

LECTURE 2 TERM 2:

MSIN0097

UCL
SCHOOL OF
MANAGEMENT

PREDICTIVE ANALYTICS Assignment Project Exam Help

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VIDEO 5: CLASSIFICATION Add WeChat powcoder

A P MOORE

A. Classification

Model requirements

Classification

$$x \in [-\infty, \infty]$$
$$y \in \{0, N\}$$

B. Regression

Model requirements

Regression

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C. Clustering

Model requirements

Clustering

$$x \in [-\infty, \infty]$$
$$y \in \{0, N\}$$

D. Decomposition

Model requirements

Decomposition

$$x \in [-\infty, \infty]$$
$$y \in [-\infty, \infty]$$

Supervised

Unsupervised

A. CLASSIFICATION

CATEGORICAL VARIABLE

Model requirements

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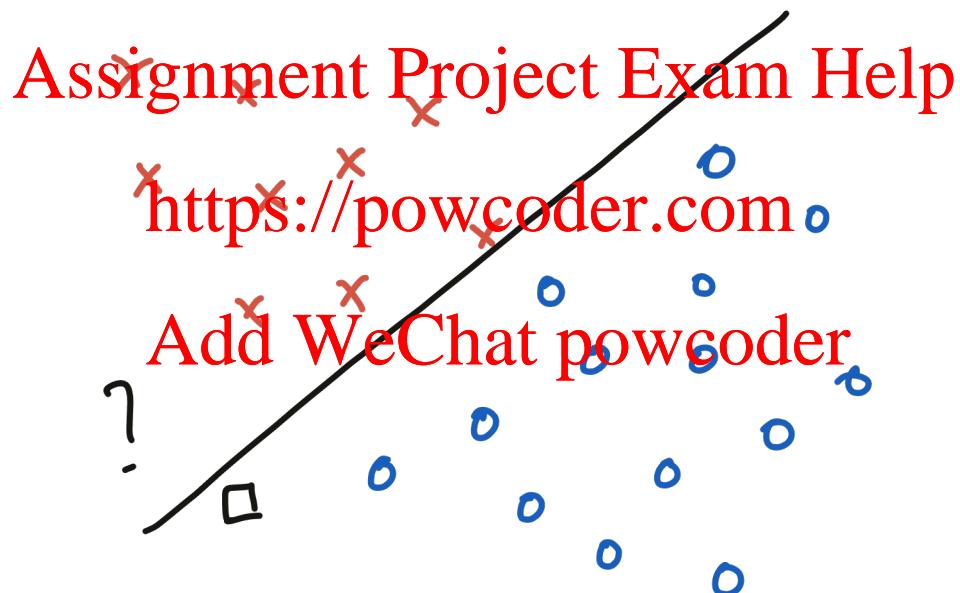
Classification

$$x \in [-\infty, \infty]$$

$$y \in \{0, N\}$$

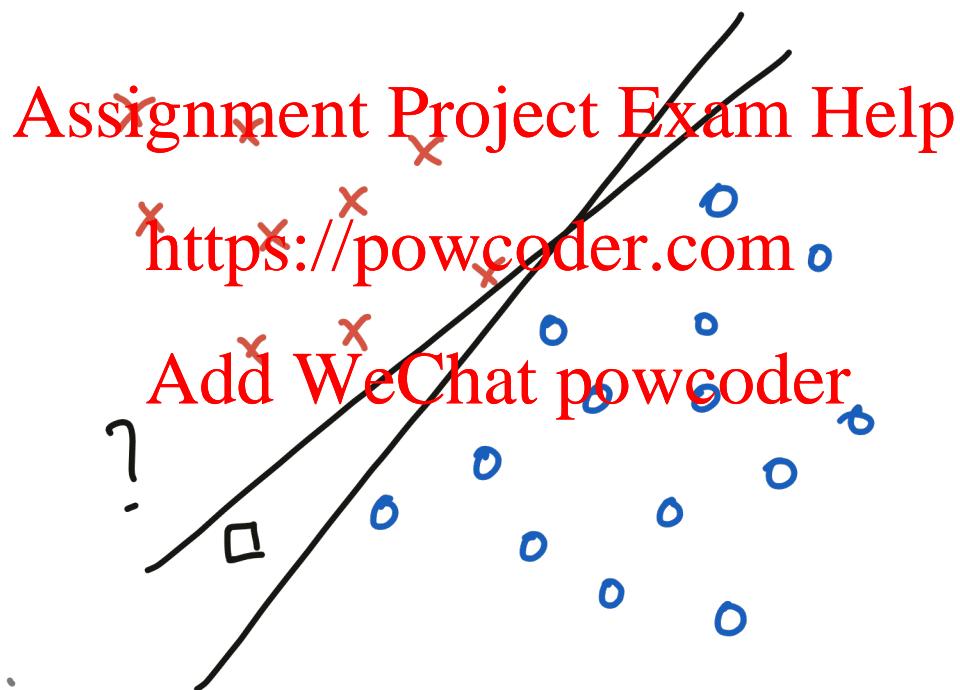
A. CLASSIFICATION

CATEGORICAL VARIABLE



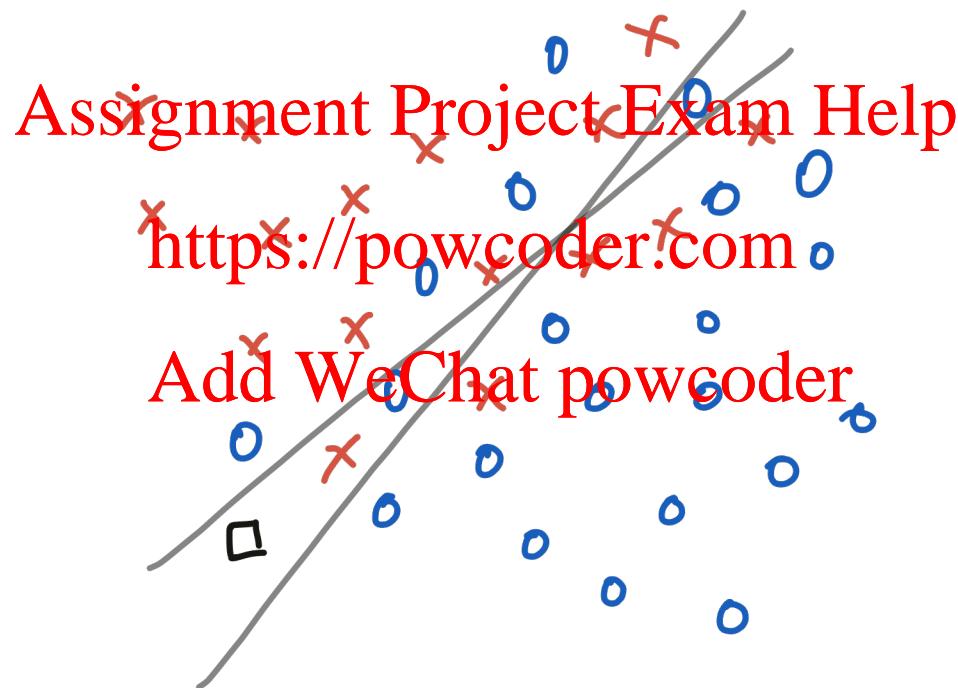
A. CLASSIFICATION

CATEGORICAL VARIABLE

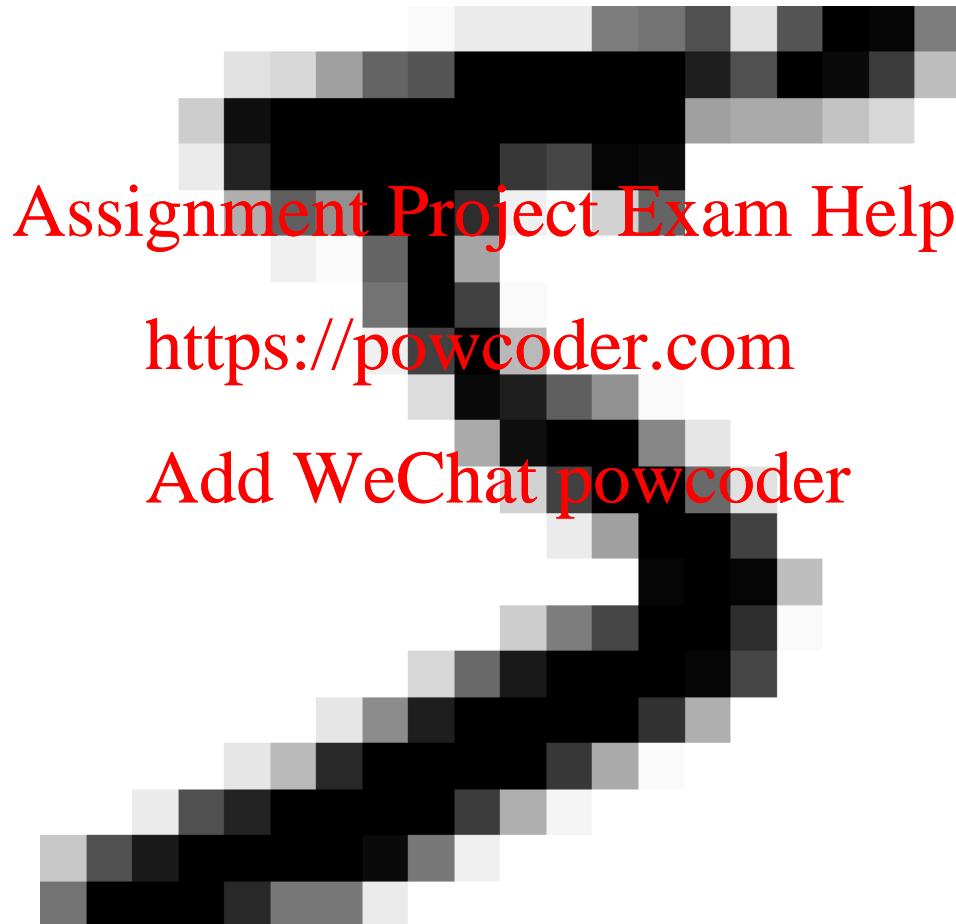


A. CLASSIFICATION

CATEGORICAL VARIABLE



GRID (PIXEL) DATA



VARIATION IN DIGITS

5 0 4 1 9 2 1 3 1 4
3 5 3 6 1 7 2 8 6 9
4 8 7 1 2 3 5 2 7
3 8 6 2 0 5 6 0 7 6
1 8 7 9 3 9 8 5 9 3
3 0 7 4 4 8 0 9 4 1
4 4 6 0 4 5 6 1 0 0
1 7 1 6 3 0 2 1 1 7
8 0 2 6 7 8 3 9 0 4
6 7 4 6 8 0 7 8 3 1

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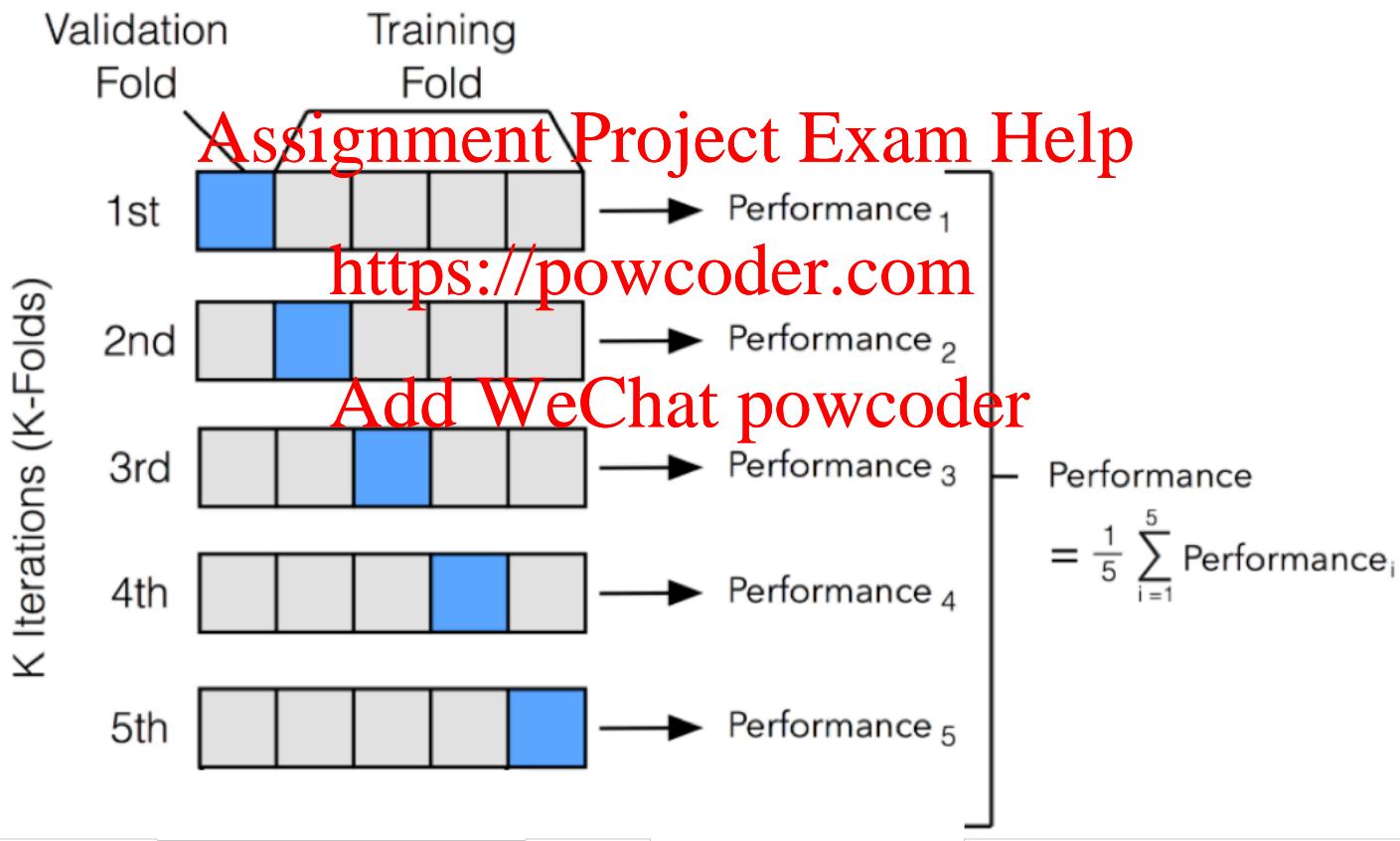
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K-FOLD VALIDATION



CONFUSION MATRIX

BINARY FORCED CHOICE



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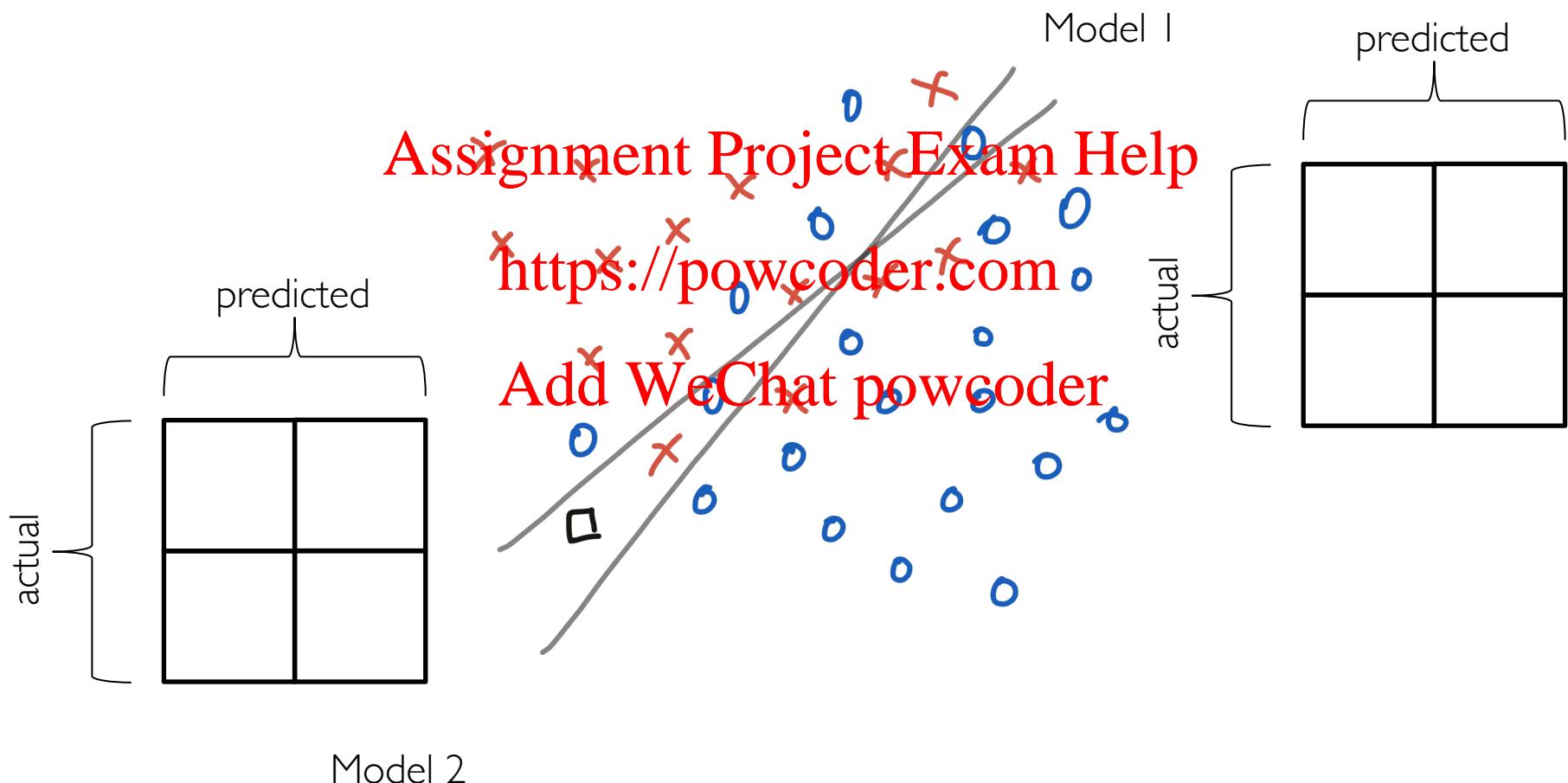
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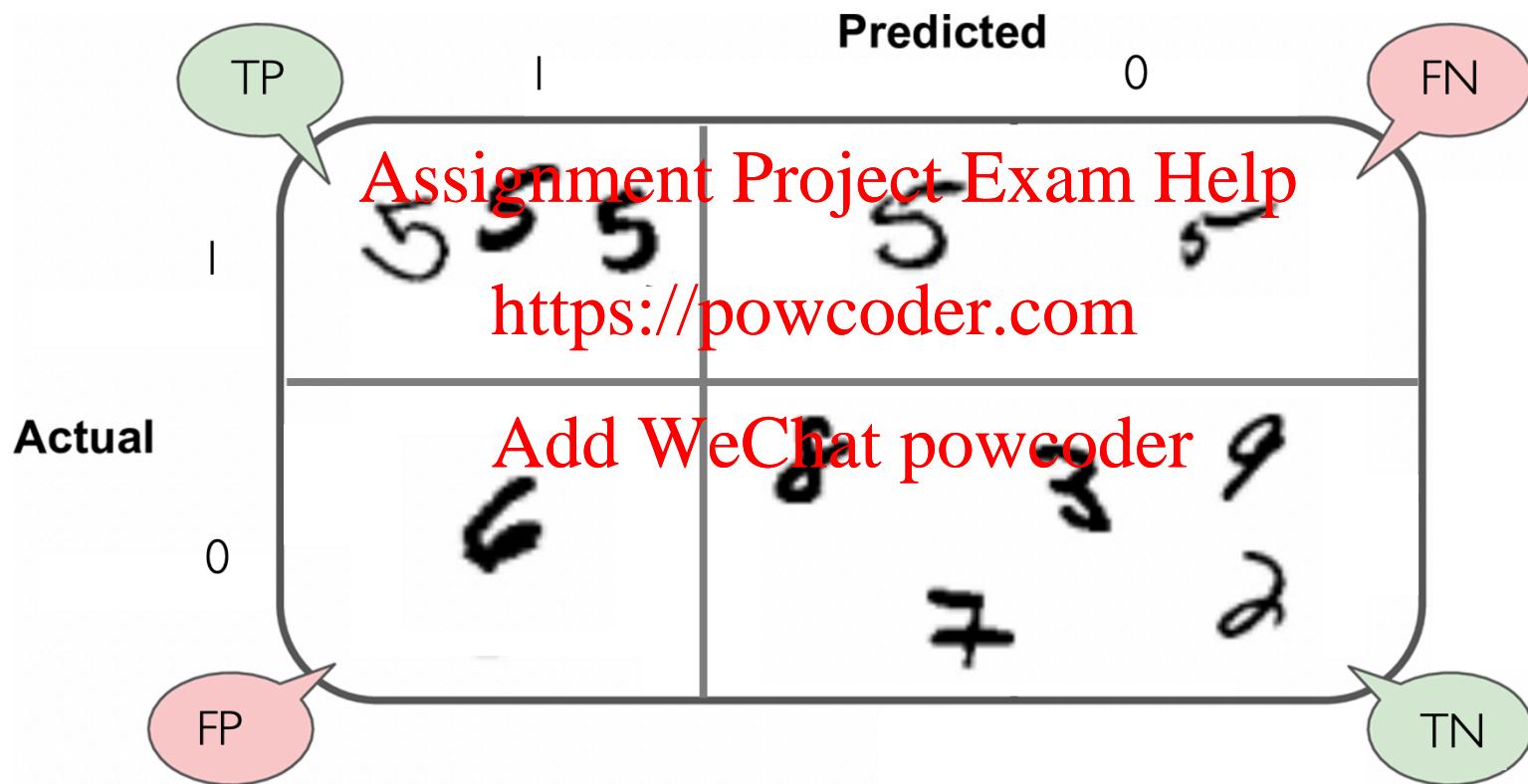
	1	0
1	TP	
0		TN

A. CLASSIFICATION

CATEGORICAL VARIABLE



CONFUSION MATRIX



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$$Precision = \frac{TP}{TP + FP}$$

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

$$F_1 = \frac{2}{\frac{1}{Precision} + \frac{1}{Recall}} = 2 \times \frac{Precision \times Recall}{Precision + Recall} = \frac{TP}{TP + \frac{FN + FP}{2}}$$

		predicted	
		P	N
actual	P	TP	FN
	N	FP	TN

SENSITIVITY, SPECIFICITY...

		True condition			
Total population	Condition positive	Condition negative	Prevalence = $\frac{\sum \text{Condition positive}}{\sum \text{Total population}}$	Accuracy (ACC) = $\frac{\sum \text{True positive} + \sum \text{True negative}}{\sum \text{Total population}}$	
Predicted condition	True positive	False positive Type I error	Positive predictive value (PPV), Precision = $\frac{\sum \text{True positive}}{\sum \text{Predicted condition positive}}$	False discovery rate (FDR) = $\frac{\sum \text{False positive}}{\sum \text{Predicted condition positive}}$	
Predicted condition positive	False negative, Type II error	True negative	False omission rate (FOR) = $\frac{\sum \text{False negative}}{\sum \text{Predicted condition negative}}$	Negative predictive value (NPV) = $\frac{\sum \text{True negative}}{\sum \text{Predicted condition negative}}$	
	True positive rate (TPR), Recall, Sensitivity, probability of detection, Power = $\frac{\sum \text{True positive}}{\sum \text{Condition positive}}$	False positive rate (FPR), Fall-out, probability of false alarm = $\frac{\sum \text{False positive}}{\sum \text{Condition negative}}$	Positive likelihood ratio (LR+) = $\frac{\text{TPR}}{\text{FPR}}$	Diagnostic odds ratio (DOR) = $\frac{\text{LR+}}{\text{LR-}}$	$F_1 \text{ score} = 2 \cdot \frac{\text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}}$
	False negative rate (FNR), Miss rate = $\frac{\sum \text{False negative}}{\sum \text{Condition positive}}$	Specificity (SPC), Selectivity, True negative rate (TNR) = $\frac{\sum \text{True negative}}{\sum \text{Condition negative}}$	Negative likelihood ratio (LR-) = $\frac{\text{FNR}}{\text{TNR}}$		

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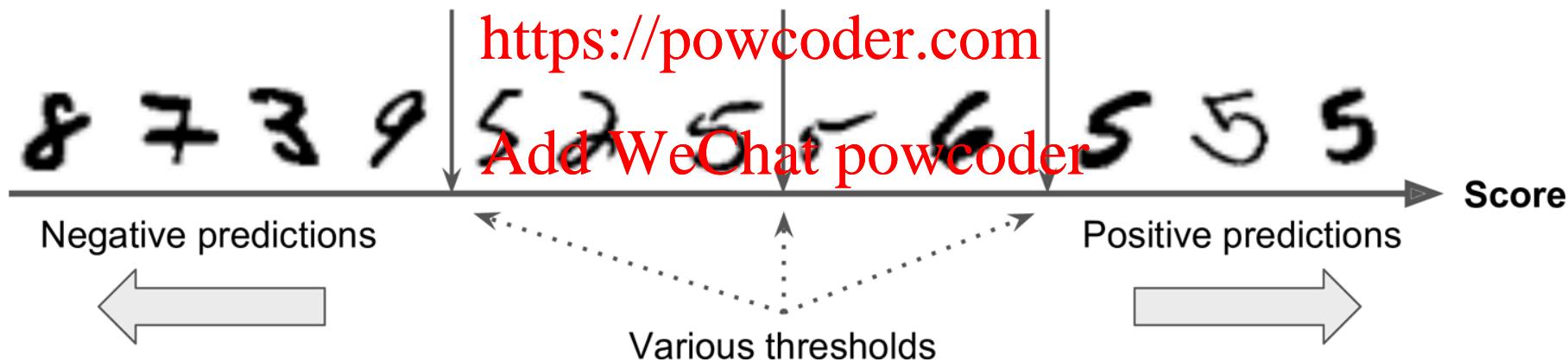
Prevalence
Accuracy
Positive predictive value
False discovery rate
False omission rate
Diagnostic odds ratio...

PRECISION / RECALL TRADE OFF

Precision: $6/8 = 75\%$ $4/5 = 80\%$ $3/3 = 100\%$
Recall: $6/6 = 100\%$ $4/6 = 67\%$ $3/6 = 50\%$

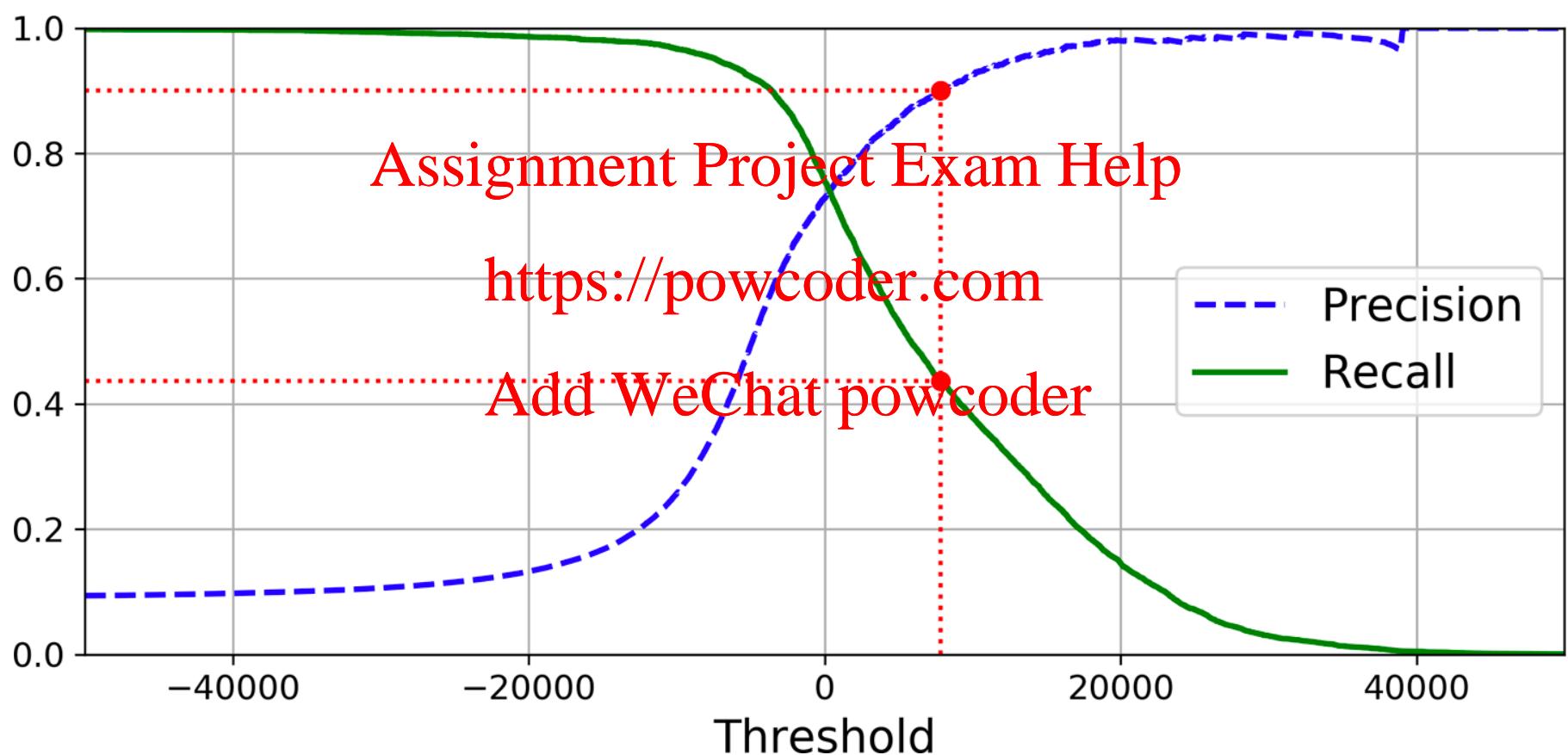
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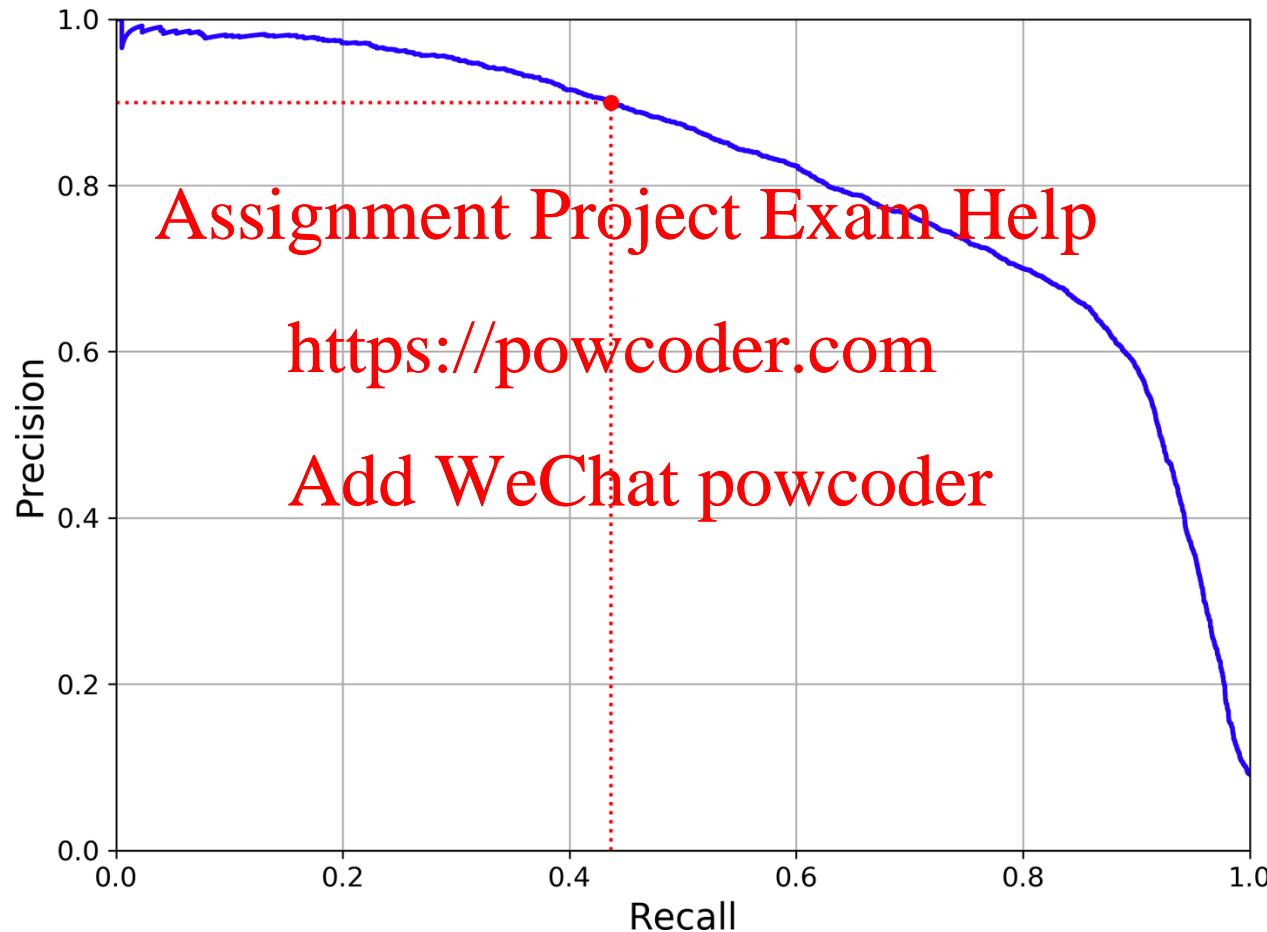


Decision function

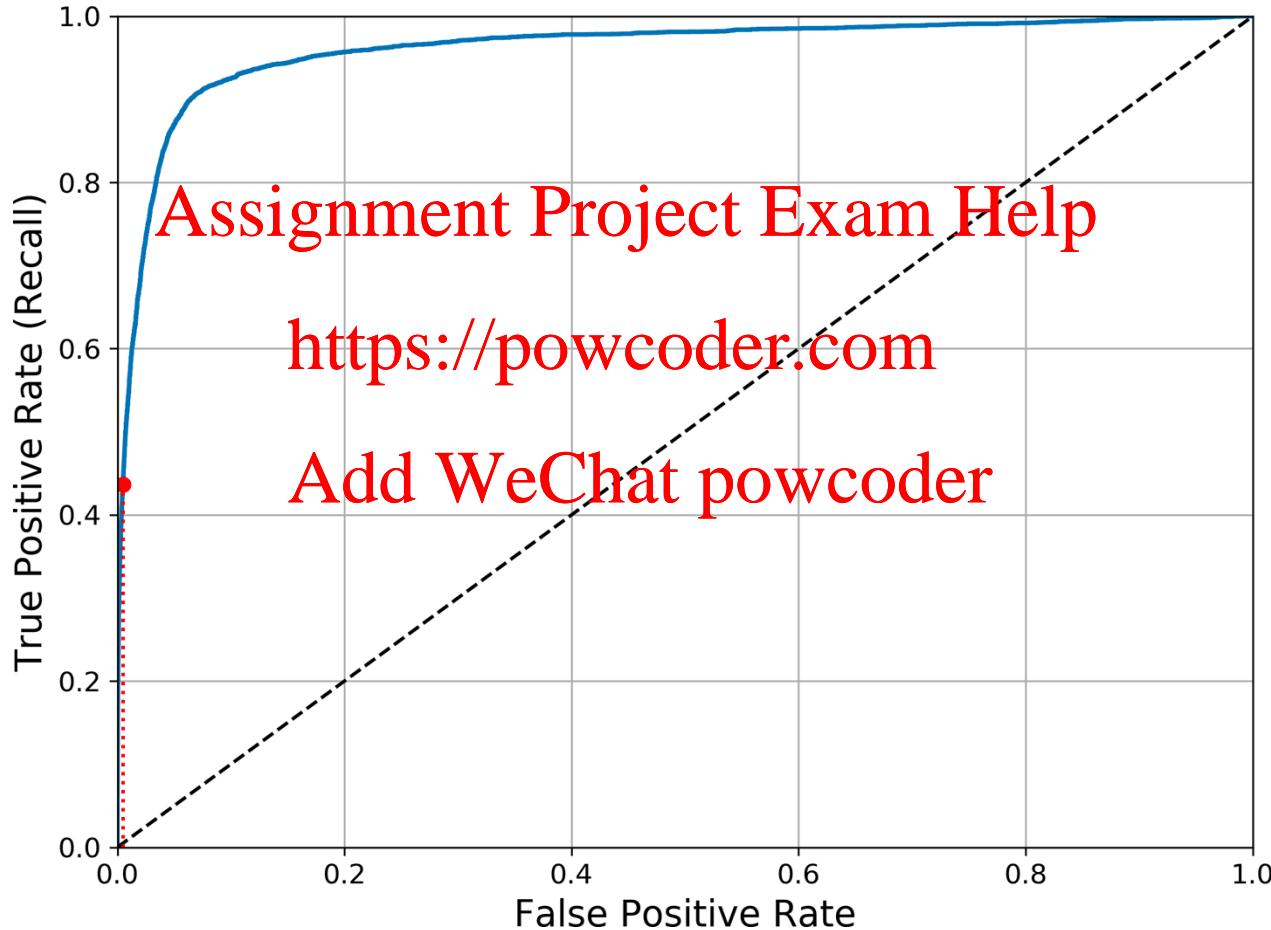
DECISION THRESHOLD



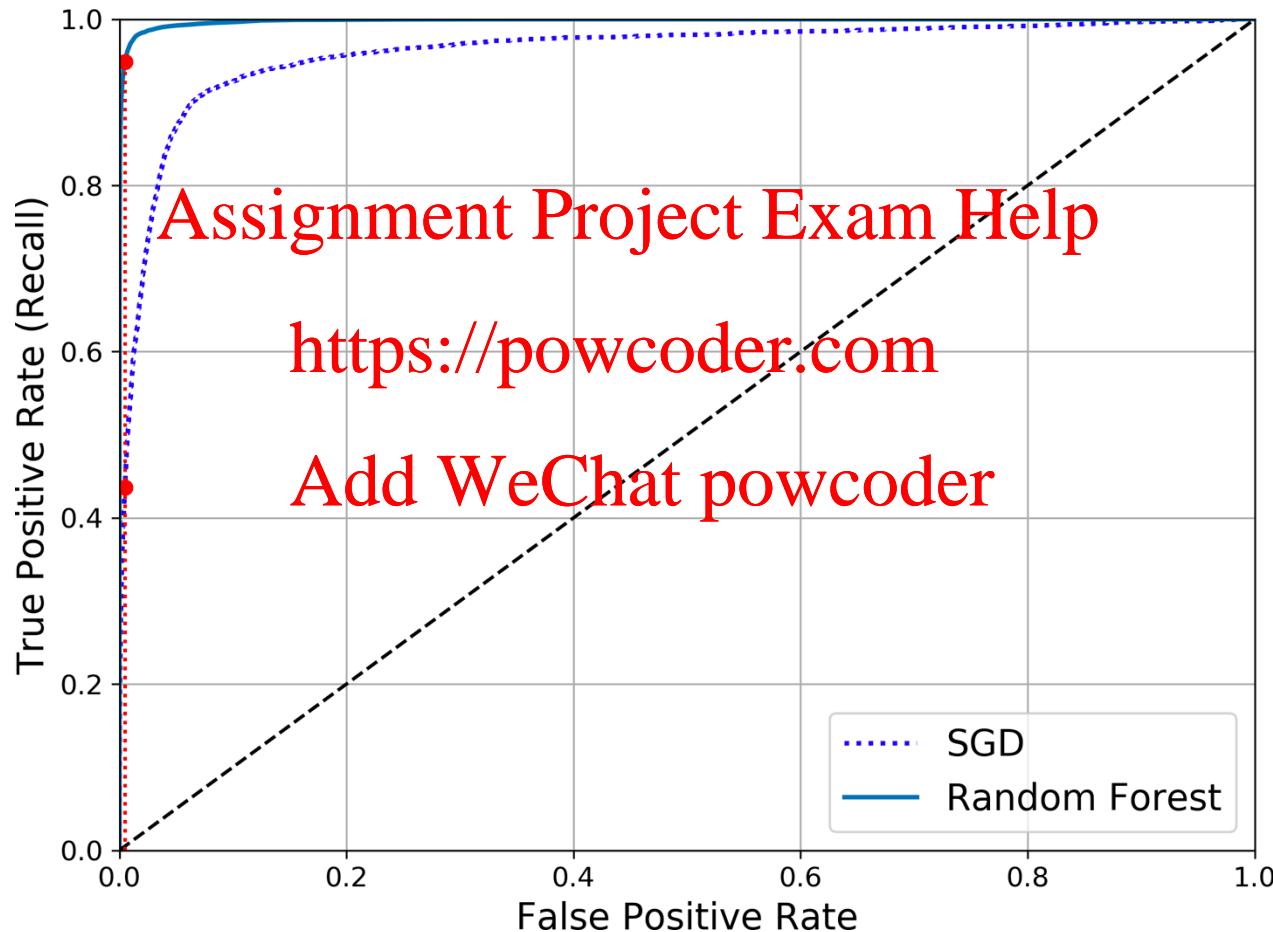
PR CURVE



ROC CURVE & AUC



AUC – MODEL SELECTION



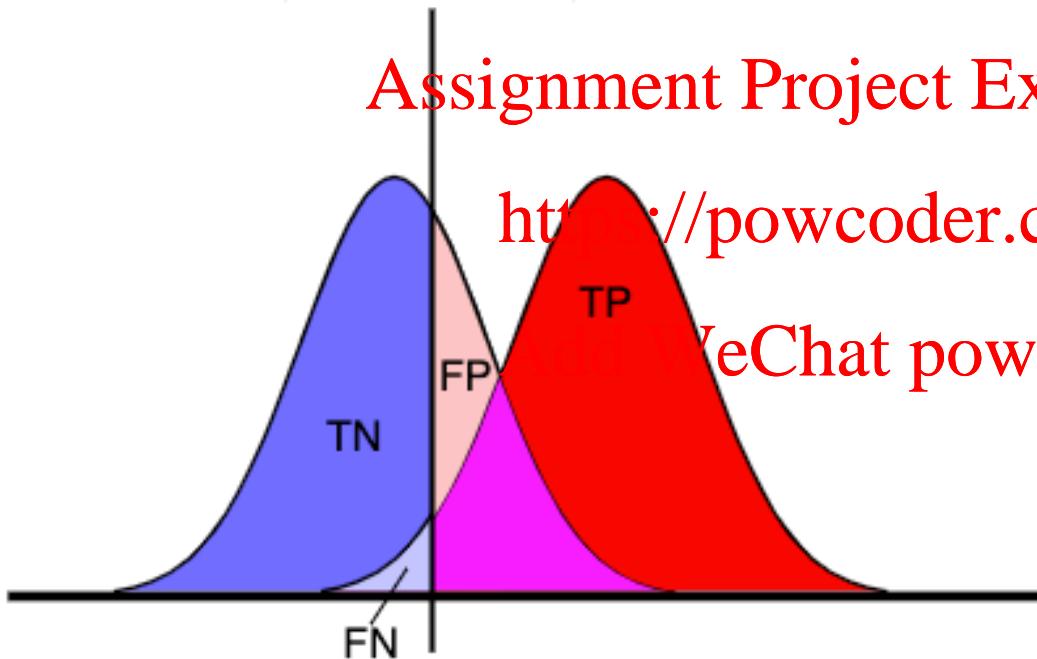
BINARY CLASSIFICATION

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TP	FP
FN	TN



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-
- ***one-versus-the-rest*** (OvR) strategy (also called one-versus-all)
 - ***one-versus-one*** (OvO) strategy

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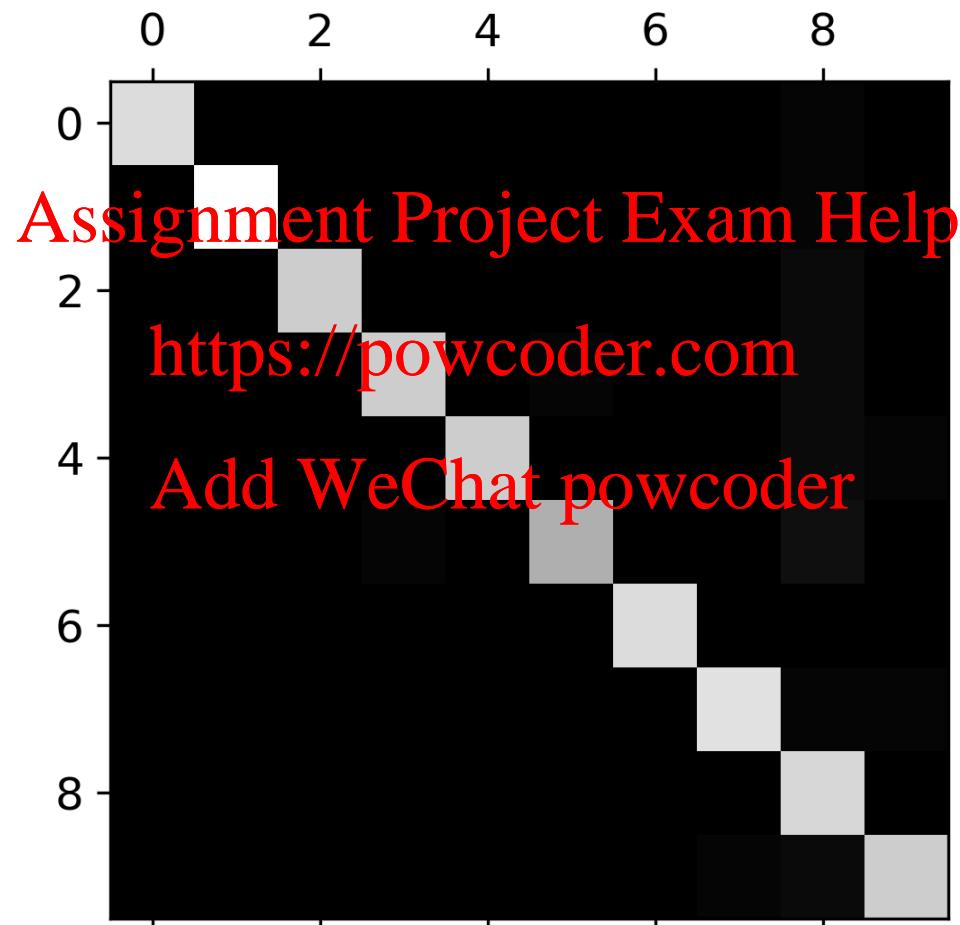
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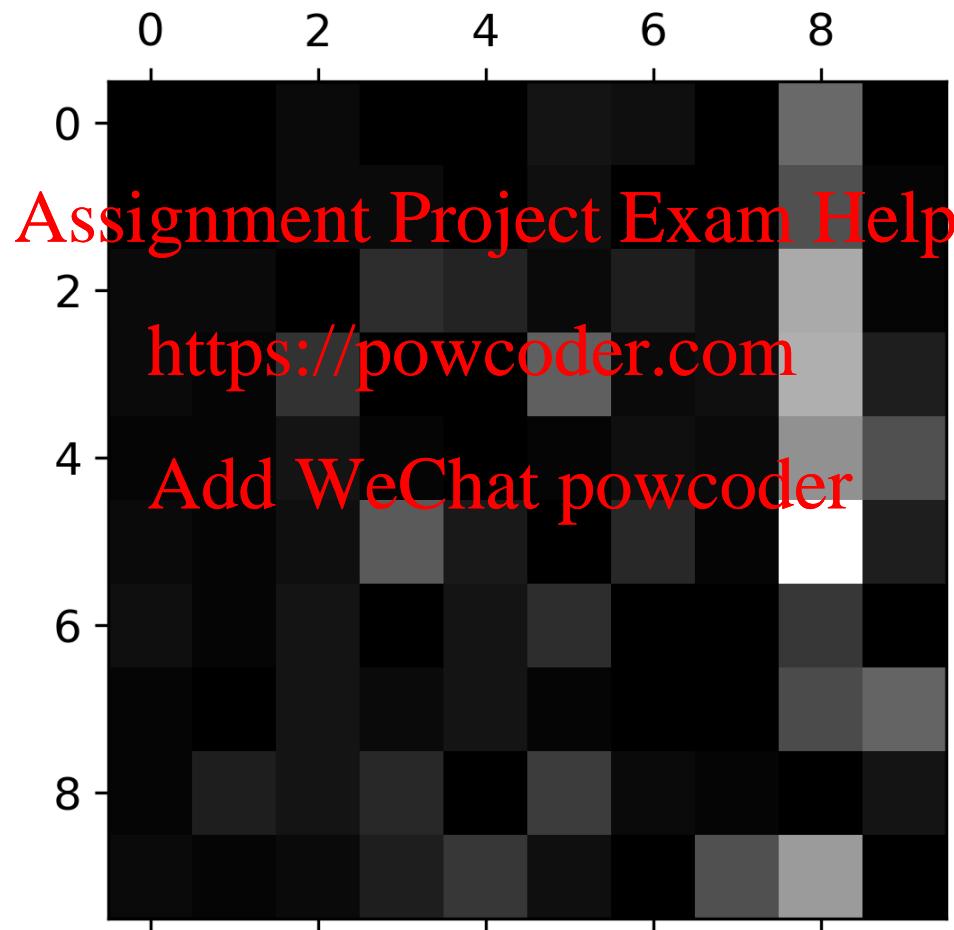
CONFUSION MATRIX

```
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       [28, 27, 5232, 100, 74, 27, 68, 37, 354, 11],  
       [23, 18, 115, 5254, 2, 209, 26, 38, 373, 73],  
       [11, 14, 45, 12, 5219, 11, 33, 26, 299, 172],  
       [26, 16, 30, 173, 54, 448, 16, 14, 482, 65],  
       [31, 17, 45, 2, 42, 98, 5556, 3, 123, 1],  
       [20, 10, 53, 27, 50, 13, 3, 5696, 173, 220],  
       [17, 64, 47, 91, 3, 125, 24, 11, 5421, 48],  
       [24, 18, 29, 67, 116, 39, 1, 174, 329, 5152]])
```

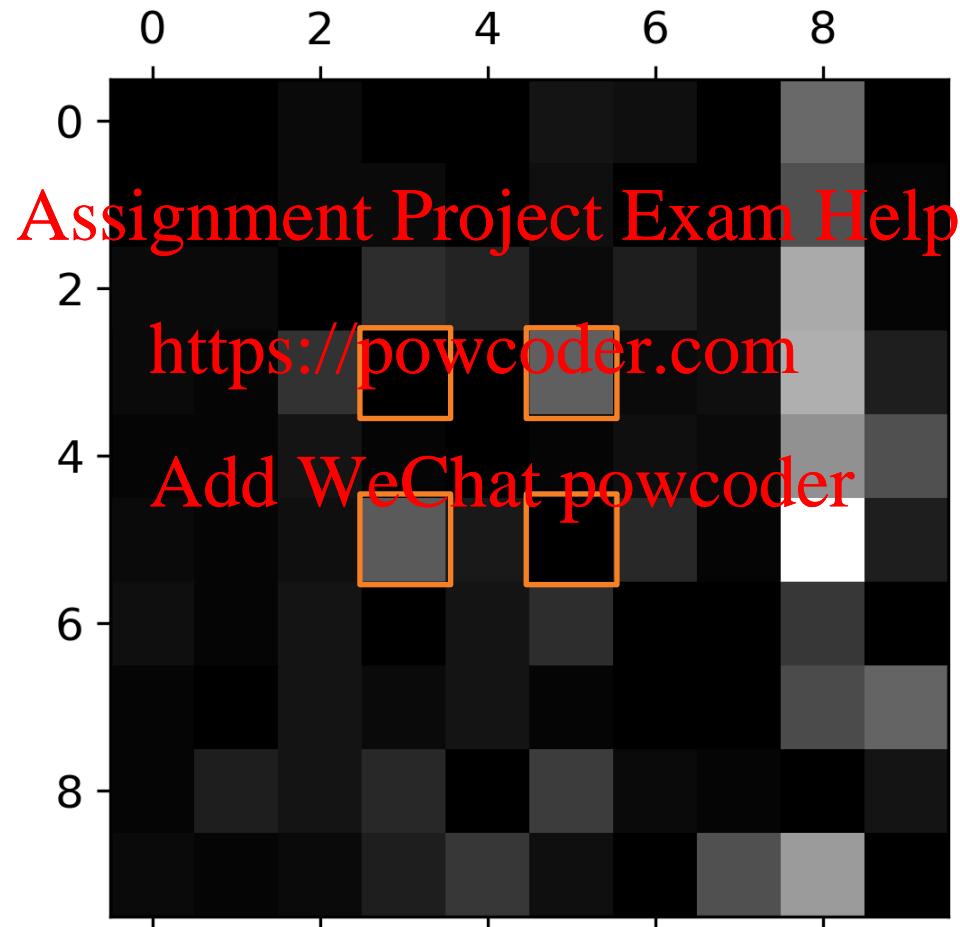
CONFUSION IMAGE



CONFUSION ERRORS



CONFUSION ERRORS



ANALYZING ERRORS

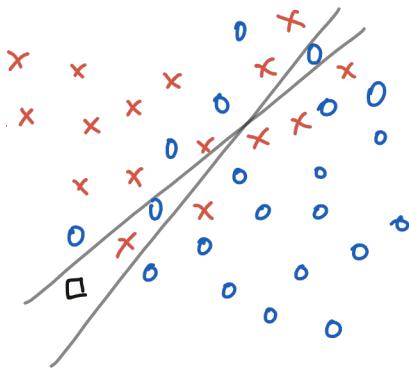
3 VS 5

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		Predicted									
		0	1	2	3	4	5	6	7	8	9
Actual	0	3	3	3	3	3	3	3	3	3	3
	1	3	3	3	3	3	3	3	3	3	3
2	3	3	3	3	3	3	3	3	3	3	3
3	5	5	5	5	5	5	5	5	5	5	5
4	5	5	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	5	5	5	5

TP FN
FP TN

FAILURE MODES – GENERALIZATION



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3 3 3 3 3 3 3 3 3

3 3 3 3 3 3 3 3 3

3 3 3 3 3 3 3 3 3

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5 5 5 5 5 5 5 5 5

5 5 5 5 5 5 5 5 5

5 5 5 5 5 5 5 5 5

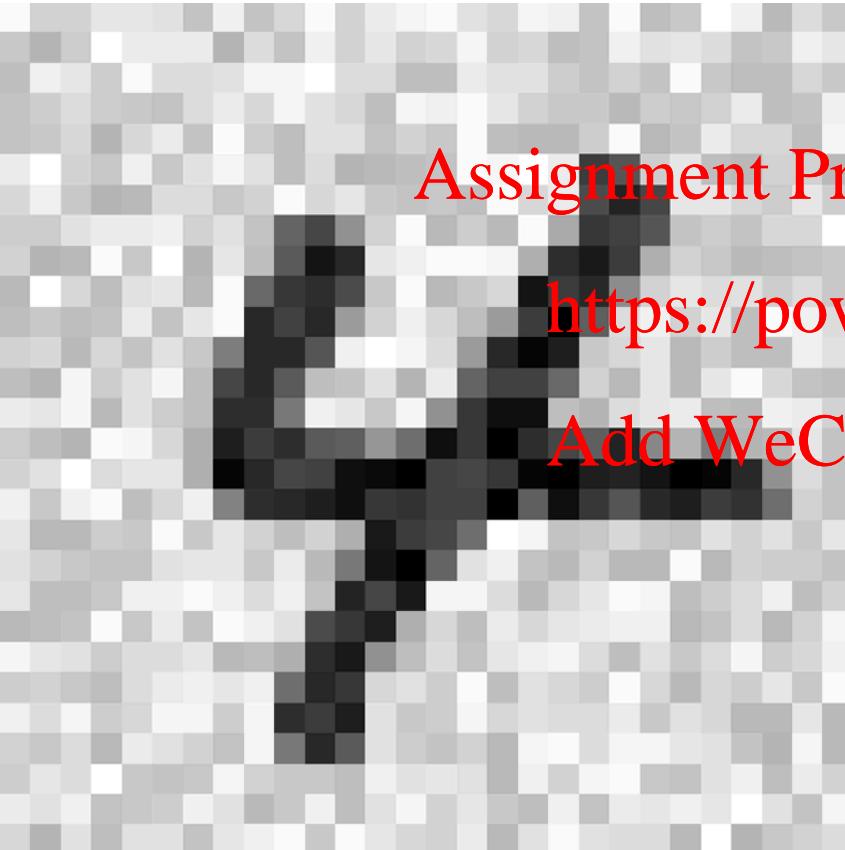
-
- Multilabel Classification

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- Multioutput Classification

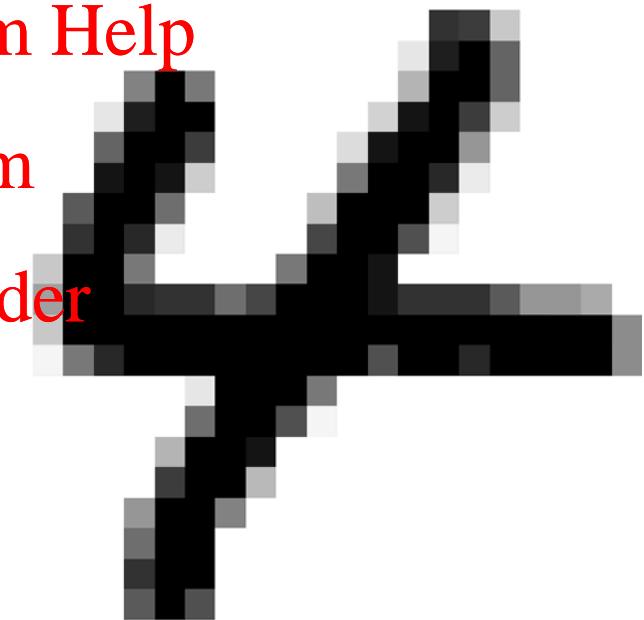
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-
- Select good metrics for classification tasks
 - How to pick the appropriate precision/recall trade-off
 - How to compare classifiers
 - Different classification systems for a variety of tasks

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- **What business problems can you think of that are classification tasks?**
 - **Can you think of some business problems that are multilable and multioutput?**
-

TEACHING TEAM



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