# Evaluation of Classifiers and ROC Curves II

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Machine Learning Course, Duke

## Evaluation (from last time)

Many ways to evaluate a classifier:

- Confusion matrix (TP, TN, FP, FN)
- Accuracy / misclassification error
- Precision, Recall, F1-score
- ROC curves, AUC/AUROC

# Handling Imbalance

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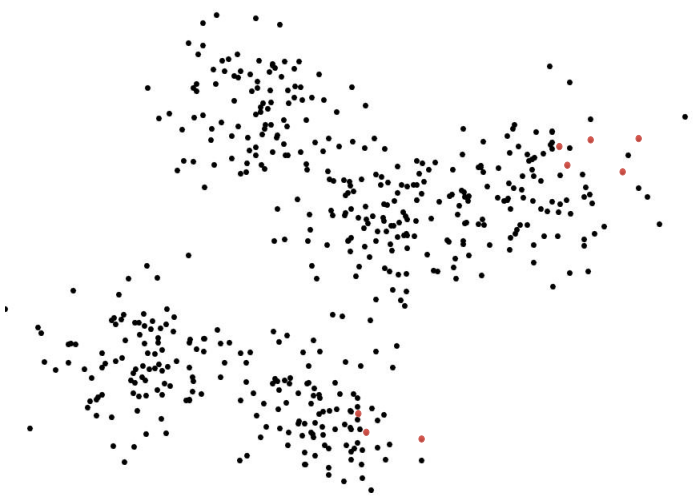

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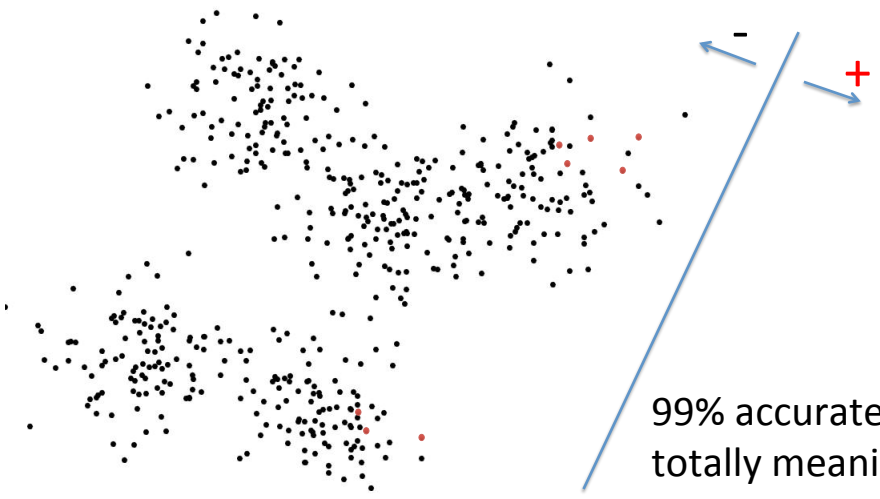

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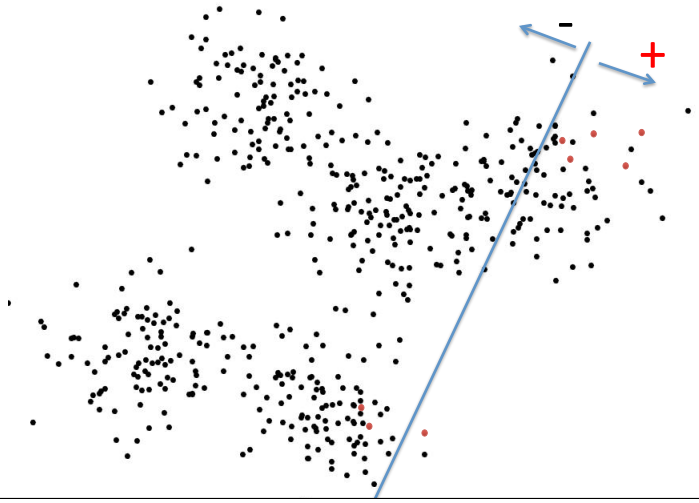


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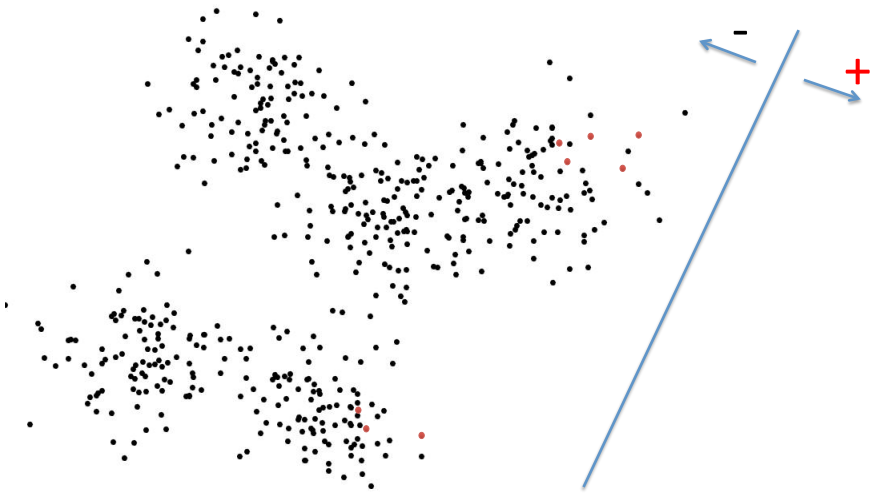

$$\frac{1}{n}\sum_{i=1}^{n}\ell(y_i f(x_i)) + \text{Regularization}(f)$$

The positives are treated the same way as the negatives.

$$\frac{1}{n}\sum_{i=1}^{n}\ell(y_i f(x_i)) + \text{Regularization}(f)$$

$$\frac{1}{n}\left( \sum_{\substack{i \text{ positives} \\ i \text{ where } y_i=1}}^{n} \ell(y_i f(x_i)) + \sum_{\substack{k \text{ negatives} \\ k \text{ where } y_k=1}}^{n} \ell(y_k f(x_k)) \right) + \text{Regularization}(f)$$

Each positive is worth C times a negative

$$\frac{1}{n}\left( C \sum_{\substack{i \text{ positives} \\ i \text{ where } y_i=1}}^{n} \ell(y_i f(x_i)) + \sum_{\substack{k \text{ negatives} \\ k \text{ where } y_k=1}}^{n} \ell(y_k f(x_k)) \right) + \text{Regularization}(f)$$

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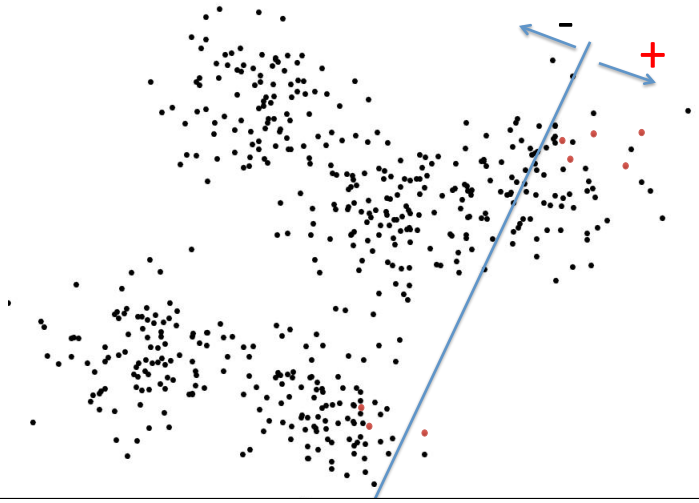


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## Imbalanced Data

- Don't report plain accuracy.
- Adjust imbalance parameter C to obtain your ideal balance between TP/FP.

# ROC Curves, Part II

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  - Using a single real-valued classifier. In that case the ROC curve evaluates the classifier.
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# ROC Curves

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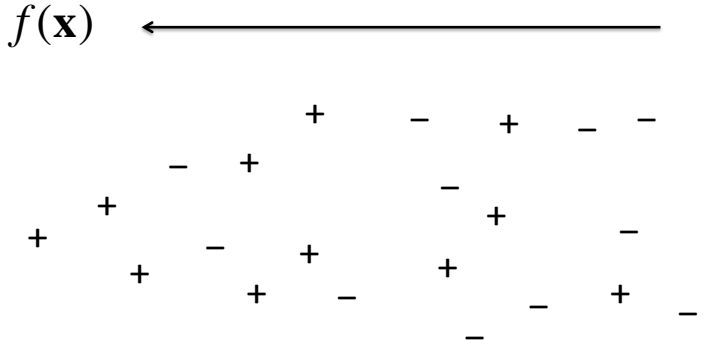


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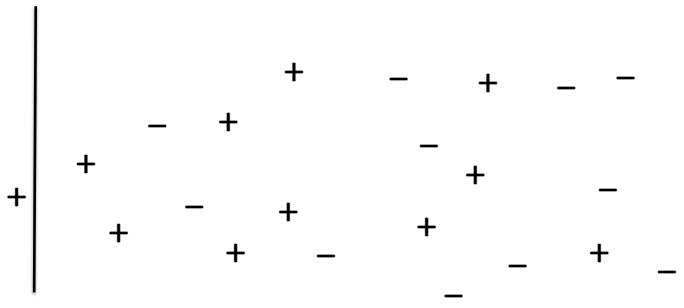

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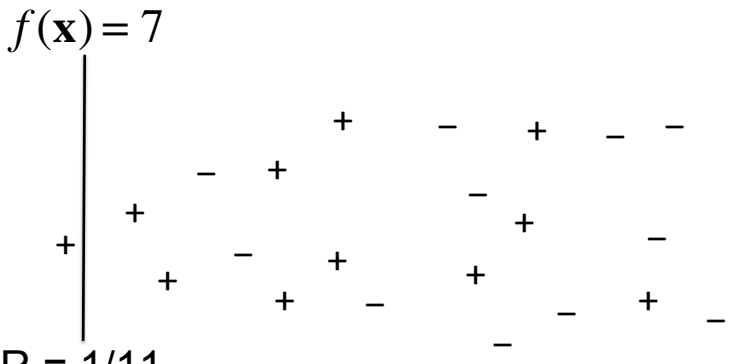


- TPR = 1/11
- FPR = 0/12

# ROC Curves

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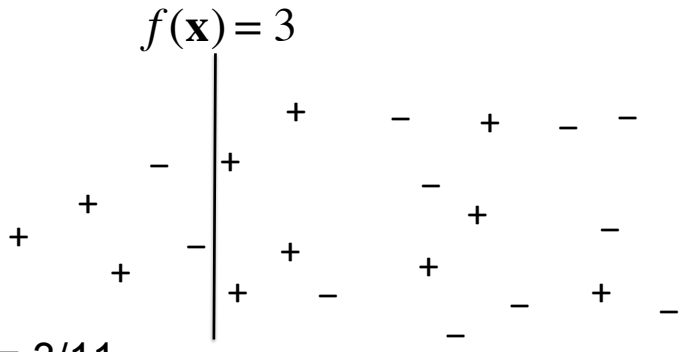


- TPR = 3/11
- FPR = 2/12

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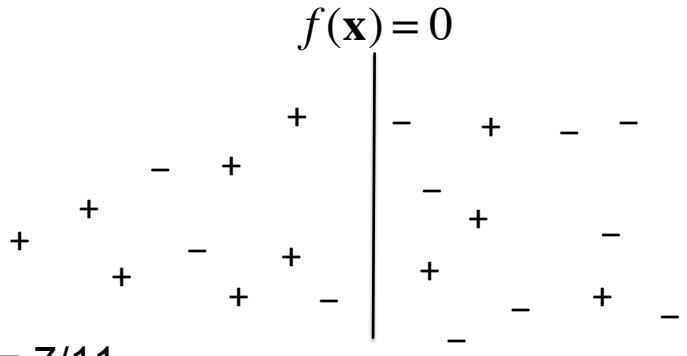


- TPR = 7/11
- FPR = 3/12

# ROC Curves

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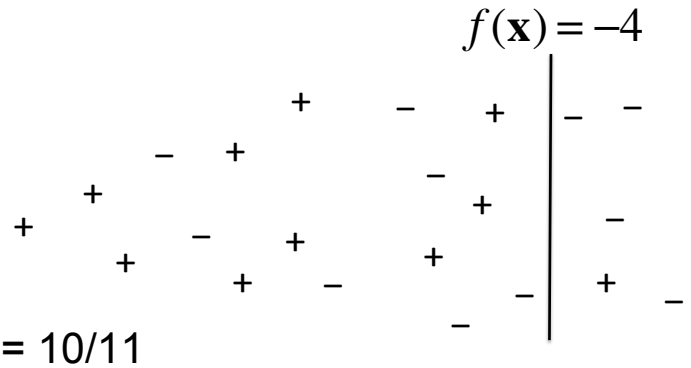


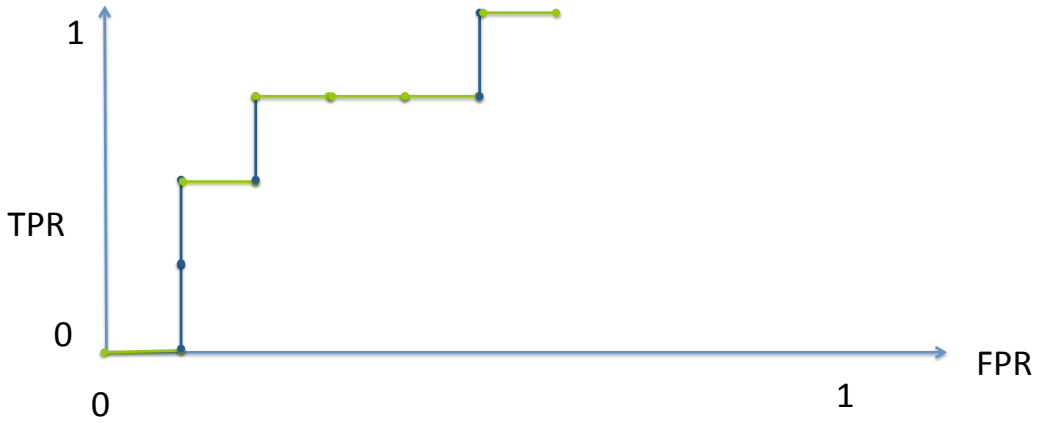

- TPR = 10/11
- FPR = 7/12

# ROC Curves

- For a particular False Positive Rate (FPR), what is the True Positive Rate (TPR)?


# ROC Curves

- To do this, you need only values of f(x) and y.
  - e.g., f(x) = 15,12,10,8,6,2,-1,-3,-14,…
  - e.g., y(x) = -1,1,1,-1,1,-1,-1,-1,1,-1,...



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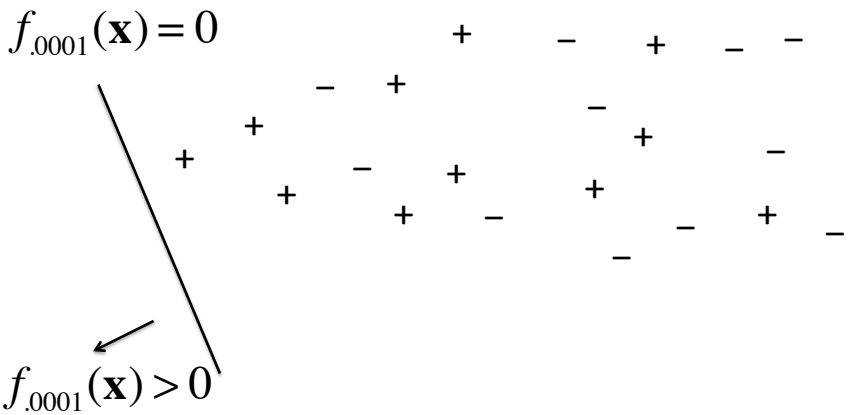
## ROC Curves

- Run the algorithm sweeping across C values.

$C = .0001$

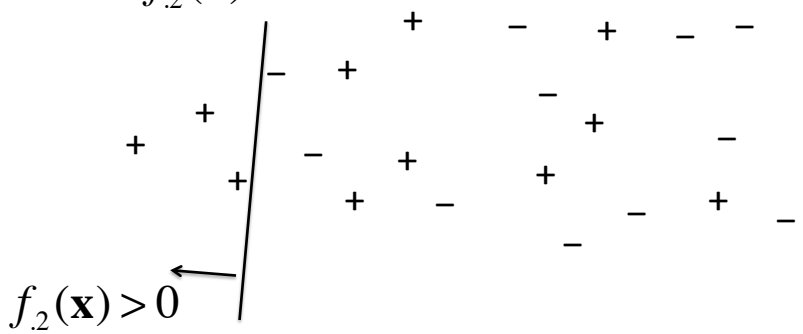


# ROC Curves

- Run the algorithm sweeping across C values.

$C = .2$

$f_{.2}(\mathbf{x}) = 0$



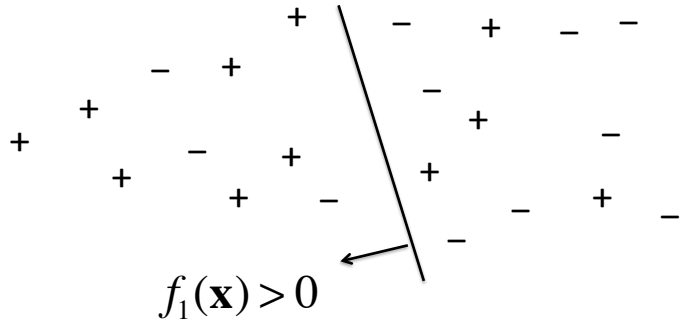
$f_{.2}(\mathbf{x}) > 0$

# ROC Curves

- Run the algorithm sweeping across C values.

$C = 1$

$f_1(\mathbf{x}) = 0$



$f_1(\mathbf{x}) > 0$

# ROC Curves

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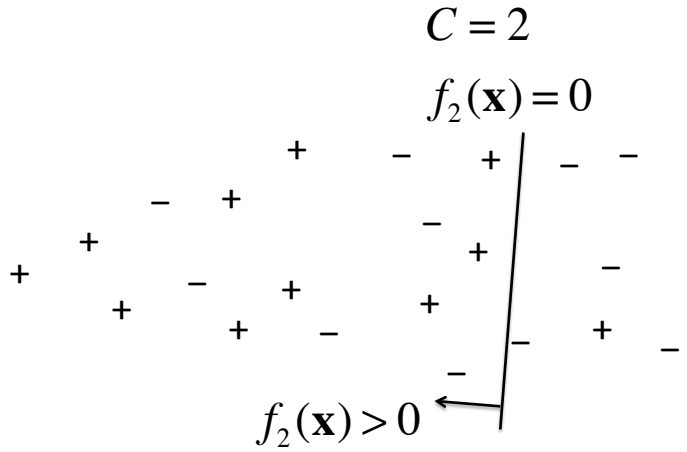


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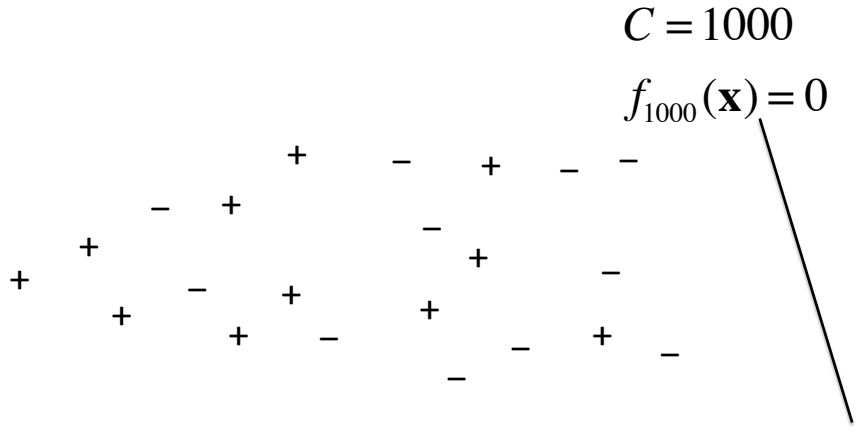

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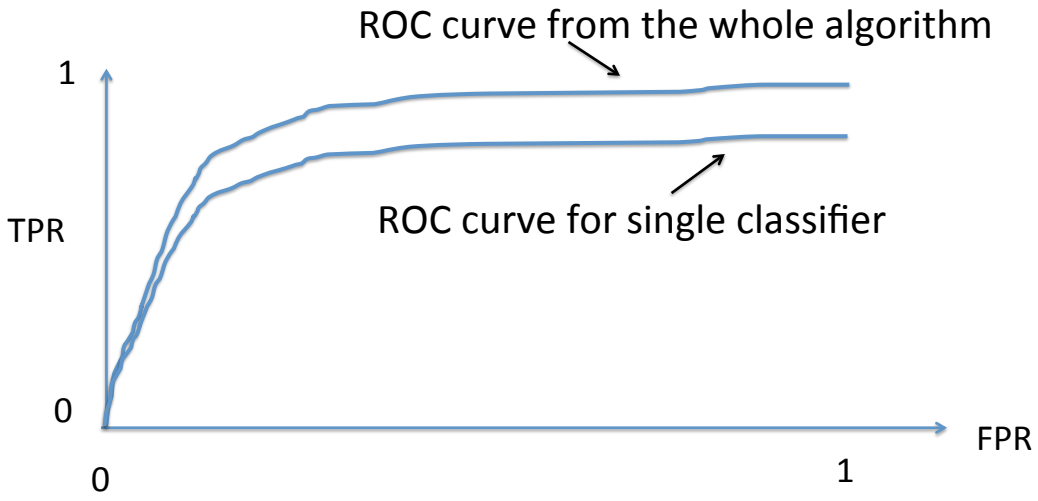
ROC curve from the whole algorithm
ROC curve for single classifier
1
TPR
0
0
1
FPR