

# Machine Learning – I

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Google classroom code: jwpk5zn

Slides are prepared from several information sources on the web and books

# Algorithm Evaluation

Let us design a simple classification  
algorithm

# Purse vs Laptop Bag: Design a classifier



# Laptop bag vs. Purse: Design a classifier

- Features:
  - Width
  - Height
  - Width
- Classifier: threshold

# Evaluation Metrics

Let the problem statement be: classifying purse and bags.  
Purses are labeled as positive class and bags are labeled as negative class

		Predicted Class	
		Negative	Positive
Actual Class	Negative	A (true negative)	C (false positive)
	Positive	D (false negative)	B (true positive)

Term	Meaning	Example
True positive	Correct classification	Purse identified as purse
False positive	Incorrect classification	Bag identified as purse
True negative	Correct classification	Bag identified as bag
False negative	Incorrect classification	Purse identified as bag

# Evaluation Metrics

		Predicted Class	
		Negative	Positive
Actual Class	Negative	A (true negative)	C (false positive)
	Positive	D (false negative)	B (true positive)

Metric	Formula
Average classification accuracy	$[TN / (TN + FP) + TP / (TP + FN)]/2$
Type I error (false positive rate)	$FP / (TN + FP)$
Type II error (false negative rate)	$FN / (FN + TP)$
True positive rate	$TP / (TP + FN)$
True negative rate	$TN / (TN + FP)$

# Evaluation Metrics

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Type I error (false positive rate)	$FP / (TN + FP)$
Type II error (false negative rate)	$FN / (FN + TP)$
True positive rate	$TP / (TP + FN)$
True negative rate	$TN / (TN + FP)$

- Type I error or false positive rate: The chance of incorrectly classifying a (randomly selected) sample as positive
- Type II error or false negative rate: The chance of incorrectly classification a (randomly selected) sample as negative

# Evaluation Metrics

Metric	Formula
Average classification accuracy	$[TN / (TN + FP) + TP / (TP + FN)]/2$
Type I error (false positive rate)	$FP / (TN + FP)$
Type II error (false negative rate)	$FN / (FN + TP)$
True positive rate	$TP / (TP + FN)$
True negative rate	$TN / (TN + FP)$

- Type I error or false positive rate: The chance of incorrectly classifying a (randomly selected) sample as positive.
- Type II error or false negative rate: The chance of failing to correctly classify a (randomly selected) sample as negative.

Prevalent in  
computer vision and  
image processing  
related classification  
problems

# Evaluation Metrics

Metric	Formula
Precision	$TP / (TP + FP)$
Recall	$TP / (TP + FN)$

Precision: Fraction of retrieved instances that are relevant

Recall: Fraction of relevant instances that are retrieved

# Evaluation Metrics

Metric	Formula
Precision	$TP / (TP + FP)$
Recall	$TP / (TP + FN)$

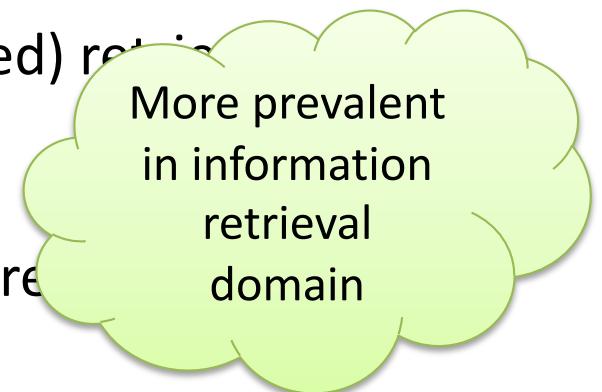
Precision: Probability that a (randomly selected) retrieved document is relevant

Recall: Probability that a (randomly selected) relevant document is retrieved in a search

# Evaluation Metrics

Metric	Formula
Precision	$TP / (TP + FP)$
Recall	$TP / (TP + FN)$

Precision: Probability that a (randomly selected) retrieved document is relevant



Recall: Probability that a (randomly selected) relevant document is retrieved in a search

# Evaluation Metrics

Metric	Formula
Sensitivity	$TP / (TP + FN)$
Specificity	$TN / (TN + FP)$
Predictive value for a positive result (PV+)	$TP / (TP + FP)$
Predictive value for a negative result (PV-)	$TN / (TN + FN)$

Sensitivity: Proportion of actual positives which are correctly identified

Specificity: Proportion of actual negatives which are correctly identified

# Evaluation Metrics

Metric	Formula
Sensitivity	$TP / (TP + FN)$
Specificity	$TN / (TN + FP)$
Predictive value for a positive result (PV+)	$TP / (TP + FP)$
Predictive value for a negative result (PV-)	$TN / (TN + FN)$

Sensitivity: The chance of correctly identifying positive samples. A sensitive test helps rule out disease (when the result is negative)

Specificity: The chance of correctly classifying negative samples. A very specific test rules in disease with a higher degree of confidence.



# Evaluation Metrics

Metric	Formula
Sensitivity	$TP / (TP + FN)$
Specificity	$TN / (TN + FP)$
Predictive value for a positive result (PV+)	$TP / (TP + FP)$
Predictive value for a negative result (PV-)	$TN / (TN + FN)$

Sensitivity: Proportion of actual positives which are correctly identified

Specificity: Proportion of actual negatives which are correctly identified

What does the sensitivity score of 1.0 mean?

What does the specificity score of 1.0 mean?

# F1 Score

- The F1 score is the harmonic mean of precision and recall:

$$F_1 = \frac{2}{\frac{1}{precision} + \frac{1}{recall}}$$

- Unlike regular mean, harmonic mean gives more weight to low values.
- Therefore, the classifier's F1 score is only high if both recall and precision are high.

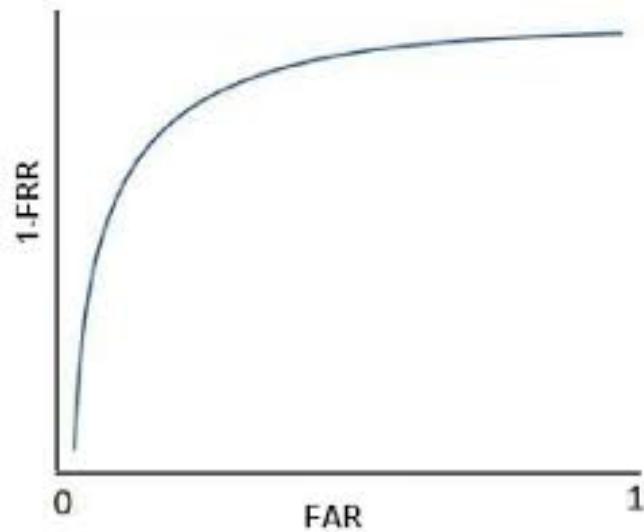
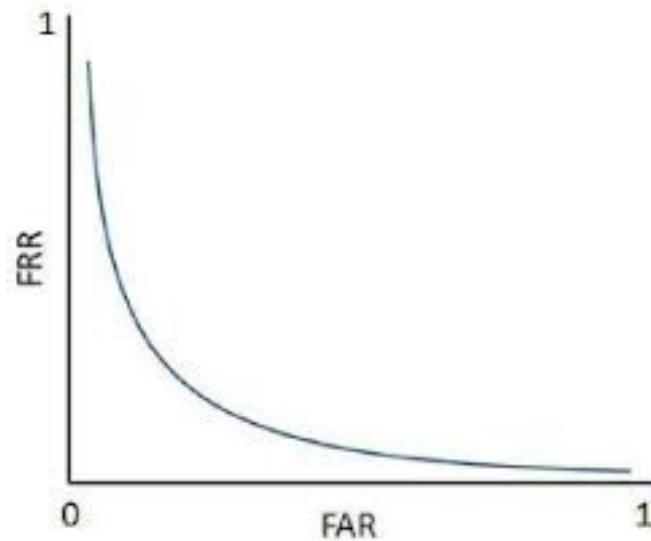
# Performance Evaluation

- Classification is of two types:
  - Authentication / verification (1:1 Matching)
    - Is she Richa?
    - Is this an image of a helicopter?
  - Identification (1:n matching)
    - Who's photo is this?
    - This image belongs to which class?

# Performance Evaluation

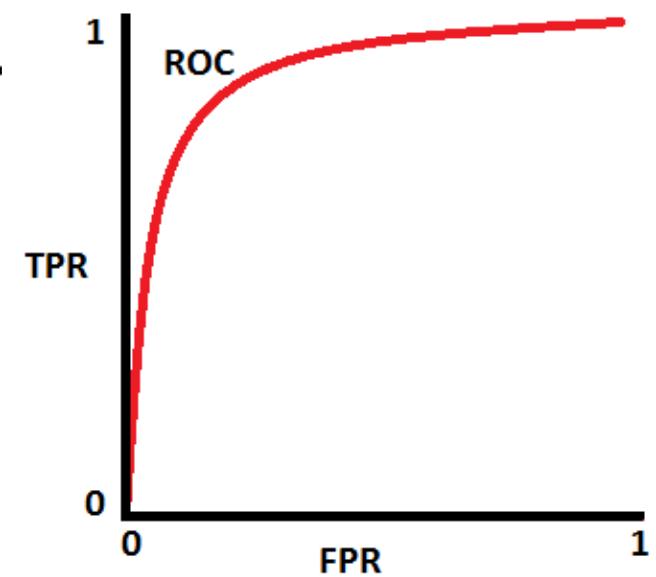
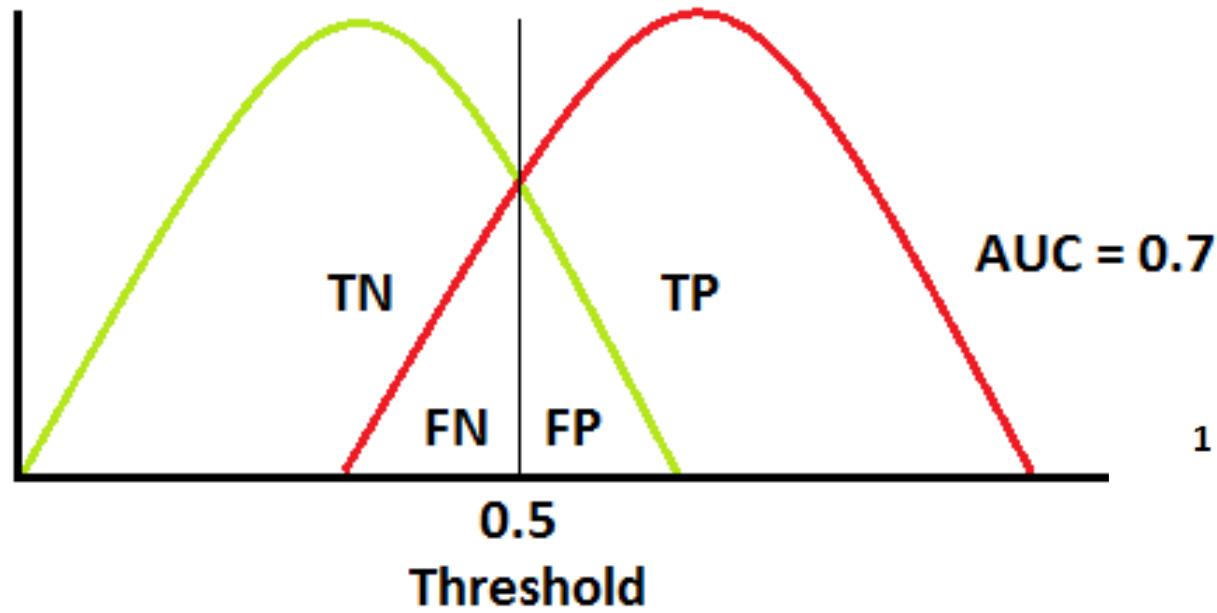
- Receiver operating characteristics (ROC) curve
  - For authentication/verification
  - False positive rate vs true positive rate
- Detection error-tradeoff (DET) curve
  - False positive rate vs false negative rate
- Cumulative match curve (CMC)
  - Rank vs identification accuracy

# ROC Curve



# Laptop bag vs. Purse: Design a classifier

- Features:
  - Width
  - Height
  - Weight
- Classifier: threshold



# CMC



Kitten A



Kitten B



Kitten C

And four test queries:



1



2



3



4

Query	Top result	Result 2	Result 3
1	A	B	C
2	B	C	A
3	A	B	C
4	C	B	A

What are the rank accuracies?

# Recap: CMC



Kitten A



Kitten B



Kitten C

And four test queries:



1



2



3



4

Query	Top result	Result 2	Result 3
1	A	B	C
2	B	C	A
3	A	B	C
4	C	B	A

What are the rank accuracies?

*Rank 1: 1/4 predicted correctly: 25%*

*Rank 2: 3/4 : 75%*

*Rank 3: 4/4 : 100%*

# CMC Curve

