Artificial Intelligence

For HEDSPI Project

Lecturer 13 – Machine Learning

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Introduction of Machine learning

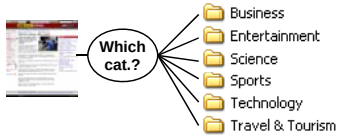
- Definitions of Machine learning…
  - → A process by which a system improves its performance `[Simon, 1983]`
  - → Any computer program that improves its performance at some task through experience `[Mitchell, 1997]`
  - → Programming computers to optimize a performance criterion using example data or past experience `[Alpaydin, 2004]`
- Representation of the learning problem `[Mitchell, 1997]`

  Learning = Improving with experience at some task
  - Improve over task **T**
  - With respect to performance measure **P**
  - Based on experience **E**

Application examples of ML (1)

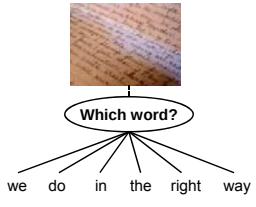
Web pages filtering problem
- **T**: to predict which Web pages a given user is interested in
- **P**: % of Web pages correctly predicted
- **E**: a set of Web pages identified as interested/uninterested for the user

Web pages categorization problem
- **T**: to categorize Web pages in predefined categories
- **P**: % of Web pages correctly categorized
- **E**: a set of Web pages with specified categories

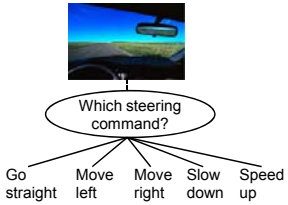


Application examples of ML (2)

Handwriting recognition problem
- **T**: to recognize and classify handwritten words within images
- **P**: % of words correctly classified
- **E**: a database of handwritten words with given classifications (i.e., labels)



Robot driving problem
- **T**: to drive on public highways using vision sensors
- **P**: average distance traveled before an error (as judged by human overseer)
- **E**: a sequence of images and steering commands recorded while observing a human driver



Key elements of a ML problem (1)

- Selection of the training examples
  - Direct or indirect training feedback
  - With teacher (i.e., with labels) or without
  - The training examples set should be representative of the future test examples
- Choosing the target function (a.k.a. hypothesis, concept, etc.)
  - F: X → {0,1}
  - F: X → a set of labels
  - F: X → R^+ (i.e., the positive real numbers domain)
  - …

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Key elements of a ML problem (2)

- Choosing a representation of the target function
  - A polynomial function
  - A set of rules
  - A decision tree
  - A neural network
  - …
- Choosing a learning algorithm that learns (approximately) the target function
  - Regression-based
  - Rule induction
  - ID3 or C4.5
  - Back-propagation
  - …

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Issues in Machine Learning (1)

- Learning algorithm
  - What algorithms can approximate the target function?
  - Under which conditions does a selected algorithm converge (approximately) to the target function?
  - For a certain problem domain and given a representation of examples which algorithm performs best?
- Training examples
  - How many training examples are sufficient?
  - How does the size of the training set influence the accuracy of the learned target function?
  - How does noise and/or missing-value data influence the accuracy?

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Issues in Machine Learning (2)

- Learning process
  - What is the best strategy for selecting a next training example? How do selection strategies alter the complexity of the learning problem?
  - How can prior knowledge (held by the system) help?
- Learning capability
  - What target function should the system learn?
    Representation of the target function: expressiveness vs. complexity
  - What are the theoretical limits of learnability?
  - How can the system generalize from the training examples?
    To avoid the overfitting problem
  - How can the system automatically alter its representation?
    To improve its ability to represent and learn the target function

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Types of learning problems

- A rough (and somewhat outdated) classication of learning problems:
  - Supervised learning, where we get a set of training inputs and outputs
    - classication, regression
  - Unsupervised learning, where we are interested in capturing inherent organization in the data
    - clustering, density estimation
  - Reinforcement learning, where we only get feedback in the form of how well we are doing (not what we should be doing)
    - Planning