DSS
Decision Sciences & Systems

Technische Universität München

Tutorial Business Analytics

Tutorial 8: Evaluation

Decision Sciences & Systems (DSS)
Department of Informatics
TU München

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Agenda

- Bias-Variance Tradeoff
- Evaluation of classifiers
  - Evaluation on training set
  - Holdout
  - Cross-Validation
- Metrics for classifiers
  - Confusion matrix
  - Gain Curves
  - Lift Curves
  - ROC Curves

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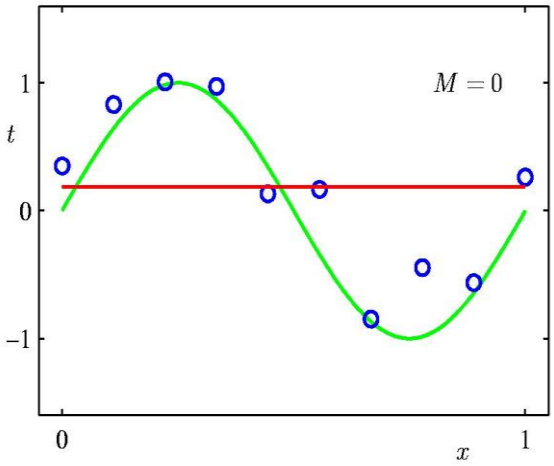
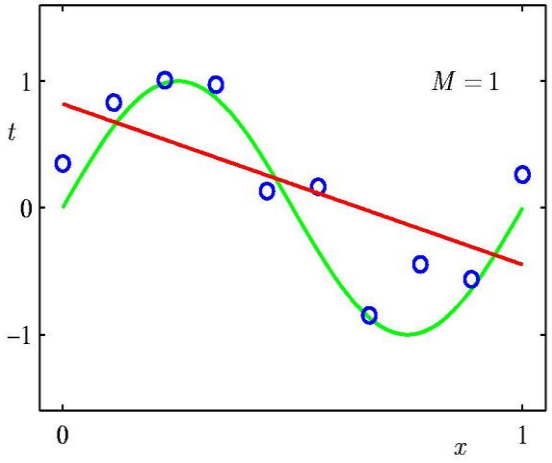
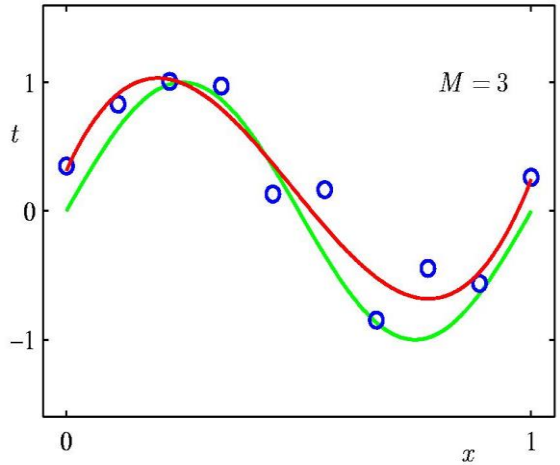
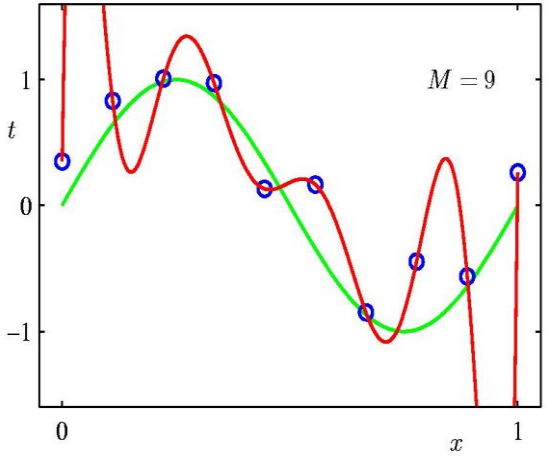
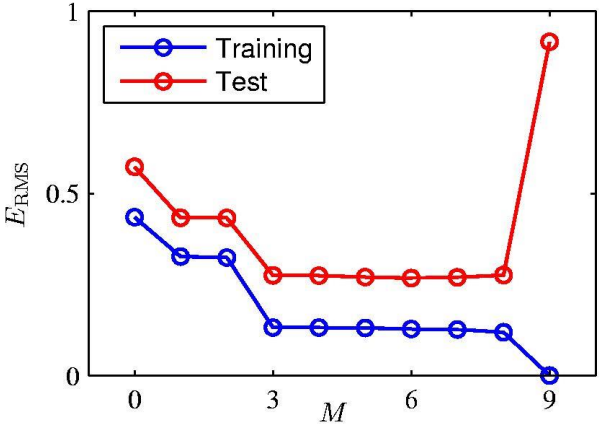
Bias-Variance Tradeoff











Root mean squared error

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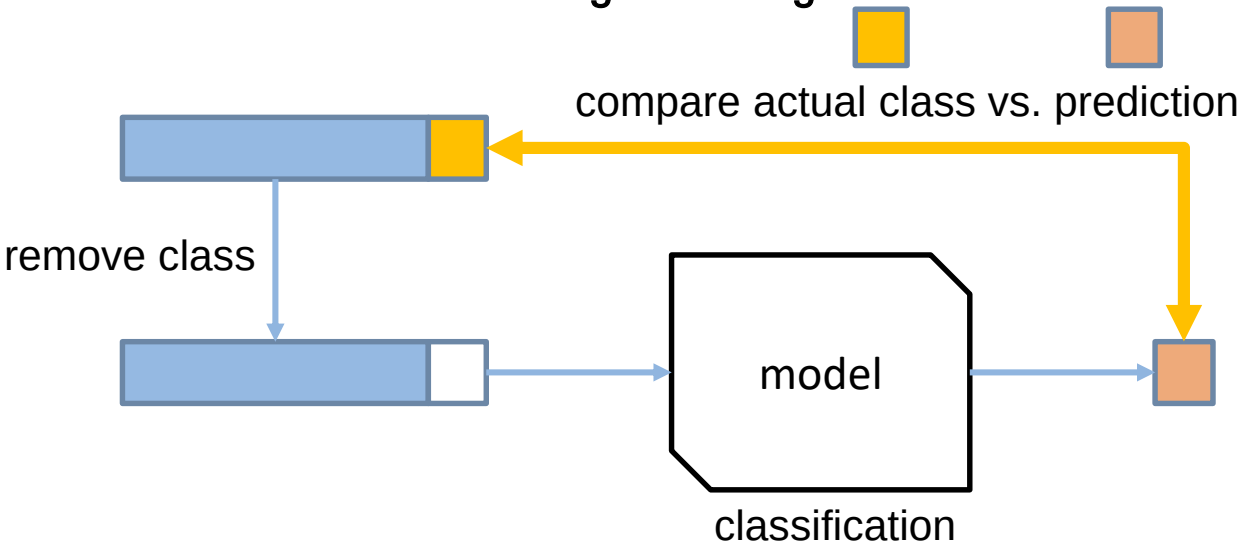
Evaluation – "How good is your model on new data?"

The model classifies an instance, of which the class is *already known*.
Then, *compare* model's prediction *to actual class*.

Which Instances to use for testing?

Instances with known class can be used for training and testing

Competition for classified instances: **training vs. testing**



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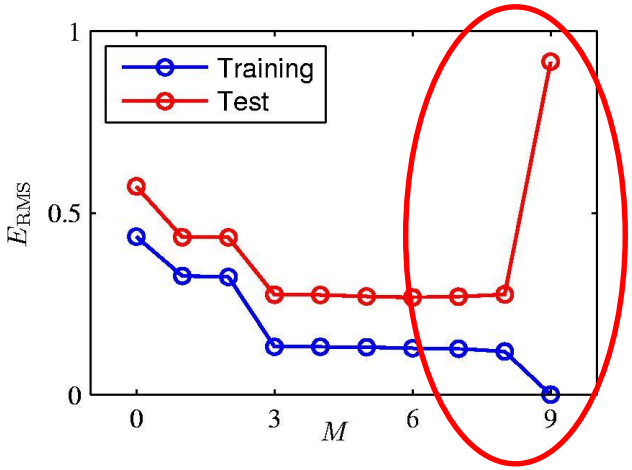
Evaluation using training sets

Using training data also for evaluation:

- Overfitting
- Evaluation is too optimistic, the actual error rate is way higher



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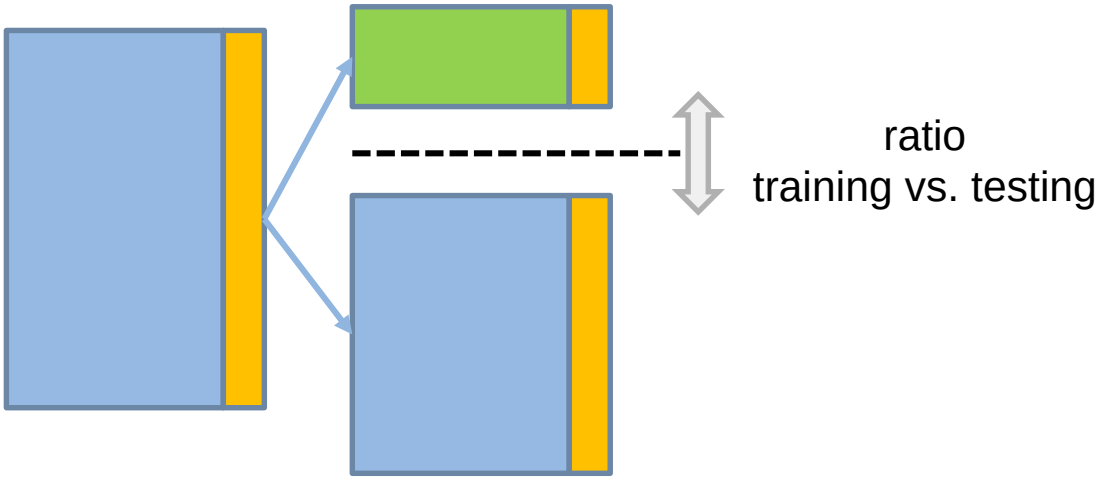
Holdout

Holding out certain instances for evaluation, not for training:

- Reduces the number of training instances
- Composition (e.g. distribution of the classes) influences results

Solution: Stratified holdout

- More reliable results using stratification
- Some instances may never be used for training/testing



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k-fold Cross-Validation

- Partition the data set into k complementary subsets
- Train on $k-1$ subsets, test on 1 subset
- Every subset is used $k-1$ times for training and 1 time for testing
- Stratification of subsets is possible

Example: k = 5

Average error,

$$\hat{e} = \frac{1}{k}\sum_{i=1}^{k} e_i$$

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Leave One Out Validation

- k-fold cross validation with k = N, where N is the number of training instances
- Deterministic, a lot of time required for computing
- Extreme class distribution of test data
- Example: N = 5000
  each of which is used 4999 times for training and 1 time for testing
  5000 models need to be trained

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Statistical tests – t-test

Results of a **validation** may be considered as random chance

- Only *significant* difference between classifiers is interesting

A paired t-test checks whether mean accuracy of two classifiers are significantly **different**

- H_0: $d = 0$
- H_1 : $d \neq 0$ (depend on question)

$$\bar{d} = \frac{1}{k}\sum_{i=1}^{k} d_i \qquad s_d = \sqrt{\frac{1}{k-1}\sum_i \left(d_i - \bar{d}\right)^2} \qquad t = \frac{\bar{d}}{s_d / \sqrt{k}} \sim t_{k-1}$$

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Confusion Matrix

Result of an evaluation containing

- the true class
- the class predicted by the classifier

True Class	Predicted Class	
1	1	True Positive
1	0	False Negative
0	1	False Positive
0	0	True Negative

Confusion Matrix

		Predicted Class	
		Positive	**Negative**
True Class	**Positive**	True Positive	False Negative
	Negative	False Positive	True Negative

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Predicting Probabilities

Classifiers can predict probabilities instead of classes

- A probability is assigned to every class
- Classify using a cutoff
- Helpful in case errors have different impacts (costs)
  - Minimize cost by selecting a suitable cutoff-value

Example:

- The cost of FN is 5 times the cost of FP
- Adjust the classifier to predict positive rather than negative
- Decrease the cutoff-value

		Predicted Class	
		Positive	**Negative**
True Class	**Positive**	0	5
	Negative	1	0

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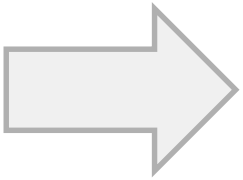
Predicting Probabilities

The probability of a positive class is displayed, instead of the predicted class (cutoff-value=0.5)

True Class	Predicted Class
0	0
0	1
1	1
1	0
0	0
1	0
0	0
1	1
0	1
1	0



True Class	Predicted Class	Probability
0	0	0.34
0	1	0.56
1	1	0.63
1	0	0.45
0	0	0.47
1	0	0.17
0	0	0.26
1	1	0.89
0	1	0.52
1	0	0.43

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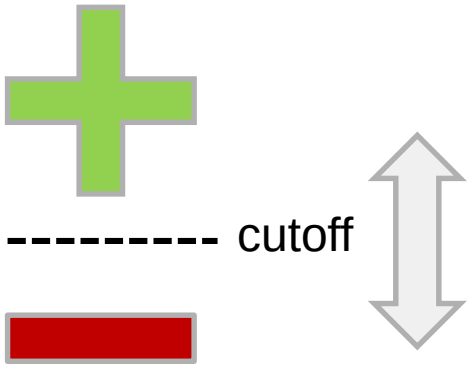
Predicting Probabilities

- Sort by probability:

True Class	Probability
+	0.89
+	0.63
-	0.56
-	0.52
-	0.47
+	0.45
+	0.43
-	0.34
-	0.26
+	0.17



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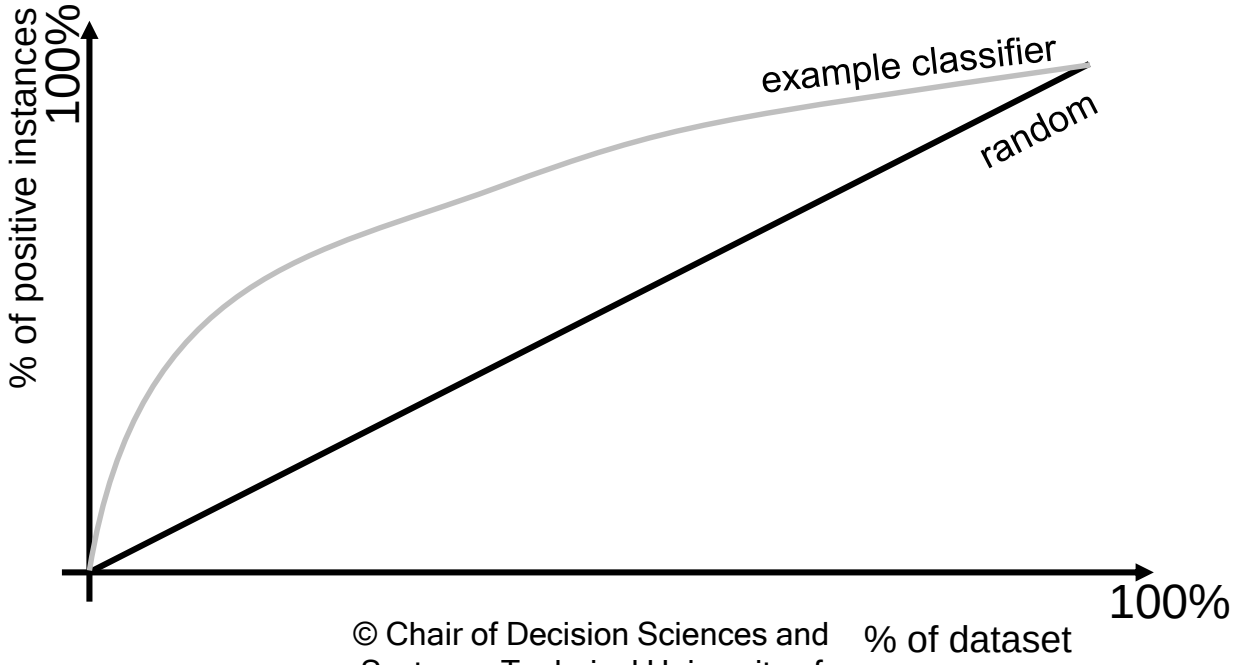
Gain Curve

To visualize results of different cutoffs

- Instances are sorted by probability (descending)
- x-axis: percentage of the data set (or number of instances)
- y-axis: percentage (or number) of positive instances in the fraction (subsample)



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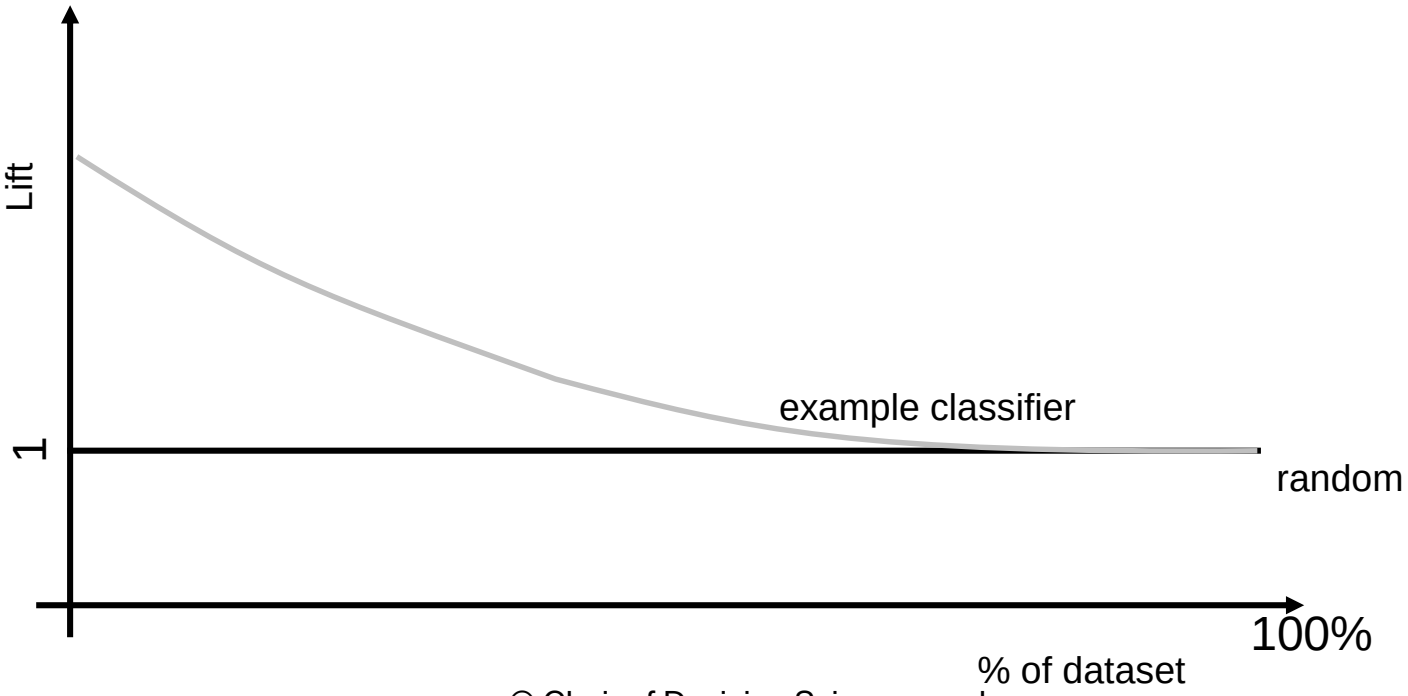
Lift Curve

Displays the factor between the classifier and random value for every part of the gain curve

- x-axis: percentage of the data set (or number of instances)
- y-axis: $\frac{Gain\ at\ x}{x}$



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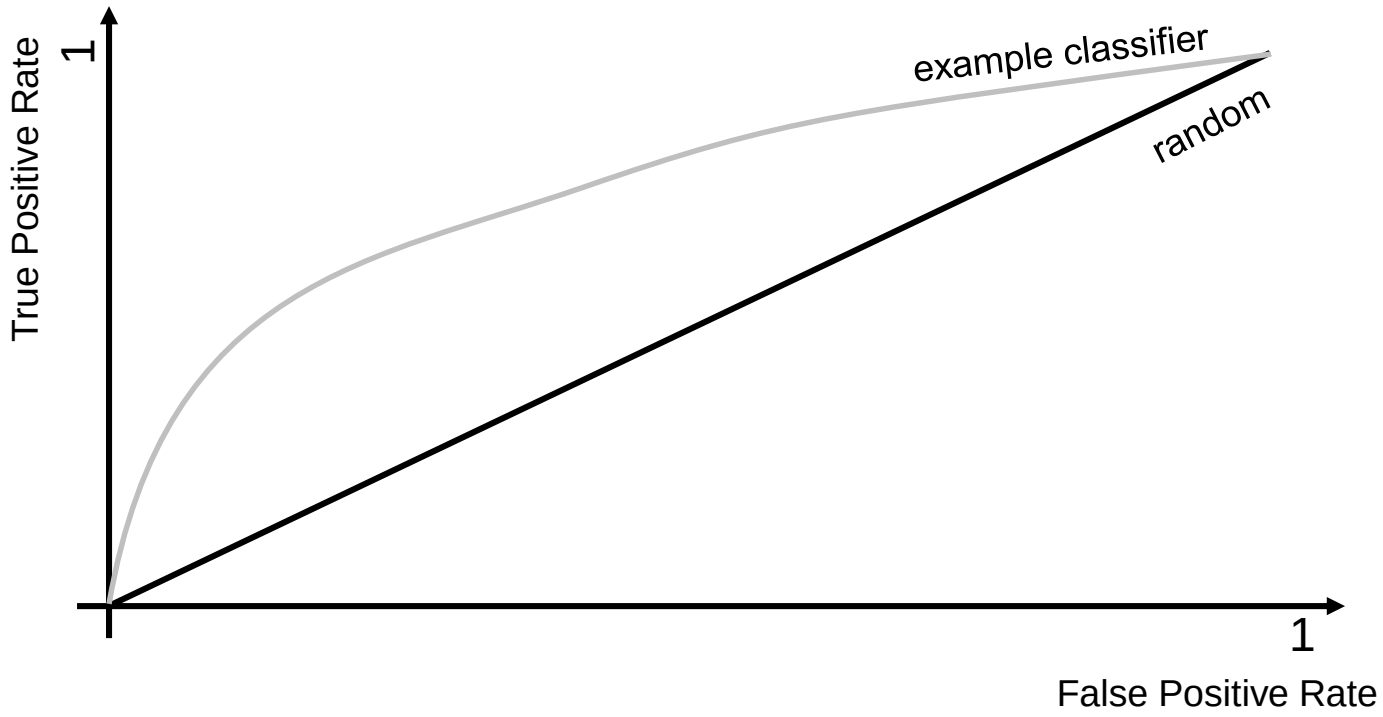
ROC Curve

Displays the ratio of False Positive Rate and True Positive Rate



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