INT304: Pattern Recognition in Computer Vision **Spring 2022**

Lab Assessment 2: Discriminant Functions & Non-parametric Classifiers

Contribution to Overall Marks: 15%

Start Date: April 12 2022

Submission Deadline: April 30, 2022

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Unit: INT Dept. of XJTLU

2.1 Objectives

- This assessment aims at evaluating students' ability to exploit the advanced pattern recognition knowledge, which is accumulated during lectures, and after-class study, to analyze, design, implement, develop, test and document the pattern classification methods.
- Implement the Parzen window and MQDF algorithms
- In this experiment, we will use one public dataset to verify our algorithm. Download the UCI Iris dataset: https://archive.ics.uci.edu/ml/datasets/Iris
- **Hints:** For Parzen algorithm, there is no training stage.

2.2 Estimation of Classification Methods

- Read the Iris dataset into a list and shuffle it with the **random.shuffle** method. Hint: fix the random seed (e.g. **random.seed(17)**) before calling **random.shuffle**
- Split the dataset as five parts to do cross-fold validation: Each of 5 subsets was used as test set and the remaining data was used for training. The 5 subsets were used for testing rotationally for evaluating the classification accuracy.

2.3 Parzen Window Method (35 marks)

- Separate the training dataset into three groups by their labels.
- Estimate the prior class probability $P(\omega_k)$

$$P(\omega_k) = \frac{n_k}{\sum_{i=1}^{K} n_i}$$

where n_k is the number of examples from the class ω_k.

- For any test example x, the conditional probability $P(x|\omega_k)$ is computed as

$$P(x|\omega_k) = \frac{1}{n_k} \sum_{x_i \in \omega_k} \frac{1}{h^d} \phi\left(\frac{x - x_i}{h}\right)$$

where h is the hyperparameter (or user-defined parameter) of the model and $\phi(u)$ is defined as

$$\phi(u) = \frac{1}{\sqrt{2\pi}} e^{-\frac{u^2}{2}}$$

- According to the Bayesian rule, we know that

$$P(\omega_k|x) \propto P(\omega_k)P(x|\omega_k)$$

  The example x is assigned to the label with the maximum $P(\omega_k|x)$.

- Show the figure that the accuracy performance changes with the hyperparameter h (real number).

2.4 Modified Quadratic Discriminant Function (35 marks)

- The MQDF model is a classifier based on Bayesian decision theory. Its discriminant function is given as below:

$$\begin{aligned} g_0(\mathbf{x},\omega_i) &= -(\mathbf{x}-\mu_i)^T\Sigma_i^{-1}(\mathbf{x}-\mu_i) - \log|\Sigma_i| \\ &= -[\Phi_i^T(\mathbf{x}-\mu_i)]^T\Lambda_i^{-1}\Phi_i^T(\mathbf{x}-\mu_i) - \log|\Sigma_i| \qquad \Sigma_i = \Phi_i\Lambda_i\Phi_i^{\mathrm{T}} \\ &= -\sum_{j=1}^{d}\frac{1}{\lambda_{ij}}[(\mathbf{x}-\mu_i)^T\phi_{ij}]^2 - \sum_{j=1}^{d}\log\lambda_{ij} \end{aligned}$$

- Design and implement a MQDF model to achieve the classification task on Iris. Show the training process and classification results. The work in [1] can be used as reference for your work.

  [1] F. Kimura, et zl., Modified quadratic discriminant functions and the application to Chinese character recognition, IEEE Trans. PAMI, 9(1): 149-153, 1987.

2.5 Analysis and Comparison (30 marks)

- Analyse and compare the advantages and disadvantages of these two models in classification from different aspects, such as effectiveness, efficiency, complexity. Your analysis and conclusion should be well justified theoretically and/or empirically.

2.6 Lab Report

- Write a technical report (no more than 10 pages) which should contain a concise description of your results and observations.
- **Please insert the clipped running image (SCREEN SHOT) into your report for the result of each step.**
- Please attach the **useful code** for each step as an **Appendix.** Appendix does not count in the total pages of the report, but only allow to put screenshots of the useful code, not the whole code.
- Submit the report and the source codes electronically into LearningMall. Reports without code will receive a zero mark.
- Relative paths must be used for the paths of read and write files.

- The report should be written with the **latex** typesetting language.
- The report in pdf format and source codes of your implementation should be zipped into a single file. The naming of report is as follows:

  e.g. StudentID LastName FirstName LabNumber.zip (123456789 Einstein Albert 1.zip)

  Failure to meet any of the above standards will result in a penalty.

Hints

Please refer to the lecture slides and PRML book for more details.

- Latex IDE: texstudio, OVERLEAF
- Python IDE: pycharm
- Use the python numpy library flexibly. (*Third-party libraries (algorithms libraries) are not allowed to use when you write all core code.*)

2.7 Marking Scheme

- 70%-100% Essentially complete and correct work.
- 60%-69% Shows understanding, but contains a small number of errors or gaps.
- 40%-59% Clear evidence of a serious attempt at the work, showing some understanding, but with important gaps.
- 20%-39% Scrappy work, bare evidence of understanding or significant work omitted.
- $\leq$ 19 % No understanding or little real attempt made.