Introduction to Machine Learning

CSE474/574: Lecture 2

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Outline

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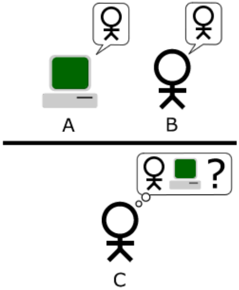
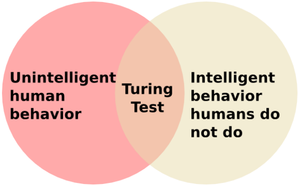
Turing's Test [1]

- Can machines think?
- Simple version - Can machines imitate humans?
- E.g., ELIZA
  - `http://www.manifestation.com/neurotoys/eliza.php3`
- Difference between "human behavior" and "intelligent behavior".





Outline

What makes a 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
        - Machine Learning

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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.

Running Example - A Robotic Furniture Sorter

- Our future overlords (Kiva)
  - https://youtube.googleapis.com/v/6KRjuuEVEZs

Make Kiva Learn

- Distinguish between **tables** and **chairs**.
- How do you represent the input?
- Distinguishing features.
  - *has back rest?*
- Good features should be:
  - Computable. Distinguishing. Representative.
  - *is a chair?*
  - *has four legs?*
  - *is white?*

Outline

Concept Learning

- Infer a boolean-valued function $c : x \rightarrow \{\texttt{true},\texttt{false}\}$
- *Input*: Attributes for input x
- *Output*: `true` if input belongs to concept, else `false`
- Go from specific to general (*Inductive Learning*).

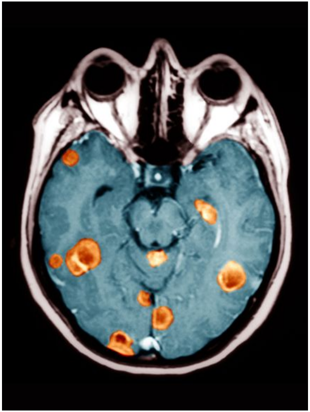
Finding Malignant Tumors from MRI Scans

Attributes

1. **Shape** `circular,oval`
2. **Size** `large,small`
3. **Color** `light,dark`
4. **Surface** `smooth,irregular`
5. **Thickness** `thin,thick`

Concept

Malignant tumor.



Notation

- X - Set of all possible instances.
  - What is $|X|$?
- Example: $\{\texttt{circular,small,dark,smooth,thin}\}$
- D - Training data set.
  - $D = \{\langle x, c(x)\rangle : x \in X, c(x) \in \{0, 1\}\}$
- Typically, $|D| \ll |X|$

Representing a Concept - Hypothesis

- A conjunction over a subset of attributes
  - A malignant tumor is: *circular* **and** *dark* **and** *thick*
  - {`circular,?,dark,?,thick`}
- Target concept c is unknown
  - Value of c over the training examples is known

Approximating Target Concept Through Hypothesis

- **Hypothesis**: a potential concept
- Example: $\{\texttt{circular},\texttt{?},\texttt{?},\texttt{?},\texttt{?}\}$
- **Hypothesis Space** $(\mathcal{H})$: Set of *all hypotheses*
  - What is $|\mathcal{H}|$?
- Special hypotheses:
  - Accept *everything*, $\{\texttt{?},\texttt{?},\texttt{?},\texttt{?},\texttt{?}\}$
  - Accept *nothing*, $\{\emptyset,\emptyset,\emptyset,\emptyset,\emptyset\}$

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References

A. M. Turing.
Computing machinery and intelligence.
Mind, 59:433–460, 1950.