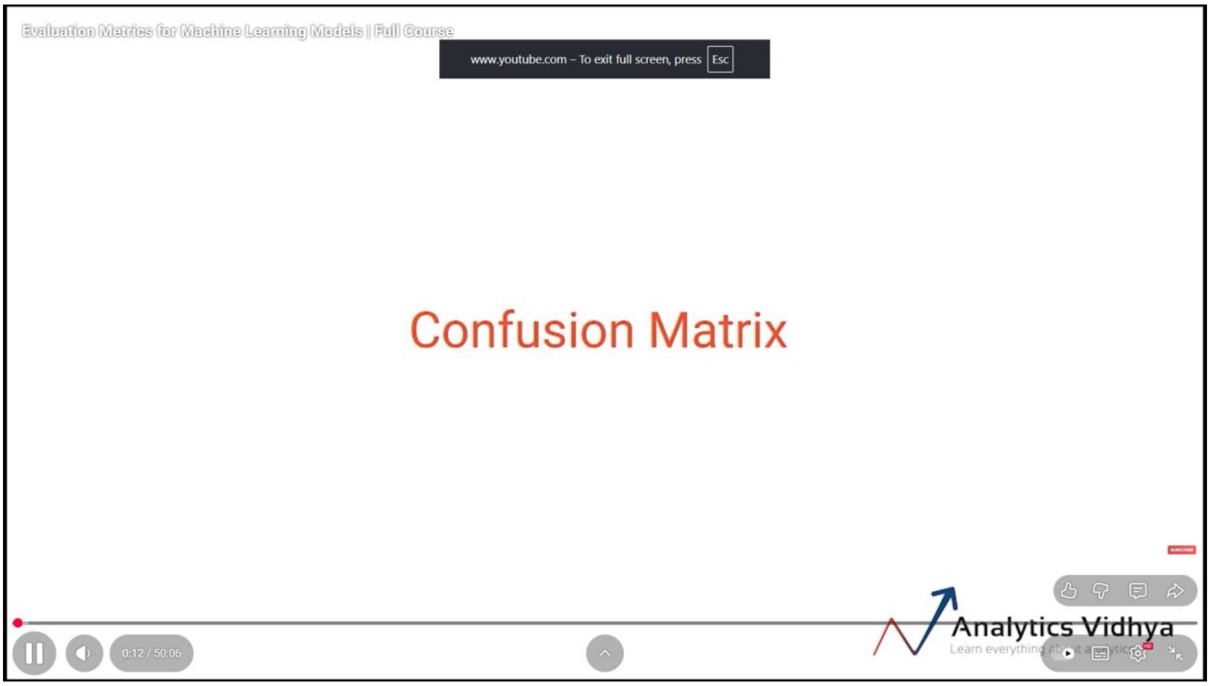
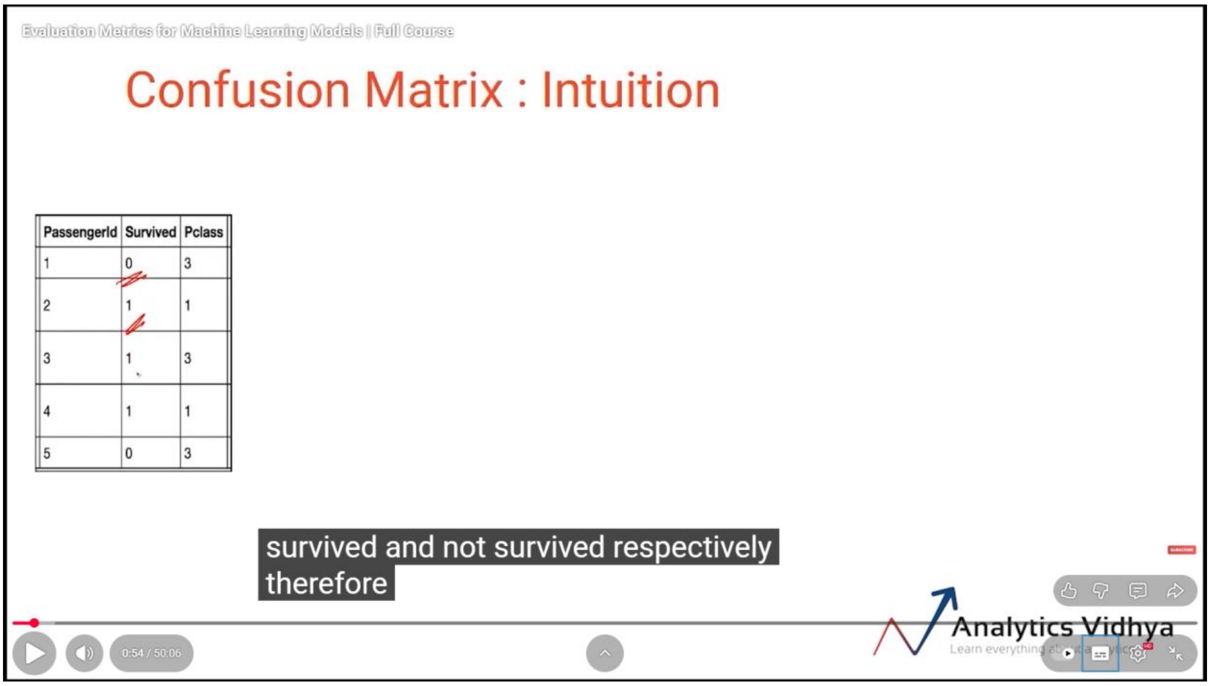
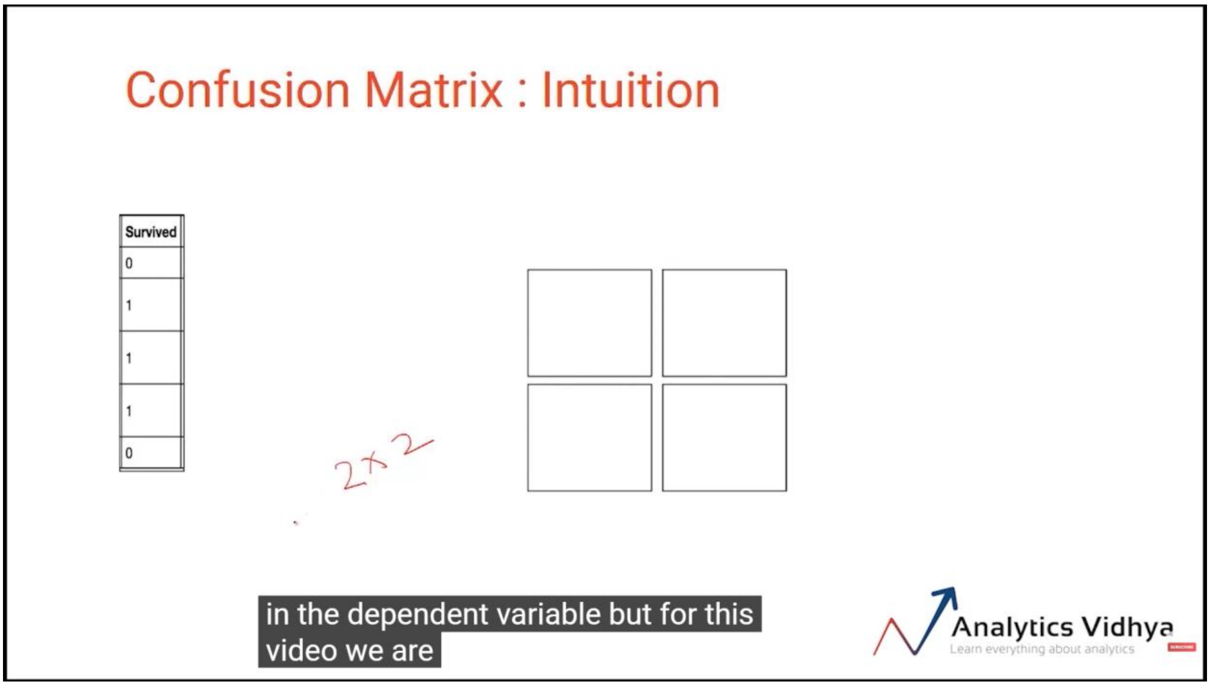
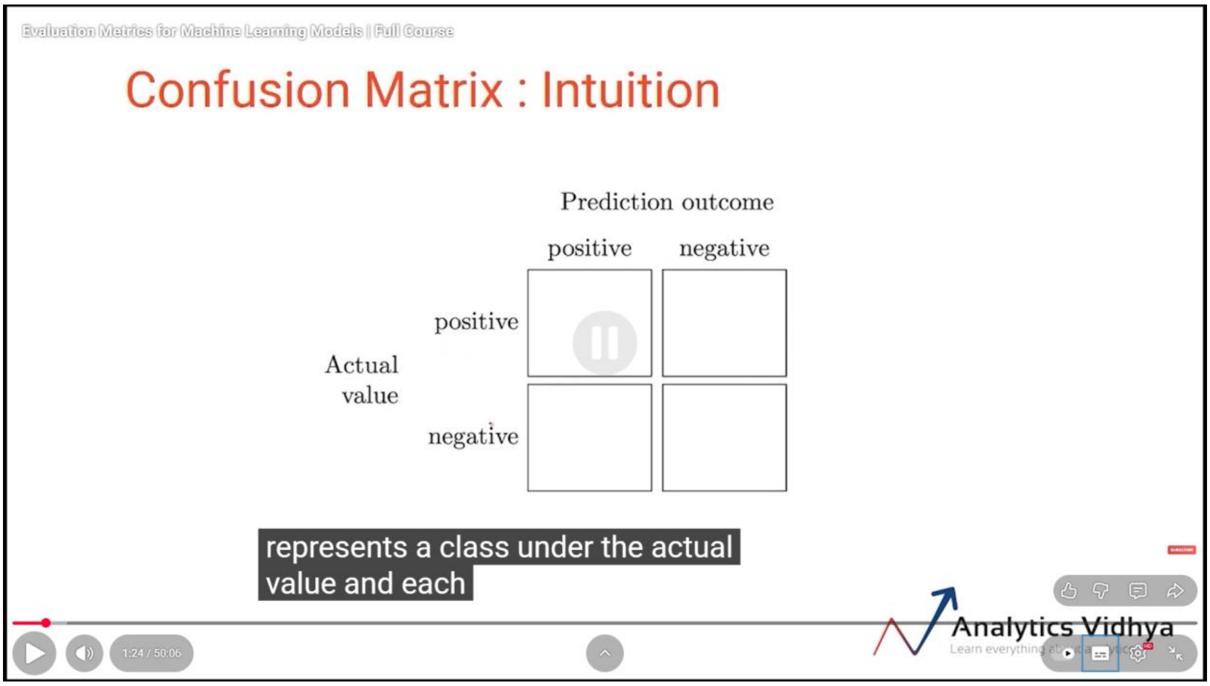




PassengerId	Survived	Pclass
1	0	3
2	1	1
3	1	3
4	1	1
5	0	3

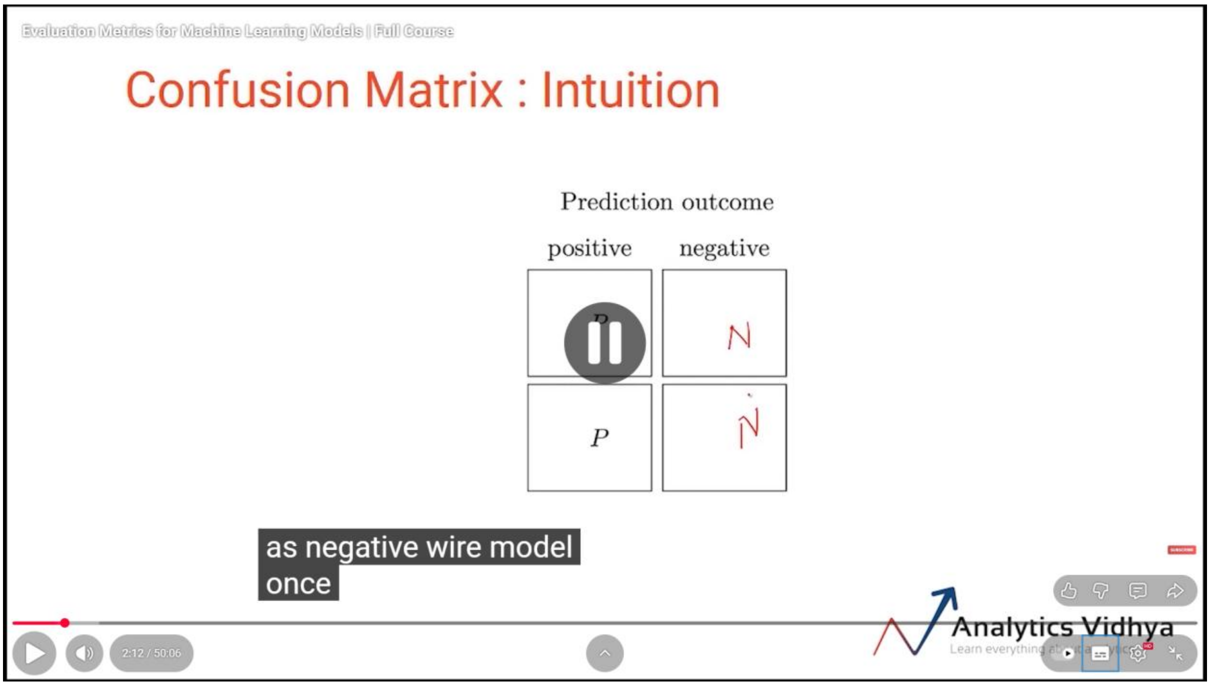
Survived only 2 classes yes or no so 2*2 matrix



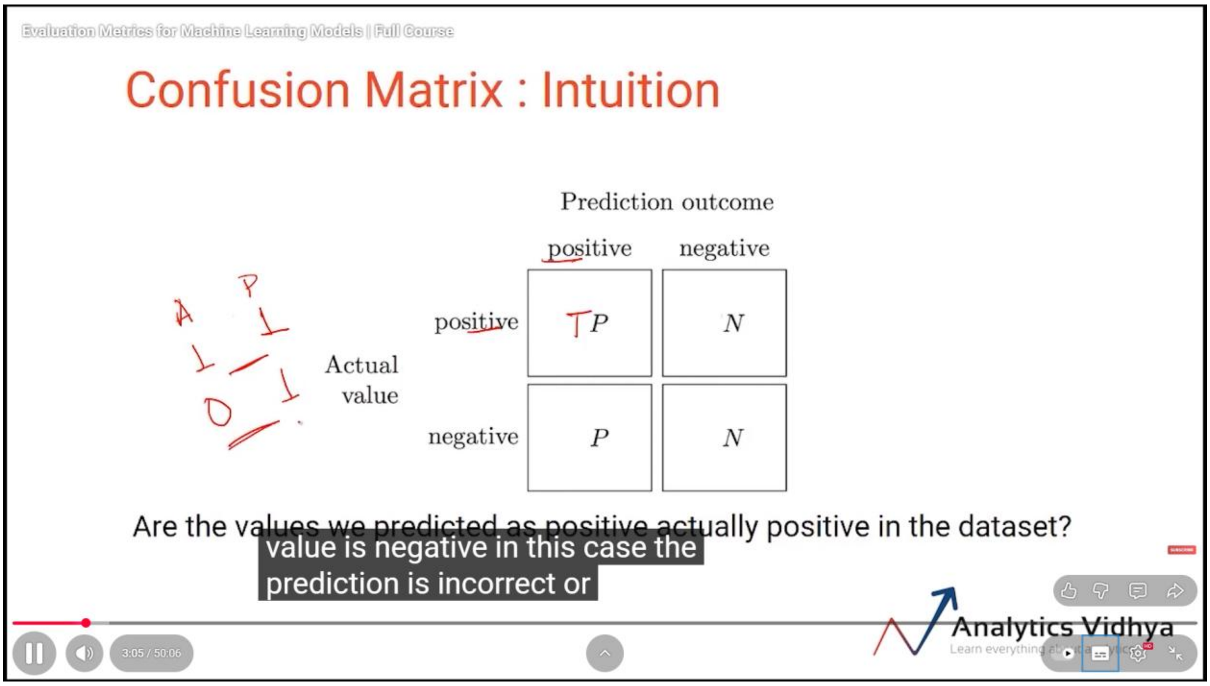


Rows-> actual value

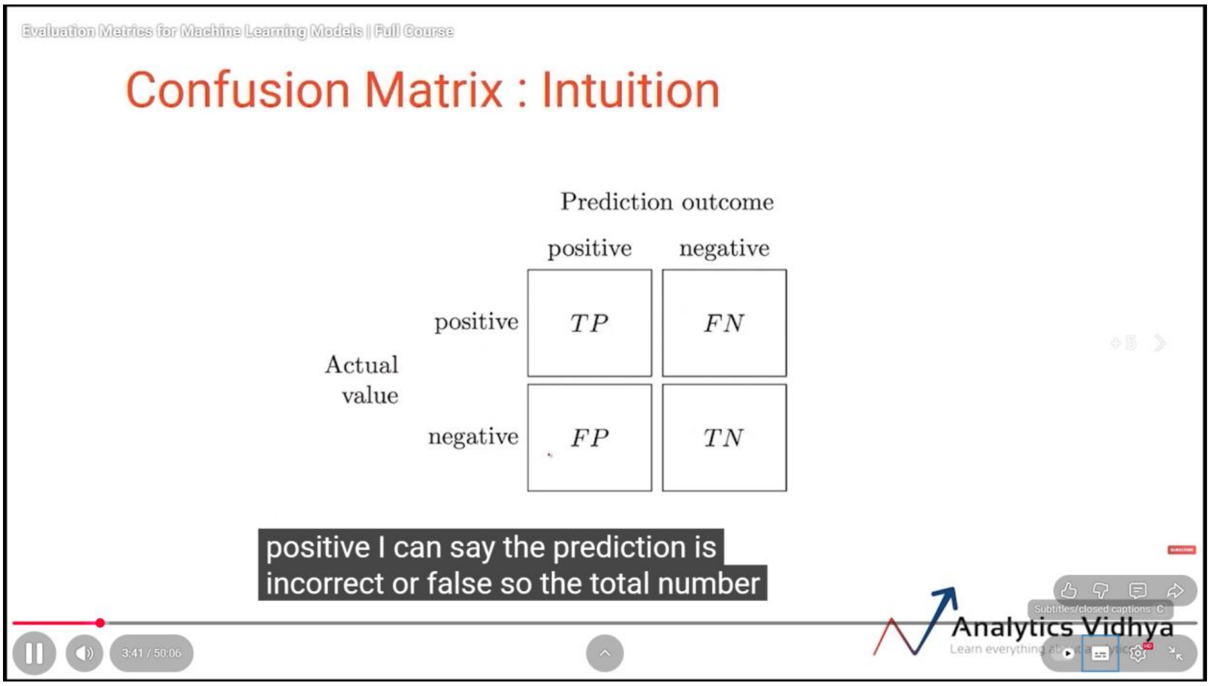
Col→ predicted values



Evaluation Metrics for Machine Learning Models | Full Course
Confusion Matrix : Intuition
Prediction outcome
positive
negative
N
P
N
as negative wire model
once
Analytics Vidhya
2:12 / 50:06



Evaluation Metrics for Machine Learning Models | Full Course
Confusion Matrix : Intuition
Prediction outcome
positive
negative
A
P
1
1
0
1
Actual
value
positive
TP
N
negative
P
N
Are the values we predicted as positive actually positive in the dataset?
value is negative in this case the
prediction is incorrect or
Analytics Vidhya
3:05 / 50:06


Evaluation Metrics for Machine Learning Models | Full Course
Confusion Matrix : Intuition
Prediction outcome
positive
negative
Actual value
positive
negative
TP
FN
FP
TN
positive I can say the prediction is
incorrect or false so the total number
3:41 / 50:06
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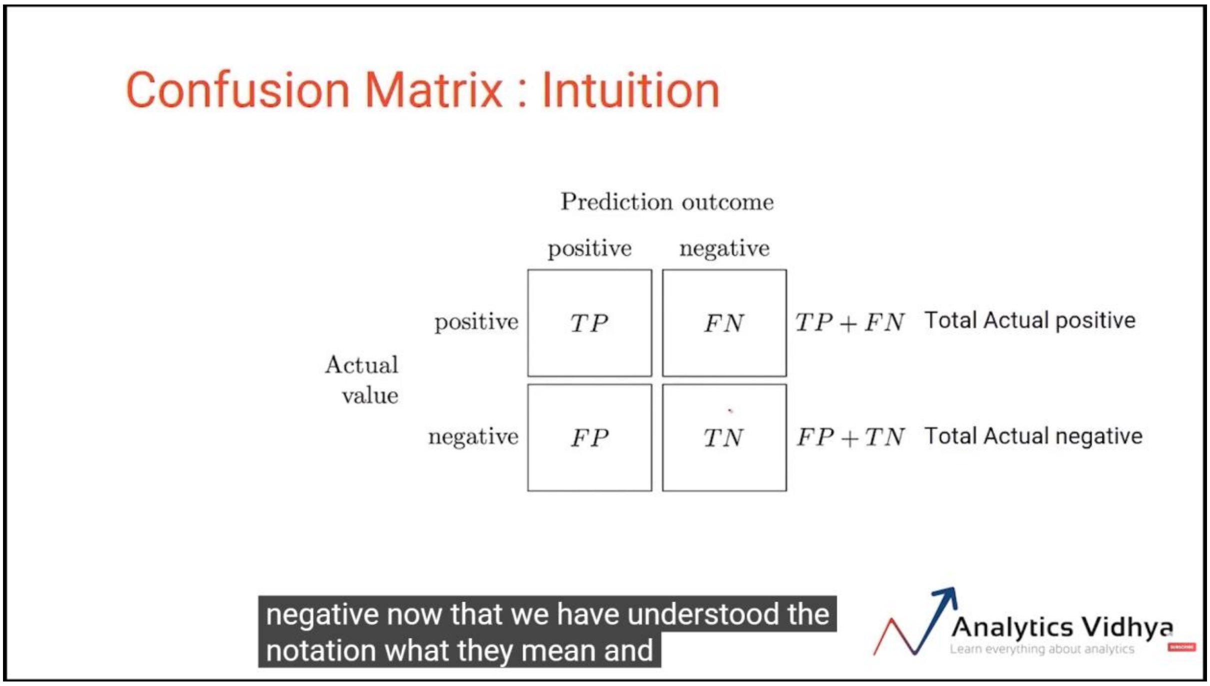
Confusion Matrix : Intuition
Prediction outcome
positive
negative
Actual value
positive
negative
TP
FN
FP
TN
$TP + FN$ Total Actual positive
$FP + TN$ Total Actual negative
negative now that we have understood the
notation what they mean and
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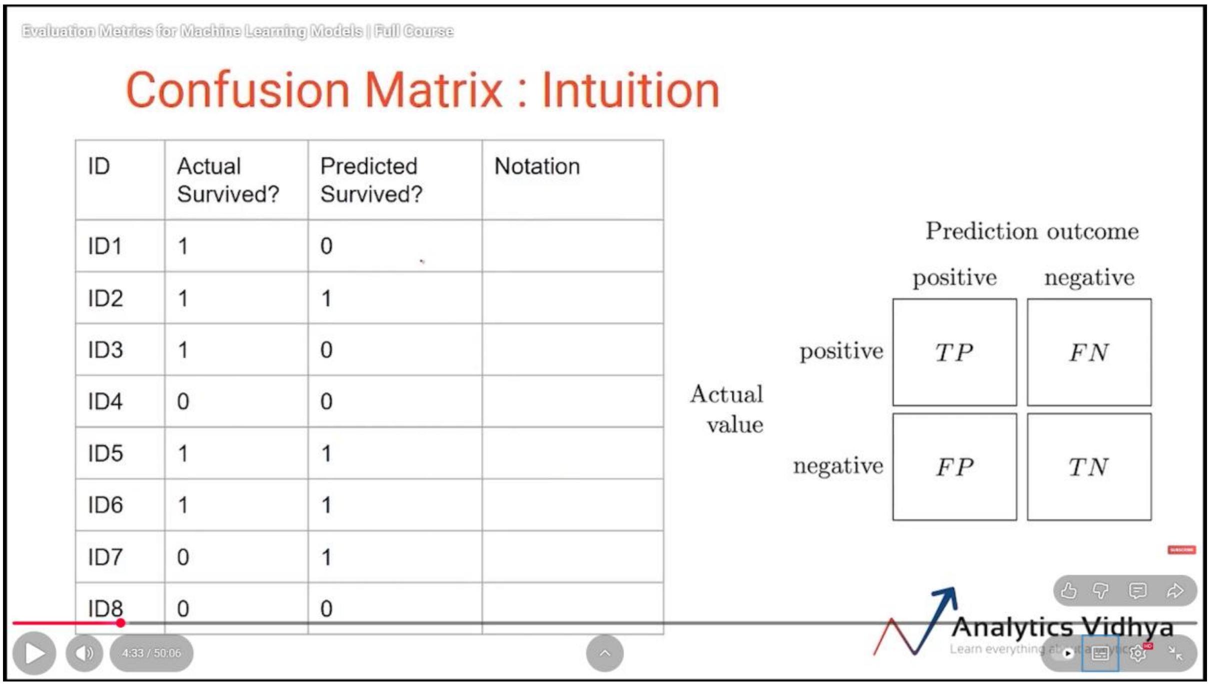

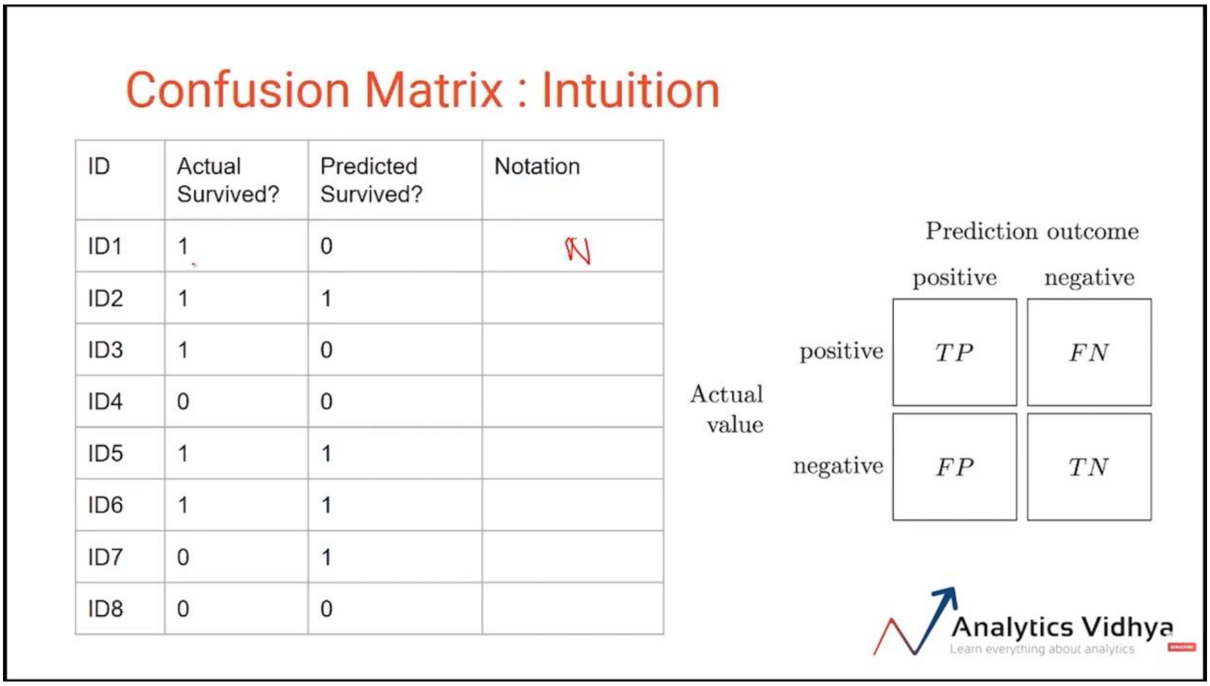

from predicted survived N

Confusion Matrix : Intuition

ID	Actual Survived?	Predicted Survived?	Notation
ID1	1	0	F N
ID2	1	1	
ID3	1	0	
ID4	0	0	
ID5	1	1	
ID6	1	1	
ID7	0	1	
ID8	0	0	

		Prediction outcome	
		positive	negative
Actual value	positive	TP	FN
	negative	FP	TN

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4:46 / 50:06

Confusion Matrix : Intuition

ID	Actual Survived?	Predicted Survived?	Notation
ID1	1	0	FN
ID2	1	1	TP
ID3	1	0	FN
ID4	0	0	TN
ID5	1	1	TP
ID6	1	1	TP
ID7	0	1	FP
ID8	0	0	TN

		Prediction outcome	
		positive	negative
Actual value	positive	TP	FN
	negative	FP	TN

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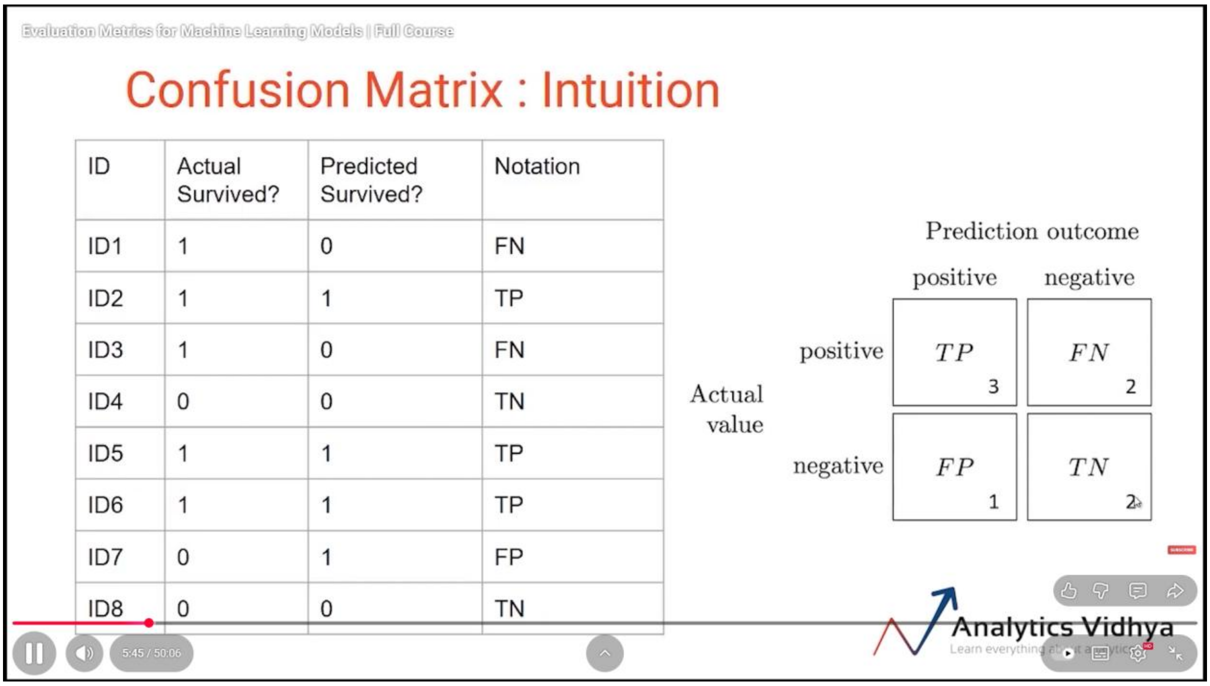
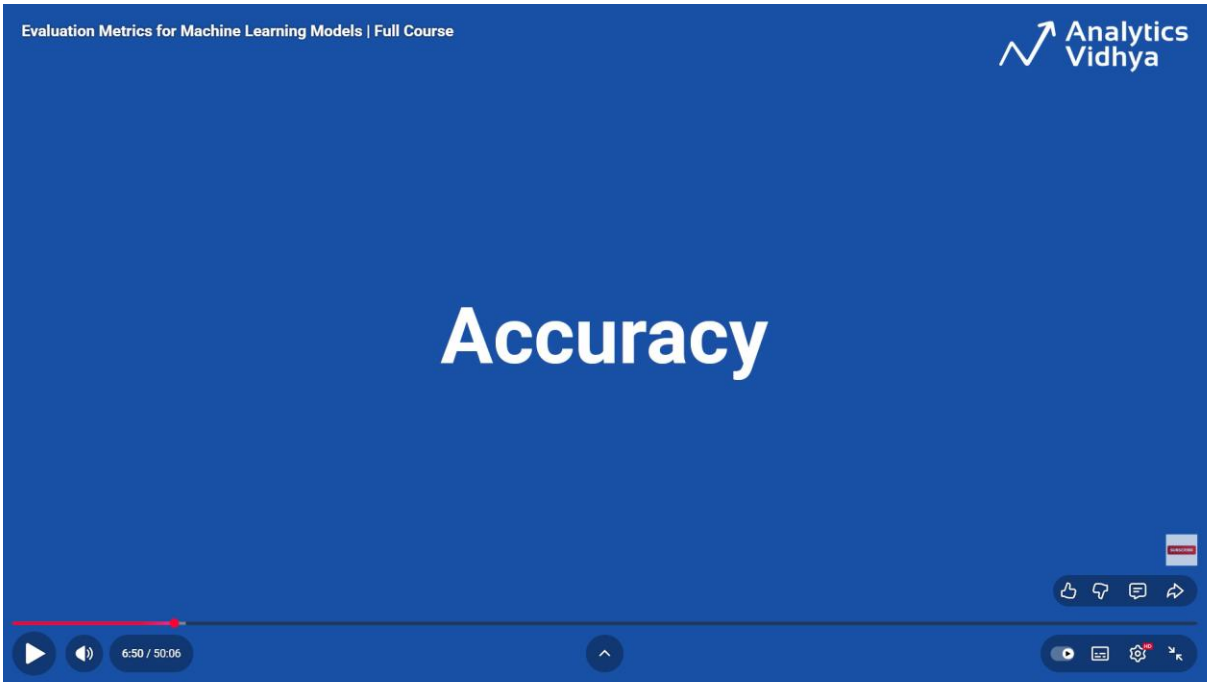


ID	Actual Survived?	Predicted Survived?	Notation
ID1	1	0	FN
ID2	1	1	TP
ID3	1	0	FN
ID4	0	0	TN
ID5	1	1	TP
ID6	1	1	TP
ID7	0	1	FP
ID8	0	0	TN



Accuracy

It is the ratio of correct predicted values over the total predicted values.

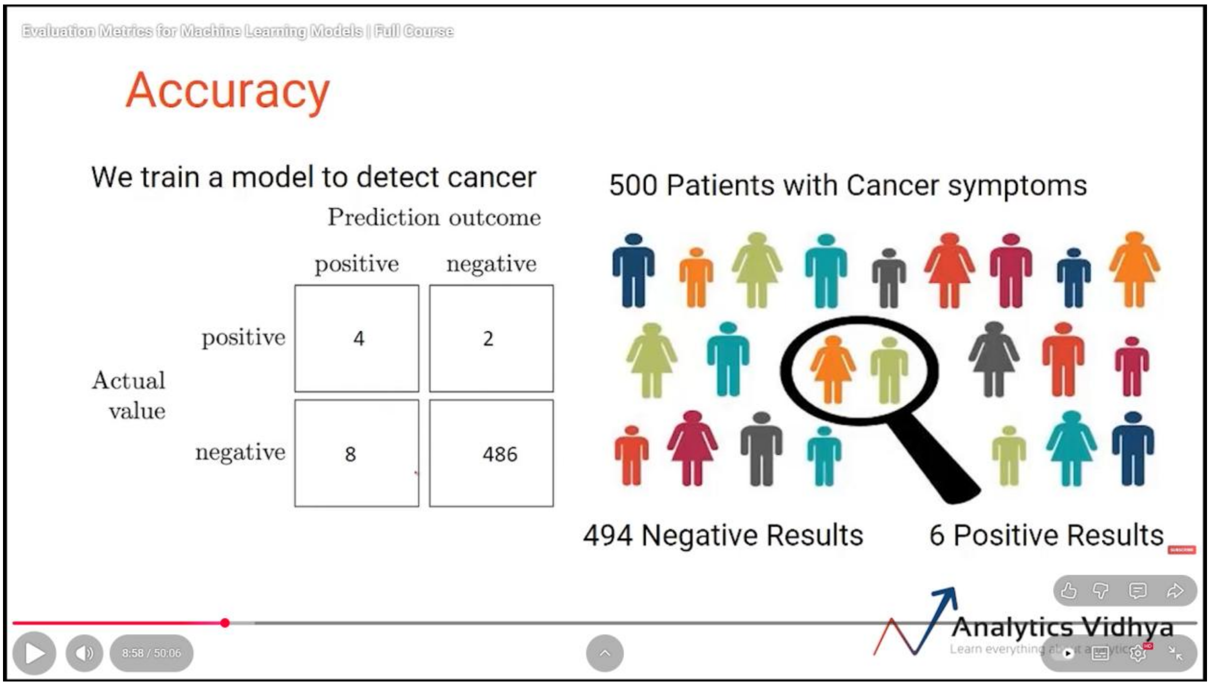
Accuracy

Accuracy: It is the ratio of correct predicted values over the total predicted values.

$$\text{Accuracy} = \frac{\text{Correct Predictions}}{\text{Total Predictions}}$$

$$\text{Accuracy} = \frac{TP + TN}{TP + FN + FP + TN}$$

		Prediction outcome	
		positive	negative
Actual value	positive	TP	FN
	negative	FP	TN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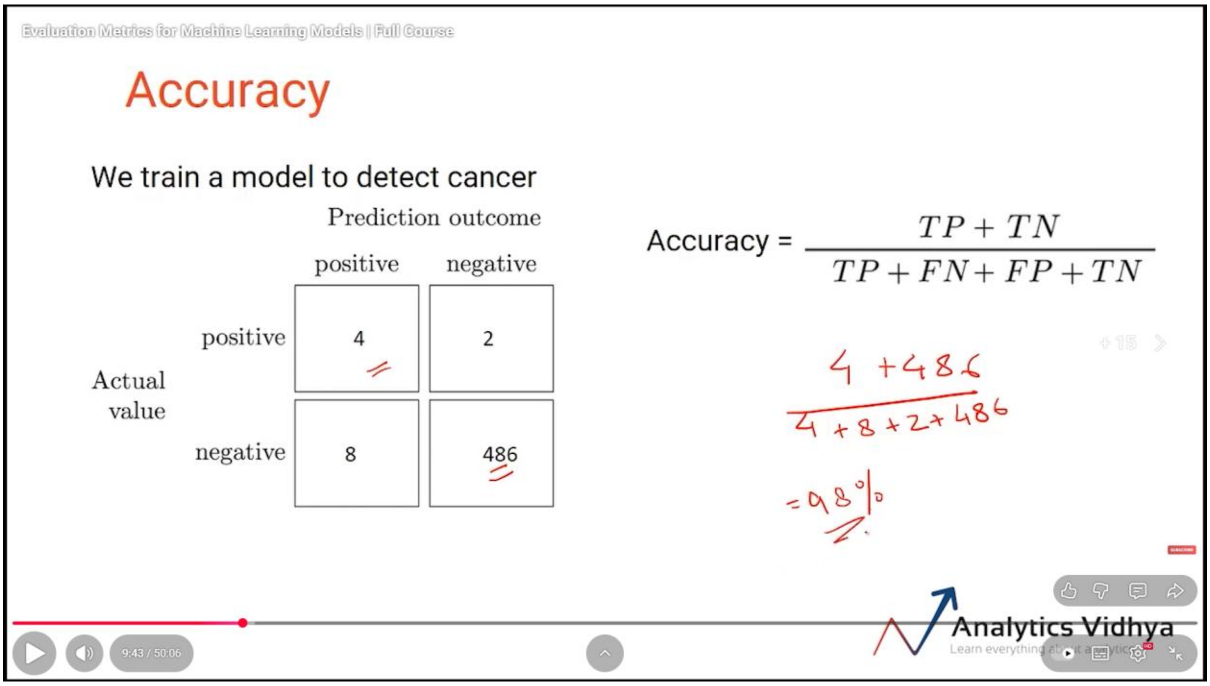
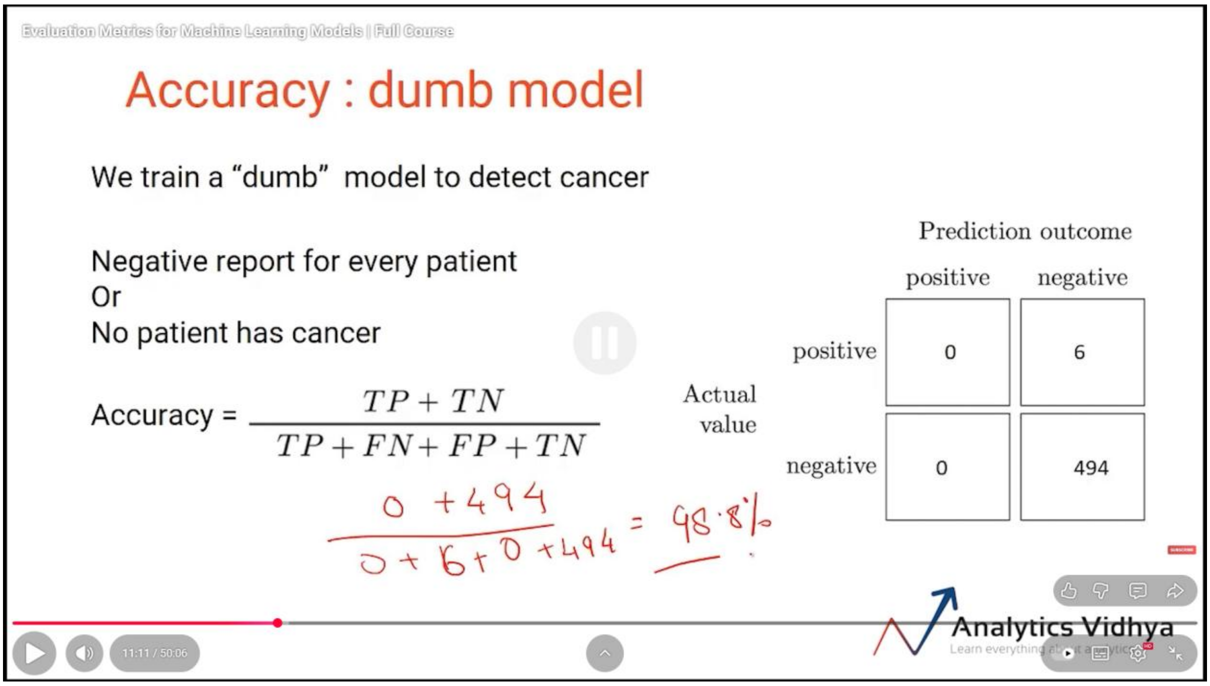
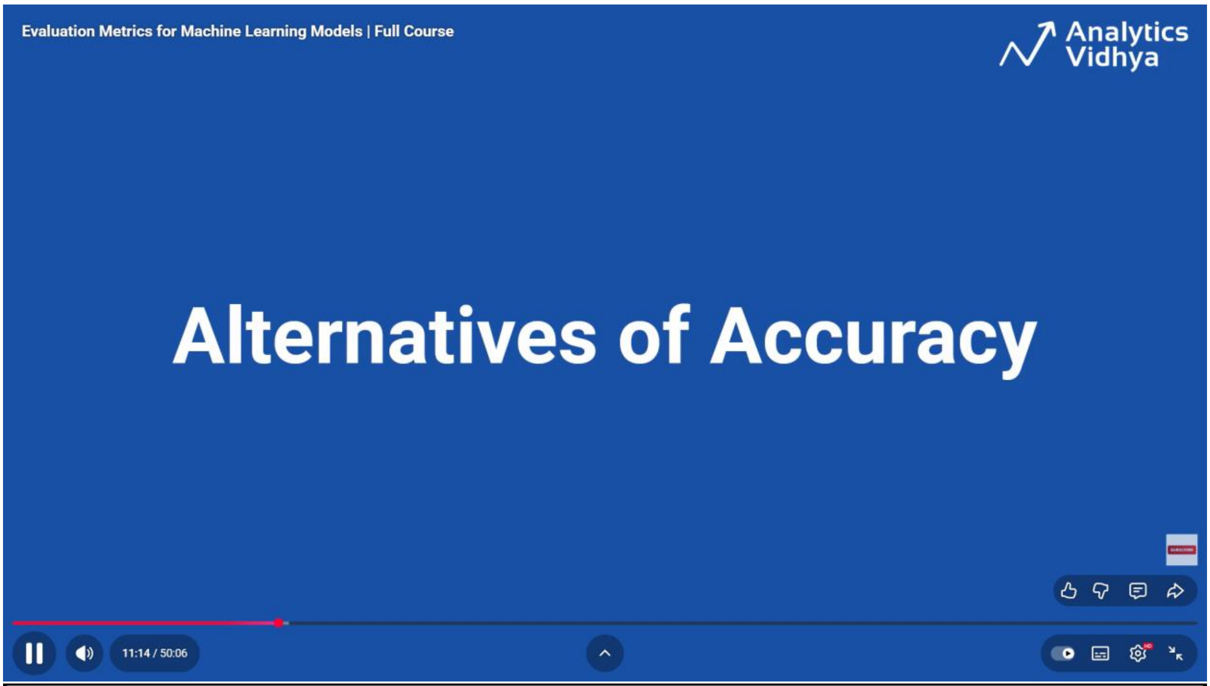
Accuracy
We train a model to detect cancer
Prediction outcome
positive
negative
Actual value
positive
negative
4
2
8
486
500 Patients with Cancer symptoms
494 Negative Results
6 Positive Results
Analytics Vidhya
8:58 / 50:06


Evaluation Metrics for Machine Learning Models | Full Course
Accuracy
We train a model to detect cancer
Prediction outcome
positive
negative
Actual value
positive
negative
4
2
8
486
Accuracy = $\frac{TP + TN}{TP + FN + FP + TN}$
$\frac{4 + 486}{4 + 8 + 2 + 486}$
= 98%
Analytics Vidhya
9:43 / 50:06



Accuracy not great on unbalanced data..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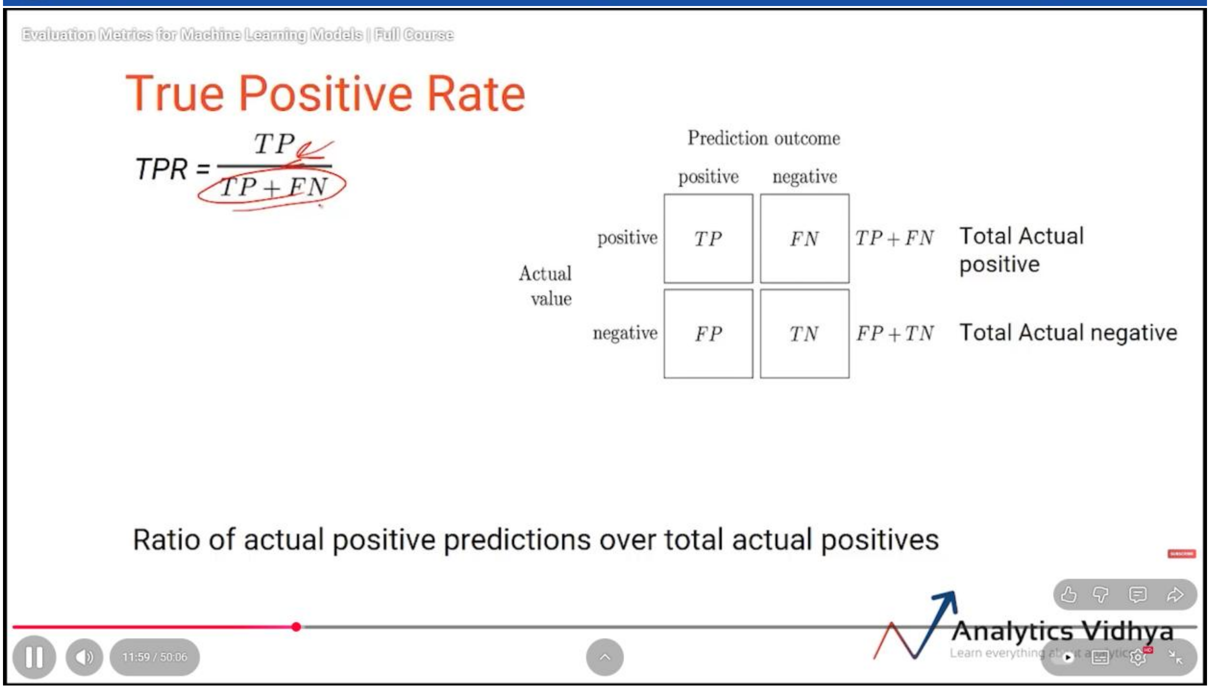
Alternatives of Accuracy
11:14 / 50:06


Evaluation Metrics for Machine Learning Models | Full Course
True Positive Rate
$TPR = \frac{TP}{TP+FN}$
Prediction outcome
positive
negative
Actual value
positive
TP
FN
$TP+FN$
Total Actual positive
negative
FP
TN
$FP+TN$
Total Actual negative
Ratio of actual positive predictions over total actual positives
Analytics Vidhya
11:59 / 50:06

False Negative Rate

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

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

Prediction outcome

		positive	negative		
Actual value	positive	TP	FN	$TP+FN$	Total Actual positive
	negative	FP	TN	$FP+TN$	Total Actual negative

Ratio of actual positive, predicted as negative; over total actual positive

12:48 / 50:06

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False Positive Rate

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

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

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

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

Prediction outcome

		positive	negative		
Actual value	positive	TP	FN	$TP+FN$	Total Actual positive
	negative	FP	TN	$FP+TN$	Total Actual negative

Ratio of actual negative, predicted as positive; over total actual negative

14:21 / 50:06

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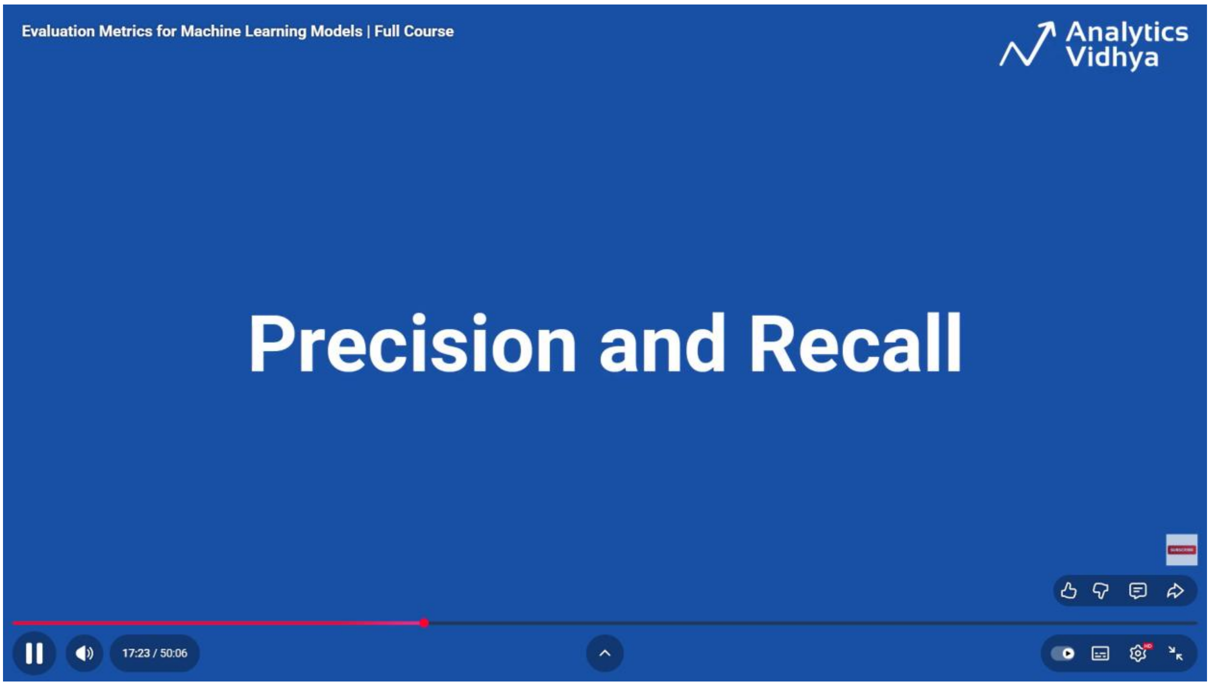
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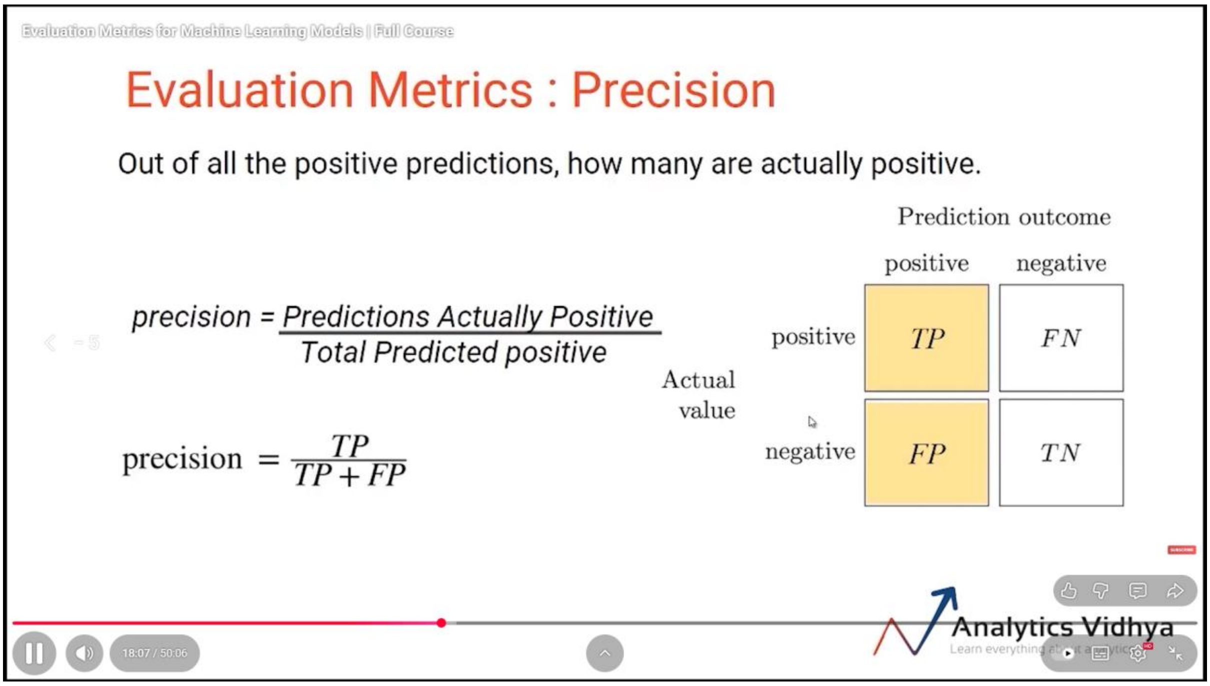
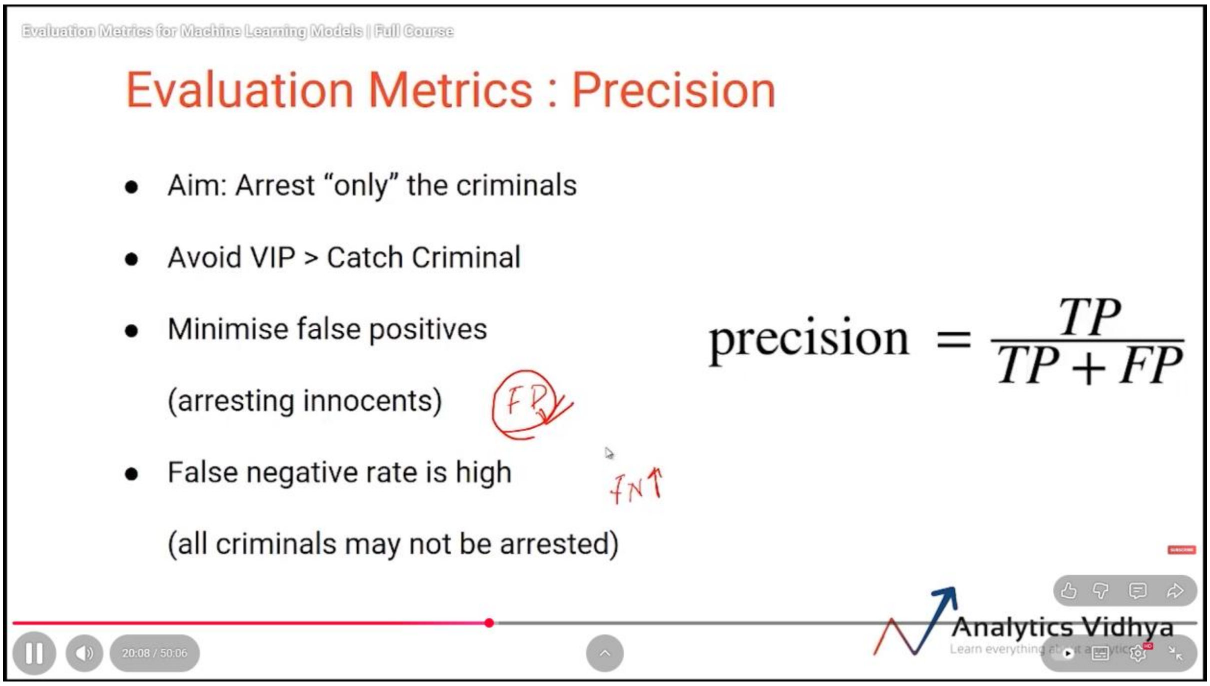
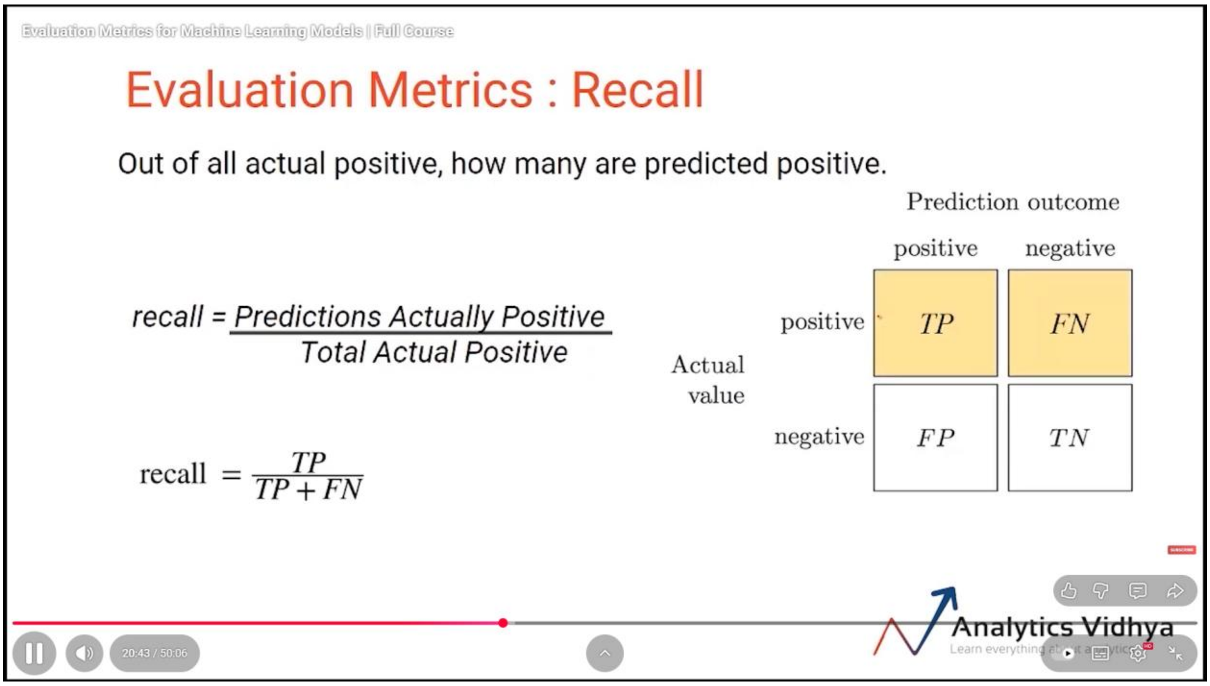
Precision and Recall
17:23 / 50:06


Evaluation Metrics for Machine Learning Models | Full Course
Evaluation Metrics : Precision
Out of all the positive predictions, how many are actually positive.
precision = Predictions Actually Positive / Total Predicted positive
$\text{precision} = \frac{TP}{TP + FP}$
Prediction outcome
positive
negative
Actual value
positive
negative
TP
FN
FP
TN
Analytics Vidhya
18:07 / 50:06



to catch criminals in party full of innocent businessman



Evaluation Metrics : Recall

- Aim: "ALL" weapon carriers "MUST" be caught
- Catching weapon > checking innocent
- Minimize False Negative (undetected weapon carrier)
- False positive rate is high (detects innocent as weapon carrier)

$$\text{recall} = \frac{TP}{TP + FN}$$

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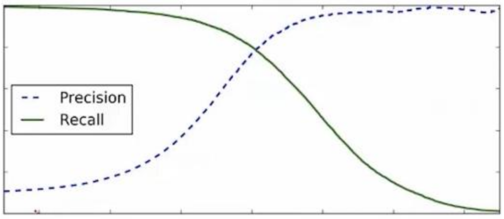
Evaluation Metrics : Precision/Recall tradeoff

- High Precision, Low Recall
- High Recall, Low Precision
- Choice depends upon the use case



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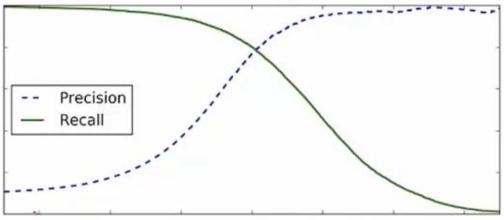
Evaluation Metrics : Precision/Recall tradeoff

- High Precision, Low Recall
- High Recall, Low Precision
- Choice depends upon the use case
- Combined using F1 Score



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

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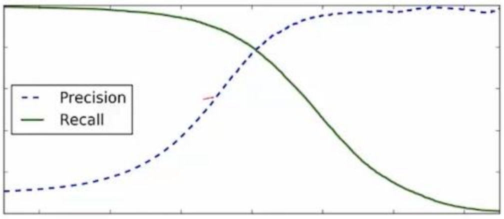
Evaluation Metrics : Precision/Recall tradeoff

- High Precision, Low Recall
- High Recall, Low Precision
- Choice depends upon the use case
- Combined using F1 Score
- F1 is maximum when precision = recall



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

Analytics Vidhya

Question:

For a given classifier, suppose the first 10 predictions of our classifier and 10 true observations are as follows:

True Label	0	1	1	1	0	0	0	1	1	1
Prediction	1	1	1	1	1	0	1	1	1	1

i. [1 Pt] What is the accuracy of our classifier on these 10 predictions? $7/10 = 0.7$

ii. [1 ½ Pts] What is the precision on these 10 predictions? $\frac{6}{9} = 1/3$

iii. [1 ½ Pts] What is the recall on these 10 predictions? $\frac{6}{6} = 1$

GO CLASSES Machine Learning GO Classes

i. [1 Pt] What is the accuracy of our classifier on these 10 predictions?

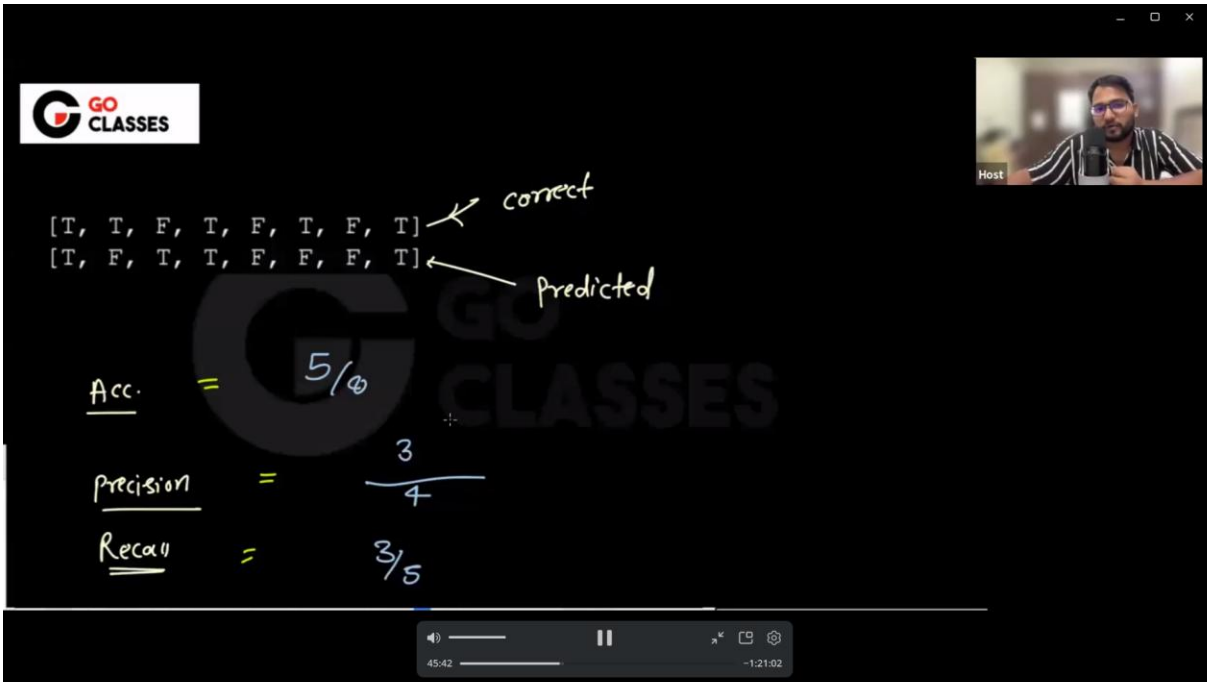
Solution: 7 of our predictions were correct, out of 10 total. Thus, our accuracy is $\boxed{\frac{7}{10}}$.

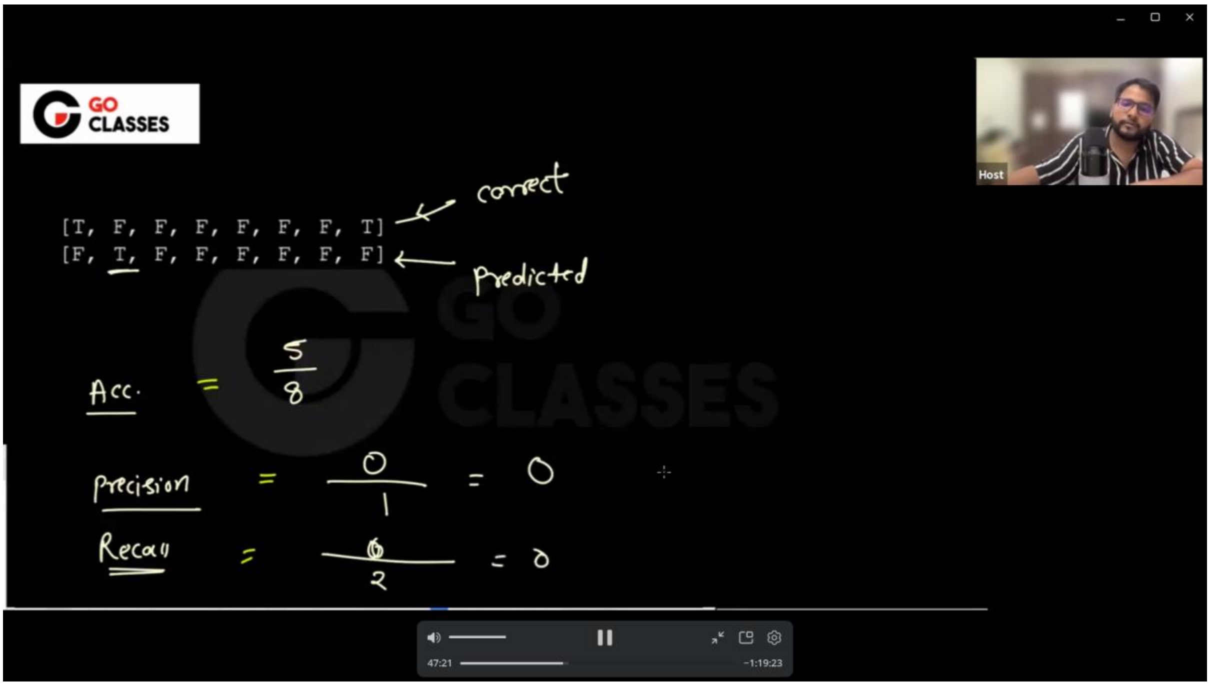
ii. [1 ½ Pts] What is the precision on these 10 predictions?

Solution: The number of true positives, TP, is 6. The number of false positives, FP, is 3. Then, the precision is $\frac{TP}{TP+FP} = \frac{6}{9} = \boxed{\frac{2}{3}}$.

iii. [1 ½ Pts] What is the recall on these 10 predictions?

Solution: From the solution to the previous part, we know that $TP = 6$. The number of false negatives, FN, here is 0 (we only predicted 0 once, and in that case the true value was actually 0). Thus, the recall is $\frac{TP}{TP+FN} = \frac{6}{6+0} = \boxed{1}$.


GO CLASSES
Host
[T, T, F, T, F, T, F, T]
correct
[T, F, T, T, F, F, F, T]
predicted
Acc. = 5/8
Precision = 3/4
Recall = 3/5
45:42
-1:21:02


GO CLASSES
Host
[T, F, F, F, F, F, F, T]
correct
[F, T, F, F, F, F, F, F]
predicted
Acc. = 5/8
Precision = 0/1 = 0
Recall = 0/2 = 0
47:21
-1:19:23

Machine Learning

GO Classes

Question:

9. Suppose we train a binary classifier on some dataset. Suppose y is the set of true labels, and $\hat{y}$ is the set of predicted labels.

y	0	0	0	0	0	1	1	1	1	1
$\hat{y}$	0	1	1	1	1	1	1	0	0	0

← Actual

← Pred.

Determine each of the following quantities.

(a) [1 Pt] The number of true positives

Solution:

(b) [1 Pt] The number of false negatives

Solution:

(c) [1 Pt] The precision of our classifier. Write your answer as a simplified fraction.

Solution:

https://ds100.org/fa20/resources/assets/exams/fa18/fa18finalsol.pdf

1:24:11 -42:33

Machine Learning

GO Classes

9. Suppose we train a binary classifier on some dataset. Suppose y is the set of true labels, and $\hat{y}$ is the set of predicted labels.

y	0	0	0	0	0	1	1	1	1	1
$\hat{y}$	0	1	1	1	1	1	1	0	0	0

Determine each of the following quantities.

(a) [1 Pt] The number of true positives

Solution: 2

(b) [1 Pt] The number of false negatives

Solution: 3

(c) [1 Pt] The precision of our classifier. Write your answer as a simplified fraction.

Solution: $\frac{2}{2+4} = \frac{1}{3}$

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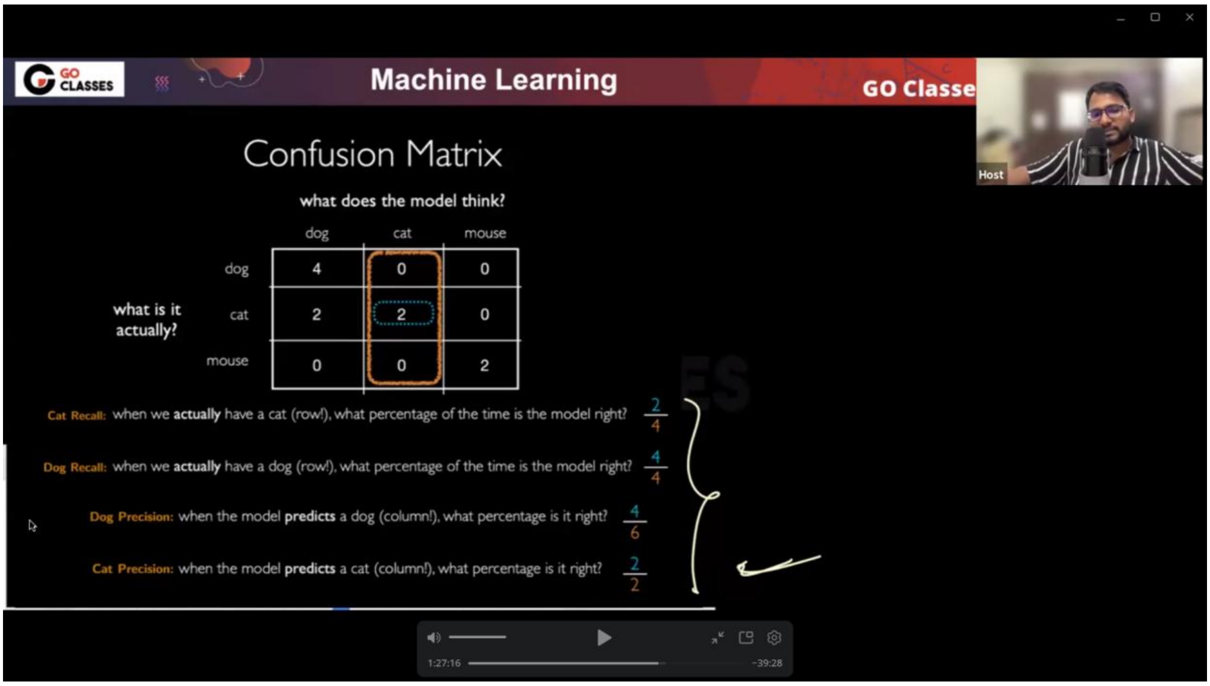
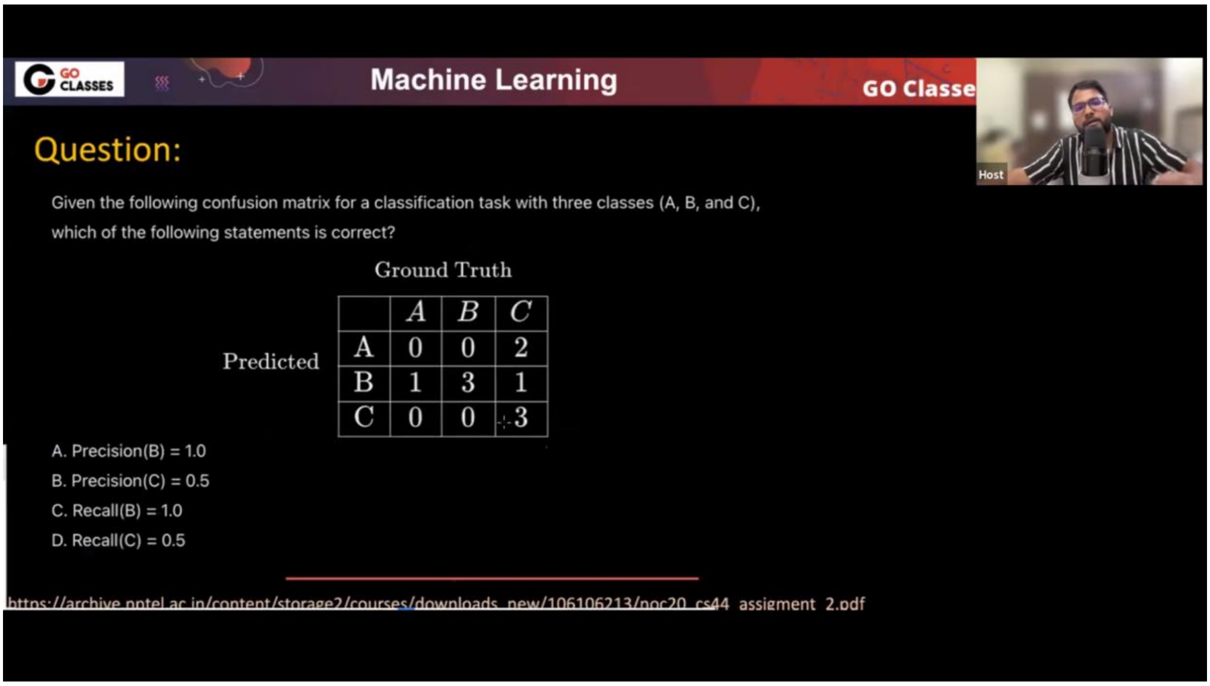
1:25:02 -41:42


GO CLASSES
Machine Learning
GO Classe
Host
Confusion Matrix
what does the model think?
dog cat mouse
what is it actually?
dog 4 0 0
cat 2 2 0
mouse 0 0 2
Cat Recall: when we actually have a cat (row!), what percentage of the time is the model right? 2/4
Dog Recall: when we actually have a dog (row!), what percentage of the time is the model right? 4/4
Dog Precision: when the model predicts a dog (column!), what percentage is it right? 4/6
Cat Precision: when the model predicts a cat (column!), what percentage is it right? 2/2
1:27:16
-39:28


GO CLASSES
Machine Learning
GO Classe
Host
Question:
Given the following confusion matrix for a classification task with three classes (A, B, and C), which of the following statements is correct?
Ground Truth
Predicted
A B C
A 0 0 2
B 1 3 1
C 0 0 3
A. Precision(B) = 1.0
B. Precision(C) = 0.5
C. Recall(B) = 1.0
D. Recall(C) = 0.5
https://archive.nptel.ac.in/content/storage2/courses/downloads_new/106106213/noc20_cs44_assigment_2.pdf

Machine Learning

GO Classes

3. (1 point) Again, consider a binary classification data set with 9000 positively labelled examples and 1000 negatively labelled examples. What is the precision and the recall of a classifier that always classifies any example as positive?

A. The precision is 0.1, and the recall is 0.9.
B. The precision is 0.9, and the recall is 0.1.
C. The precision is 1.0, and the recall is 0.9.
D. The precision is 0.9, and the recall is 1.0.
E. The precision is 0.1, and the recall is 1.0.

Solution: D. The precision is 9000/10000 = 0.9 since all examples are classified as positive. The recall is 9000/9000 = 1.0 (perfect recall) since all positive examples are classified as positive.

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Machine Learning

GO Classes

Combining precision and recall

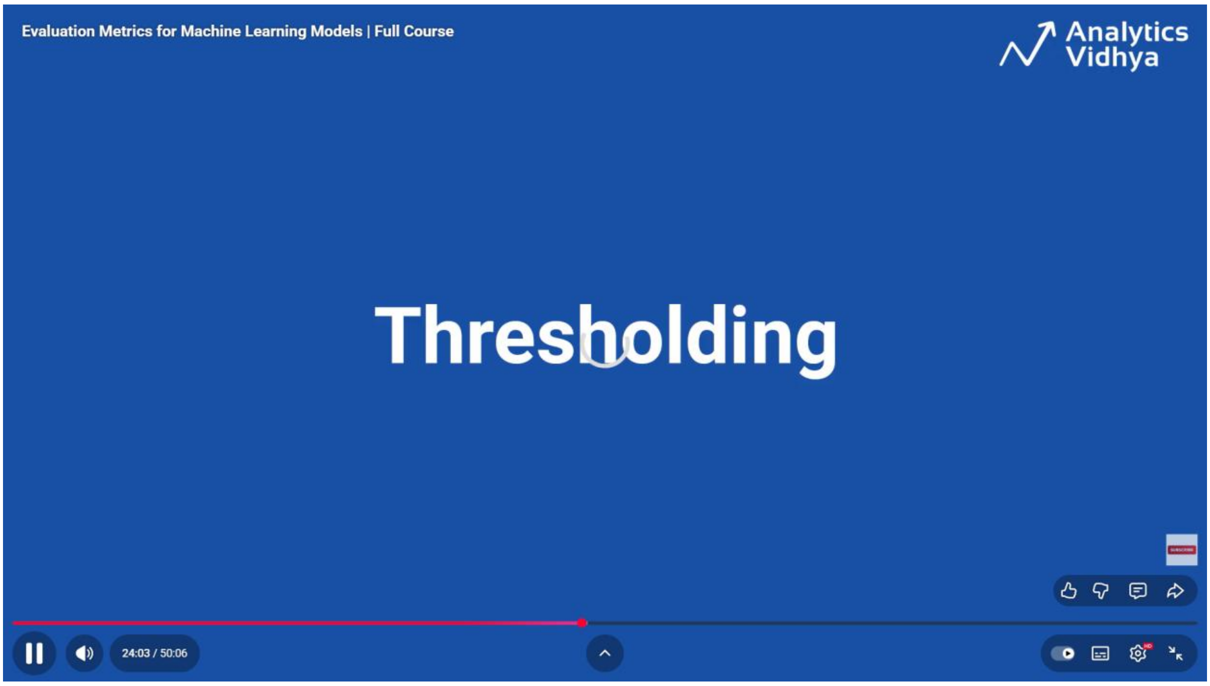
- **Key insight:** Two moderate values are better than two extremes. Use the product, which shrinks when either term in the product is small.
- New way of combining precision and recall: **F-score**

$$\frac{2PR}{P+R}$$

(harmonic mean of P, R)

$$2 \cdot \frac{1}{\frac{1}{P}+\frac{1}{R}}$$

- Compare:
  - Classifier A ($P = 0$, $R = 1$) $\rightarrow \frac{2 \cdot 0 \cdot 1}{0+1} = 0$ bad
  - Classifier B ($P = 0.5$, $R = 0.6$) $\rightarrow \frac{2 \cdot 0.5 \cdot 0.6}{0.5+0.6} = \frac{6}{11}$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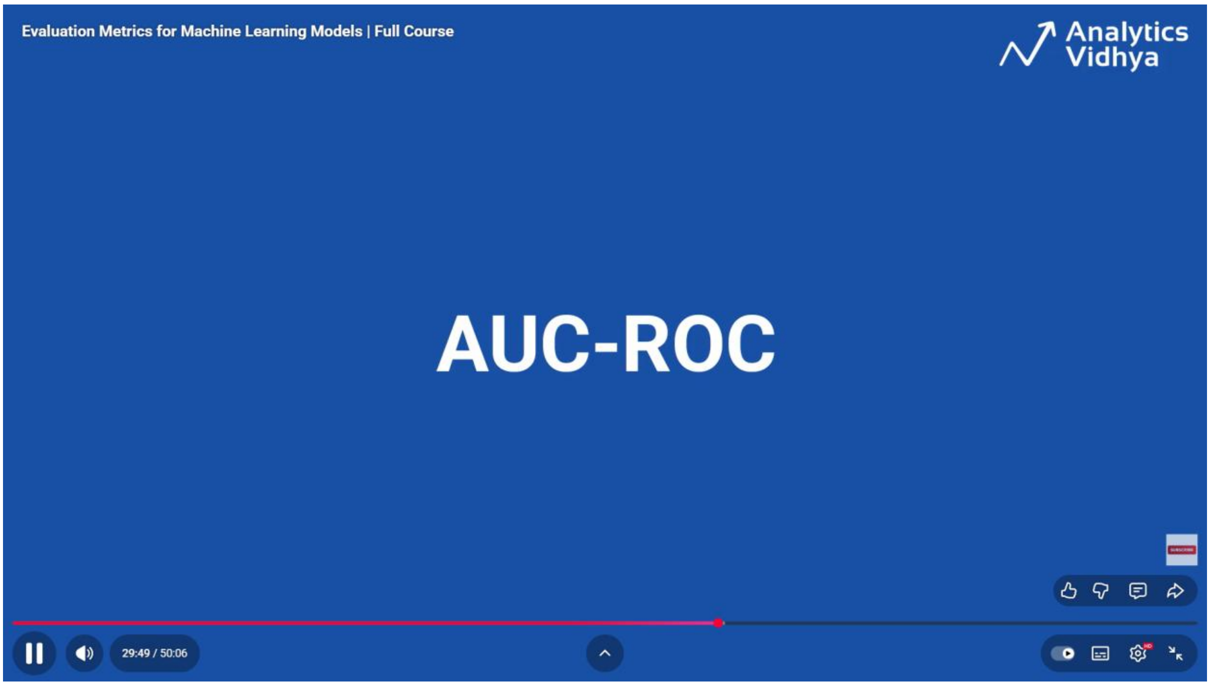
Analytics Vidhya
Thresholding
24:03 / 50:06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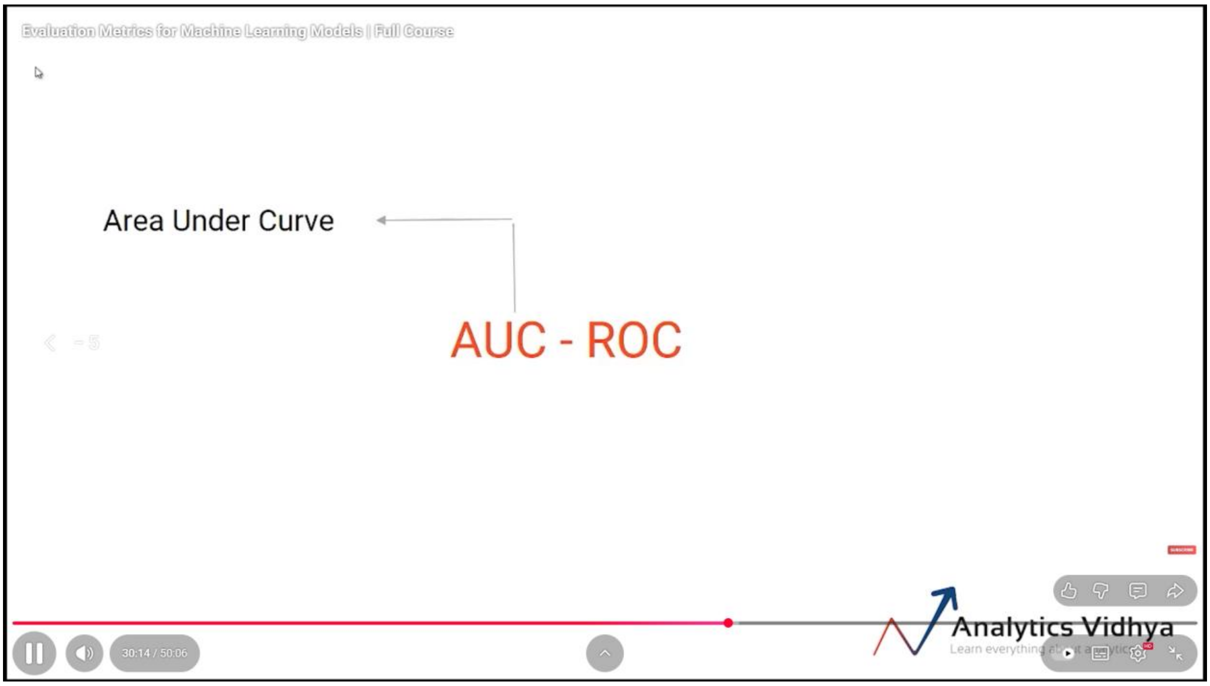
AUC-ROC
29:49 / 50:06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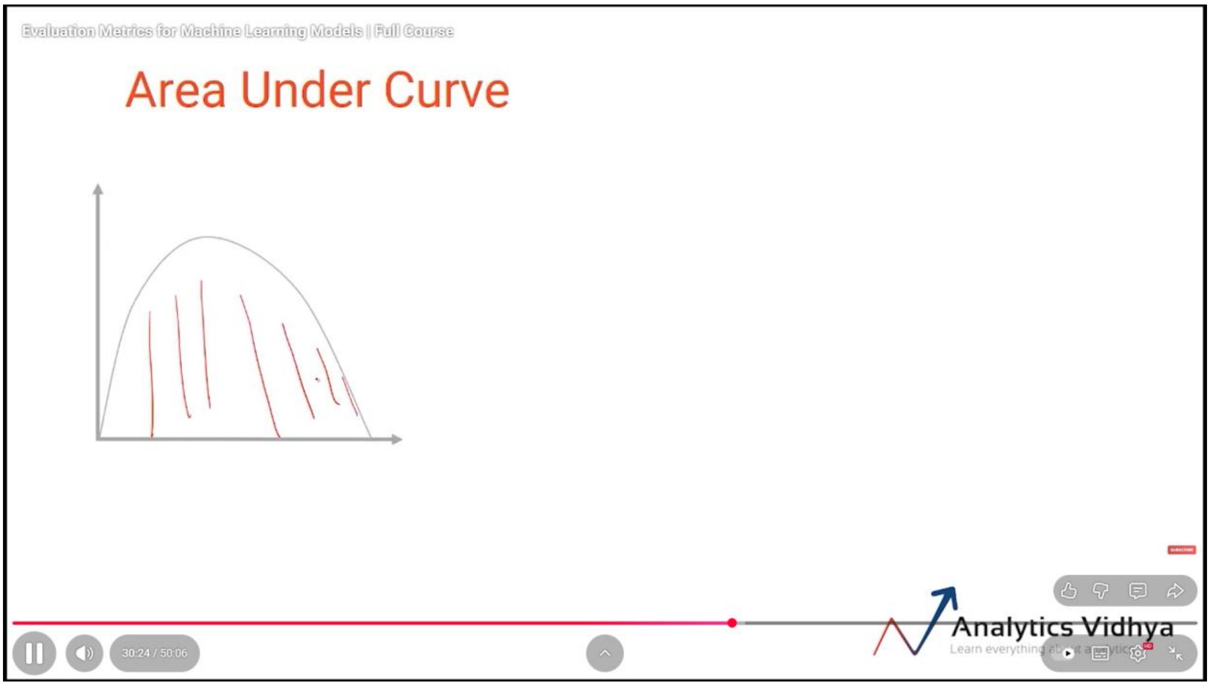
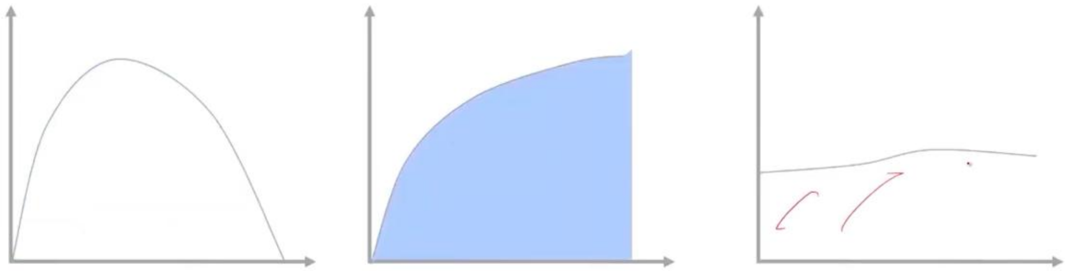
Area Under Curve
AUC - ROC
Analytics Vidhya
30:14 / 50:06


Evaluation Metrics for Machine Learning Models | Full Course
Area Under Curve
Analytics Vidhya
30:24 / 50:06

Area Under Curve



The ROC Curve

- ROC: Receiver Operating Characteristic
- Originally used for distinguishing ‘noise’ from ‘not noise’
- Evaluation Metric for Binary Classification
- Gives trade-off between True Positives and False Positives

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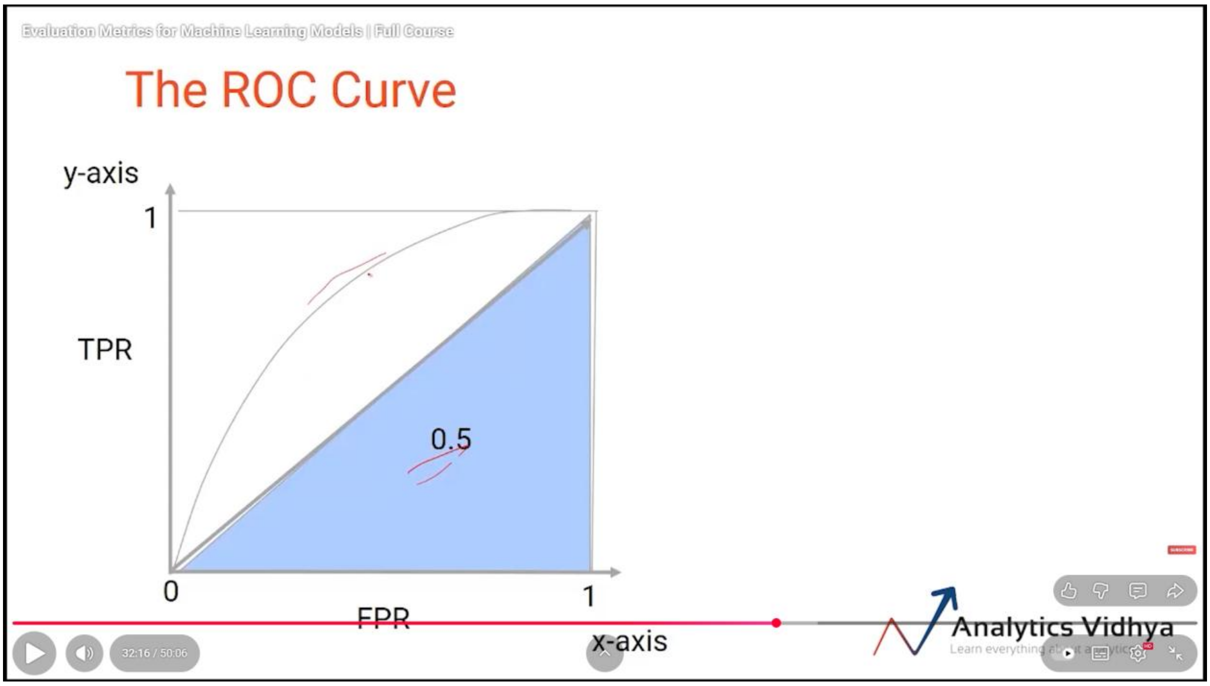
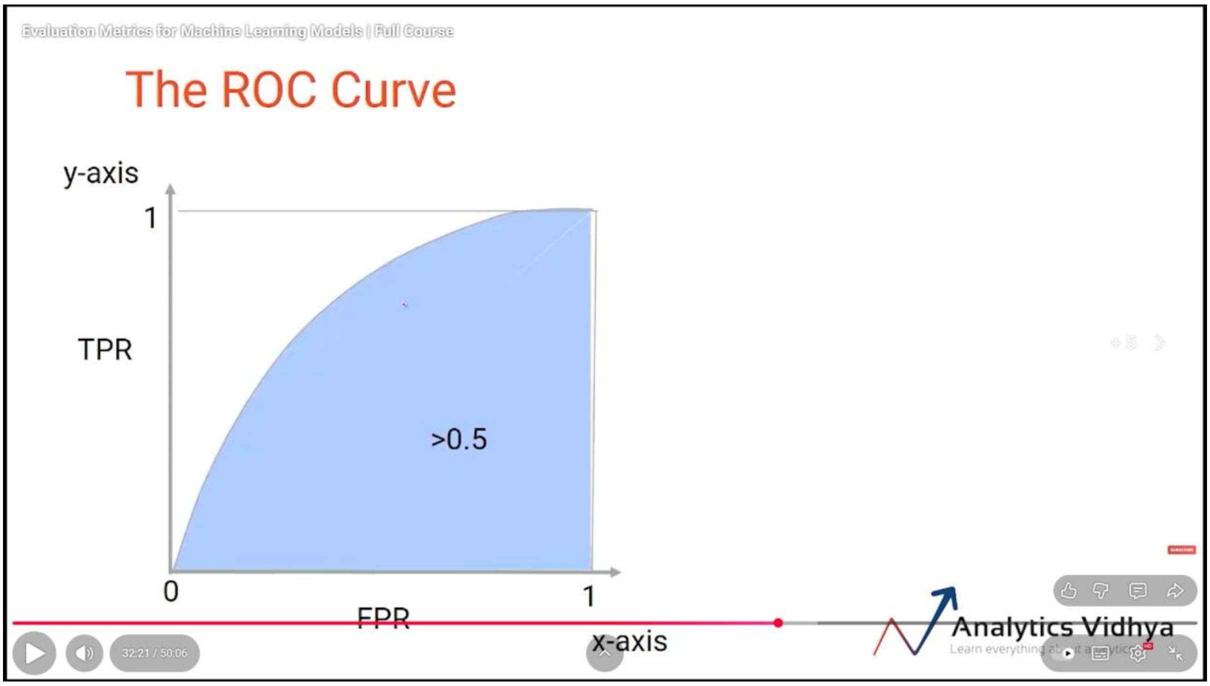
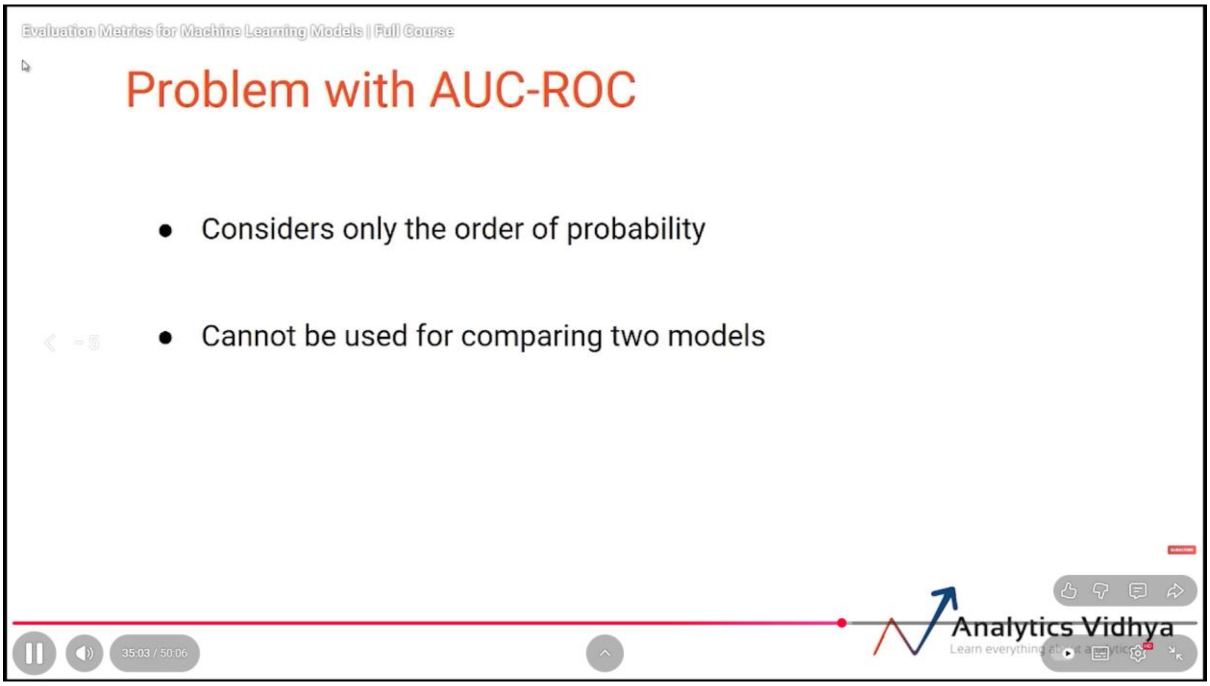




The more the area under curve better the pedcition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Problem with AUC-ROC
Considers only the order of probability
Cannot be used for comparing two models
35:03 / 50:06
Analytics Vidhya