# Introduction to Machine Learning

## Subtitle

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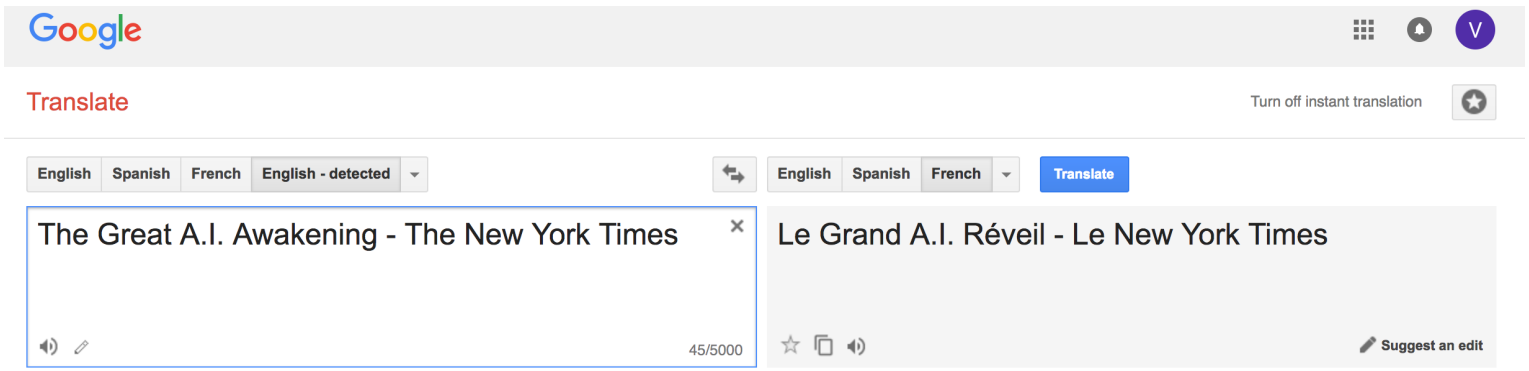
# Outline

# Making Machines Intelligent

The world is woven from billions of lives, every strand crossing every other. What we call premonition is just movement of the web. If you could attenuate to every strand of quivering data, the future would be entirely calculable, as inevitable as mathematics.

Sherlock Holmes, 2017

# What makes an artificial machine **intelligent**?

1. Talk. See. Hear.
   - Natural Language Processing, Computer Vision, Speech Recognition
2. Store. Access. Represent. (Knowledge)
   - Ontologies. Semantic Networks. Information Retrieval.
3. Reason.
   - Mathematical Logic. Bayesian Inference.
4. **Learn.**
   - Improve with Experience

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   - Improve with Experience
     - Machine Learning

# Human Learning?

- What do we learn?
  - Concepts (this is a chair, that is not a chair)
  - Distinguishing concepts (this is a chair, that is a table)
  - Other things (language, juggling, using a remote)
- How do we learn?
  1. Teaching (Passive).
  2. Experience (Active).
     - 2.1 Examples.
     - 2.2 Queries.
     - 2.3 Experimentation.

# What is Machine Learning?

- Computers learn without being **explicitly programmed**.
  - Arthur Samuel (1959)
- A computer program learns from experience E with respect to some task T, if its performance P while performing task T improves over E.
  - Tom Mitchell (1989)

# Why Machine Learning?

- Machines that know everything from the beginning?
  - Too bulky. Creator already knows everything. Fails with new experiences.
- Machines that learn?
  - Compact. Learn what is necessary.
  - Adapt.
  - Assumption: Future experiences are not too different from past experiences.
    - Have (structural) relationship.


# Learning from (Past) Data

## Deductive Logic

- All birds can fly
- Dodo is a bird
- $\Rightarrow$ Dodo can fly

## Inductive Logic

- A stingray can swim
- Stingray is a fish
- $\Rightarrow$ All fish can swim

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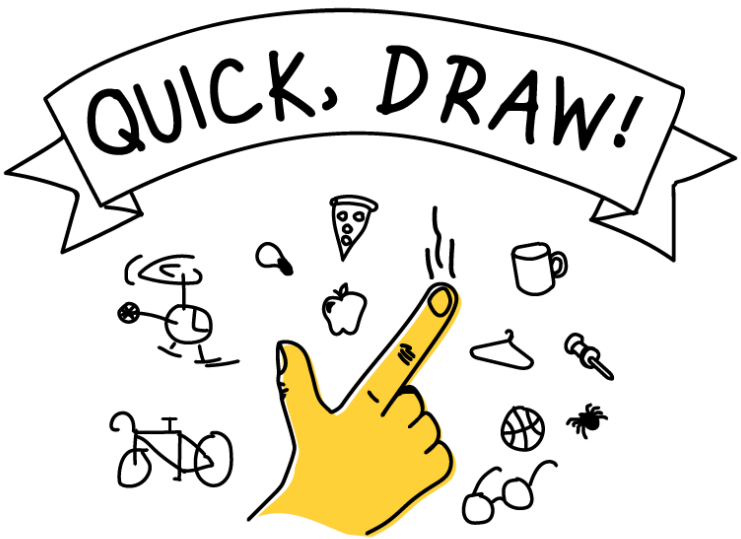
## Core Tenet

- ~~Deduce~~ Induce from past
- Generalize for future

# A Simple ML Example

https://quickdraw.withgoogle.com/



# Machine Learning meet Mother Nature

- Data: A collection of data objects
- A suitable data representation, e.g., $\mathbb{R}^d$
- Generated via an unknown natural process
- Optionally, a target is assigned to each object via another natural process, e.g., $y = f(\mathbf{x})$

# Machine Learning Problems

## Supervised Learning

- Given a finite set of **x**'s and corresponding $y$'s, **learn** $f()$
- **Infer** $y$ for a new **x**
  - $y$ - continuous (regression)
  - $y$ - discrete (classification)

## Unsupervised Learning

- Given only **x**'s, infer structure in data
  - hidden (latent) relationships among the objects
- e.g., clustering, embedding, dimensionality reduction, etc.

## Reinforcement Learning*

- Find the best mapping of situations to actions to maximize a numerical reward
- Agent learns to behave in an environment

# References