Introduction to Machine Learning

Subtitle

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Outline

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1 Making Intelligent Machines

Artificial Intelligence or AI has been getting immense publicity in recent years, mostly due to advances in deep learning methods and their applications to areas such as self driving cars, robotic assistants, and language translation systems. The area of AI is more than half a century old, when computer scientists and mathematicians embarked on the quest for making intelligent machines. Now that idea pervades or threatens to pervade every aspect of our daily life. Read an interesting article on AI in "The Great A.I. Awakening" in New York Times, December 2016.

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
     - Machine Learning

2 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).
     (a) Examples.
     (b) Queries.
     (c) Experimentation.

3 Definition of 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)

3.1 Why Machine Learning?

One could argue as to why one would want a machine to "learn" over experience instead of programming a machine to "know" everything. But such approach is infeasible. First, because knowing everything will require a significant amount of storage. Second, the success of such a system assumes that the creator already knows everything about the problem, which often is an optimistic and false assumption.

Machine learning is implicitly based on the notion that the new experiences that a machine will encounter will be similar to the past experiences. Hence, instead of "pre-loading" the machine with knowledge about all possible experiences, it is efficient to selectively learn from these experiences. Moreoever, as long as the new experience has some structural relationship with the past experiences, the machine can perform well in unseen situations as well.

- 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.

4 Learning from (Past) Data

Deductive Logic

- All birds can fly
- Dodo is a bird
- ⇒ Dodo can fly

Inductive Logic

- A stingray can swim
- Stingray is a fish
- ⇒ All fish can swim

Core Tenet

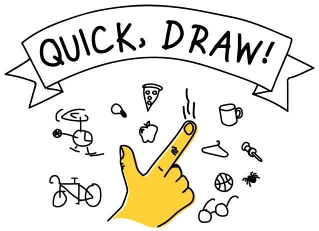
- ~~Deduce~~ Induce from past
- Generalize for future

5 Simple ML Example

`https://quickdraw.withgoogle.com/`

6 Overview of ML

- 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., $y = f(\mathbf{x})$



Supervised Learning

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

Unsupervised Learning

- Given only $\mathbf{x}$'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