Artificial Intelligence

COURSE INSTRUCTOR: MUHAMMAD SAIF UL ISLAM

Outline

- Learning
- Supervised Learning
  - Classification
  - Prediction
- Unsupervised Learning
  - Clustering
- Reinforcement Learning

What is Learning

- Webster s definition of **to learn**

  "To gain **knowledge** or **understanding** of, or **skill** in **by study, instruction** or **experience**"

  - Learning a set of new facts
  - Learning HOW to do something
  - Improving ability of something already learned

Why Learn?

- There is no need to "learn" to calculate payroll
- **Learning is used when:**
  - Human expertise does not exist
  - Humans are unable to explain their expertise (speech recognition)
  - Solution changes in time (routing on a computer network)
  - Solution needs to be adapted to particular cases (user biometrics)

Learning

- Examples
  - Walking (motor skills)
  - Riding a bike (motor skills)
  - Telephone number (memorizing)
  - Playing backgammon (strategy)
  - Develop scientific theory (abstraction)
  - Language
  - Recognize fraudulent credit card transactions Etc.

(One) Definition of Learning

- **Definition [Mitchell]:**

  A computer program is said to learn from
  - experience E with respect to some class of
  - tasks T and
  - performance measure P,

  if its performance at tasks in T, as measured by P, improves with experience E.

Examples

- Spam Filtering
  - T: Classify emails HAM /SPAM
  - E: Examples $(e_1, \text{HAM}), (e_2, \text{SPAM}), (e_3, \text{HAM}), (e_4, \text{SPAM}), \ldots$
  - P: Prob. of an error on new emails
- Personalized Retrieval
  - T: find documents the user wants for query
  - E: watch person use Google (queries/clicks)
  - P: # relevant docs in top 10
- Play Checkers
  - T: Play checkers
  - E: games against self P: percentage wins

Supervised Learning

Supervised Learning

- Supervised learning is the machine learning task of inferring a function from supervised training data.
- The training data consist of a set of training examples.
- In supervised learning, each example is a pair consisting of an input object (typically a vector) and the desired output value (also called the supervisory signal).

Supervised Learning Algorithms

A supervised learning algorithm analyzes the training data and produces

- (Inferred function) classifier
  - If the output is discrete.

  OR
- Regression function
  - If the output is continuous

Working of supervised learning algorithms

Given a set of training examples of the form:

$$\{ (x_1, y_1), \ldots, (x_N, y_N) \}$$

a learning algorithm seeks a function

$$g : X \rightarrow Y$$

where X is the input space and Y is the output space and the function g is an element of some space of possible functions G, usually called the hypothesis space.

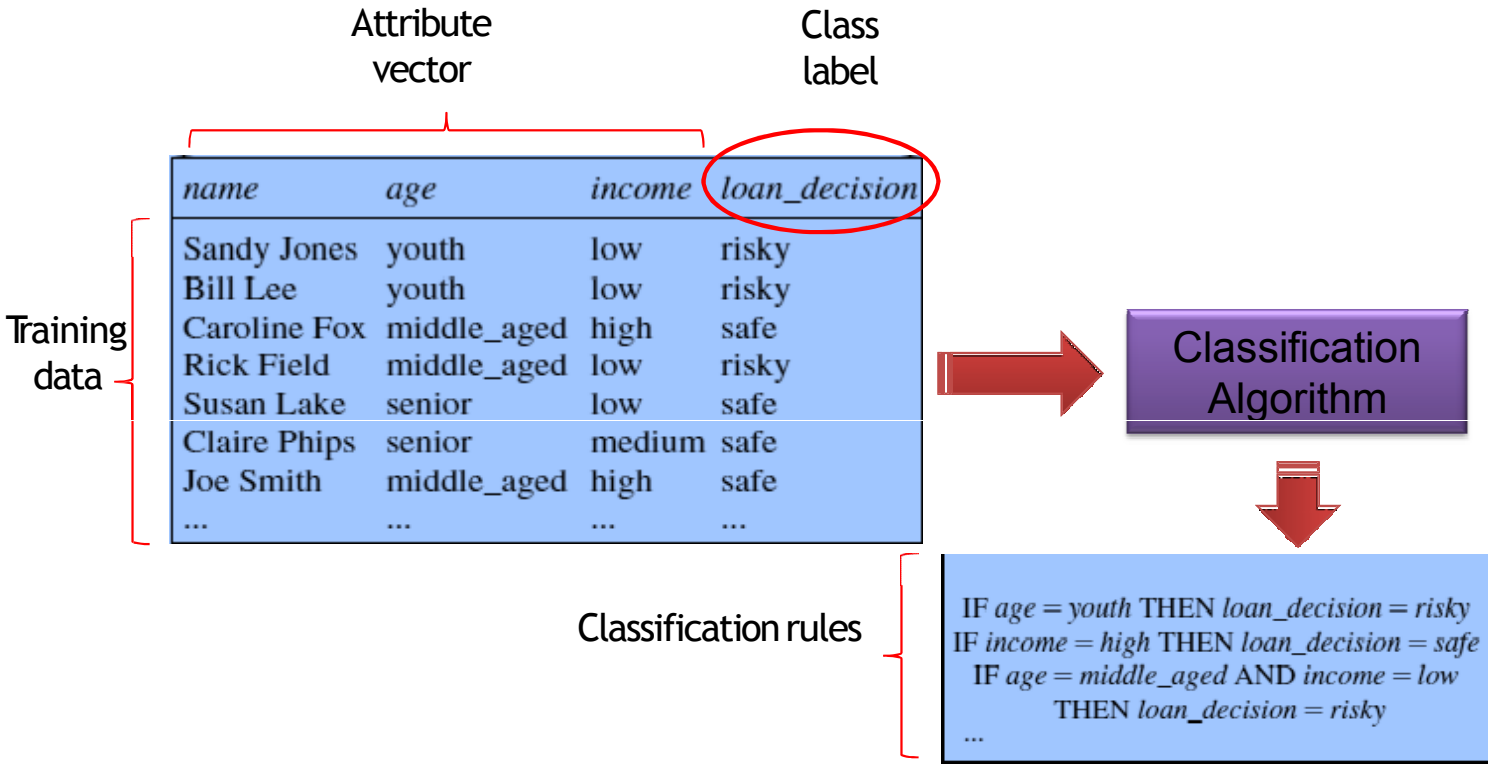
Classification

Classification: Definition

- Given a collection of records (*training set*)
- Each record contains a set of *attributes*, one of the attributes is the *class*.
- Find a *model* for class attribute as a function of the values of other attributes.
- **Goal**: previously unseen records should be assigned a class as accurately as possible.

- A *test set* is used to determine the accuracy of the model. Usually, the given data set is divided into training and test sets, with the training set used to build the model and the test set used to validate it.

The Basics - General Approach



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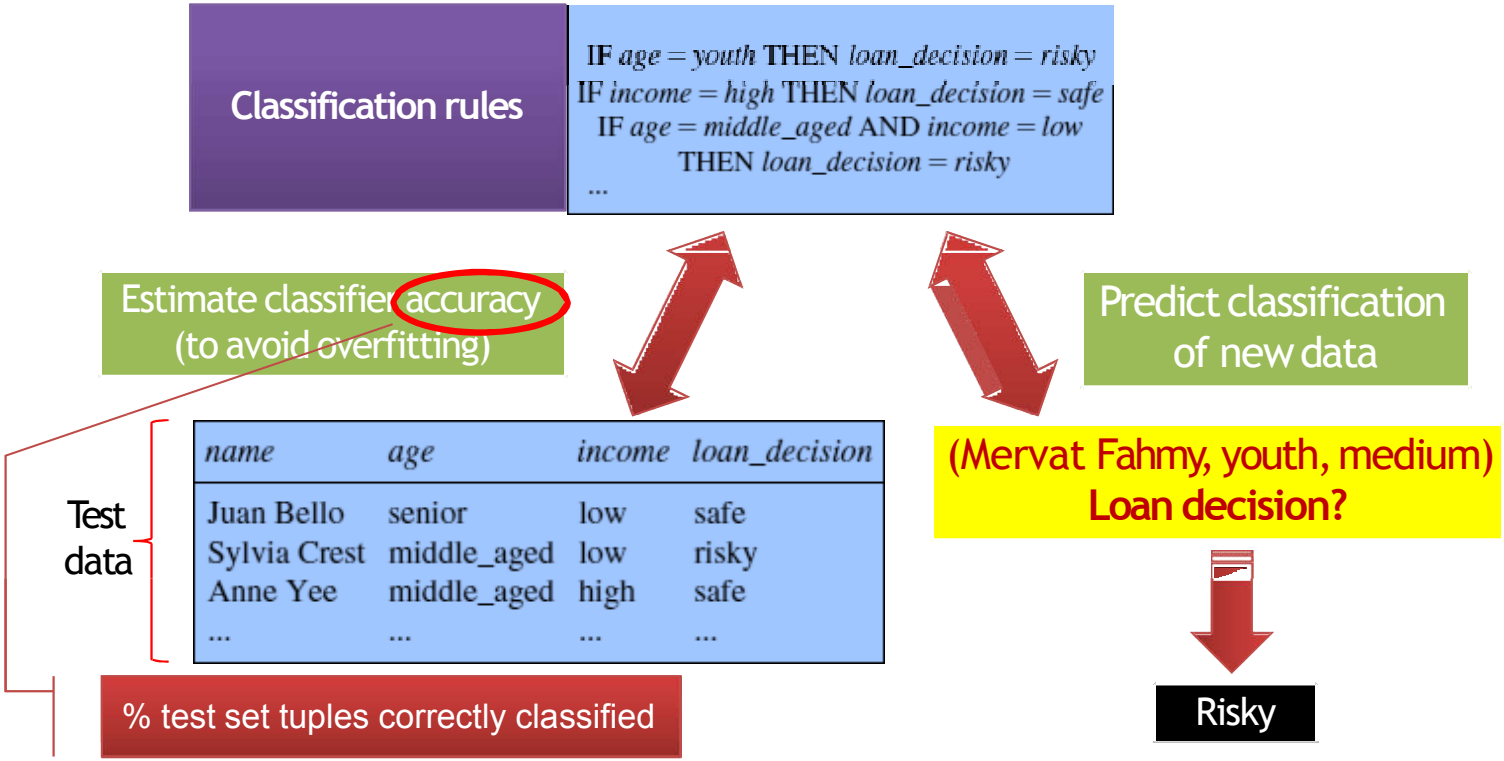


Examples of Classification Task Applications

- Predicting tumor cells as benign or malignant
- Classifying credit card transactions as legitimateor fraudulent
- Categorizing news stories asfinance, weather, entertainment, sports, etc

Different Types of Classifiers

- Back propagation
- Bayesian Classifiers
- Decision Trees
- Density estimation methods
- Fuzzy set theory
- Linear discriminant analysis (LDA)
- Logistic regression
- Naive bayes classifier
- Nearest Neighborhood Classification
- Neural networks
- Quadratic discriminant analysis (QDA)
- Support Vector Machine
- many more…


Prediction

What Is Prediction?

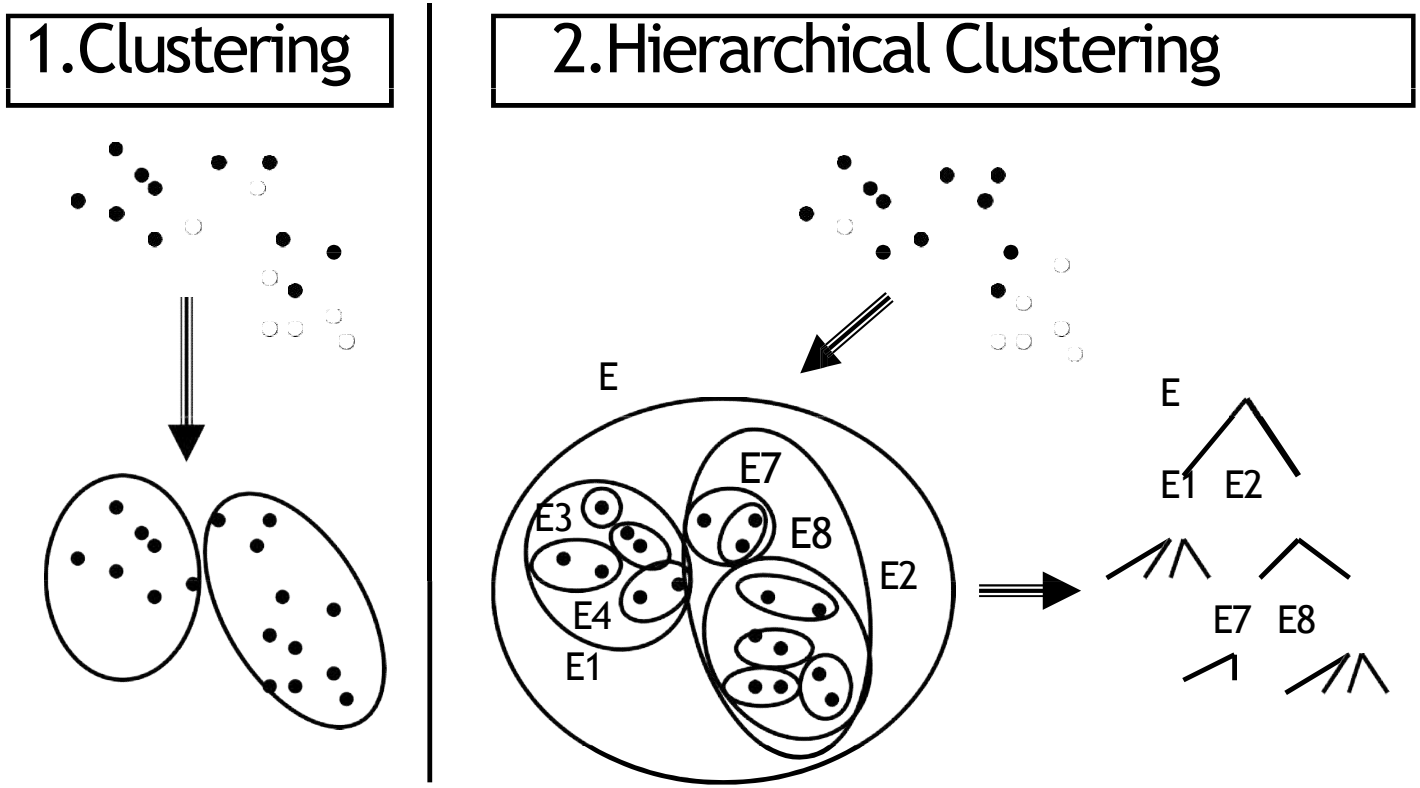
- Prediction is similar to classification
  - First, construct a model
  - Second, use a model to predict the unknown value
    - Major method for prediction is regression
      - Linear and multiple regression
      - Non-linear regression
- Prediction is different from classification
  - Classification refers to predicting the categorical class label
  - Prediction models continuous-valued functions

Unsupervised Learning

Unsupervised Learning

- Unsupervised Learning takes the set of attributes/features as training examples alone.
- The purpose of unsupervised learning is to attempt to find natural partitions in the training set.
- Two general strategies for Unsupervised learning include *Clustering* and *Hierarchical Clustering*.

Clustering and Hierarchical Clustering



What is Unsupervised Learning Usefulfor?

- Collecting and labeling a large set of sample patterns can be very expensive. By designing a basic classifier with a small set of labeled samples, and then tuning the classifier up by allowing it to run without supervision on a large, unlabeled set, much time and trouble can be saved.
- Training with large amounts of data often less expensive, unlabeled data, and then using

  supervision to label the groupings found. This may be used for large "data mining" applications where the contents of a large database are not known beforehand.

What is Unsupervised Learning Useful for?

- Unsupervised methods can also be used to find features that can be useful for categorization. There are unsupervised methods that represent a form of data-dependent "smart pre-processing" or "smart feature extraction."
- Lastly, it can be of interest to gain insight into the nature or structure of the data. The discovery of similarities among patterns or of major departures from expected characteristics may suggest a significantly different approach to designing the classifier.

Other Unsupervised Methods

- There are a lot of other Unsupervised Learning Methods.
- **Examples:**
  - k-means
  - The EM Algorithm
  - Competitive Learning
  - Kohonen's Neural Networks: Self-Organizing Maps
  - Principal Component Analysis, Autoassociation

Reinforcement Learning

Reinforcement learning

- Intelligent learning algorithm
- Doesn't require the presence of a teacher
- The algorithm is given a reward (a reinforcement) for good actions
- The algorithm tries to figure out what is the best action to take in a given state, without knowing the final optimal solution.
- The actions are based on rewards and penalties.

Applications

- Robot control
- Elevator scheduling (search for patterns)
- Telecommunications (finding networks)
- Games (Chess, Backgammon)
- Financial trading