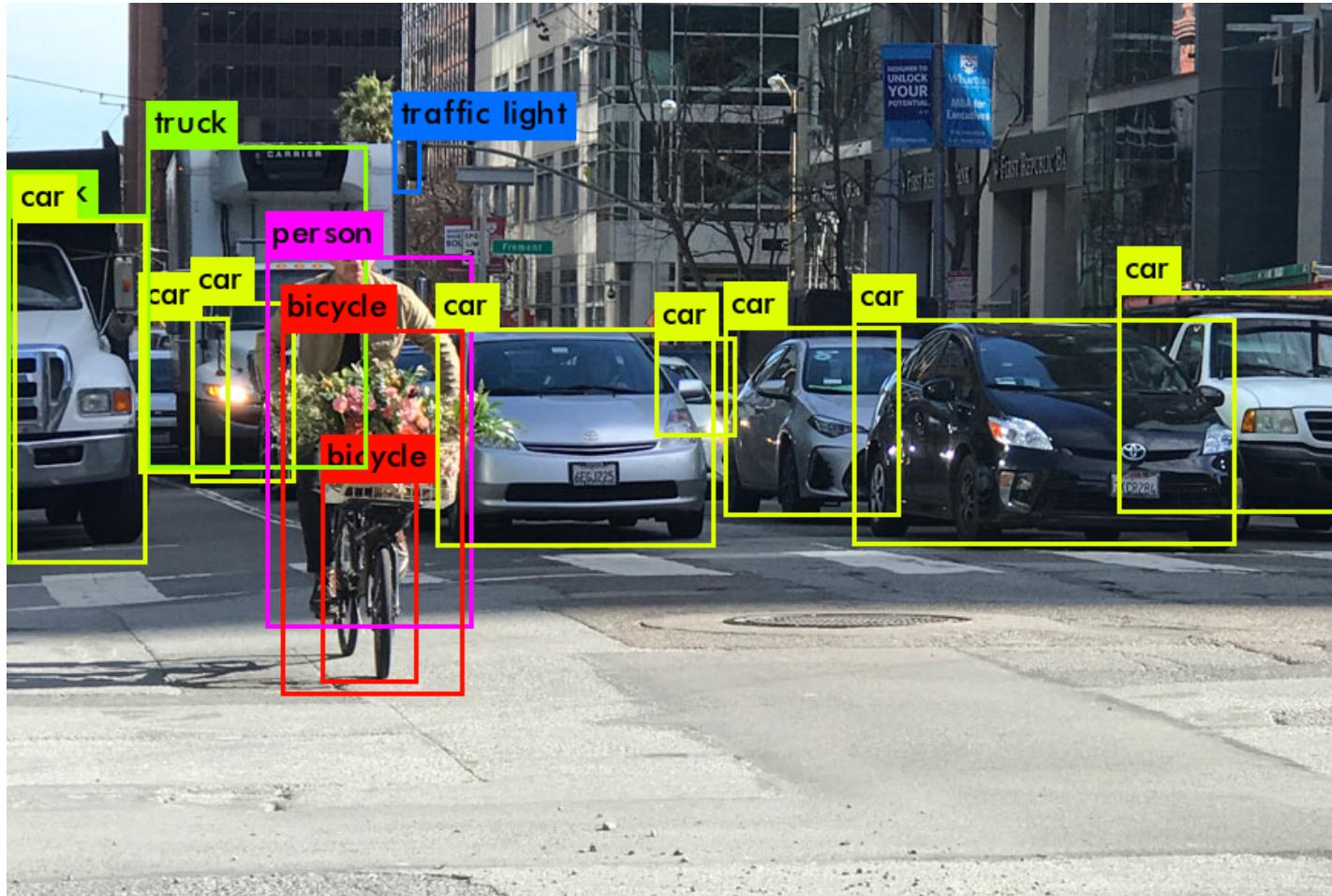


Self-driving cars



Object detection^[8]

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



Generating captions for images^[5]

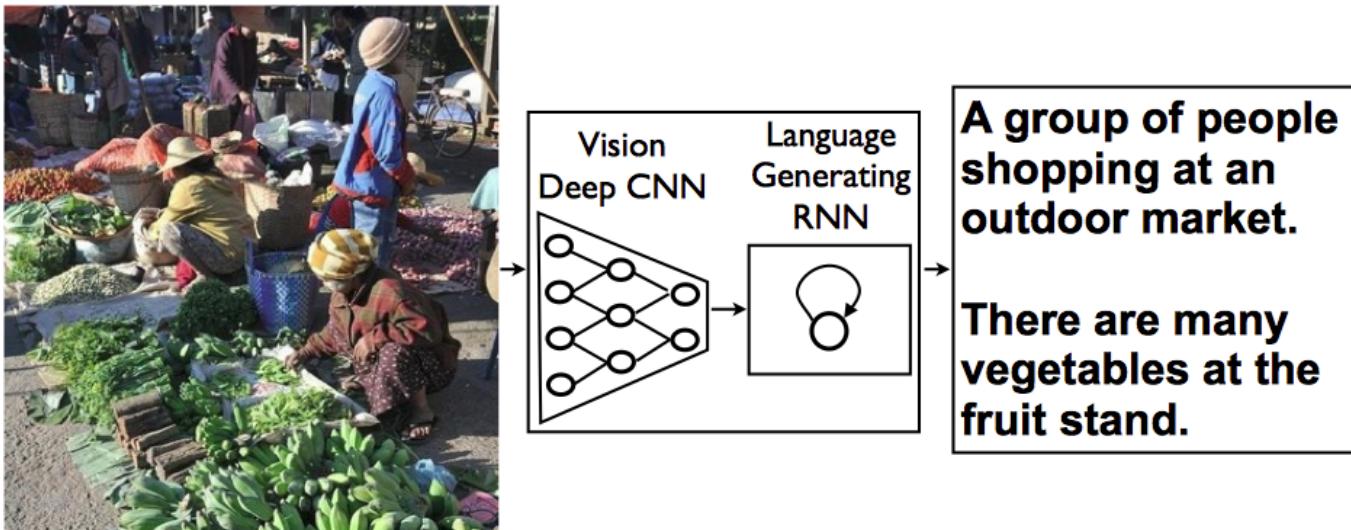


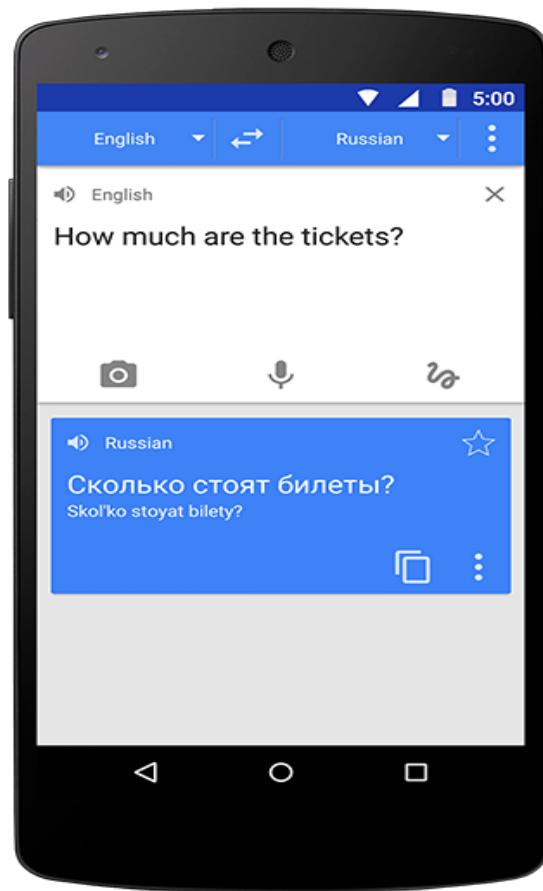
Figure 1. NIC, our model, is based end-to-end on a neural network consisting of a vision CNN followed by a language generating RNN. It generates complete sentences in natural language from an input image, as shown on the example above.

Sample application: Language translation

Youtube automatic captions

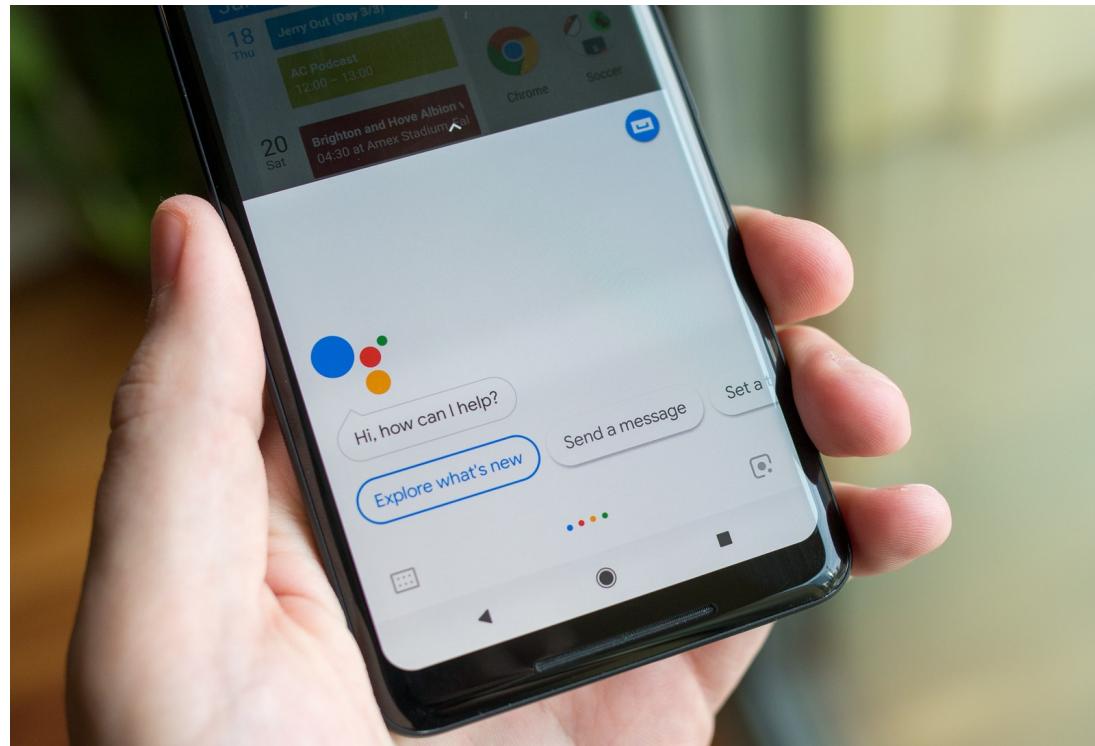
Google translate

<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=36IE9tV9vm0>



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/jwSbzNHGfIM?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

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>