

School of Computing and Information Technology

Student to complete:

Family name	
Other names	
Student number	

CSCI933

Machine Learning: Algorithms and Applications

South West Sydney and Wollongong

Examination Paper

Autumn 2023

Exam duration	2 hours + 15 minutes
Weighting	50%
Items permitted by examiner	OPEN BOOK - any reference materials permitted
Aids supplied	Nil.
Directions to students	Four (4) questions are to be answered. Marks allocated to each question are as indicated in the paper. Any act of copying and pasting from lecture notes or world wide web will incur a zero mark. All answers must be in your own words. Please be warned. Answer each question neatly and legibly. ONLY PDF documents can be submitted.

Question 1 (15 marks)

Imagine you are Head of Machine Learning Unit at POGGIO AutoVision Pty. Ltd. The company desires to develop a computer vision system that can be installed in an automobile to assist drivers. Essentially, this vision system will scan the environment in front of the car (say about 120 degrees field of view measured from the centre of the dashboard and 15 metres ahead of the automobile) and warn the driver about the presence of a small set of objects including refuse bins, humans, mailboxes, fire hydrant and traffic signs.

Write a **one-page report** on the steps you will take in your design of a machine learning system that can accomplish this task. In your write-up pay particular attention to problem definition, data collection and preparation, and algorithm/model choice (specification and parameters). You will also consider the implications of model complexity (over-fitting, under-fitting), training schedule (e.g. data split), generalisation error and regularization, on your proposed solution.

Question 2 (10 marks)

In a simple three-class ($\omega_1, \omega_2, \omega_3$) classification problem there are two features ($\mathbf{x}_1, \mathbf{x}_2$) forming the feature vector \mathbf{x} . The feature vectors in each class are normally distributed with covariance matrix

$$\Sigma = \begin{bmatrix} 1.2 & 0.4 \\ 0.4 & 1.8 \end{bmatrix}.$$

The mean vectors for each class are respectively, $\mu_1 = [0.1 \ 0.1]^t$, $\mu_2 = [2.1 \ 1.9]^t$ and $\mu_3 = [-1.5 \ 2.0]^t$; the superscript $(\cdot)^t$ implies transpose operation. Assume that the classes are equiprobable (i.e. $p(\omega_1) = p(\omega_2) = p(\omega_3)$). Furthermore the distribution of the feature vectors in each class can be written as:

$$p(\mathbf{x}|\omega_i) = \frac{1}{(2\pi|\Sigma|^{\frac{1}{2}})} \exp \left[-\frac{1}{2}(\mathbf{x} - \mu_i)^t \Sigma^{-1} (\mathbf{x} - \mu_i) \right]; i = 1, 2, 3.$$

Note that for a real matrix $G = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$, $|G| = (a \times d) - (b \times c)$ and $G^{-1} = \frac{1}{|G|} \times \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$.

Classify the feature vector $\mathbf{x} = [1.6 \ 1.5]^t$ according to the Bayes minimum risk classifier with loss matrix:

$$\Lambda = \begin{bmatrix} 0 & 0.1 & 0.1 \\ 1 & 0 & 1 \\ 1 & 0.1 & 0 \end{bmatrix}.$$

Question 3 (15 marks)

In a binary classification task you are given a set of 25 features and you are unsure about the relevance of each feature. The method you plan to use for this task may be based on a neural network or conventional statistical method.

- (a) [5 marks] Name two methods you may use to determine the appropriate subset of these features and why you will choose them.
- (b) [10 marks] For each of the methods named in part (a) describe the intuition behind it and how you will set it up for use in your classification task. In your response also pay particular attention to how these methods constitute regularization strategies. **Your response must not be more than one page.**

Question 4 (10 marks)

You are required to design a neural machine translation system.

- (a) [3 marks] Between the choice of a system based on recurrent neural network (LSTM or GRU) or transformer model, explain why you will choose one over the other.

- (b) [7 marks] Assume we can model an image captioning task as a translation from image to words, describe how you will design such a system using transformer model. Your design must mention the key subsystems (or algorithms) and the role they play in the overall design. **Please limit your response to no more than a page and half.**

-END OF EXAMINATION PAPER-