Evaluating Classifiers : Precision & Recall

- They are betters measures of the quality when compared to accuracy.
- Thus far, we considered
  - accuracy = #correct / # total;
  - classification error = #mistakes / #total;

Imbalanced Classes

- This can be subjected to the majority class issue. In case of a restuarant review that has majority of negative classes, then the predicted output will be negative. The positive review will bw hard to extract.
- Binary classifier : Classification Error - 0.5;
- For k classes, error = 1 - 1/k
  - error = 0.666 for 3 classes; 0.75 for 4 classes.

Task -> Automated marketing campaign

- The restuarant must display positive review inorder to boom.
- Website shows 10 sentences from reent reviews

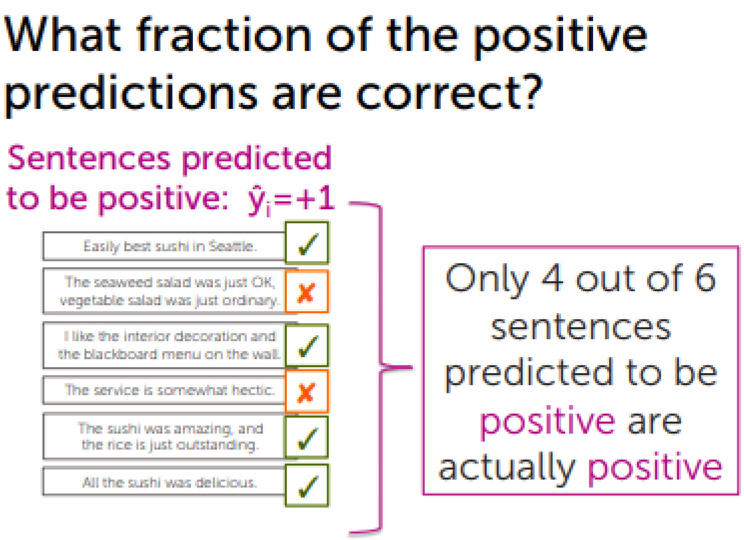
Precision -> Did I (mistakenly) show a negative sentence? (Show only Positive sentence precisely)

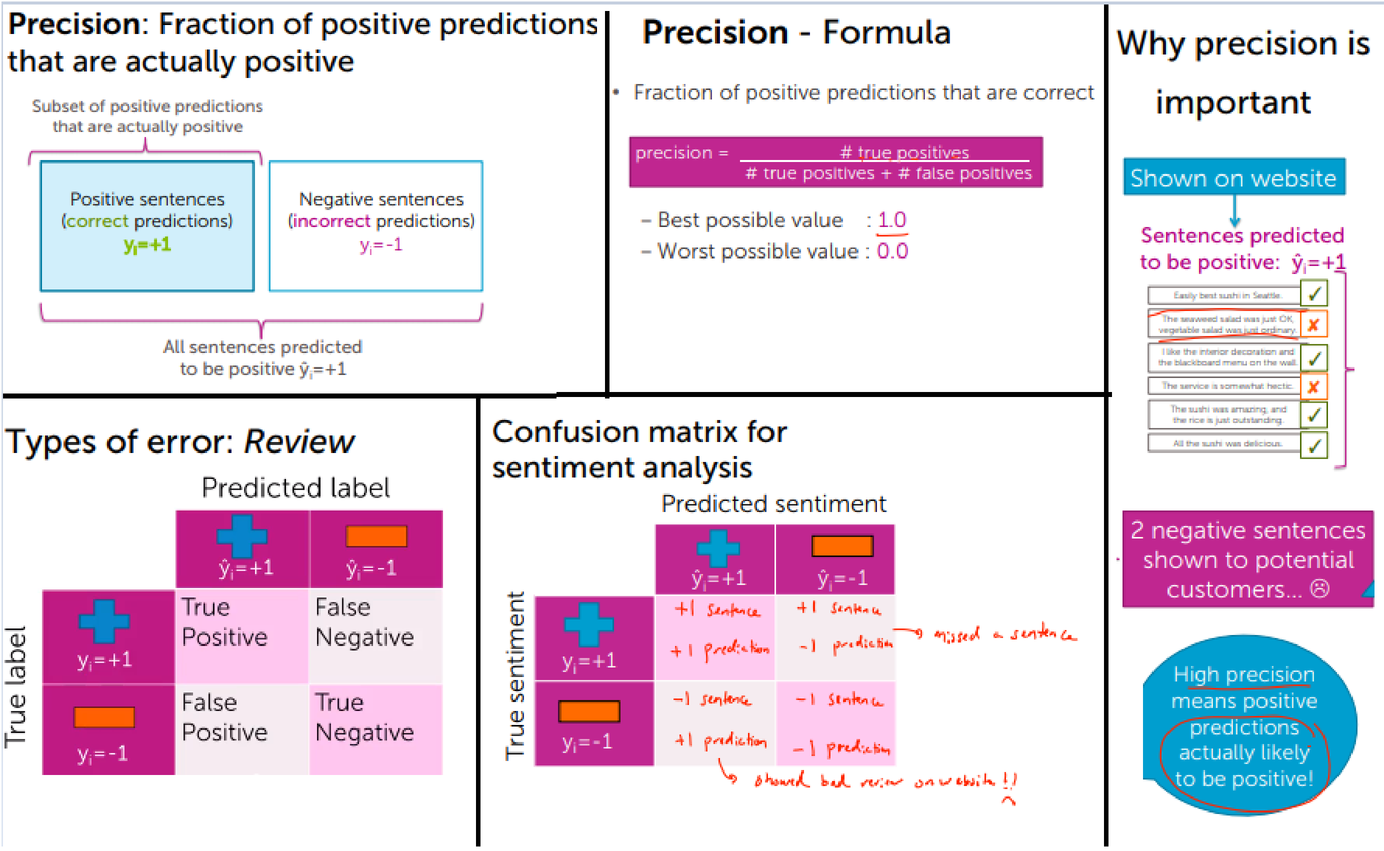
Recall -> Did I not show a (great) positive sentence ? (Show all the positive review from the total)

Precision

Fraction of positive predictions that are actually positive

- It is the fraction of positive predictions that are actually positive.
- Consider the below, the algorithm predicts that six of the sentences are positive, but in reality only 4 are positive.
- Thus, precision = 4 / 6;





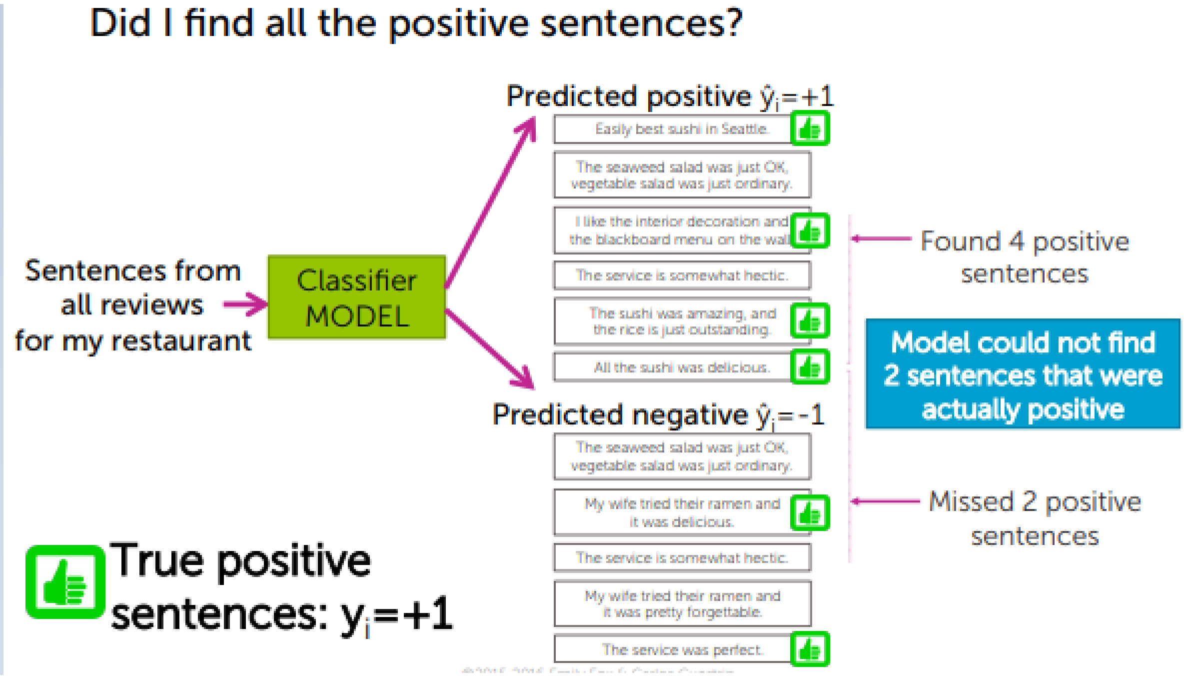
Precision = # true positives / (# true positives + # false positives)

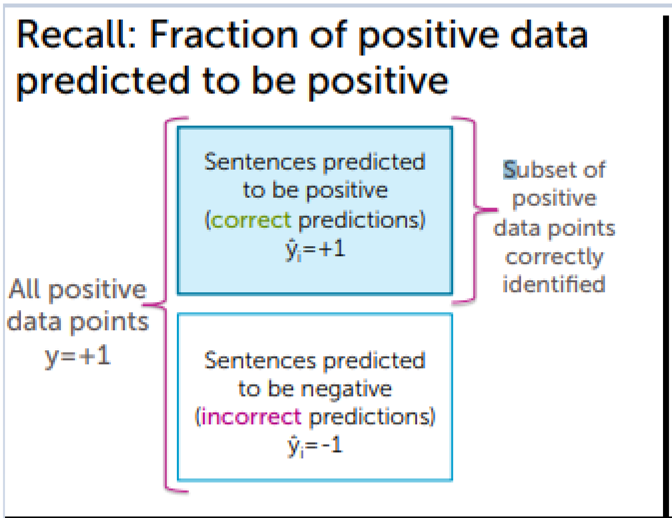
- Best possible value = 1.0
- Worst possible value = 0.0

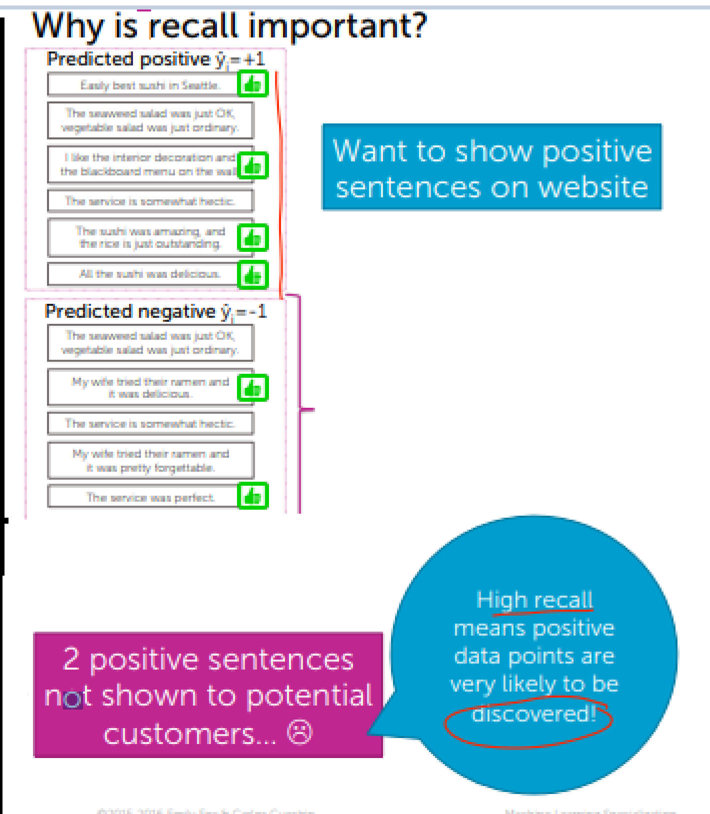
Recall

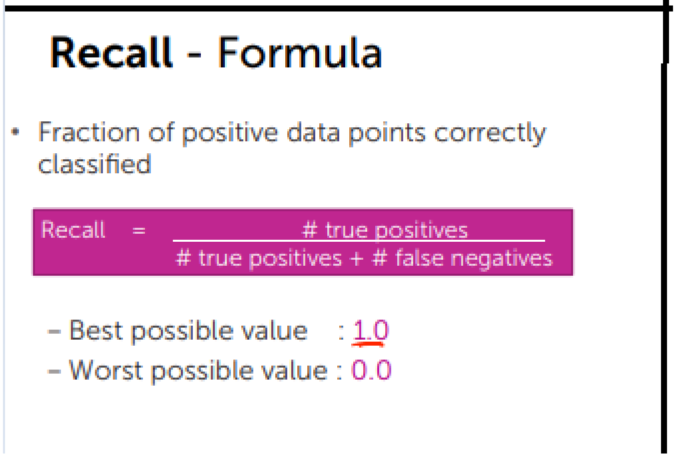
Fraction of positive data predicted to be positive.

- Given a dataset with reviews that's feed to a classifier model and the model predicts.
- Say the model predicts 6 postive and 4 negative.
- But the true label among the positive predictions are 4 while there are 2 true labels lost among the negative predictions.
- Thus the model has lost two positive reviews.









Recall = # true positives / (# true positives + # false negatives)

The precision-recall tradeoff

Precision-recall extremes :

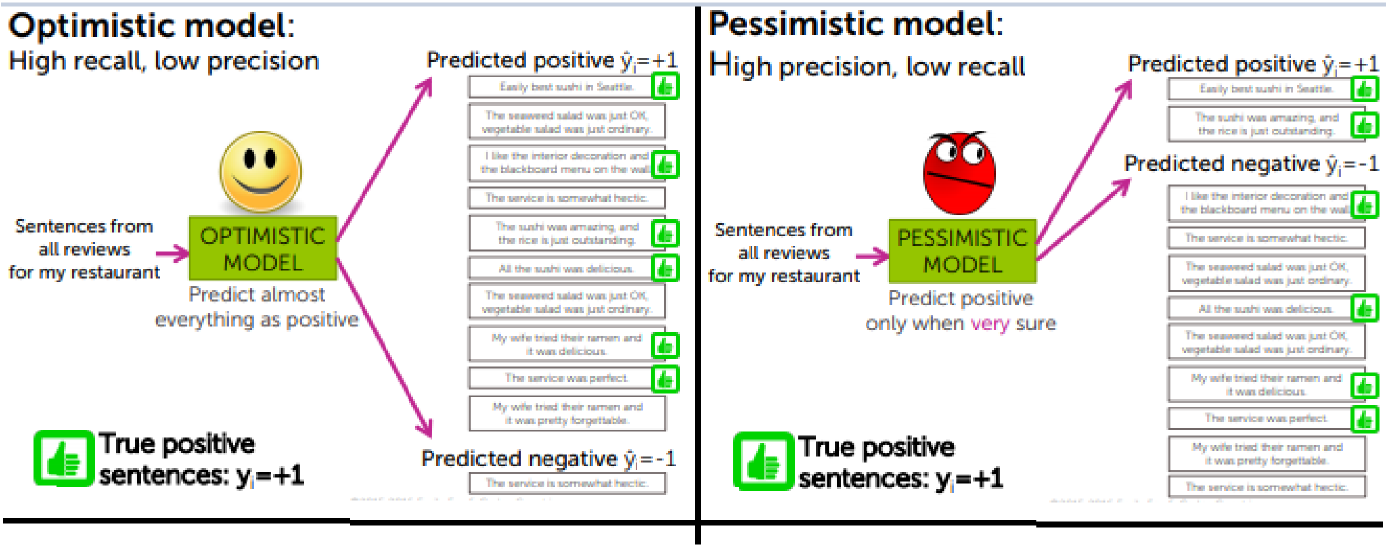
Optimistic Model - High recall, low precision.

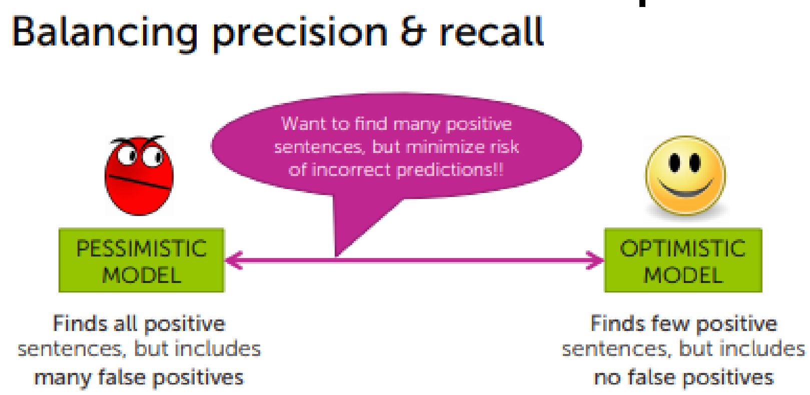
```
- Mostly predicts the data to be positive.
- Hence most of the positive true label will be predicted positive - high recall.
- Since most reviews are predicted positive, many negatives can also be categorize
d as positives - low precision.
```

Pessimistic Model - High Precision, low recall.

```
- Mostly predicts the data negative.
- Hence few records that are predicted to be positive are positive actually, there
fore high precision.
- Since most reviews are predicted negative, many positive records will also be ma
rked negative. Therefore low recall.
```

Therefore require a model that minimizes incorrect predictions.





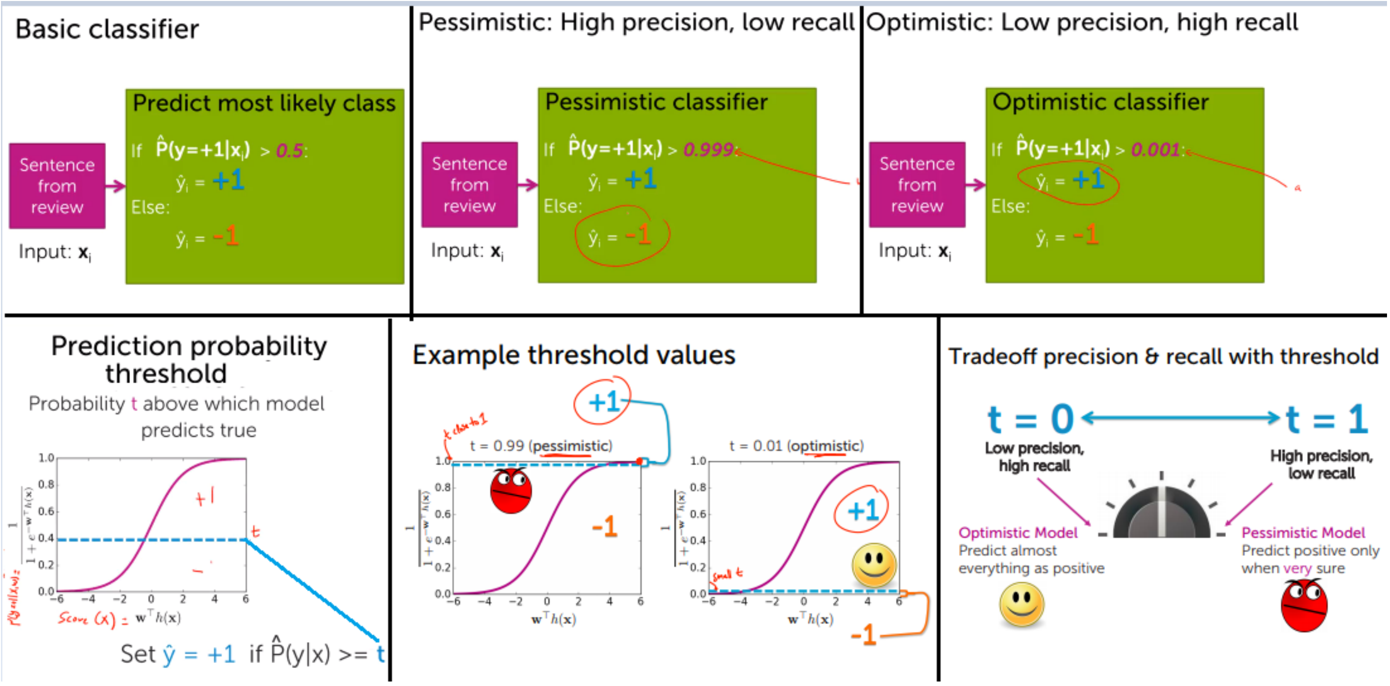
Confidence in the predictions

- In the model, since all reviews cannot be segregated into absolute positives or absolute negatives. A confidence probability is associated with the reviews to indicate and emphasis the sentiment of the review.
- Although the reviews are either +1 (positive) / -1 (negative);
- The confidence probability associated with the reviews can range from 0 to 1.
- This probability can be used to tradeoff precision and recall.

- Thus far, we considers classifiers that considered the threshold predition probability = 0.5; below that are negative, while above that are positive.

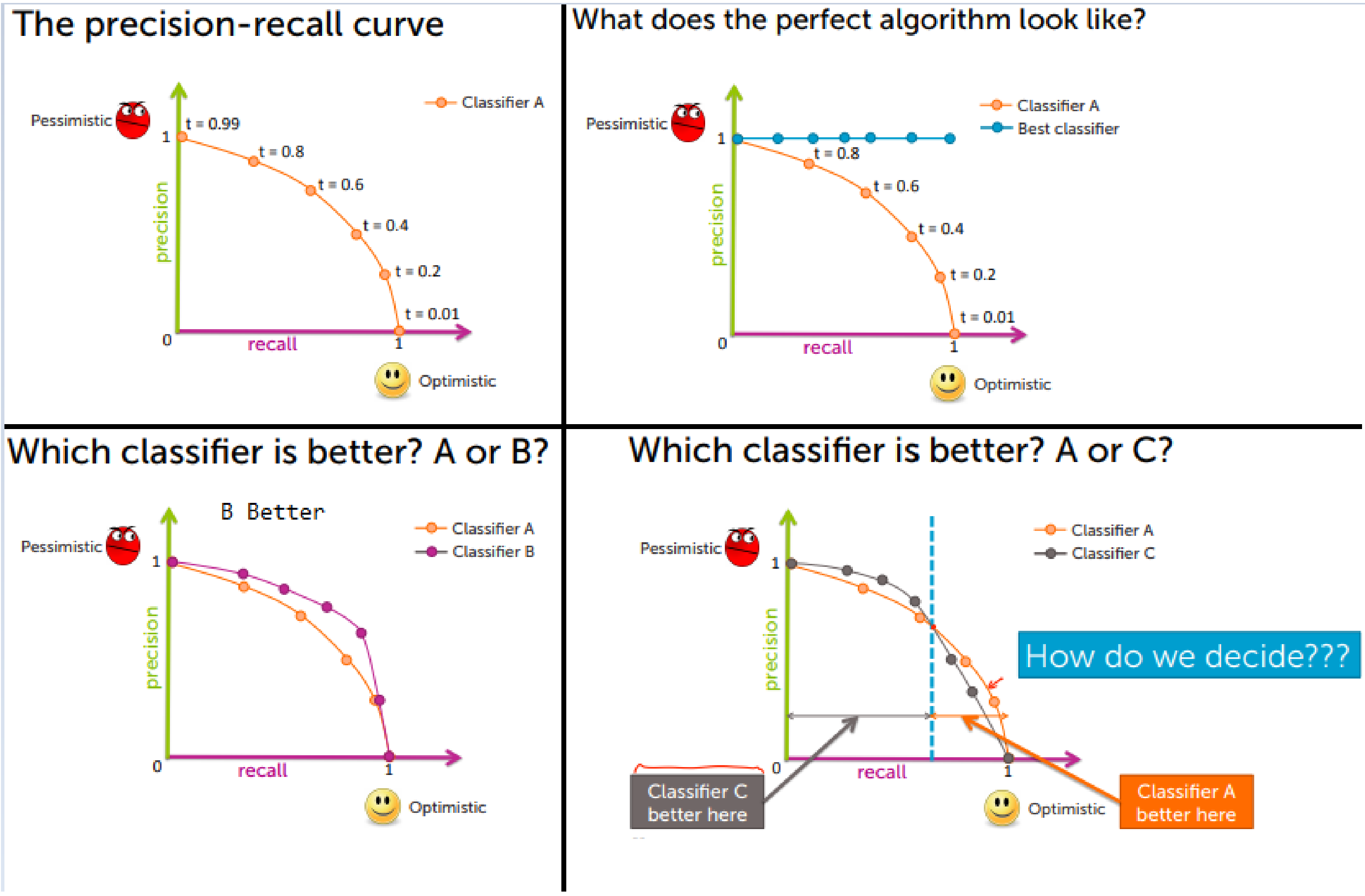
- Optimistic model -> threshold -> 0.001;
- Pessimistic model -> threshold -> 0.999;

Therefore the tradeoff can be represented by a letter 't' that ranges between 0 & 1.



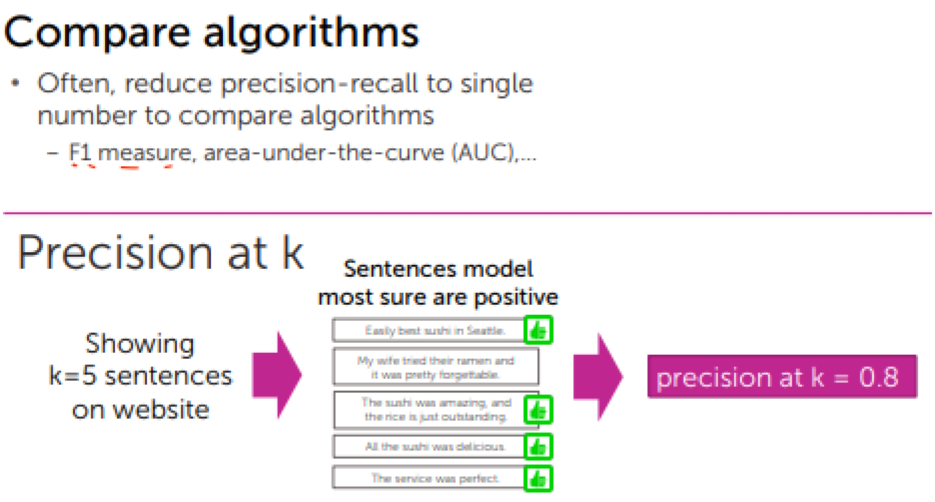
The precision-recall curve

- The best classifier will have a precision 1 irrespective of the recall. But this is an ideal model difficult to achieve in practice.
- For classifiers A, B. B is a better classifier since is closer to the ideal than A.
- For classifiers A, C. It is complicated since there are regions where A is closer to ideal than C and vice-versa.



Compare Algorithms:

- Often reduce the precision-recall to a single number to compare algorithms.
  - F1 measure, area-under-the-curve (AUC), ...
- Precision at k
  - Showing k=5 sentence on websites.
  - Precision (of the given sentences how many are positive = 0.8);



Quiz

1. Questions 1 to 5 refer to the following scenario:

Suppose a binary classifier produced the following confusion matrix.

	Predicted Positive	Predicted Negative
Actual Positive	5600	40
Actual Negative	1900	2460

What is the **accuracy** of this classifier? Round your answer to 2 decimal places.

0.81

acurracy = total correct / total = 0.81 recall = true positive / true positive + false negative = 0.99 precision = true positive / true positive + false positive = 0.75

---

2. Refer to the scenario presented in Question 1 to answer the following:

(True/False) This classifier is better than random guessing.

- (•) True
- ( ) False

recall 0.99 > accuracy 0.81 - random guessing;

---

3. Refer to the scenario presented in Question 1 to answer the following:

(True/False) This classifier is better than the majority class classifier.

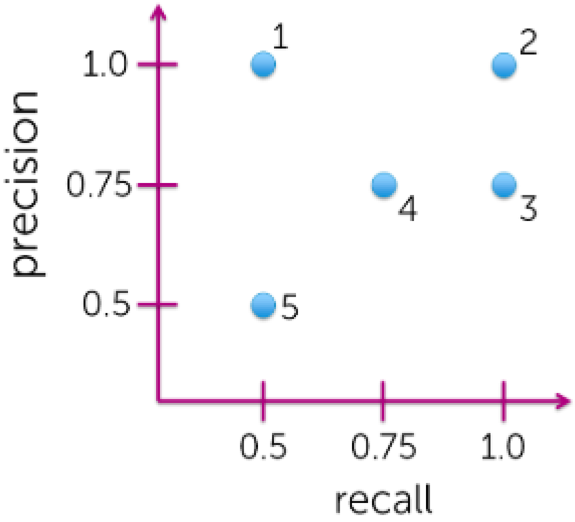
- (•) True
- ( ) False

majority classifiers are biased.

---

4. Refer to the scenario presented in Question 1 to answer the following:

Which of the following points in the precision-recall space corresponds to this classifier?



- ( ) (1)
- ( ) (2)
- (•) (3)
- ( ) (4)
- ( ) (5)

Answer

Precision: 5600/float(5600 + 1900)= 0.75 Recall = 5600 /(5600 + 40) = 0.99

---

5. Refer to the scenario presented in Question 1 to answer the following:

Which of the following best describes this classifier?

- (•) It is optimistic
- ( ) It is pessimistic
- ( ) None of the above

- recall > precision -> optimistic

---

6. Suppose we are fitting a logistic regression model on a dataset where the vast majority of the data points are labeled as positive. To compensate for overfitting to the dominant class, we should

- (•) Require higher confidence level for positive predictions
- ( ) Require lower confidence level for positive predictions

More info: https://www.coursera.org/learn/ml-classification/lecture/IMHs2/trading-off-precision-and-recall (https://www.coursera.org/learn/ml-classification/lecture/IMHs2/trading-off-precision-and-recall)

---

7. It is often the case that false positives and false negatives incur different costs. In situations where false negatives cost much more than false positives, we should

- ( ) Require higher confidence level for positive predictions
- (•) Require lower confidence level for positive predictions

8. We are interested in reducing the number of false negatives. Which of the following metrics should we primarily look at?

- ( ) Accuracy
- ( ) Precision
- (•) Recall

9. Suppose we set the threshold for positive predictions at 0.9. What is the lowest score that is classified as positive? Round your answer to 2 decimal places.

2.20

- Class probability =/= score.
- In the context of linear classifier, score is the dot product of coefficieints and features.
- Recall that P(y = +1 | x,w) = sigmoid(score).
- If we want P(y=+1|x,w) to be greater than 0.9, how large should the score be?

$$\frac{1}{1+e^{-score}} = 0.9$$

$$=> 0.9 + 0.9e^{-score} = 1$$

$$=> \frac{0.1}{0.9} = e^{-score}$$

$$=> \ln(\frac{0.1}{0.9}) = \ln(e^{-score})$$

$$=> score = 2.20$$