"One day Workshop with Hands-on Training on Machine Learning and Its Applications"

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at

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on

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26.1

# TOPICS FOR DISCUSSION

1. Introduction
2. Knowledge discovery from data
3. Human and Machine learning
4. Developing models
5. Performance evaluation
6. Performance improvement


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# Introduction

- **Learning**
  - The cognitive process of acquiring skill or knowledge

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# Introduction

- **What is Knowledge?**
  - **The psychological result of perception, learning and reasoning**
  - **Facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject.**
  - **Ability to**
    - Recognize
    - Predict
    - Classify
    - Detect
    - Identify the things or objects, etc. using the attributes

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# Introduction

- Why Knowledge?
  - Used for making decisions to solve the problems (satisfying the needs)
- Decision making
  - Plays a significant role in day-to-day life
  - In every second the human mind makes decision
    - » Do I want to listen this seminar?
    - » What subject should I read?
    - » When should I reach to the college?
    - » What dress should I wear for today?
    - » Whether watching movie is good or bad?



# Introduction

- The good decision maker
  - Can be successful person
  - Can be a good worker
  - Can be a good leader
  - Can be a good manager
  - Can be seated in higher position



# Knowledge Discovery from Data



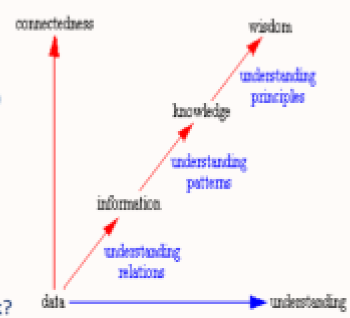

# Knowledge Discovery from Data

**Data:** (symbols, raw facts)
Book, $, is, 1, price

**Information:** (processed data)
Price of 1 book is 50$
(pattern/rule)

**Knowledge**: I have 50 $ therefore I can buy only one book (making decision)

**Wisdom:** Who wrote this book? Whether it is worth full or not? Is it very essential for me?



## Knowledge Discovery from Data

- **Data**
  - Raw facts
- **Types of data (based of forms)**
  - Image (E.g.  )
  - Text (E.g. Apple)
  - Audio (E.g.  )
  - Video
    - (Sequence of images) with or without audio 
  - Multimedia



## Knowledge Discovery from Data

- **Types of data** (Statistical perspective)
  - Numerical data
    - Discrete data
      - E.g. (Height, Width, Length)
    - Continuous data
      - E.g. Temperature
  - Categorical data
    - E.g. ({Yes/no}, { Average, Good, Excellent})
  - Ordinal data
    - Mixes numerical and categorical data



## Knowledge Discovery from Data

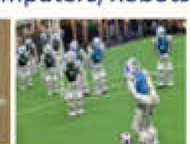
- **Knowledge discovery**
  - Knowledge is discovered through learning the data
- **Learning**
  - The cognitive process of acquiring skill or knowledge
  - Learning is a process of developing/ updating and training the models from data



## Learning

- Human learning (Human)


- Machine learning (Computers/Robots)


## Human Learning

- **Types of learners based on comfort with data**
  - Visual learner (visual) (listen the demonstration/ reading the book)
  - Auditory learner (listening the audio)
  - Kinesthetic learner (Experience)
- **Phases of human learning**
  - Learning/Training phase
  - Testing phase
  - Performance evaluation phase



## Human Learning

- **Learning/ Training phase**
  - Learning the name of the animals



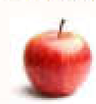

## Human Learning

- **Learning/ Training phase**
  - Learning the name of the fruits




## Human Learning

- **Testing phase**
  - Prediction/detection/classification/recognition



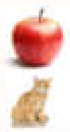
**? Apple**

**? Cat**

**Attributes :** colour, size, shape , texture

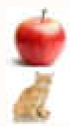
# Human Learning

- **Performance evaluation phase**
  - Student1 recognizes the objects as follows:




Accuracy = 2/2 *100=100%

  - Student2 recognizes the objects as follows:




Accuracy = 1/2 *100=50%



# Machine Learning

- **Machine learning**
  - Machine learning is a field of computer science and a field of artificial intelligence
  - Enables the computers/machines/ robots to learn the data for acquiring knowledge and make data-driven decisions



# Applications of Machine Learning

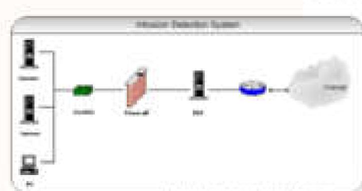
- **Applications of machine learning** (based on terminology)
  - Recognition (E.g. Face or object recognition)
  - Prediction (E.g. Weather prediction)
  - Classification (E.g. Document classification)
  - Detection (E.g. Intrusion detection)



# Applications of Machine Learning

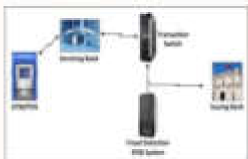
- **Computer networks**
  - Antivirus
  - Intrusion detection

F-PROT AVG McAfee PANDA SOPHOS ESET KASPERSKY



## Applications of Machine Learning

- **Banking**
  - Loan approval prediction
  - Fraudulent detection
  - Currency recognition (Fake currency identification)

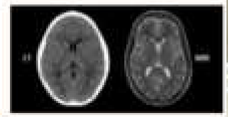




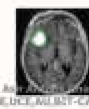
## Applications of Machine Learning

- **Medical**
  - Disease diagnosis

Computed tomography (CT or CAT) scan



Magnetic resonance imaging (MRI) SCAN





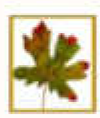
## Applications of Machine Learning

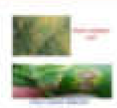
- **Recruitment**
  - Automated job suggestion for recruitment



## Applications of Machine Learning

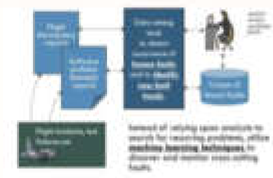
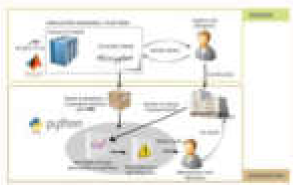
- **Agriculture**
  - Plant disease detection
  - Leaf disease
  - Soil classification
  - Soil fertility prediction



## Applications of Machine Learning

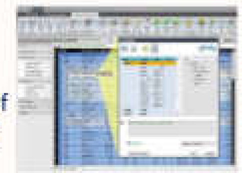
- **Software engineering**
  - Software fault detection



## Applications of Machine Learning

- **Construction industry**
  - Automated cost estimation
  - Analyzing the performance of suppliers and sub-contractors
  - Estimation of materials (cement, sand, water, bricks, etc.)
  - Estimation of resources such as fuels, electricity, etc.





## Applications of Machine Learning

- **Advertisement**
  - Advertisement in blog sites and emails (Google AdSense)



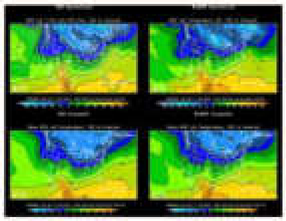

## Applications of Machine Learning

- **Commercial**
  - Buyer behavior analysis
  - Market basket analysis



## Applications of Machine Learning

- **Metrological**
  - Weather prediction
    - Cyclone
    - Storm
    - Rain
  - Weather forecasting





## Applications of Machine Learning

- **Social media**
  - Friends suggestion
  - Categorize subscribers

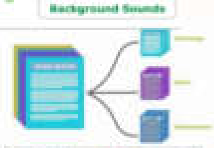



## Other Applications of Machine Learning

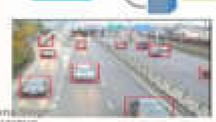
- Face recognition

- Speech recognition


- Document classification



- Vehicle detection





## Phases of Machine Learning

- Learning/Training phase
- Testing phase
- Performance evaluation phase

# Phases of Machine Learning

- **Machine learning algorithm**
  - The machine learning algorithm receives the numerical or categorical data to develop the model
  - The data is in various forms such as image, audio, text and multimedia
  - Hence, the different data acquisition devices are used to acquire the data from the real world
  - Moreover, different techniques are used to convert the data into machine understandable data such as numerical and categorical



# Phases of Machine Learning

- **Data acquisition devices**

| Sensory organ | Sense | Data | Data Acquisition Devices |
|---|---|---|---|
| **Eyes** | Visual | Image | Cameras |
| **Ears** | Hearing | Audio | Voice recorder |
| **Nose** | Small | data | Gas sensor |
| **Tongue** | Taste | Data | Chemical sensor |
| **Skin** | Touch | Data | Temperature/wind/humidity sensors, etc. |



# Phases of Machine Learning

- **Technique for data conversion** (Numerical/categorical)

| Data | Technique for Conversion | Application Example |
|---|---|---|
| Image | Digital image processing | Object recognition |
| Text | Data processing | Text classification |
| Audio | Digital signal processing | Signal classification |



# Phases of Machine Learning

- **Representation of dataset**

| Attributes | | | | | Class/Label |
|---|---|---|---|---|---|
| $X_1$ | $X_2$ | $X_3$ | ... | $X_N$ | C |
| $x_{11}$ | $x_{21}$ | $x_{31}$ | ... | $x_{N1}$ | $c_1$ |
| $x_{12}$ | $x_{22}$ | $x_{32}$ | ... | $x_{N2}$ | $c_2$ |
| $x_{13}$ | $x_{23}$ | $x_{33}$ | ... | $x_{N3}$ | $c_1$ |
| . | . | . | | . | . |
| . | . | . | ... | . | . |
| . | . | . | | . | . |
| $x_{1M}$ | $x_{2M}$ | $x_{3M}$ | ... | $x_{NM}$ | $c_2$ |

## Phases of Machine Learning

- **Models**
  - Model is also called as **Pattern**
  - The models are used to
    - Recognize
    - Predict
    - Classify
    - Detect the label of the unknown data.



## Phases of Machine Learning

- **Example of Model**

Mathematical Model of a Straight Line

**y = mX +b**

Where X – Axis variable
m – Slope
Y – Axis variable
b – Intercept

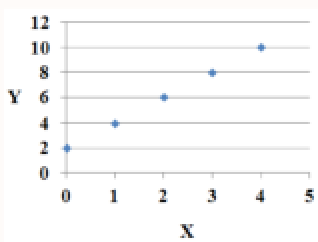


## Phases of Machine Learning

- **Example of Model**

Predict the value of variable Y from model **Y=mX+b**
where **m=2, b=2**

X=0 Y=2*0+2=2
X=1 Y=2*1+2=4
X=2 Y=2*2+2=6
X=3 Y=2*3+2=8
X=4 Y=2*4+2=10
X=5 Y=?






## Overview of Knowledge Discovery from Data

- **Database**
  - Collection of data from various sources
- **Data selection**
  - Select the needed data from the database
  - Transformation process can be carried out
- **Dataset**
  - Structured numerical or categorical data
- **Data preprocessing**
  - Data cleaning (to remove noise and inconsistent data)

# Overview of Knowledge Discovery from Data

- **Preprocessed dataset**
  - The preprocessed dataset is obtained after preprocessing
- **Machine learning algorithm**
  - Learn the data and build the pattern/model
- **Patterns/model**
  - Statistical or mathematical model is used for prediction/ classification /detection /recognition
- **Evaluation of the model**
  - Testing the model to obtain the knowledge (predicted data /unknown data for known data) for decision making



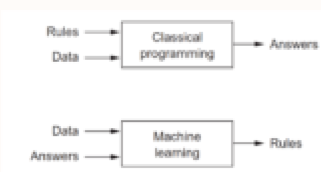
# Classification of Machine Learning Algorithms

- **Unsupervised learning**
  - Learning with unlabeled data Eg. Clustering algorithm
- **Supervised learning**
  - Learning with labeled data Eg. Classification algorithms.
- **Types of Supervised learning**
  - **Decision Tree based**
    - J48 Java implementation decision Tree
  - **Probability based**
    - Naive Bayes (NB)
  - **Instant based**
    - IB1 (instance based learning)



# Classical Programming vs Machine learning

- Ex. Classical
  - Data: a=10; b=10;
  - Rule : c=a+b;




- Ex: Machine learning
  - Dataset:
    - data +answer (label)



# Example of Prediction

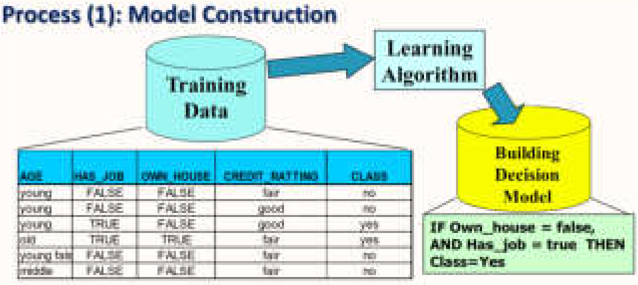
**Dataset :** Historical Loan data of Bank

**Decision :** The Bank Manager has to predict which person shall able to repay the loan amount.

**Historical Loan data form the Bank Enterprise**

| Customer | AGE | HAS_JOB | OWN_HOUSE | CREDIT_RATTING | (Loan repay) CLASS |
|---|---|---|---|---|---|
| 1 | young | FALSE | FALSE | fair | no |
| 2 | young | FALSE | FALSE | good | no |
| 3 | young | TRUE | FALSE | good | yes |
| 4 | old | TRUE | TRUE | fair | yes |
| 5 | young | FALSE | FALSE | fair | no |
| 6 | middle | FALSE | FALSE | fair | no |

## Process (1): Model Construction




| AGE | HAS_JOB | OWN_HOUSE | CREDIT_RATTING | CLASS |
|---|---|---|---|---|
| young | FALSE | FALSE | fair | no |
| young | FALSE | FALSE | good | no |
| young | TRUE | FALSE | good | yes |
| old | TRUE | TRUE | fair | yes |
| young b/w | FALSE | FALSE | fair | no |
| middle | FALSE | FALSE | fair | no |

## Process (2): Prediction of unknown data


| AGE | HAS_JOB | OWN_HOUSE | CREDIT_RATTING |
|---|---|---|---|
| young | FALSE | FALSE | fair |



## Demonstration

With
Decision Tree based Supervised Learner

PRACTICAL SESSION



## Construction and testing the model using decision tree based supervised learner



## Dataset

Class-labeled training tuples from the *AllElectronics* customer database.

| *RID* | *age* | *income* | *student* | *credit_rating* | *Class: buys_computer* |
|---|---|---|---|---|---|
| 1 | youth | high | no | fair | no |
| 2 | youth | high | no | excellent | no |
| 3 | middle_aged | high | no | fair | yes |
| 4 | senior | medium | no | fair | yes |
| 5 | senior | low | yes | fair | yes |
| 6 | senior | low | yes | excellent | no |
| 7 | middle_aged | low | yes | excellent | yes |
| 8 | youth | medium | no | fair | no |
| 9 | youth | low | yes | fair | yes |
| 10 | senior | medium | yes | fair | yes |
| 11 | youth | medium | yes | excellent | yes |
| 12 | middle_aged | medium | no | excellent | yes |
| 13 | middle_aged | high | yes | fair | yes |
| 14 | senior | medium | no | excellent | no |

## Decision tree Construction by Information Gain

- Select the attribute with the highest information gain
- 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:

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

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

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

- **Information gained** by branching on attribute A

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



Class-labeled training tuples from the *AllElectronics* customer database.

| RID | age | income | student | credit_rating | Class: buys_computer |
|---|---|---|---|---|---|
| 1 | youth | high | no | fair | $\boxed{\text{no}}$ |
| 2 | youth | high | no | excellent | $\boxed{\text{no}}$ |
| 3 | middle_aged | high | no | fair | yes |
| 4 | senior | medium | no | fair | yes |
| 5 | senior | low | yes | fair | yes |
| 6 | senior | low | yes | excellent | no |
| 7 | middle_aged | low | yes | excellent | yes |
| 8 | youth | medium | no | fair | $\boxed{\text{no}}$ |
| 9 | youth | low | yes | fair | $\boxed{\text{yes}}$ |
| 10 | senior | medium | yes | fair | yes |
| 11 | youth | medium | yes | excellent | $\boxed{\text{yes}}$ |
| 12 | middle_aged | medium | no | excellent | yes |
| 13 | middle_aged | high | yes | fair | yes |
| 14 | senior | medium | no | excellent | no |



Yes No

youth

$$Info_{age}(D) = \frac{5}{14} \times \left(-\frac{2}{5}\log_2\frac{2}{5} - \frac{3}{5}\log_2\frac{3}{5}\right)$$

Middle-aged

$$+\frac{4}{14} \times \left(-\frac{4}{4}\log_2\frac{4}{4} - \frac{0}{4}\log_2\frac{0}{4}\right)$$

Senior

$$+\frac{5}{14} \times \left(-\frac{3}{5}\log_2\frac{3}{5} - \frac{2}{5}\log_2\frac{2}{5}\right)$$

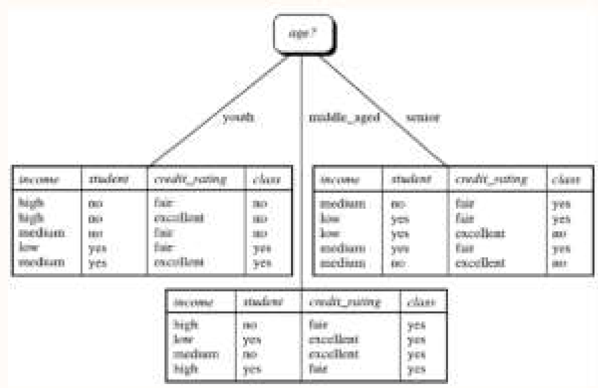
$$= 0.694 \text{ bits.}$$

$$Info(D) = -\frac{9}{14}\log_2\left(\frac{9}{14}\right) - \frac{5}{14}\log_2\left(\frac{5}{14}\right) = 0.940 \text{ bits.}$$

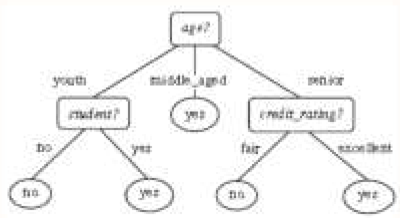
$$Gain(age) = Info(D) - Info_{age}(D) = 0.940 - 0.694 = 0.246 \text{ bits.}$$

Similarly, we can compute $Gain(income) = 0.029$ bits, $Gain(student) = 0.151$ bits, and $Gain(credit\_rating) = 0.048$ bits. Because age has the highest information gain among





## Now you can Make Decision by this Decision Tree




| Age | Income | Student | Credit rating | Class |
|---|---|---|---|---|
| Youth | High | No | Fair | ? |
| Youth | High | No | Excellent | ? |
| Middle aged | High | No | Fair | ? |

**Unlabelled data** **Demo**



## Construction and testing the probabilistic model using naive Bayes based supervised learner



## Naive Bayes Model Construction

**Bayes' Theorem:** is a way of finding a probability when we know certain other probabilities.

The formula is:

$$P(A|B) = \frac{P(A)\,P(BA)}{P(B)}$$

P(A|B) : how often A happens given that B happens
P(B|A) : how often B happens given that A happens,
P(A) : how likely A is on its own
P(B) : how likely B is on its own

**Remembering**
First think "AB AB AB" then remember to group it like: "AB = A BA / B"



Let us say

**P(Fire)** means how often there is fire
**P(Smoke)** means how often we see smoke

**P(Fire|Smoke)** means how often there is fire when we can see smoke
**P(Smoke|Fire)** means how often we can see smoke when there is fire

So the formula kind of tells us "forwards" P(Fire|Smoke) when we know "backwards" P(Smoke|Fire)

Example: If dangerous fires are rare (1%) but smoke is fairly common (10%) due to barbecues, and 90% of dangerous fires make smoke then:

$$P(Fire|Smoke) = \frac{P(Fire)\,P(Smoke|Fire)}{P(Smoke)} = \frac{1\% \times 90\%}{10\%} = 9\%$$

So the "Probability of dangerous Fire when there is Smoke" is 9%

## Dataset

Class-labeled training tuples from the *AllElectronics* customer database.

| RID | *age* | *income* | *student* | *credit_rating* | *Class: buys_computer* |
|---|---|---|---|---|---|
| 1 | youth | high | no | fair | no |
| 2 | youth | high | no | excellent | no |
| 3 | middle_aged | high | no | fair | yes |
| 4 | senior | medium | no | fair | yes |
| 5 | senior | low | yes | fair | yes |
| 6 | senior | low | yes | excellent | no |
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| 11 | youth | medium | yes | excellent | yes |
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| 13 | middle_aged | high | yes | fair | yes |
| 14 | senior | medium | no | excellent | no |



P(X|H) is the posterior probability of X conditioned on H.

That is, it is the probability that customers, X, is 35 years old and earns $40,000, given that we know the customer will buy a computer.
P(X) is the prior probability of X. Using our example, it is the probability that a person from our set of customers is 35 years old and earns $40,000.

"How are these probabilities estimated?"

P(H), P(X|H), and P(X) may be estimated from the given data, as we shall see next.

Bayes' theorem is useful in that it provides a way of calculating the posterior probability, P(H|X), from P(H), P(X|H), and P(X).

Bayes' theorem is $P(H|X) = \frac{P(X|H)\,P(H)}{P(X)}$



Class-labeled training tuples from the *AllElectronics* customer database.

| RID | *age* | *income* | *student* | *credit_rating* | *Class: buys_computer* |
|---|---|---|---|---|---|
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Predict the person X will buy the computer or not ?

X = (age = youth, income = medium, student = yes, credit rating = fair)

That is, the naive Bayesian classifier predicts that tuple X belongs to the class $C_i$ if and only if

$$P(C_i|X) > P(C_j|X) \text{ for } 1 \le j \le m,\ j \ne i.$$

Thus, we maximize $P(C_i|X)$.

The class $C_i$ for which $P(C_i|X)$ is maximized is called the maximum posteriori hypothesis.

$$P(C_i|X) = \frac{P(X|C_i)P(C_i)}{P(X)}$$

$$P(X|C_i) = \prod_{k=1}^{n} P(x_k|C_i)$$

$$= P(x_1|C_i) \times P(x_2|C_i) \times \cdots \times P(x_n|C_i).$$

X = (age = youth, income = medium, student = yes, credit rating = fair)

We need to maximize $P(X|C_i)P(C_i)$, for i = 1, 2. $P(C_i)$, the prior probability of each class, can be computed based on the training tuples:

P(buys computer = yes) = 9/14 = 0.643
P(buys computer = no) = 5/14 = 0.357



To compute $P(X|C_i)$, fori = 1, 2, we compute the following conditional probabilities:
P(age = youth | buys computer = yes) = 2/9 = 0.222
P(age = youth | buys computer = no) = 3/5 = 0.600
P(income = medium | buys computer = yes) = 4/9 = 0.444
P(income = medium | buys computer = no) = 2/5 = 0.400
P(student = yes | buys computer = yes) = 6/9 = 0.667
P(student = yes | buys computer = no) = 1/5 = 0.200
P(credit rating = fair | buys computer = yes) = 6/9 = 0.667
P(credit rating = fair | buys computer = no) = 2/5 = 0.400

Using these probabilities, we obtain

P(X|buys computer = yes) =
P(age = youth | buys computer = yes) ×
P(income = medium | buys computer = yes) ×
P(student = yes | buys computer = yes) ×
P(credit rating = fair | buys computer = yes)
= 0.222 × 0.444 × 0.667 × 0.667 = 0.044.
Similarly, P(X|buys computer = no) =
0.600 × 0.400 × 0.200 × 0.400 = 0.019



To find the class, $C_i$ , that maximizes $P(X|C_i)P(C_i)$,

We compute

P(X|buys computer = yes)P(buys computer = yes) = 0.044 × 0.643 = 0.028
P(X|buys computer = no)P(buys computer = no) = 0.019 × 0.357 = 0.007

Therefore,

The person X will buy the computer.



# Performance Evaluation

## Performance Evaluation Techniques

- The performance of the model is evaluated using test dataset
- **Types of dataset**
  - Training dataset
    - For model development
  - Testing dataset
    - For testing performance of the model



## Performance Evaluation Techniques

- **Performance evaluation techniques**
  - Classified based on how the training dataset is supplied for performance evaluation
    1. Use training dataset as test dataset
    2. Supplied test dataset
    3. N-Fold cross - validation
    4. Percentage split
- **Performance evolution metrics**
  - Accuracy
  - Precision
  - Recall
  - ROC (Receiver operating characteristics)



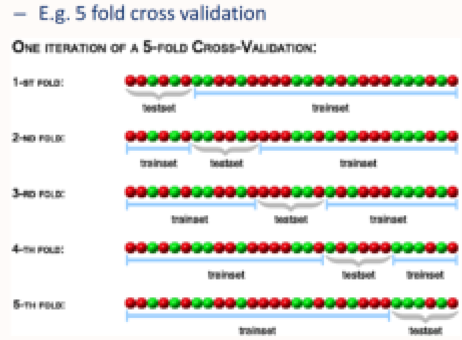
## Performance Evaluation Techniques

- **Use training dataset as test dataset**
  - The entire training dataset is given as the test dataset
- **Supplied test dataset**
  - The separate test dataset is given for testing



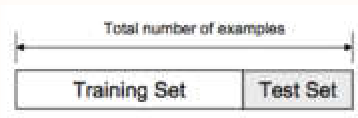
## Performance Evaluation Techniques

- **N-Fold-Cross- Validation**
  - E.g. 5 fold cross validation



## Performance Evaluation Techniques

- **Percentage split**
  - A portion of the whole dataset is splitted (in %) for test dataset
  - E.g.






## Performance Evaluation Metrics

- Accuracy
- Precession
- Recall
- True positive rate (TPR)
- False positive rate (FPR)
- ROC (Receiver operating characteristics)



## Performance Evaluation Metrics

- **Confusion matrix**
  - Confusion matrix (Positive /Negative)

| | | Predicted class | |
|---|---|---|---|
| | | Positive | Negative |
| Actual class | Positive | TP | FN |
| | Negative | FP | TN |

**True positive (TP):** Number of correctly predicted positive instances.

**False negative (FN):** Number of incorrectly predicted positive instances

**False positive (FP):** Number of incorrectly predicted negative instances.

**True negative (TN):** Number of correctly predicted negative instances.



## Performance Evaluation Metrics

- Accuracy

  Accuracy = $\frac{TP+TN}{TP+TN+FP+FN}$ x 100

- Precision

  Precision = $\frac{TP}{TP+FP}$ x 100

- Recall

  Precision = $\frac{TP}{TP+FP}$ x 100

## Performance Evaluation Metrics

- True positive rate (TPR)

$$TPR = \frac{TP}{TP+FN}$$

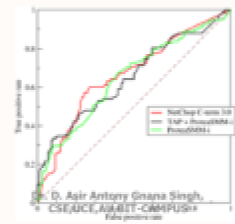
- False positive rate (FPR)

$$FPR = \frac{FP}{FP+TN}$$



## Performance Evaluation Metrics

- **Receiver operating characteristic**
  - The ROC curve is created by plotting the **true positive rate (TPR)** against the **false positive rate (FPR)** at various threshold settings. The true-positive rate is also known as sensitivity, recall or probability of detection in machine learning.





## Performance Evaluation Metrics

- Example of accuracy calculation for Diabetes dataset

=== Confusion Matrix ===

a b <-- classified as

407 93 | a = tested_negative = 500

108 160 | b = tested_positive = 268

Total instances 768

((407+160)/768)X100= 73.8281 %



## Performance Improvement

- **Attribute selection**
  - Also called as:
    - Attribute selection
    - Dimensionality reduction
    - Variable selection
    - Feature selection
  - Removing the redundant attribute
  - Removing the irrelevant attributes that are not participating in prediction

## Performance Improvement

- **Types of attribute selection**
  - Filter
    - E.g. Correlation, information gain, chi-squared
  - Wrapper
  - Embedded