CS 412 Intro. to Data Mining

Chapter 8. Classification: Basic Concepts

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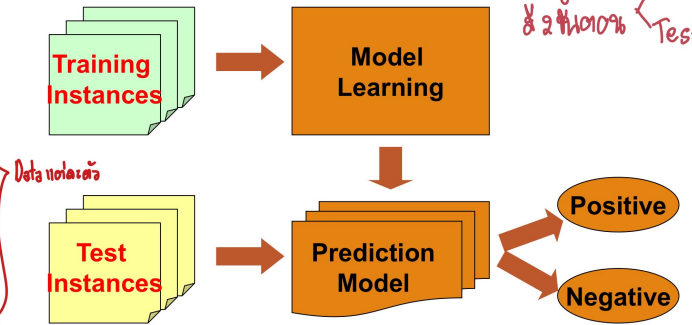
Supervised vs. Unsupervised Learning (1)

- Supervised learning (classification)
  - 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

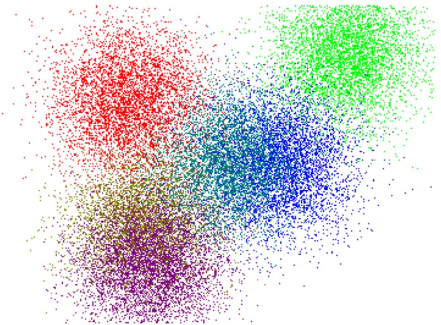
Training Data with class label:

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



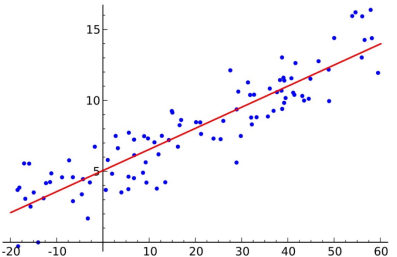
Supervised vs. Unsupervised Learning (2)

- Unsupervised learning (clustering)
  - The class labels of training data are unknown
  - 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 ใช้ทำนาย Class Ex. ลูกค้าซื้อ/ไม่ซื้อ
  - Predict categorical class labels (discrete or nominal) ทำนายข้อมูลกลุ่มใหม่ ซื้อ/ไม่ซื้อ
  - 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
  - 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

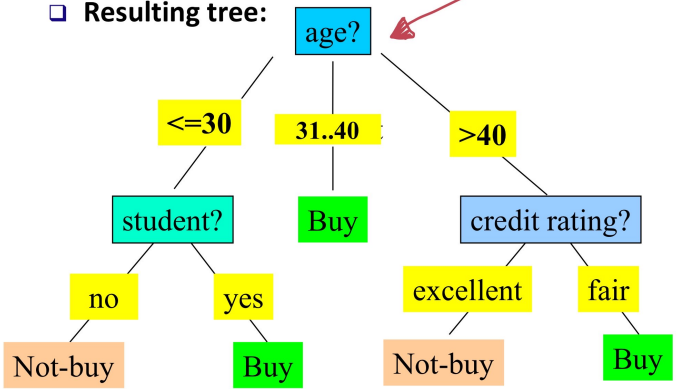
- **Model construction** เอา Data ที่มีคำตอบมาเข้าขบวน train Model สร้าง Model มาทำนายคำตอบ
  - Each sample is assumed to belong to a predefined class (shown by the **class label**)
  - The set of samples used for model construction is **training set**
  - Model: Represented as decision trees, rules, mathematical formulas, or other forms
- **Model Validation and Testing**:
  - **Test:** Estimate accuracy of the model
    - 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

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

Decision Tree Induction: An Example

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



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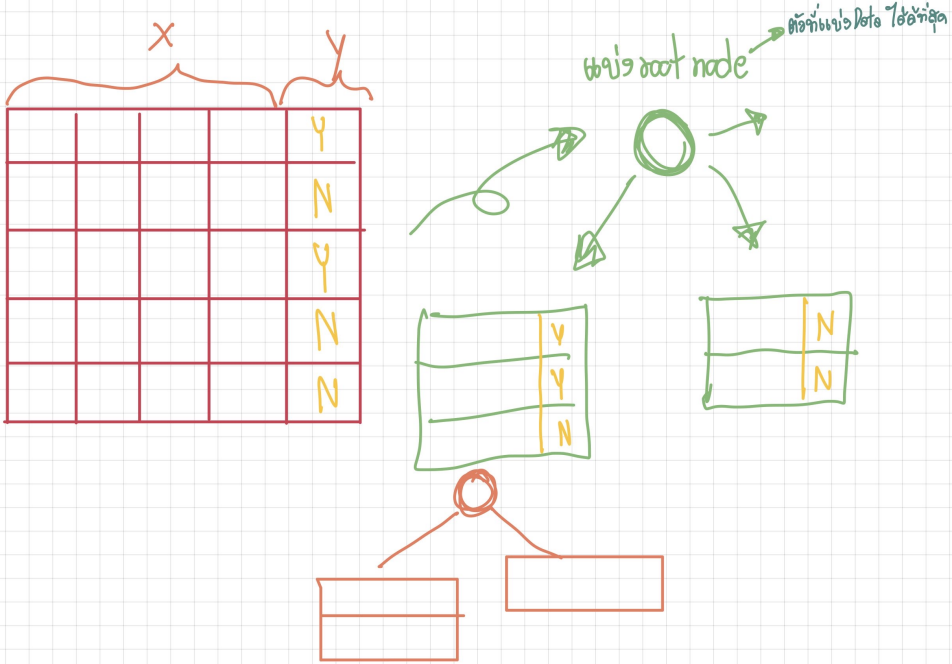
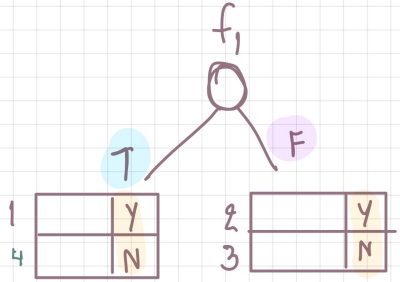
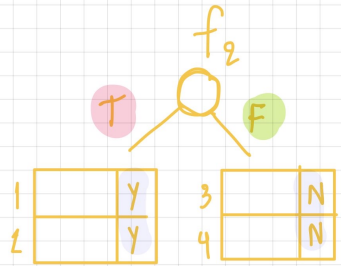
Note: The data set is adapted from "Playing Tennis" example of R. Quinlan


X
Y
Y
N
Y
N
N
แบ่ง root node
ตัวที่แบ่ง Data ได้ดีที่สุด
Y
Y
N
N
N

	f_1	f_2	f_3	y
1	T	T	F	Y
2	F	T	F	Y
3	F	F	F	N
4	T	F	T	N





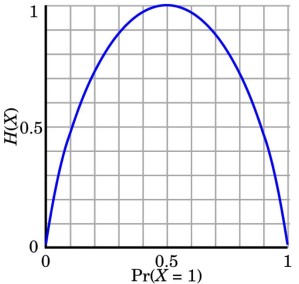
From Entropy to Info Gain: A Brief Review of Entropy

- Entropy (Information Theory)
  - A measure of uncertainty associated with a random number
  - Calculation: For a discrete random variable Y taking m distinct values $\{y_1, y_2, \ldots, y_m\}$

$$H(Y) = -\sum_{i=1}^{m} p_i \log(p_i) \quad where\ p_i = P(Y = y_i)$$

  - Interpretation
    - Higher entropy → higher uncertainty
    - Lower entropy → lower uncertainty
- Conditional entropy

$$H(Y|X) = \sum_{x} p(x) H(Y|X = x)$$



m = 2

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 p_i be the probability that an arbitrary tuple in D belongs to class C_i, estimated by $|C_{i,D}|/|D|$
- Expected information (entropy) needed to classify a tuple in D:

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

prob

ทุกคำตอบ Info(D) จะเหมือนกัน หมดเลย หารอบเดียว

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

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

คำนวณตามฟีเจอร์ รู้ค่าตัวก็ตามนั้น

- 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"

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

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
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$$Info_{age}(D) = \frac{5}{14}I(2,3) + \frac{4}{14}I(4,0) + \frac{5}{14}I(3,2) = 0.694$$

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

Hence

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

Similarly, we can get

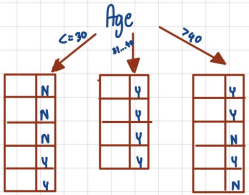
$$Gain(income) = 0.029$$

$$Gain(student) = 0.151$$

$$Gain(credit\_rating) = 0.048$$

Homework

Gain (age)



$Info(D) = I(9,5) = -\frac{9}{14}\log_2\frac{9}{14} - \frac{5}{14}\log_2\frac{5}{14} = 0.940$

- Gain (age)

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

$Info_{age}(D) = \frac{5}{14}I(2,3) + \frac{4}{14}I(4,0) + \frac{5}{14}I(3,2)$

$= 0.694$

$Gain(age) = 0.940 - 0.694 = 0.246$

- Gain (income)

Income	p_i	n_i	$I(p_i, n_i)$
high	2	2	1
medium	4	2	0.918
low	3	1	0.811

$Info_{income}(D) = \frac{4}{14}I(2,2) + \frac{6}{14}I(4,2) + \frac{4}{14}I(3,1)$

$= 0.911$

$Gain(income) = 0.940 - 0.911 = 0.029$

- Gain (student)

student	p_i	n_i	$I(p_i, n_i)$
yes	6	1	0.592
no	3	4	0.985

$Info_{student}(D) = \frac{7}{14}I(6,1) + \frac{7}{14}I(3,4)$

$= 0.789$

$Gain(student) = 0.940 - 0.789 = 0.151$

- Gain (credit_rating)

credit_rating	p_i	n_i	$I(p_i, n_i)$
fair	6	2	0.8111
excellent	3	3	1

$Info_{credit\_rating}(D) = \frac{8}{14}I(6,2) + \frac{6}{14}I(3,3)$

$= 0.892$

$Gain(credit\_rating) = 0.940 - 0.892 = 0.048$

$Gain(age) = 0.246$
$Gain(income) = 0.029$
$Gain(student) = 0.151$
$Gain(credit\_rating) = 0.048$

ดังนั้นเลือกตัวแปรที่มี $Gain(age)$ เป็น root node

อัน age <= 30

$Info(D) = I(2,3) = 0.971$

$Info_{income}(D)$ ของ age(<=30)

income	p_i	n_i	$I(p_i,n_i)$
high	0	2	0
medium	1	1	1
low	1	0	0

$Info_{income}(D)$ ของ age(<=30) $= \frac{2}{5}I(0,2) + \frac{2}{5}I(1,1) + \frac{1}{5}I(1,0)$

$= 0.4$

$\therefore Gain(income)$ ของ age(<=30) $= 0.971 - 0.4 = 0.571$

$-Info_{student}(D)$

$Info_{student}(D)$ของage(<=30) $= \frac{2}{5}I(2,0) + \frac{3}{5}I(0,3)$

ดูข้อมูล yes → yes (buy_computer) → ซื้อ

No → No (buy_computer) → ไม่ซื้อ

- age (>40)

$Info(D) = I(3,2) = 0.971$

$Info_{income}(D)$ ของ age(>40)

income	p_i	n_i	$I(p_i,n_i)$
low	1	1	1
medium	2	1	0.918

$Info_{income}(D)$ ของ age(>40) $= \frac{2}{5}I(1,1) + \frac{3}{5}I(2,1)$

$= 0.951$

$\therefore Gain(income)$ ของ age(>40) $= 0.971 - 0.951 = 0.020$

$-Info_{student}$ ของ age(>40)

student	p_i	n_i	$I(p_i,n_i)$
yes	2	1	0.916
No	1	1	1

$Info_{student}(D)$ age(>40) $= \frac{3}{5}I(2,1) + \frac{2}{5}I(1,1)$

$= 0.951$

$\therefore Gain(student)$ ของ age(>40) $= 0.971 - 0.951 = 0.020$

$-Info_{credit\_rating}(D)$ ของ age(>40)

$Info_{credit_rating}(D)$ของage(>40) $= \frac{3}{5}I(3,0) + \frac{2}{5}I(0,2)$

ดูข้อมูล fair → Yes

excellent → No

สรุป