CS 412 Intro. to Data Mining

Chapter 8. Classification: Basic Concepts

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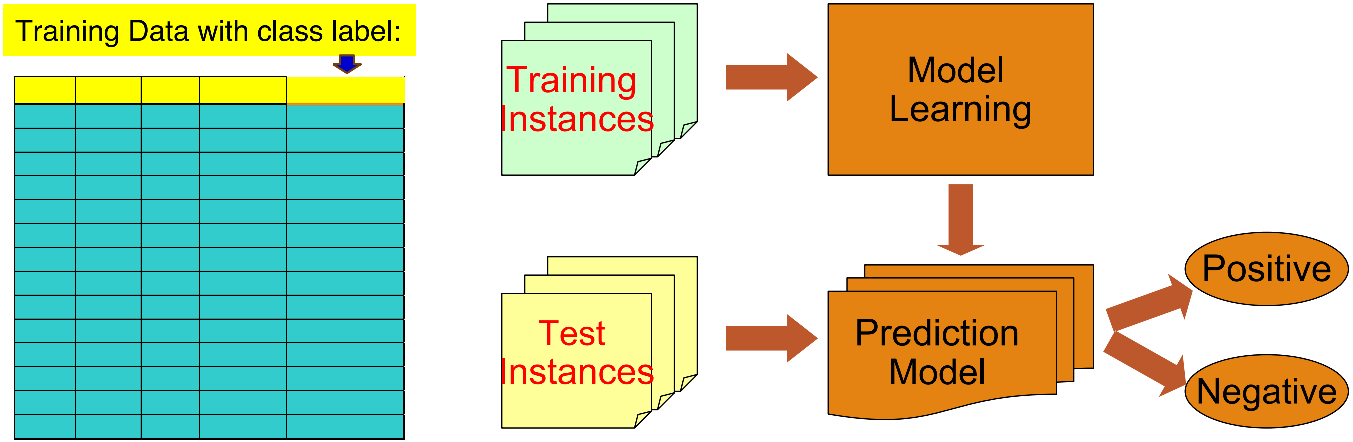
Chapter 8. Classification: Basic Concepts

- Classification: Basic Concepts
- Decision Tree Induction
- Bayes Classification Methods
- Linear Classifier
- Model Evaluation and Selection
- Techniques to Improve Classification Accuracy: Ensemble Methods
- Additional Concepts on Classification
- Summary

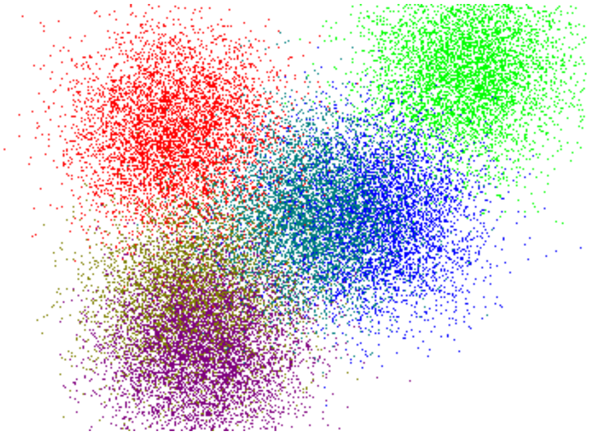
Supervised vs. Unsupervised Learning (1)

- Supervised learning (classification) → มีตัวเฉลย เป็นจุดมุ่งหมาย (มีผู้สอน)
  - Supervision: The training data such as observations or measurements are accompanied by labels indicating the classes which they belong to
  - New data is classified based on the models built from the training set



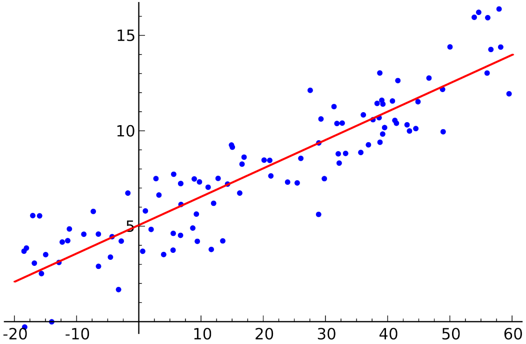
Supervised vs. Unsupervised Learning (2)

- Unsupervised learning (clustering) → ไม่มีผู้สอน
  - The class labels of training data are unknown   แบ่งกลุ่มเฒพๆ
  - Given a set of observations or measurements, establish the possible existence of classes or clusters in the data



Prediction Problems: Classification vs. Numeric Prediction

- Classification → เป็น binary ทำนายว่าอยู่กลุ่มไหน
  - Predict categorical class labels (discrete or nominal)
  - Construct a model based on the training set and the class labels (the values in a classifying attribute) and use it in classifying new data
- Numeric prediction → เป็นตัวเลข "Regression"
  - Model continuous-valued functions (i.e., predict unknown or missing values)
- Typical applications of classification
  - Credit/loan approval
  - Medical diagnosis: if a tumor is cancerous or benign
  - Fraud detection: if a transaction is fraudulent
  - Web page categorization: which category it is



Classification—Model Construction, Validation and Testing

- Model construction เอา Data ที่มี featured + คำตอบมาtrain
  - Each sample is assumed to belong to a predefined class (shown by the class label)
  - The set of samples used for model construction is training set
  - Model: Represented as decision trees, rules, mathematical formulas, or other forms
- Model Validation and Testing:
  - Test: Estimate accuracy of the model → แต่ ข ทำนายเลย
    - The known label of test sample is compared with the classified result from the model
    - Accuracy: % of test set samples that are correctly classified by the model
    - Test set is independent of training set
  - Validation: If the test set is used to select or refine models, it is called validation (or development) (test) set
- Model Deployment: If the accuracy is acceptable, use the model to classify new data

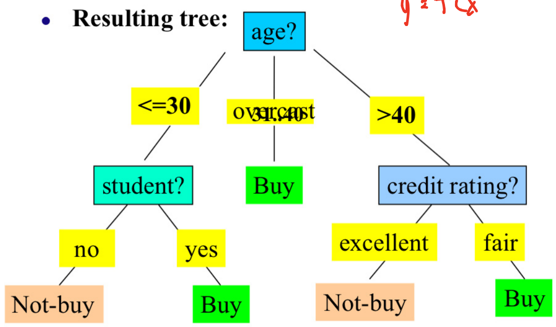
x = feature

y = label

Decision Tree Induction: An Example

- **Decision tree construction**:
  - A top-down, recursive, divide-and-conquer process
- **Resulting tree:**

y = f(x)



Training data set: Who buys computer?

age	income	student	credit_rating	buys_computer
<=30	high	no	fair	no
<=30	high	no	excellent	no
31…40	high	no	fair	yes
>40	medium	no	fair	yes
>40	low	yes	fair	yes
>40	low	yes	excellent	no
31…40	low	yes	excellent	yes
<=30	medium	no	fair	no
<=30	low	yes	fair	yes
>40	medium	yes	fair	yes
<=30	medium	yes	excellent	yes
31…40	medium	no	excellent	yes
31…40	high	yes	fair	yes
>40	medium	no	excellent	no

Note: The data set is adapted from "Playing Tennis" example of R. Quinlan

Information Gain: An Attribute Selection Measure

- Select the attribute with the highest information gain (used in typical decision tree induction algorithm: ID3/C4.5)
- Let *pi* be the probability that an arbitrary tuple in D belongs to class Ci, estimated by |*Ci*, D|/|D|
- Expected information (entropy) needed to classify a tuple in D:

$$Info(D) = -\sum_{i=1}^{m} p_i \log_2(p_i)$$

- Information needed (after using A to split D into v partitions) to classify D:

$$Info_A(D) = \sum_{j=1}^{v} \frac{|D_j|}{|D|} \times Info(D_j)$$

- Information gained by branching on attribute A

$$Gain(A) = Info(D) - Info_A(D)$$

Example: Attribute Selection with Information Gain

- Class P: buys_computer = "yes"
- Class N: buys_computer = "no"

$$Info(D) = I(\overset{Y}{9},\overset{N}{5}) = -\frac{9}{14}\log_2\left(\frac{9}{14}\right) - \frac{5}{14}\log_2\left(\frac{5}{14}\right) = 0.940$$

age	p_i	n_i	$I(p_i, n_i)$
<=30	2	3	0.971
31…40	4	0	0
>40	3	2	0.971

age	income	student	credit_rating	buys_computer
<=30	high	no	fair	no
<=30	high	no	excellent	no
31…40	high	no	fair	yes
>40	medium	no	fair	yes
>40	low	yes	fair	yes
>40	low	yes	excellent	no
31…40	low	yes	excellent	yes
<=30	medium	no	fair	no
<=30	low	yes	fair	yes
>40	medium	yes	fair	yes
<=30	medium	yes	excellent	yes
31…40	medium	no	excellent	yes
31…40	high	yes	fair	yes
>40	medium	no	excellent	no

$$Info_{age}(D) = \overset{<=30}{\frac{5}{14}I(2,3)} + \overset{31...40}{\frac{4}{14}I(4,0)} + \overset{>40}{\frac{5}{14}I(3,2)} = 0.694$$

$\frac{5}{14}I(2,3)$ means "age <=30" has 5 out of 14 samples, with 2 yes'es and 3 no's. Hence

$$Gain(age) = Info(D) - Info_{age}(D) = 0.246$$

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Similarly, we can get

$$Gain(income) = 0.029$$
$$Gain(student) = 0.151$$
$$Gain(credit\_rating) = 0.048$$

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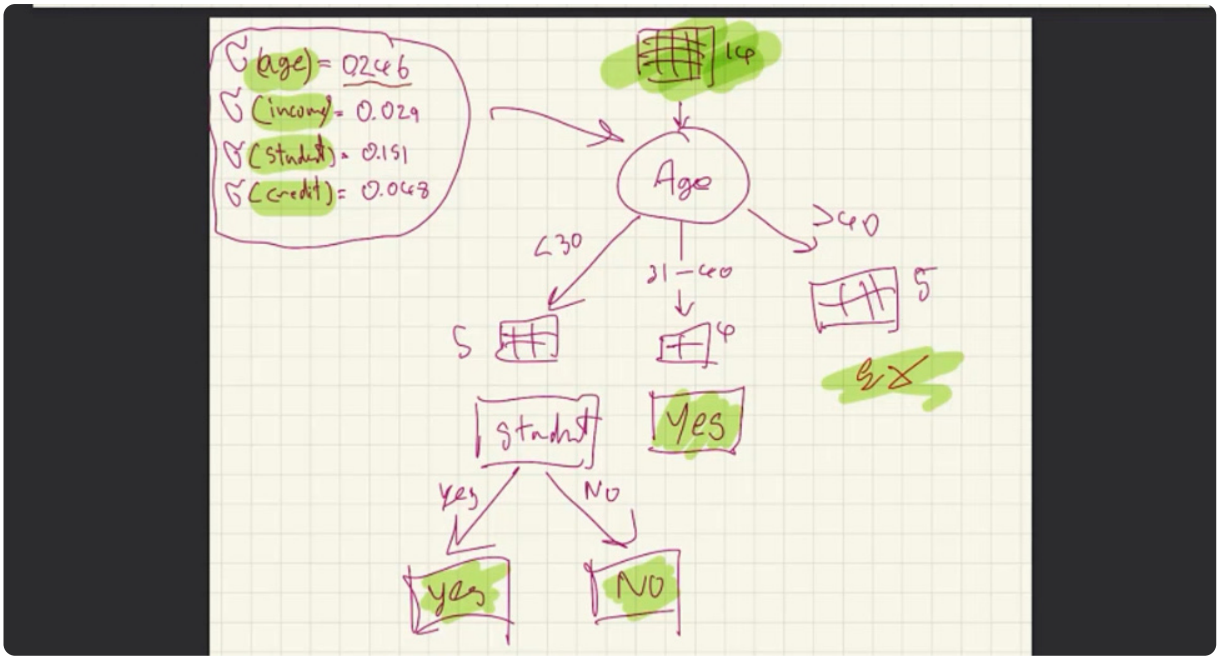
หลักการสร้าง Decision tree

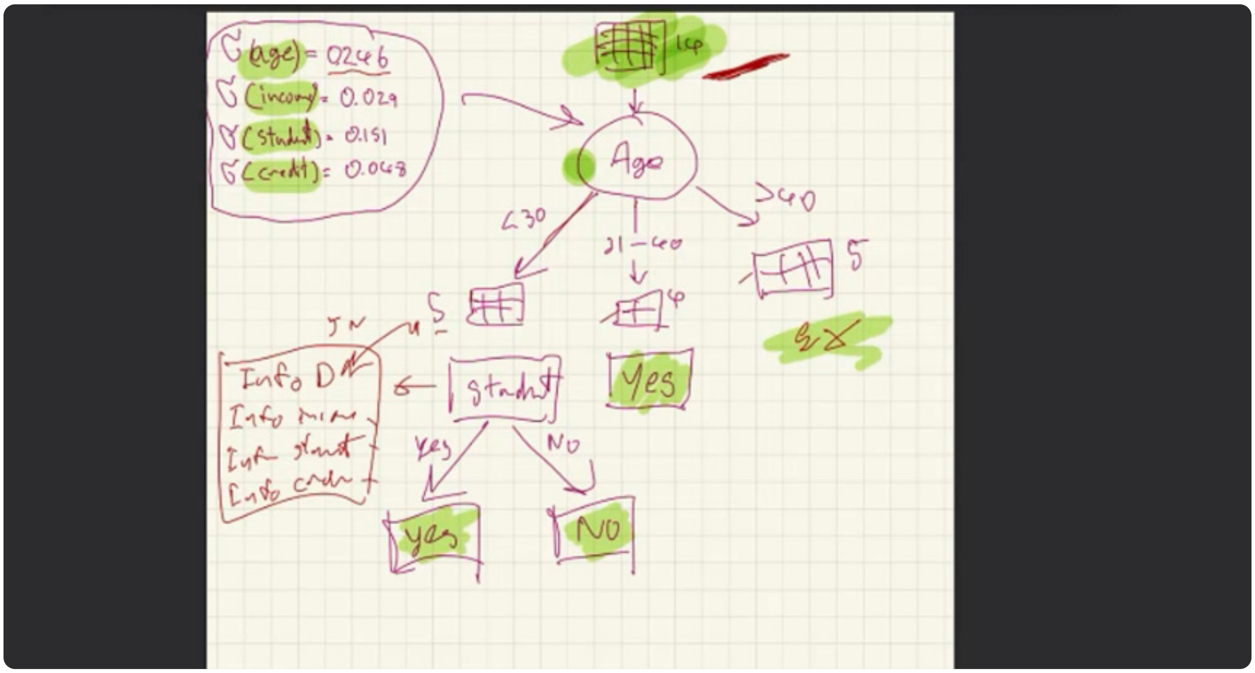


$$Info(D) = I(2,3) = -\frac{2}{5}\log_2\frac{2}{5} - \frac{3}{5}\log_2\frac{3}{5}$$

$$Info_{income}(D) = \underbrace{\frac{2}{5}I(0,2)}_{\text{high}} + \underbrace{\frac{2}{5}I(1,1)}_{\text{medium}} + \underbrace{\frac{1}{5}I(1,0)}_{\text{low}}$$

$$Info_{student}(D) = \underbrace{\frac{2}{5}I(2,0)}_{\text{yes}} + \underbrace{\frac{3}{5}I(0,3)}_{\text{No}}$$

$$Info_{credit}(D) = \underbrace{\frac{3}{5}I(1,2)}_{\text{fair}} + \underbrace{\frac{2}{5}(1,1)}_{\text{excellent}}$$



เลือกค่า Gain สูงๆ