Lab6: Logistic Regression and Metrics

Chia-Han Lu & DataLab

2022.10.05

Outline

- Brief Review: Logistic Regression

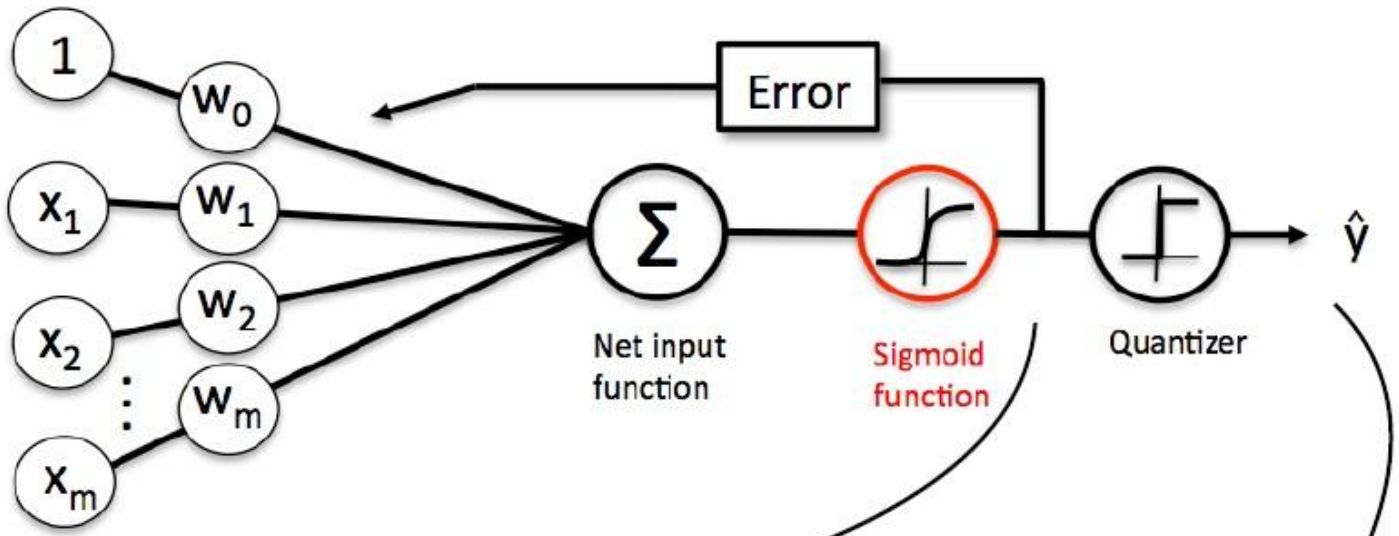
- Common Evaluation Metrics for Binary Classification
  - Confusion Matrix
  - Soft Classifiers – ROC Curve

Outline

- Brief Review: Logistic Regression

- Common Evaluation Metrics for Binary Classification
  - Confusion Matrix
  - Soft Classifiers – ROC Curve

Logistic Regression



$$P(y \mid \boldsymbol{x}; \boldsymbol{w}) = \sigma(\boldsymbol{w}^\top \boldsymbol{x})^{y'}[1 - \sigma(\boldsymbol{w}^\top \boldsymbol{x})]^{(1-y')}$$

Soft prediction

$$\arg\max_y \{\sigma(\boldsymbol{w}^\top \boldsymbol{x}), 1 - \sigma(\boldsymbol{w}^\top \boldsymbol{x})\} = \text{sign}(\boldsymbol{w}^\top \boldsymbol{x})$$

Label prediction

Logistic Regression + Regularization

- 把Regularization Term加到Loss內，讓模型在學weights的時候，會傾向選擇比較簡單的模型。

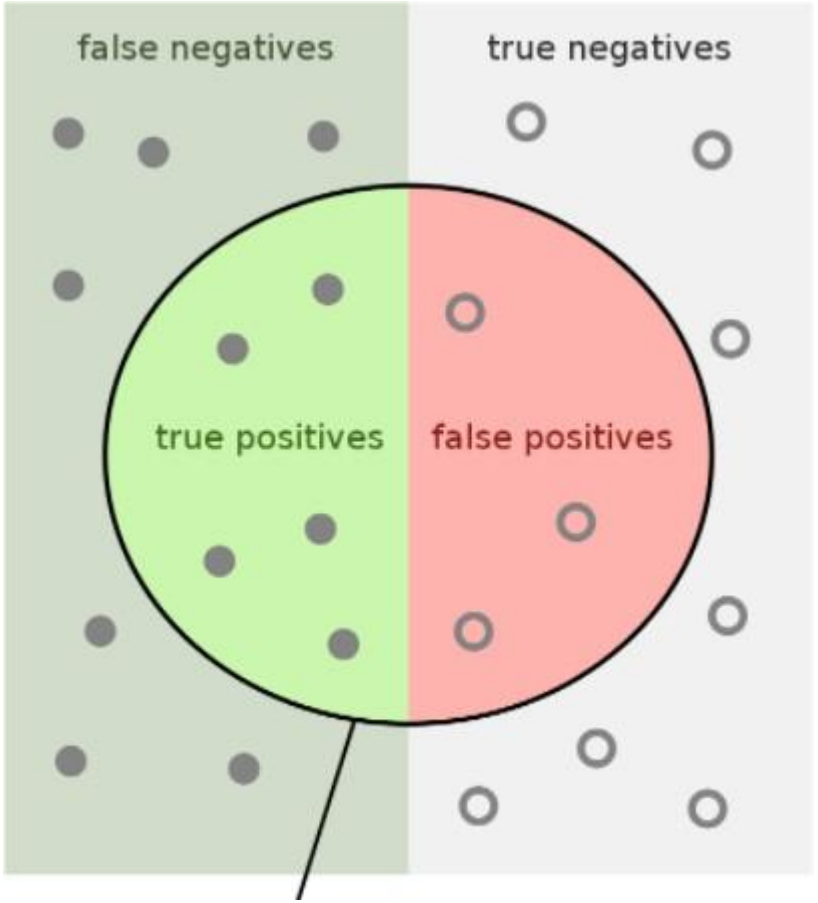
Outline

- Brief Review: Logistic Regression

- Common Evaluation Metrics for Binary Classification
  - Confusion Matrix
  - Soft Classifiers – ROC Curve

Confusion Matrix

- It is important to know how the model make wrong prediction.
- In binary classification, confusion matrix is a common tool to analyze the predictions.



Confusion Matrix

- It is important to know how the model make wrong prediction.

- e.g. 檢測絕症
  - 寧可讓多一點人到TP & FP，也不要讓FN很高。

- Other metrics we can use:

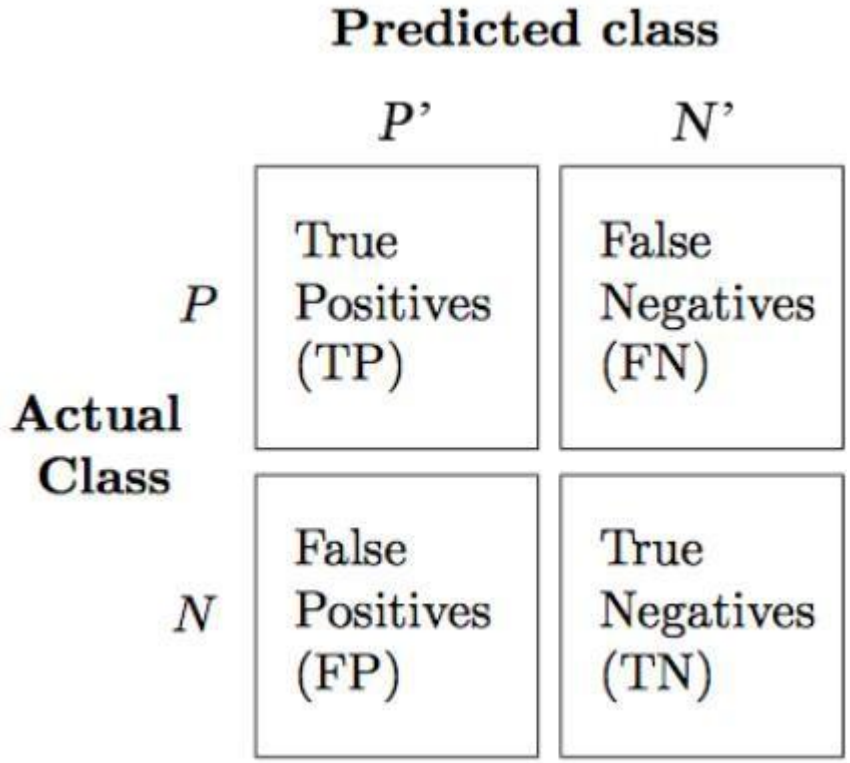
$$TPR = \frac{TP}{TP + FN} \qquad FPR = \frac{FP}{FP + TN}$$

		Predicted class: P'	Predicted class: N'
Actual Class	P	True Positives (TP)	False Negatives (FN)
	N	False Positives (FP)	True Negatives (TN)

Confusion Matrix

- It is important to know how the model make wrong prediction.

- e.g. 檢測絕症
  - 寧可讓多一點人到TP & FP，也不要讓FN很高。
  - i.e. TPR higher



$$TPR = \frac{TP}{TP + FN} \qquad FPR = \frac{FP}{FP + TN}$$

Confusion Matrix

- Precision(PRE), Recall

$$PRE = \frac{TP}{TP + FP}, \quad \text{(the higher, the better)}$$

$$REC = \frac{TP}{TP + FN} = TPR. \quad \text{(the higher, the better)}$$

- F-1 Score

$$F_1 = 2\frac{(PRE * REC)}{PRE + REC}, \quad \text{(the higher, the better)}$$

		Predicted class: P'	Predicted class: N'
Actual Class	P	True Positives (TP)	False Negatives (FN)
	N	False Positives (FP)	True Negatives (TN)

Confusion Matrix

- Precision(PRE), Recall

$$PRE = \frac{TP}{TP + FP}, \quad \text{(the higher, the better)}$$

$$REC = \frac{TP}{TP + FN} = TPR. \quad \text{(the higher, the better)}$$

- F-1 Score

$$F_1 = 2\frac{(PRE * REC)}{PRE + REC}, \quad \text{(the higher, the better)}$$

		Predicted class: P'	Predicted class: N'
Actual Class	P	True Positives (TP)	False Negatives (FN)
	N	False Positives (FP)	True Negatives (TN)

Outline

- Brief Review: Logistic Regression

- Common Evaluation Metrics for Binary Classification
  - Confusion Matrix
  - Soft Classifiers – ROC Curve

ROC Curve

- ROC curve analyze the performance for every threshold in soft classifiers.

- In X-axis: FPR

$$FPR = \frac{FP}{FP + TN}$$

- In Y-axis: TPR

$$TPR = \frac{TP}{TP + FN}$$

1	
1	
0.87	θ
0.64	$\Downarrow$
$\vdots$	
−0.88	
−0.93	
−1	

ROC Curve

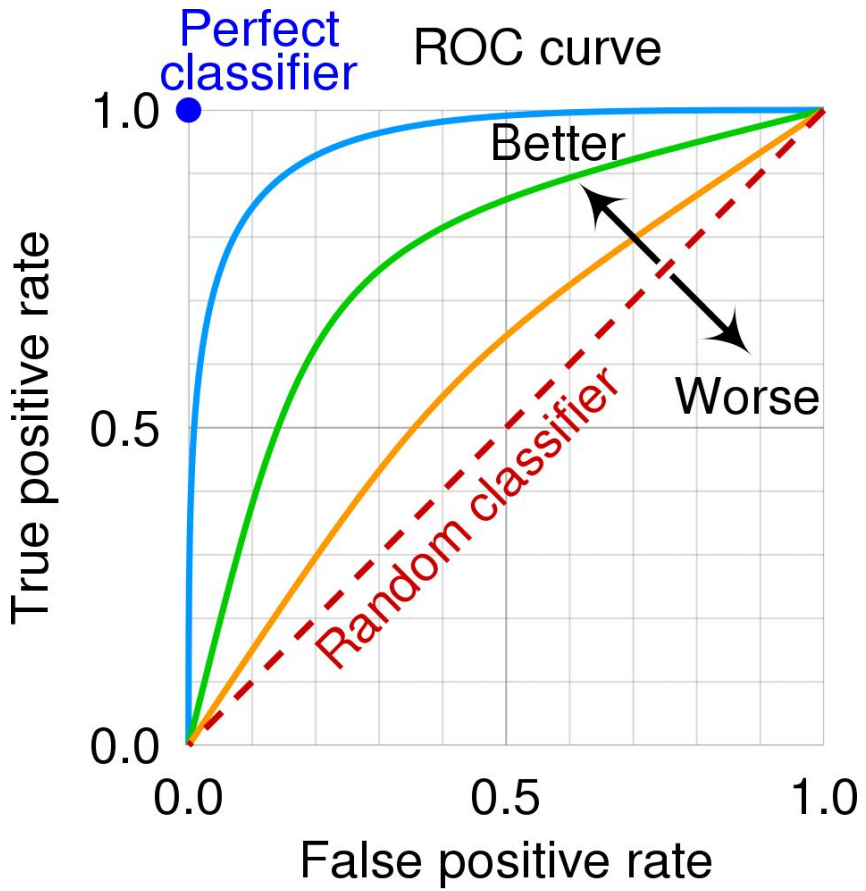
- ROC curve analyze the performance for every threshold in soft classifiers.

- In X-axis: FPR

$$FPR = \frac{FP}{FP + TN}$$

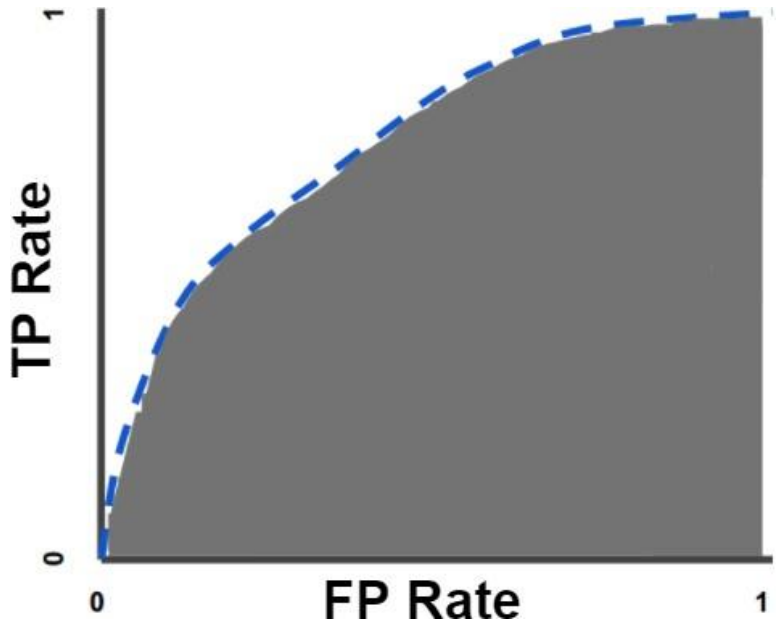
- In Y-axis: TPR

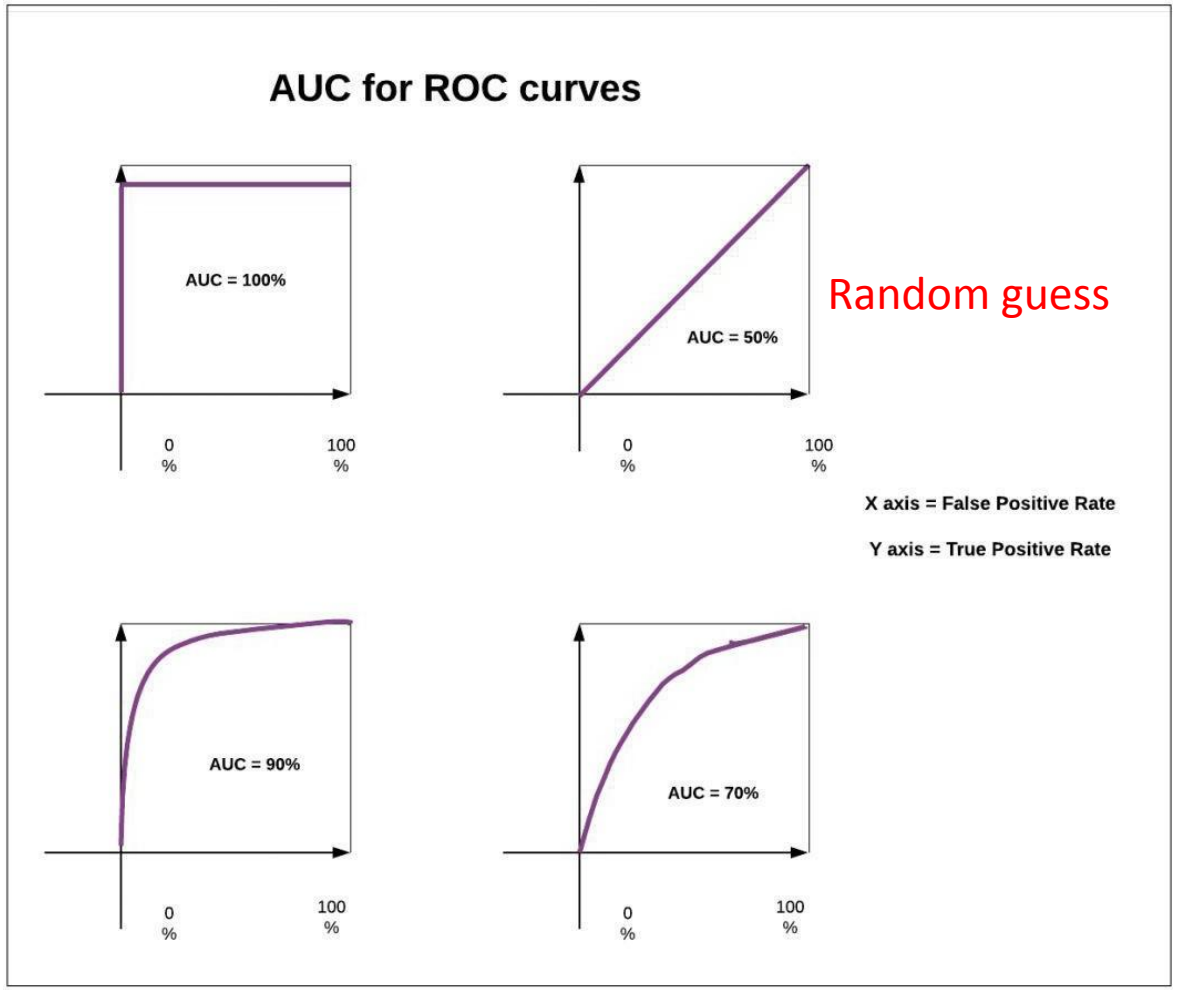
$$TPR = \frac{TP}{TP + FN}$$



AUC

- AUC - Area Under the ROC Curve.
  - ROC can be quantified using AUC.





https://developers.google.com/machine-learning/crash-course/classification/roc-and-auc
https://medium.com/acing-ai/what-is-auc-446a71810df9

Homework

- Homework: Lab06
  - Lab06: Logistic Regression, Metrics

- Bonus: Lab07 && Lab08
  - Lab07: Support Vector Machine, k-Nearest Neighbors
  - Lab08: Cross Validation, Ensemble

Reference

- https://bookdown.org/ccwang/medical_statistics6/section-43.html
- https://bookdown.org/ccwang/medical_statistics6/bernoulli.html
- https://bookdown.org/ccwang/medical_statistics6/binomial.html
- https://bookdown.org/ccwang/medical_statistics6/likelihood-definition.html
- https://en.wikipedia.org/wiki/Sensitivity_and_specificity
- https://commons.wikimedia.org/w/index.php?curid=109730045
- https://developers.google.com/machine-learning/crash-course/classification/roc-and-auc
- https://medium.com/acing-ai/what-is-auc-446a71810df9
- https://github.com/dariyasydykova/open_projects/tree/master/ROC_animation