PROBLEM SOLVING USING PATTERN RECOGNITION
DAY 1A

Dr Zhu Fangming
Institute of Systems Science
National University of Singapore
fangming@nus.edu.sg

Not be reproduced in any form or by any means, without the written permission of ISS, NUS, other than for the purpose for which it has been supplied.

© 2019 National University of Singapore. All Rights Reserved

DAY 1 AGENDA

1.1 Introduction to Problem Solving Using Pattern Recognition

1.2 How to analyse, model and solve pattern recognition problems

1.3 Solving Pattern Recognition Problems Using Supervised Learning Techniques (I)

1.4 Pattern Recognition Workshop 1

© 2019 National University of Singapore. All Rights Reserved

1.1
Introduction to Problem Solving Using Pattern Recognition

© 2019 National University of Singapore. All Rights Reserved

Topics

- What is Pattern?
- What is Pattern Recognition?
- Examples of Pattern Recognition
- Applications of Pattern Recognition

© 2019 National University of Singapore. All Rights Reserved

Patterns

- Pattern is everything around in this digital world.

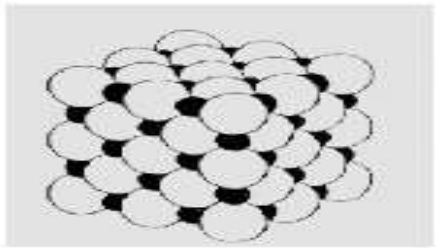
- Visual, audio, text, temporal…

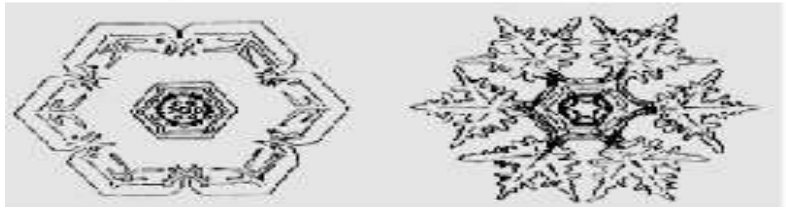
- A pattern can either be seen physically or it can be observed mathematically by applying algorithms.

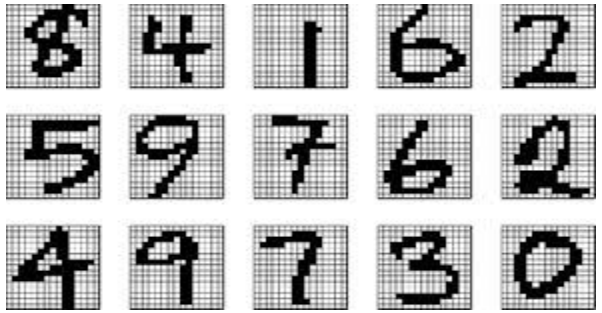
  e.g.: The colours on the clothes, speech pattern etc.

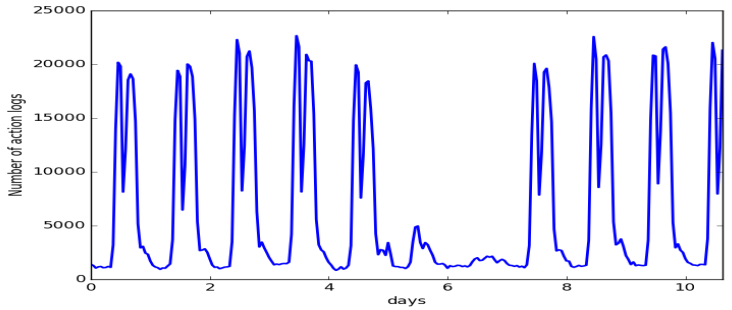
© 2019 National University of Singapore. All Rights Reserved

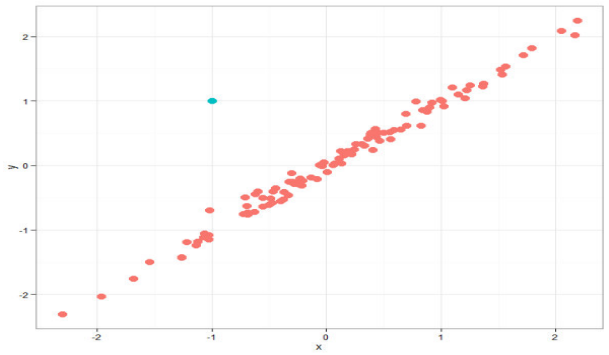
Patterns

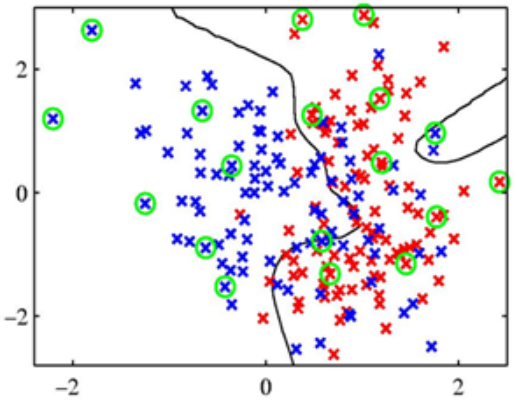


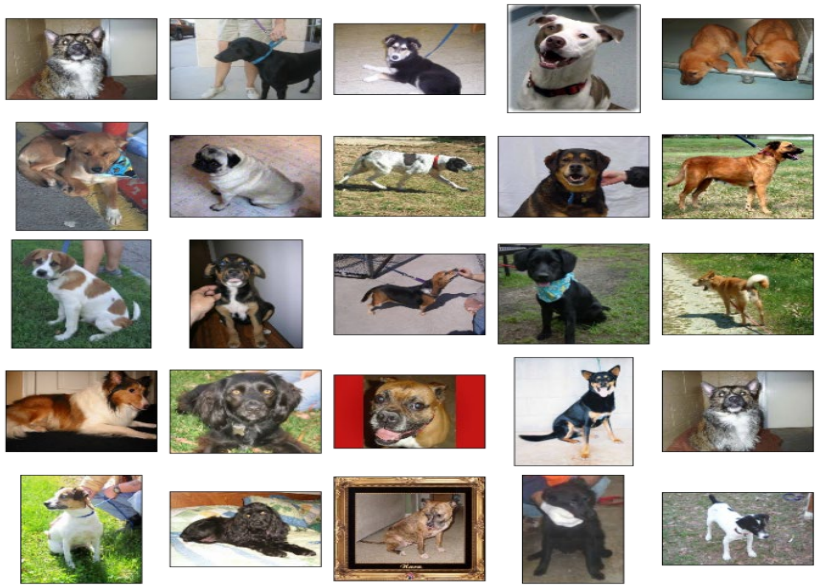












© 2019 National University of Singapore. All Rights Reserved

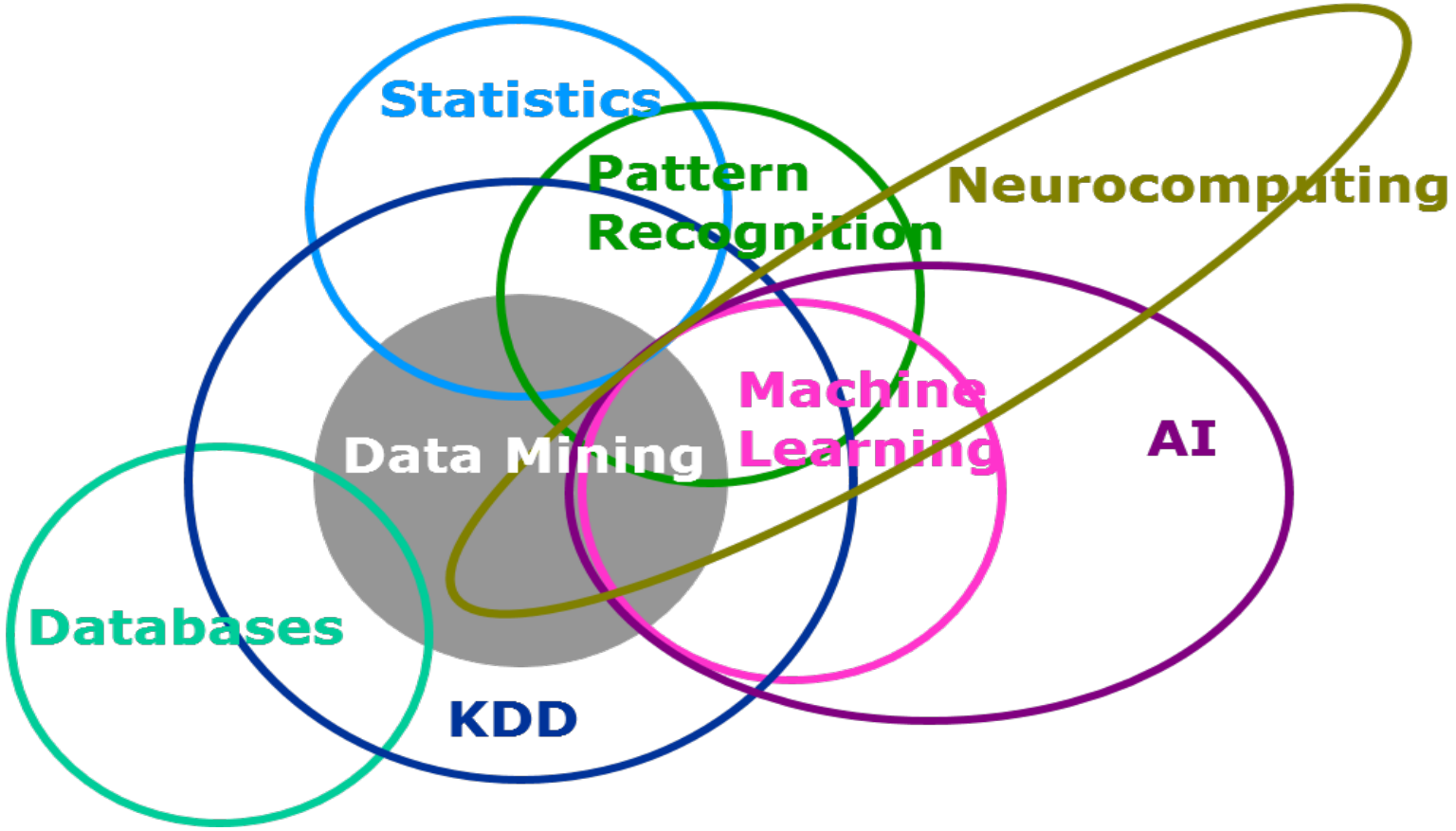
Pattern Recognition

- Pattern recognition is the automated recognition of patterns and regularities in data. Pattern recognition is closely related to artificial intelligence and machine learning, together with applications such as data mining and knowledge discovery in databases, and is often used interchangeably with these terms.

--- Wikipedia

© 2019 National University of Singapore. All Rights Reserved

Pattern Recognition

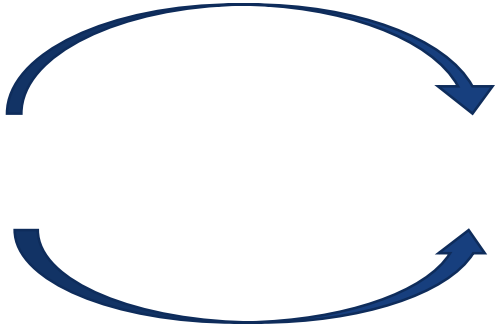


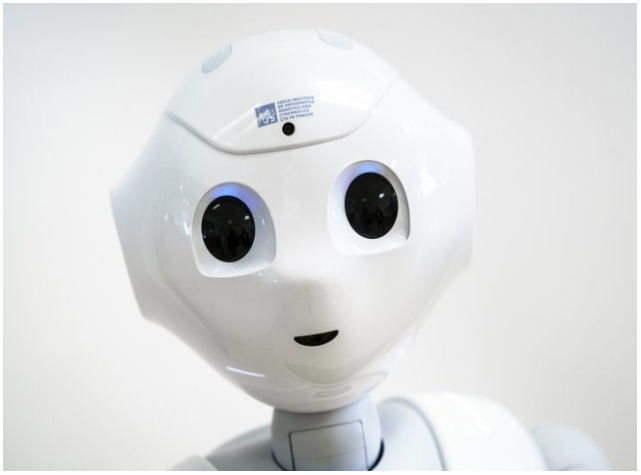
https://www.analyticsvidhya.com

© 2019 National University of Singapore. All Rights Reserved

Pattern Recognition

From Human Perception to Machine Perception





© 2019 National University of Singapore. All Rights Reserved

From Human Perception to Machine Perception

- **Humans have developed highly sophisticated skills for sensing their environment and taking actions according to what they observe, e.g.,**
  - Recognizing a face.
  - Understanding spoken words.
  - Reading handwriting.
  - Distinguishing fresh food from its smell.
- **We are often influenced by the knowledge of how patterns are modeled and recognized in nature when we develop pattern recognition algorithms.**
- **Research on machine perception also helps us gain deeper understanding and appreciation for pattern recognition systems in nature.**

© 2019 National University of Singapore. All Rights Reserved

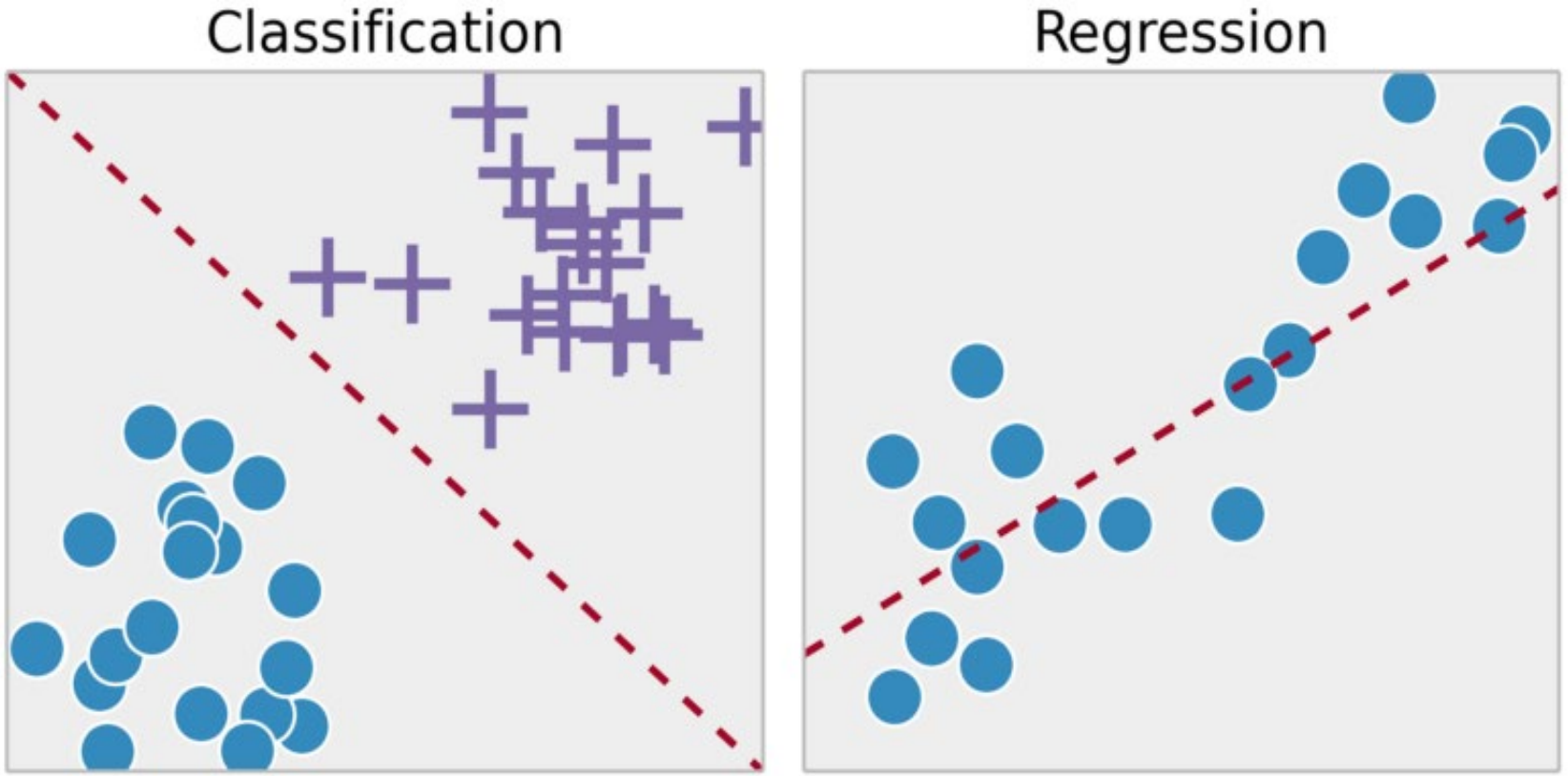
Machine Leaning for PR

"Pattern Recognition is a type of problem while Machine Learning is a type of solution."

- **Supervised learning**
  - A teacher provides a category label or cost for each pattern in the training set.
- **Unsupervised learning**
  - The system forms clusters or natural groupings of the input patterns (based on some similarity criteria).
- **Reinforcement learning**
  - No desired category is given but the teacher provides feedback to the system such as the decision is right or wrong.

© 2019 National University of Singapore. All Rights Reserved

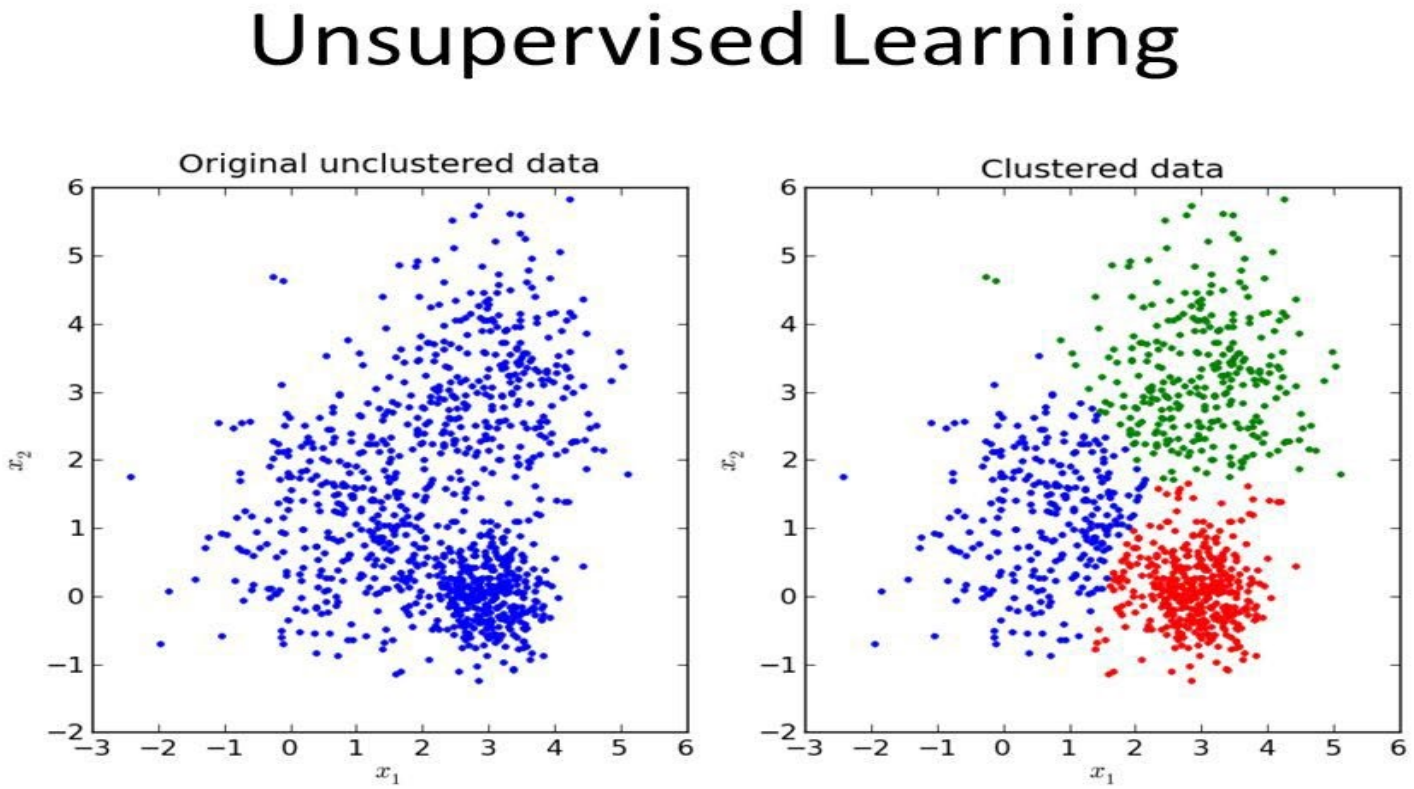
Supervised Learning



Source: KDnuggets

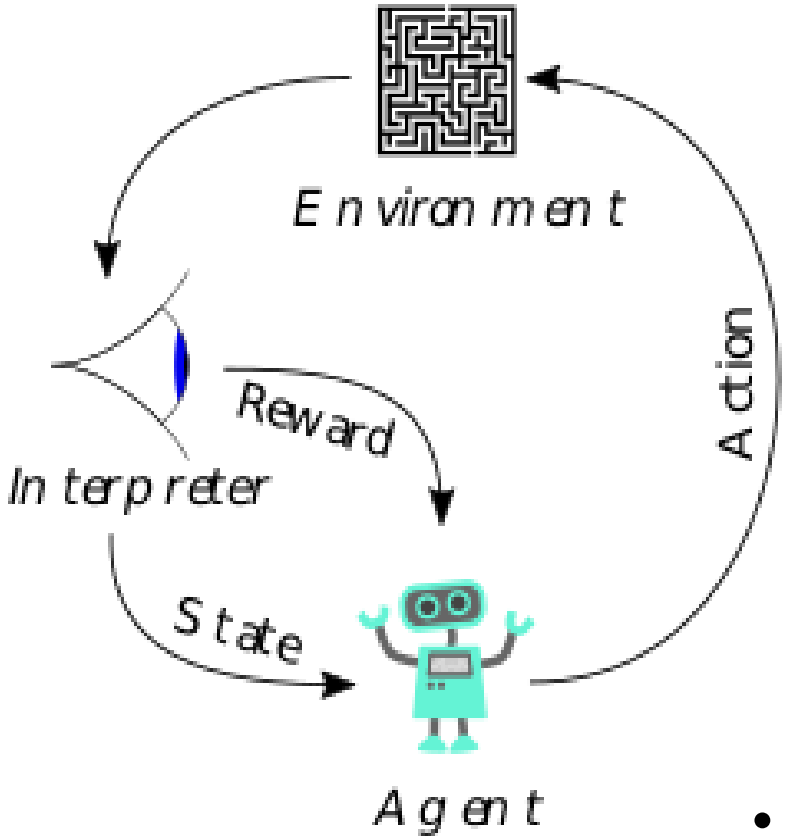
© 2019 National University of Singapore. All Rights Reserved

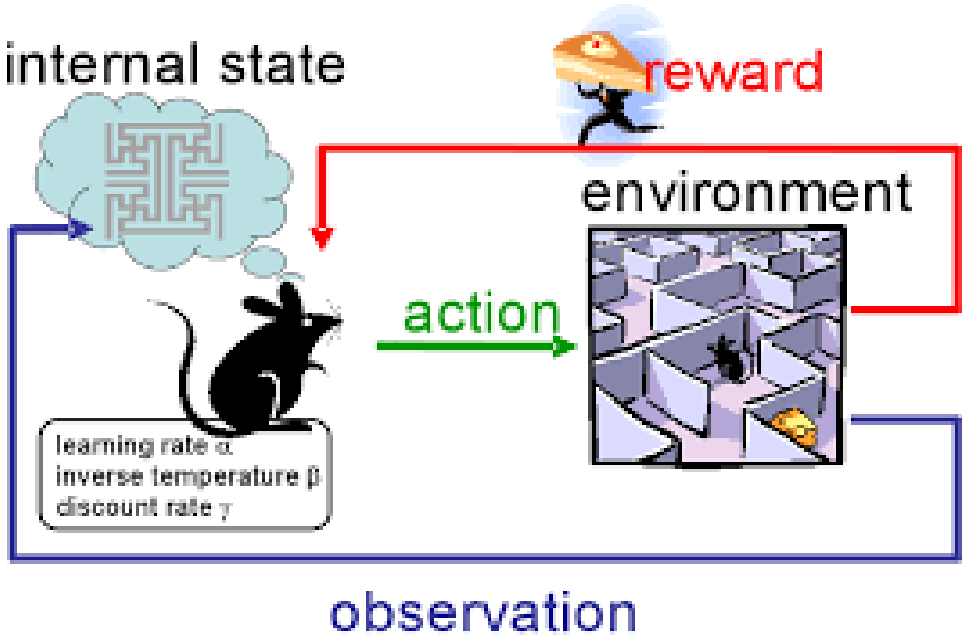
Unsupervised Learning



© 2019 National University of Singapore. All Rights Reserved

Reinforcement Learning



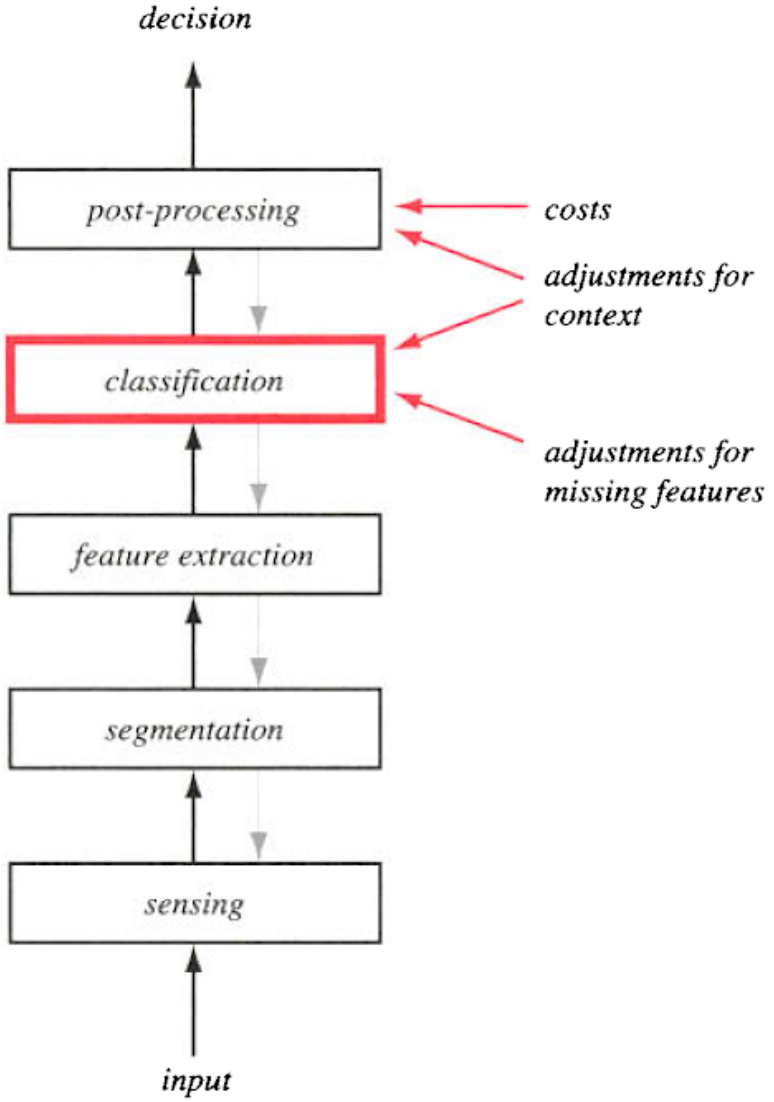


- A reinforcement learning agent interacts with its environment in discrete time steps.

© 2019 National University of Singapore. All Rights Reserved

Pattern Recognition Process

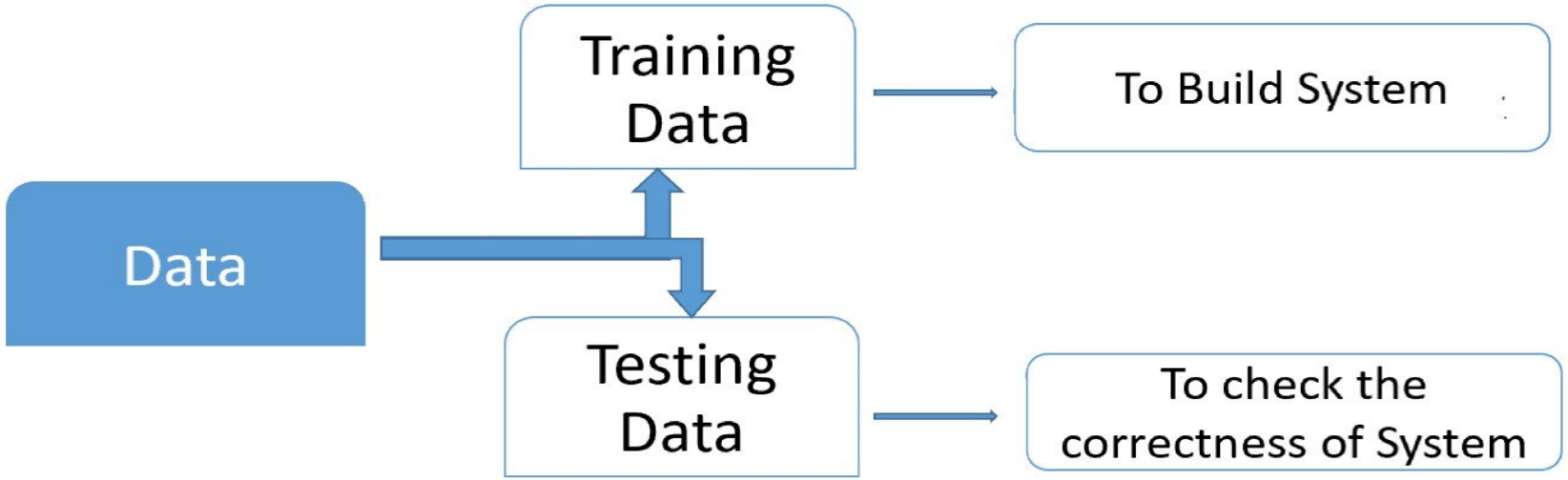
- **Data acquisition and sensing:**
  - Measurements of physical variables.
  - Important issues: bandwidth, resolution , etc.
- **Pre-processing:**
  - Removal of noise in data.
  - Isolation of patterns of interest from the background.
- **Feature extraction:**
  - Finding a new representation in terms of features.
- **Classification/Clustering**
  - Using features to learn models for different tasks.
- **Post-processing**
  - Evaluation of confidence in decisions.



© 2019 National University of Singapore. All Rights Reserved

Training and Testing Models in PR

- **Learning (training)**: Learn a model using the **training data**
- **Testing**: Test the model using unseen **test data** to assess the model accuracy



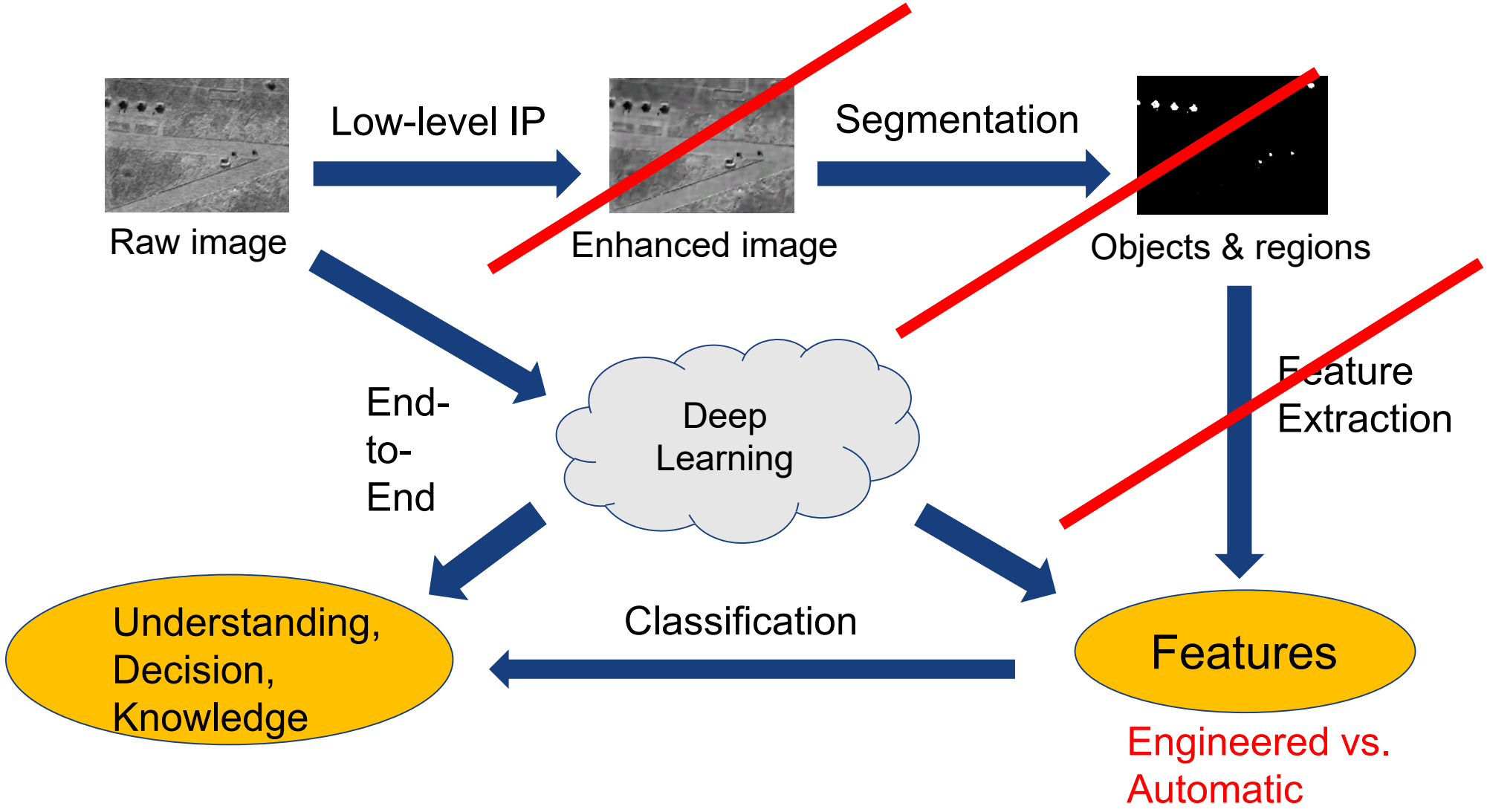
© 2019 National University of Singapore. All Rights Reserved

Machine Learning Techniques/Algorithms for PR

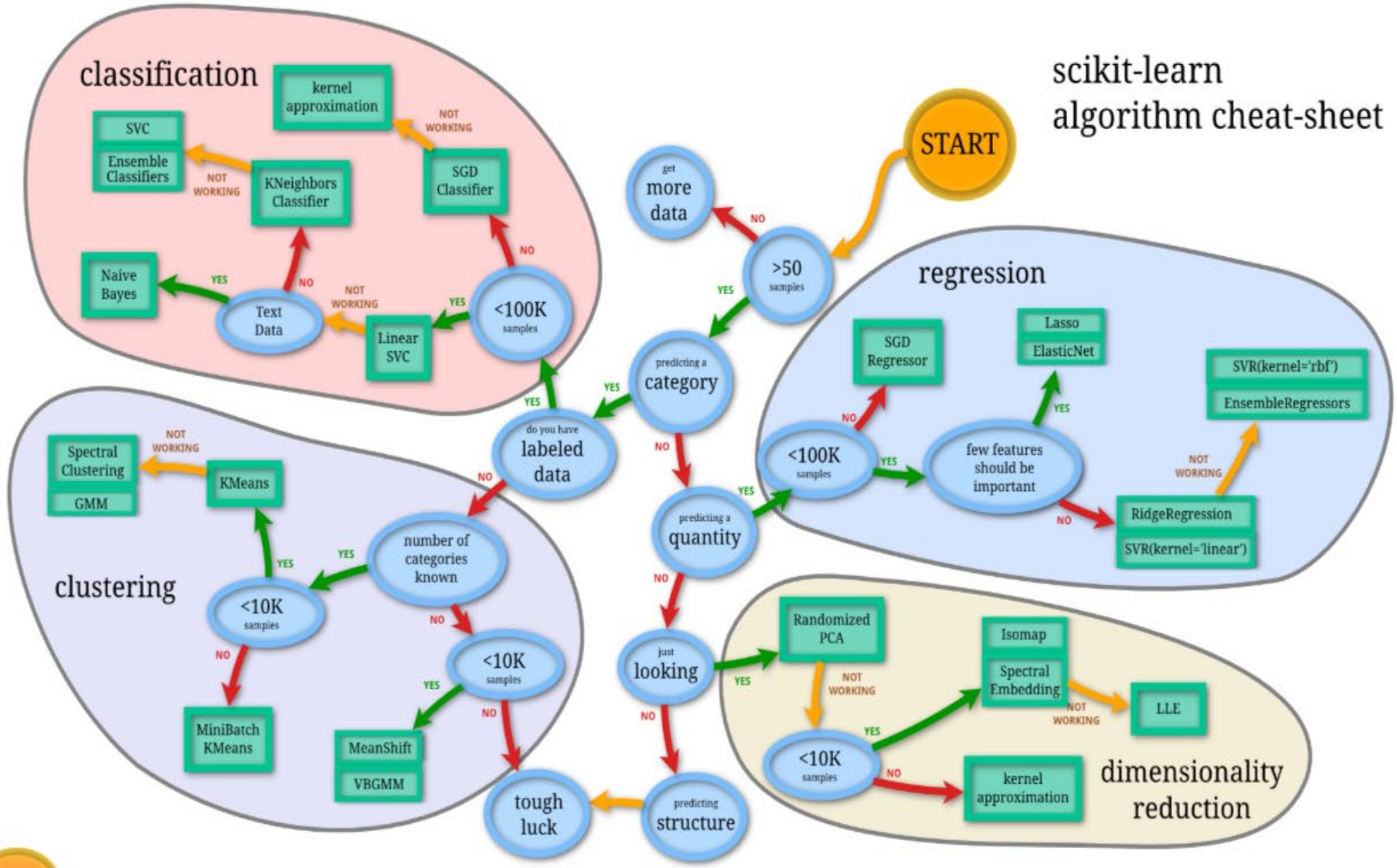
- Linear regression / Logistic regression
- Decision tree (C5.0, CART, …)
- Naïve Bayes, Bayesian Network
- Neural network (MLFF, Radial Basis, SOM, …)
- Deep Learning (CNN, LSTM, GAN, VAE…)
- Support Vector Machine
- Memory-based reasoning (K-NN)
- K-Means
- Hierarchical Clustering
- ……

© 2019 National University of Singapore. All Rights Reserved

Deep Learning Paradigm



Scikit-learn's Algorithms



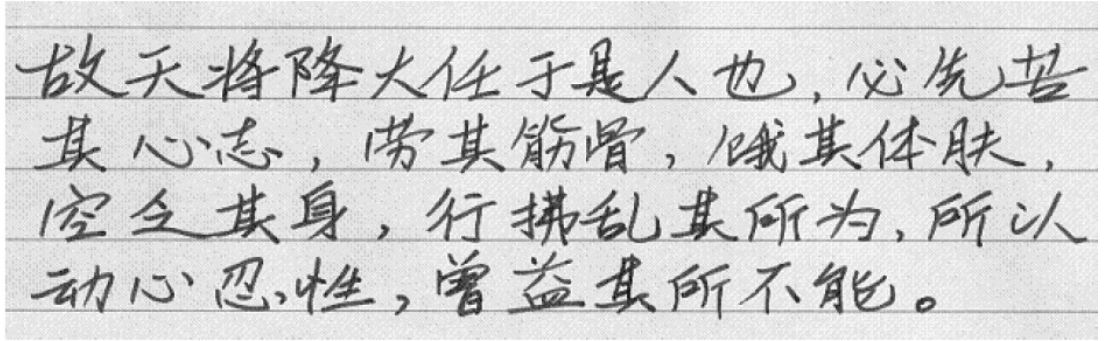
Applications of Pattern Recognition

- Handwritten digit/letter recognition
- Biometrics: voice, iris, fingerprint, face, and gait recognition
- Speech recognition
- Smell recognition (e-nose, sensor networks)
- Defect detection in chip manufacturing
- Interpreting DNA sequences
- Medical diagnosis
- Terrorist Detection
- Credit Fraud Detection
- Credit Applications
- … …

© 2019 National University of Singapore. All Rights Reserved

Applications of Pattern Recognition (cont.)

- **Hand-Written Character Recognition**



(a) Handwriting

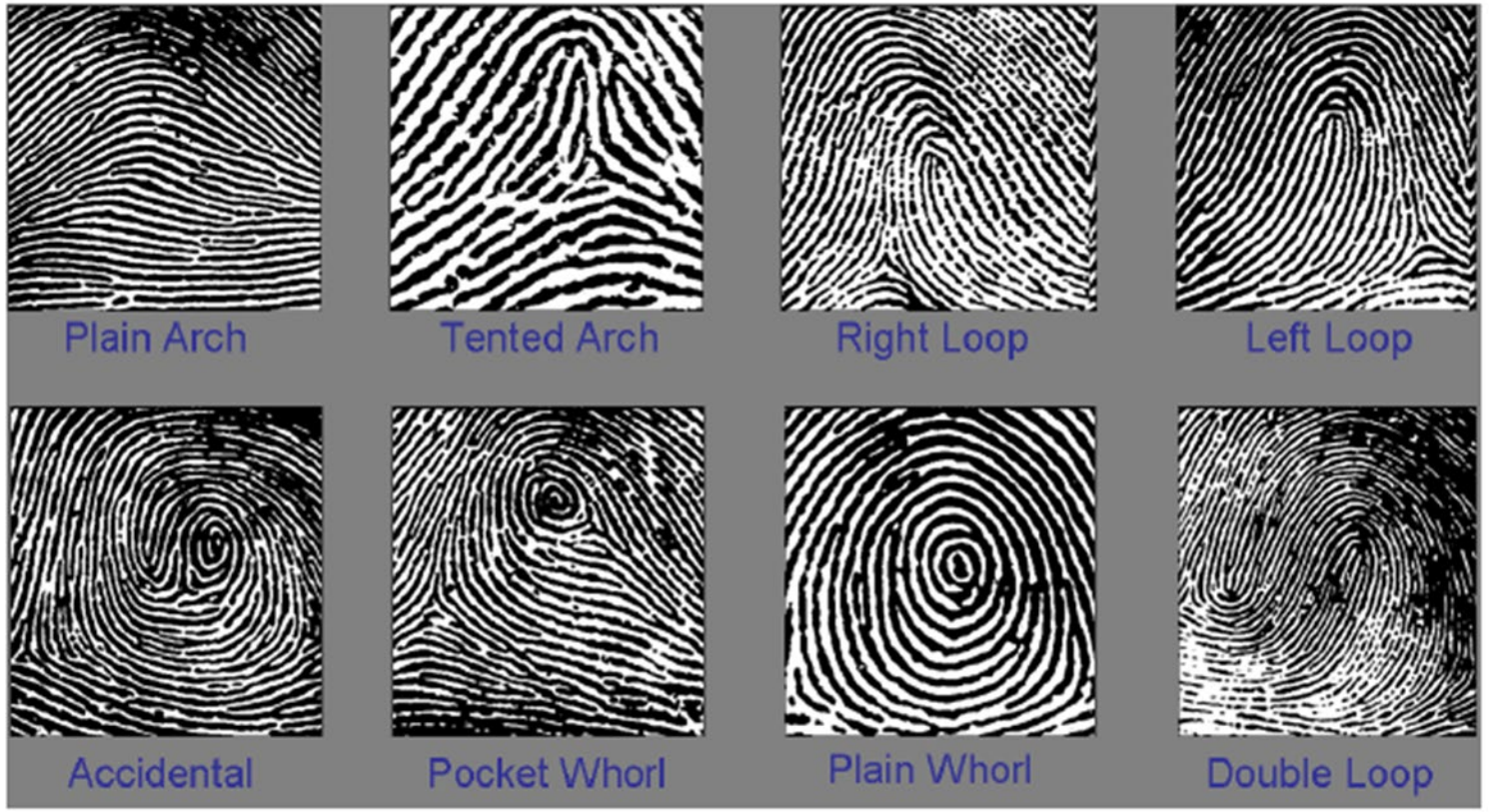
故天将降大任于是人也，必先苦
其心志，劳其筋骨，饿其体肤，
空乏其身，行拂乱其所为，所以
动心忍性，曾益其所不能。

(b) Corresponding Machine Print

© 2019 National University of Singapore. All Rights Reserved

Applications of Pattern Recognition (cont.)

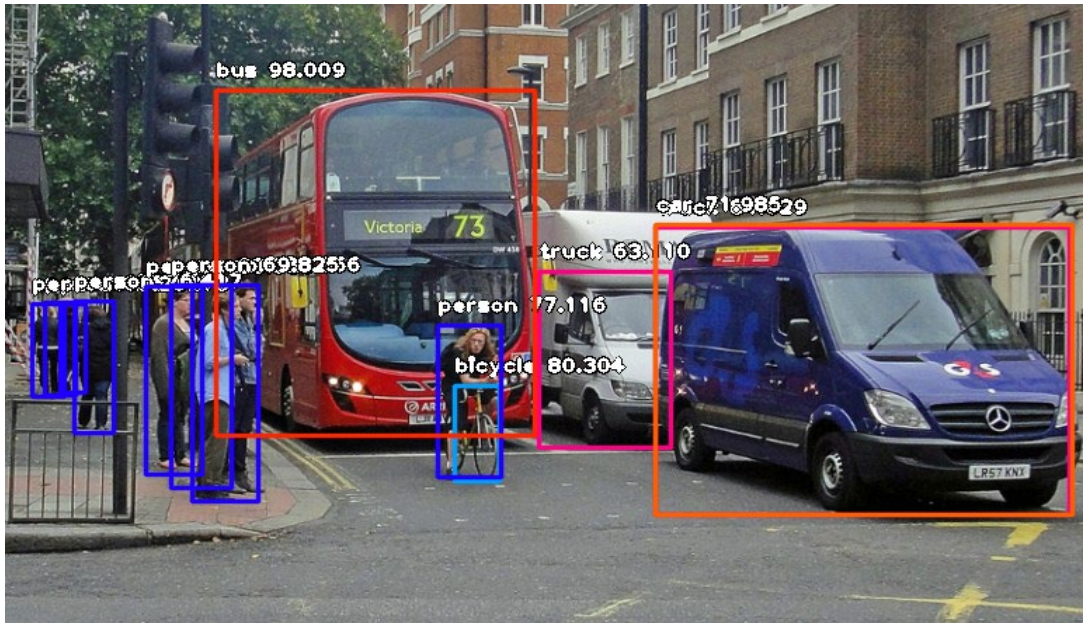
- **Fingerprint Classification**



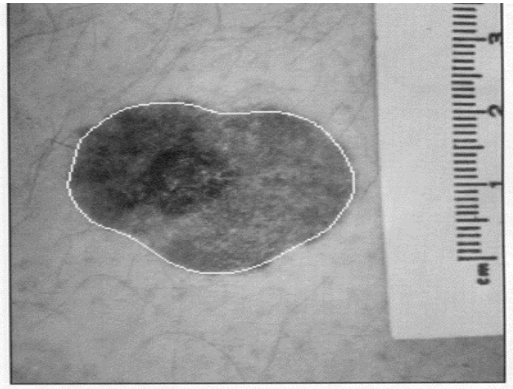
© 2019 National University of Singapore. All Rights Reserved

Applications of Pattern Recognition (cont.)

Autonomous Systems



Object Detection



Medical Applications - Skin cancer detection

© 2019 National University of Singapore. All Rights Reserved

References

- Pattern Classification, 2nd Edition,Richard O. Duda, Peter E. Hart, David G. Stork, 2000.
- Jain, Anil K., Robert P. W. Duin, and Jianchang Mao. "Statistical Pattern Recognition: A Review." Pattern Analysis and Machine Intelligence, IEEE Transactions on 22 (1): 4–37, 2000.
- Sebastian Raschka, Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow, 2nd Edition 2017.
- Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2011.
- Rokach, Lior; Maimon, O. Data mining with decision trees: theory and applications. World Scientific Pub Co Inc. 2008
- Kecman, V., "Learning and Soft Computing, Support Vector Machines, Neural Networks, and Fuzzy Logic Models", MIT, 2001
- Haykin, S., "Neural Networks, A Comprehensive Foundation", Prentice Hall, 1999
- Shawe-Taylor, J. & N. Cristianini, "Kernel Methods for Pattern Analysis", Cambridge Univ. Press, 2004

© 2019 National University of Singapore. All Rights Reserved