Subject:	Statistical Inference EE2102575
Instructor:	Suwichaya Suwanwimolkul
Place:	Eng. Building 3, 205
Data & Time:	17/02/2025 Wed. 11:00 – 12:30

Exam Instructions

Total 75 marks to be collected as Homework3 ($\approx$ 10%) of the scores.

1. **Time Limit:** you have **1.5 hours** to complete this examination.
2. **Materials:** Open books. **You will find the necessary information and Python tools within the provided Jupyter notebook to answer the questions in this lab. Use the notebook to run code, analyze the data, and derive the solutions.**
3. **Electronic Devices:** switch off and stow away all electronic devices, including mobile phones, smartwatches, and any other electronic gadgets, and **leave all of them at the provided locations**.
4. **Seating:** Maintain a one-seat gap between you and other candidates. Do not communicate or share any materials during the exam.
5. **Answering format:** use **a pen with blue or black ink** for the exam. Don't forget to fill in **your name and student ID** at the top of the pages.
6. **Instructions:** read all questions carefully!!! Ensure you understand the directions and requirements for each section.
7. **Early Submission:** if you finish early, quietly leave the examination hall, ensuring not to disturb others.

"I hereby acknowledge that my signature constitutes my understanding and agreement to comply with the conditions stipulated above."

Signature _____

Name _____

Student ID _____

Section	1	2	3.1	3.2
Your Scores				
Total Scores	5	30	30	10

1 Quizs (5 scores)

1.1 True/False Questions (5 scores)

For each statement, answer True or False. (Put one "x" in each.)	True	False
a) KNN is a supervised learning.		
b) The parameters of LDA is estimated from the mean and covariance of training data		
c) LDA assumes that the equal covariance between $X\|Y_j$ for all $j \in \{1, 2, ..., K\}$		
d) Unlike LDA, QDA did not assume the equal covariance		
e) Unlike KNN, LDA and QDA estimate a set of parameters to draw the boundaries which depend on the data distributions. Then, estimates the posterior probability of the classes using the estimated parameters.		

2 Logistic Regression: loan amount dataset (30 scores)

Data.

- **Input features**: `Loan_ID, Gender, Married, Dependents, Education, Self_Employed ApplicantIncome, CoapplicantIncome, LoanAmount, Loan_Amount_Term, CreditHistory Property_Area`

- **Target**: `Loan_status`

2.1 Logistic regressoin (intro)

In this section, let's analyze the results from logistic regression. The logistic regressor will try to give you the answer of whether or not you you give the loan to a person, based on his/her information ?

Here, we ran the logistic regressor given **2 different sets of input features**.

- **Input features**: `LoanAmount`

```
Optimization terminated successfully.
         Current function value: 0.607423
         Iterations 4
                           Logit Regression Results
==============================================================================
Dep. Variable:                      y   No. Observations:                  246
Model:                          Logit   Df Residuals:                      245
Method:                           MLE   Df Model:                            0
Date:                Sun, 18 Feb 2024   Pseudo R-squ.:                0.001087
Time:                        21:59:14   Log-Likelihood:                -149.43
converged:                       True   LL-Null:                       -149.59
Covariance Type:            nonrobust   LLR p-value:                       nan
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
x1             0.0081      0.001      6.142      0.000       0.005       0.011
==============================================================================
```

- **Input features**: `LoanAmount, Credit_History, Gender, Education`

```
Optimization terminated successfully.
         Current function value: 0.476945
         Iterations 6
                           Logit Regression Results
==============================================================================
Dep. Variable:                      y   No. Observations:                  246
Model:                          Logit   Df Residuals:                      242
Method:                           MLE   Df Model:                            3
Date:                Sun, 18 Feb 2024   Pseudo R-squ.:                  0.2157
Time:                        21:59:14   Log-Likelihood:                -117.33
converged:                       True   LL-Null:                       -149.59
Covariance Type:            nonrobust   LLR p-value:                 6.353e-14
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
x1            -0.0122      0.004     -2.966      0.003      -0.020      -0.004
x2             2.9862      0.452      6.603      0.000       2.100       3.873
x3            -0.1059      0.397     -0.267      0.790      -0.884       0.672
x4            -0.5153      0.361     -1.426      0.154      -1.224       0.193
==============================================================================
```

2.2 True/False Questions (10 scores)

You should use the given codes to recheck your answer.

For each statement, answer True or False. (Put one "X" in each.)	True	False
a) `LoanAmount` alone has a positive relationship with '`Loan_status` == True'		
b) `Credit_History` alone has a positive relationship with '`Loan_status` == True'		
c) At a `Credit_History`, the `LoanAmount` alone has a negative relationship with '`Loan_status` == True'		
d) At a fixed values of `Credit_History`, `Gender`, `Education`, the `LoanAmount` alone has a negative relationship with '`Loan_status` == True'		
e) P-value indicates that the coefficients of `Gender` and `Education` are likely to have zero values.		
f) From the P-values of `Credit_History`, the parameter coefficient associated with `Credit_History` is likely to be non-zero, so it could give a crucial information.		
g) The correlation between `LoanAmount` and `Credit_History` can cause the confusing conclusion between `LoanAmount` and `Loan_status`.		
h) The correlation between `LoanAmount` and `Education` can cause the confusing conclusion between `LoanAmount` and `Loan_status`.		
i) `Credit_History` alone has a negative correlation with `LoanAmount`		
j) `Loan_amount_term` is one of the least correlated features with `Loan_status`		

3 KNN, LDA, and QDA Classifiers (40 scores)

3.1 Two features (30 scores)

- Use **two features** `Credit_History` `LoanAmount` for the classification of `Loan_status`.
- Find the precision-recall trade-off of each k of the KNN, LDA and QDA on the validated dataset.

Two features, 3.1.1: Based on the precision-recall trade-off, which value of k of the KNN algorithm gives the best trade-off (you can also use other evaluations, *e.g.*, specifity to help)...(5 scores)

- confirm by plotting the graph and explain.

Answer:

Two features, 3.1.2: Compare the results of LDA and QDA with the previous precision-recall trade-off (you can also use other evaluations, *e.g.*, specifity to help)...(5 scores)

- Between LDA, QDA, and KNN, which is the best ? confirm by plotting the graph and explain.

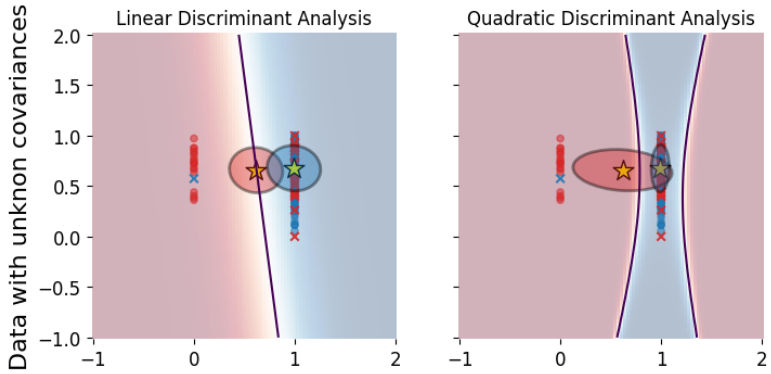
Answer:

Two features, 3.1.3: Compare the confusion matrix of KNN with the best-k, LDA and QDA ...(5 scores)

- Between LDA, QDA, and KNN, which is the best ? confirm by drawing the confusion matrix of KNN, LDA and QDA. Your analysis should be supported by the quantity derived from the confusion matrix, *e.g.*, true positive, false positive, true negative, and false negative.

Answer:

Two features, 3.1.4: Visualize the boundary of LDA and QDA. (5 scores)



- The classification bounary of LDA and QDA are plot on the 2D planar of the input features `Credit_History` and `LoanAmount`.
- Here x and x are the classification results of the training samples, where x denotes the training training samples on the red class, and x denotes the training samples on the blue class. The stars are the center of the samples in class red and blue.
- From the above figure can you explain how LDA and QDA decide the boundary.
- Which of the two features that LDA and QDA rely on the most ?

Answer:

Two features, 3.1.5: Suggestions from the bounary. Which of the two features that LDA and QDA rely on the most when deciding the boundary? (10 scores)

- Check the performance of LDA and QDA when using `Credit_History /LoanAmount`.
- Please compare the performance using the confusion matrix.

Answer:

3.2 7 features (10 scores)

- **7 features**: `Gender, Married, LoanAmount, Dependents, Self_Employed, ApplicantIncome CoapplicantIncome, Credit_History` for the classification of `Loan_status`.

7 features, 3.2.1: On validation set:

- Between LDA, QDA, and KNN, which is the best ? confirm by plotting the graph and explain.
- Do you get different best value of k for KNN compared to when using only two features?

Answer:

7 features, 3.2.2: which is the best ? The confusion matrix of KNN with the best-k vs LDA vs QDA...

- Do you get a different testing performance from using two features? Why do you think?

Answer: