MULTICLASS CLASSIFICATION

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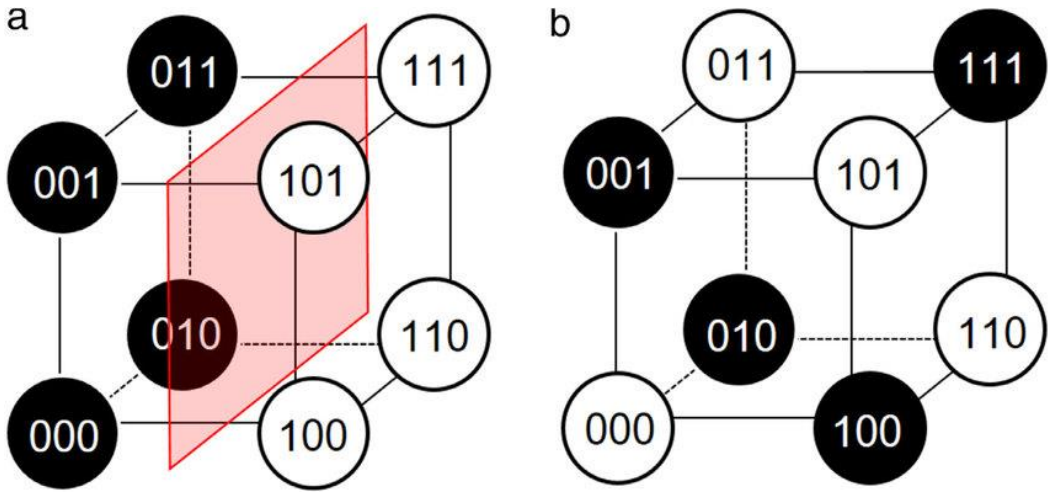
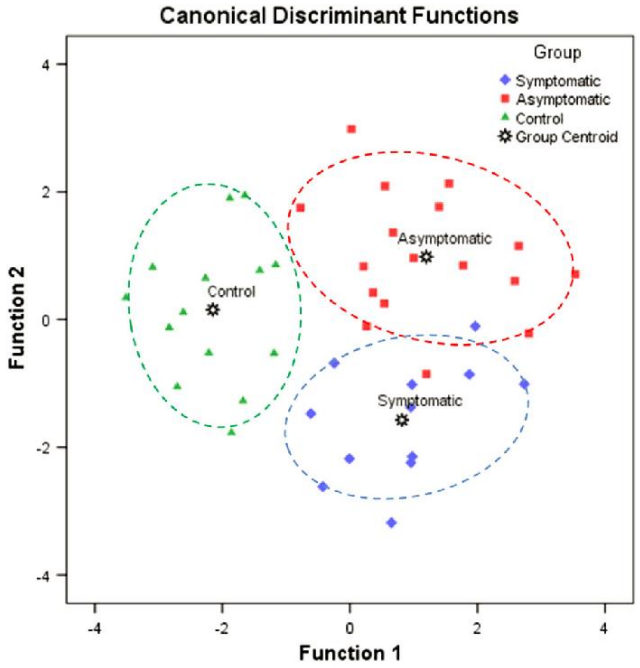
Binary classification

- Example: Use one hyperplane to dichotomize an *d*-dimensional space (only two classes exist)
  - https://www.researchgate.net/figure/Binary-patterns-a-A-simple-pattern-and-b-a-complex-pattern-for-an-input-dimension-N_fig6_287251036



Multiclass classification

- **Multiclass** or multinomial classification: classifying instances into one of three or more classes
- Ref. https://en.wikipedia.org/wiki/Multiclass_classification



Multiclass classification

- To deal with multiclass problems, we have
  - Transformation to binary
  - Extension from binary
  - Hierarchical classification

Transformation to binary

- Classes: $C_1, C_2, \cdots, C_5$
- **One-vs-all**
  - 1st classifier: to distinguish C_1 & $(C_2 \cup C_3 \cup \cdots \cup C_5)$
  - 2nd classifier: to distinguish C_2 & $(C_1 \cup C_3 \cup \cdots \cup C_5)$
  - Etc. (Need 5 classifiers)
- **One-vs-one**
  - 1st classifier: to distinguish C_1 & C_2
  - 2nd classifier: to distinguish C_1 & C_3
  - Etc. (Need $5*4/2$ classifiers)
    - Ref: https://medium.com/@chih.sheng.huang821(機器學習:如何在多類別分類問題上使用用二元分類器進行分類)

Extension from binary

- Some algorithms can be easily extend for multiclass classification
- Example 1: *K*-NN can be extend to deal with multiclass problems
- Example 2: Neural networks can have more than one output node to handle multiclass problems

Hierarchical classification

- Classes: $C_1, C_2, \cdots, C_5$
  - 1st-level classifier: to distinguish $(C_1 \cup C_2)$ & $(C_3 \cup C_4 \cup C_5)$
  - 2nd-level classifiers: (1) C_1 & C_2 ; (2) C_3 & $(C_4 \cup C_5)$
  - 3rd-level classifier: $C_4 \& C_5$
- Arranged in tree structure