http://poloclub.gatech.edu/cse6242

CSE6242 / CX4242: Data & Visual Analytics

Visualization for Classification

ROC, AUC, Confusion Matrix

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Partly based on materials by
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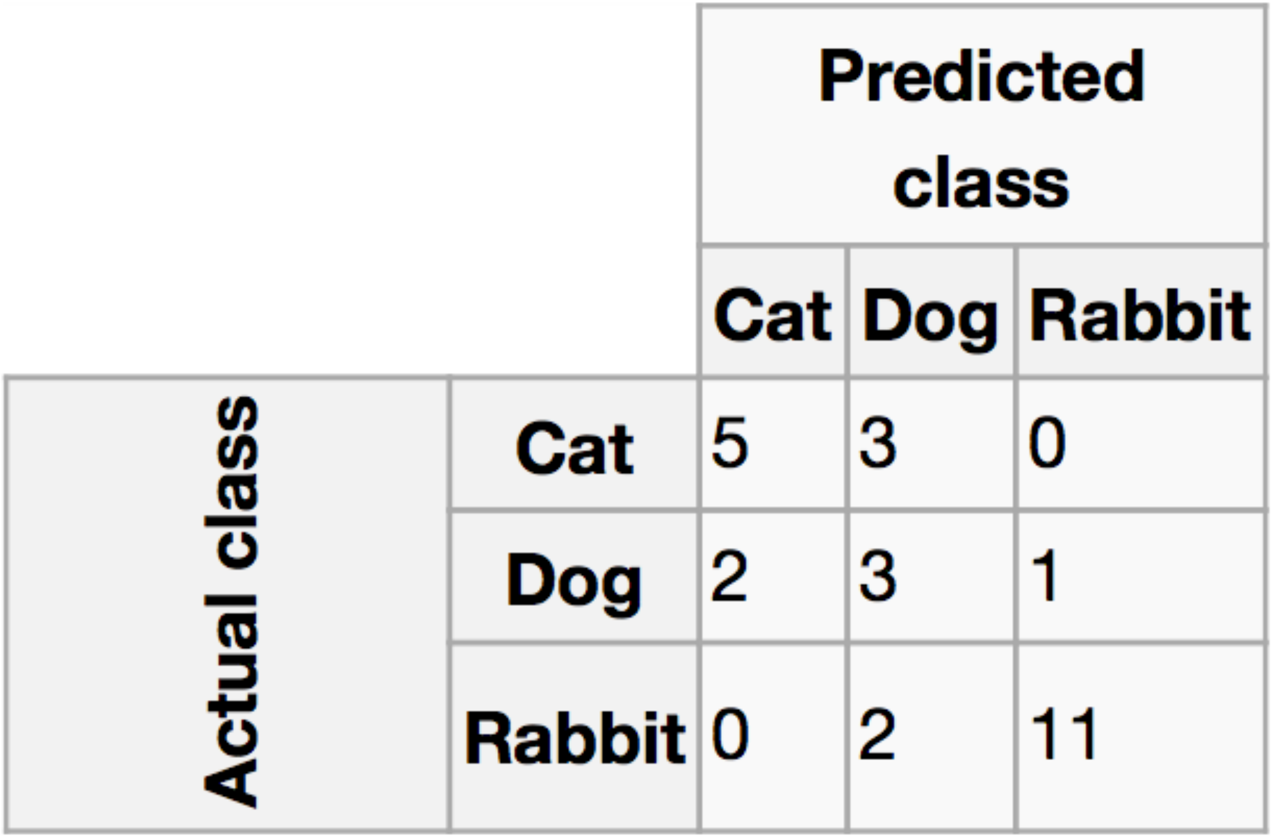
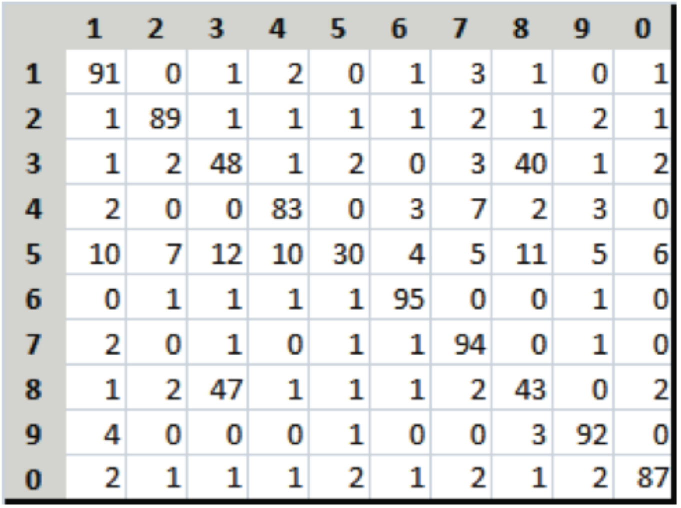
Visualizing Classification Performance

Confusion matrix



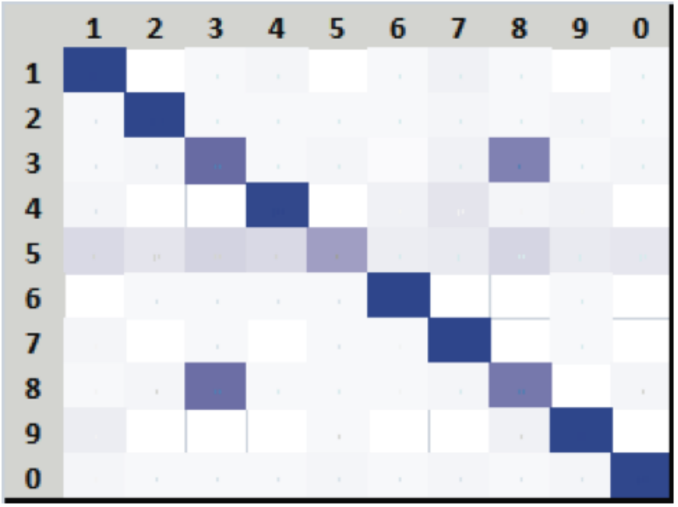
		Predicted class		
		Cat	Dog	Rabbit
Actual class	Cat	5	3	0
	Dog	2	3	1
	Rabbit	0	2	11

https://en.wikipedia.org/wiki/Confusion_matrix



	1	2	3	4	5	6	7	8	9	0
1	91	0	1	2	0	1	3	1	0	1
2	1	89	1	1	1	1	2	1	2	1
3	1	2	48	1	2	0	3	40	1	2
4	2	0	0	83	0	3	7	2	3	0
5	10	7	12	10	30	4	5	11	5	6
6	0	1	1	1	1	95	0	0	1	0
7	2	0	1	0	1	1	94	0	1	0
8	1	2	47	1	1	1	2	43	0	2
9	4	0	0	0	1	0	0	3	92	0
0	2	1	1	1	2	1	2	1	2	87

Hard to spot trends and patterns



Much easier!

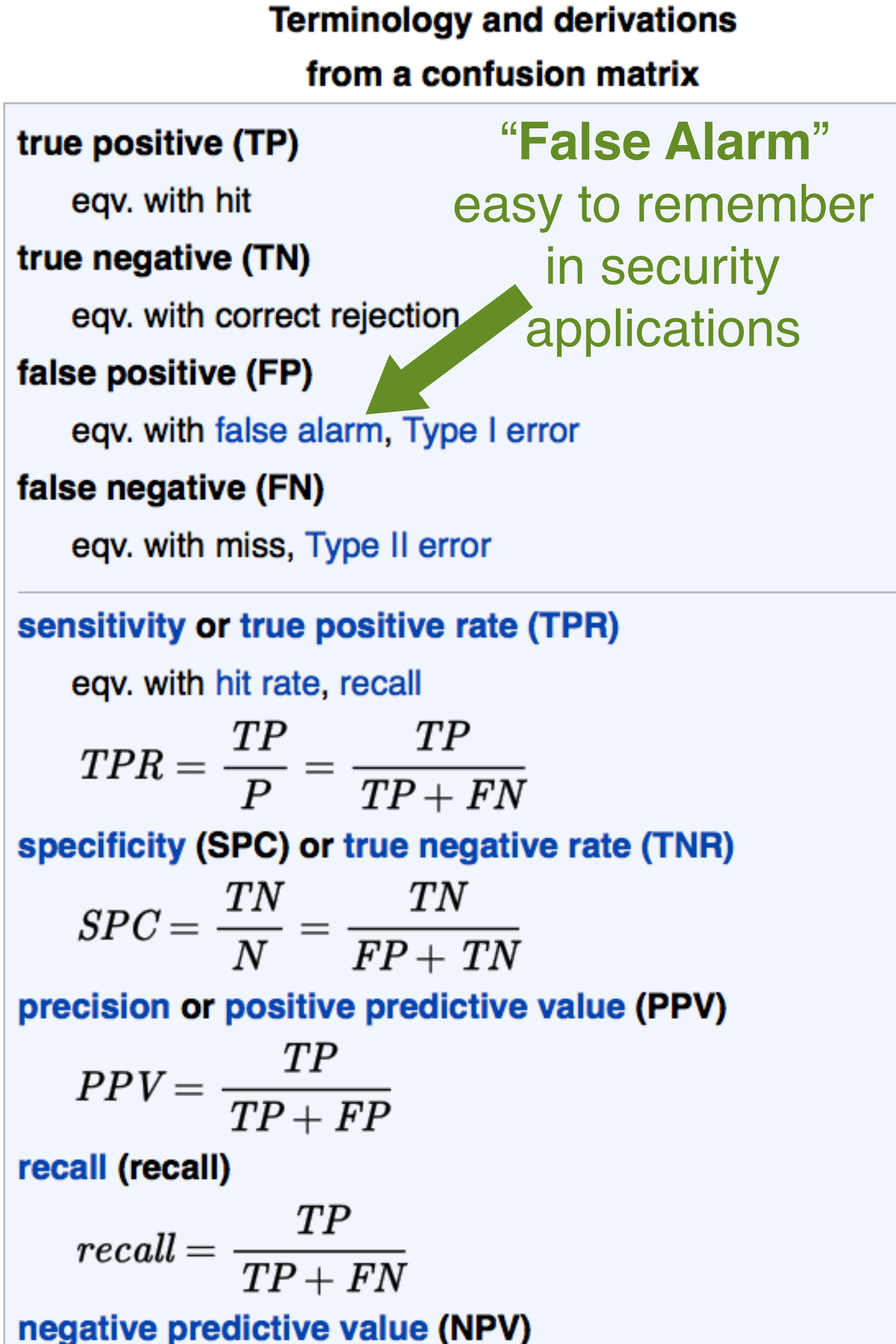
Figure 2. Representations of confusion matrix for a handwritten digit classification task. (top) standard confusion matrix; (bottom) heat-map confusion matrix. It is much easier to identify underlying patterns in the visual representation; 3 and 8 are often misclassified as each other and 5 is misclassified as many different numbers.

http://research.microsoft.com/en-us/um/redmond/groups/cue/publications/CHI2009-EnsembleMatrix.pdf

Very important:
Find out what “positive” means

		Predicated	
		Cat	Dog
Actual	Cat	5	3
	Dog	2	4

Very important: Find out what “positive” means



Terminology and derivations from a confusion matrix

true positive (TP)

eqv. with hit

true negative (TN)

eqv. with correct rejection

false positive (FP)

eqv. with false alarm, Type I error

false negative (FN)

eqv. with miss, Type II error

sensitivity or true positive rate (TPR)

eqv. with hit rate, recall

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

specificity (SPC) or true negative rate (TNR)

$$SPC = \frac{TN}{N} = \frac{TN}{FP + TN}$$

precision or positive predictive value (PPV)

$$PPV = \frac{TP}{TP + FP}$$

recall (recall)

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

negative predictive value (NPV)

“False Alarm”
easy to remember
in security
applications

https://en.wikipedia.org/wiki/Confusion_matrix

Visualizing Classification Performance

using

ROC curve

(Receiver Operating Characteristic)

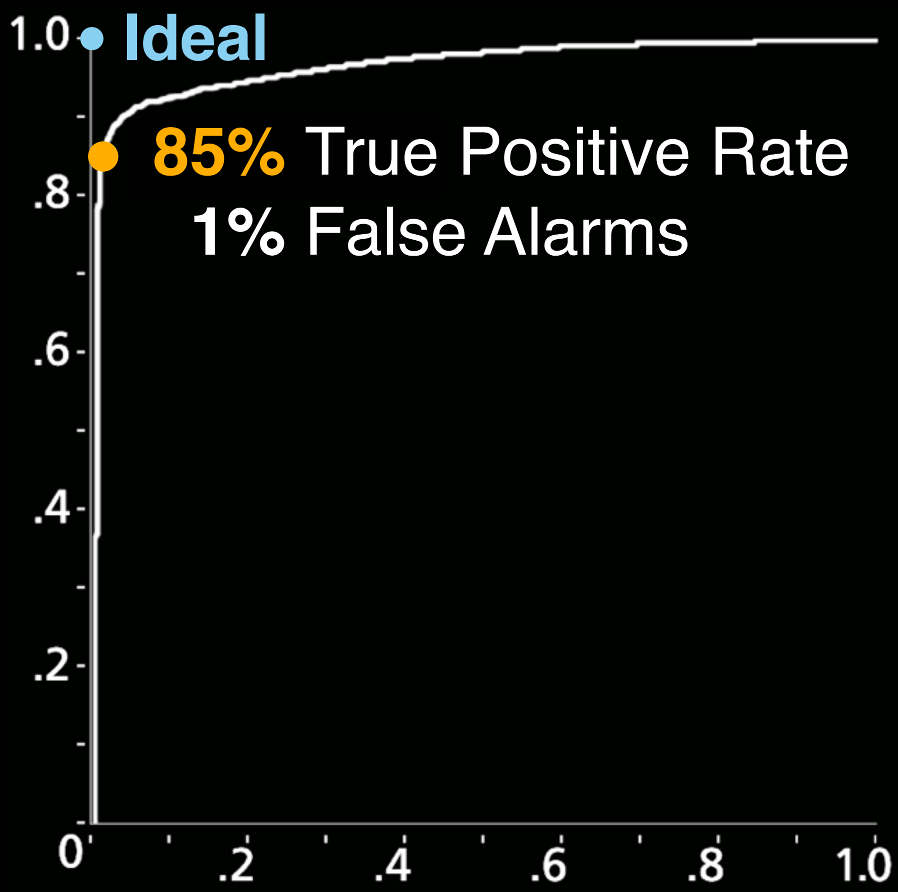
Polonium's ROC Curve

Positive class: malware

Negative class: benign

True Positive Rate

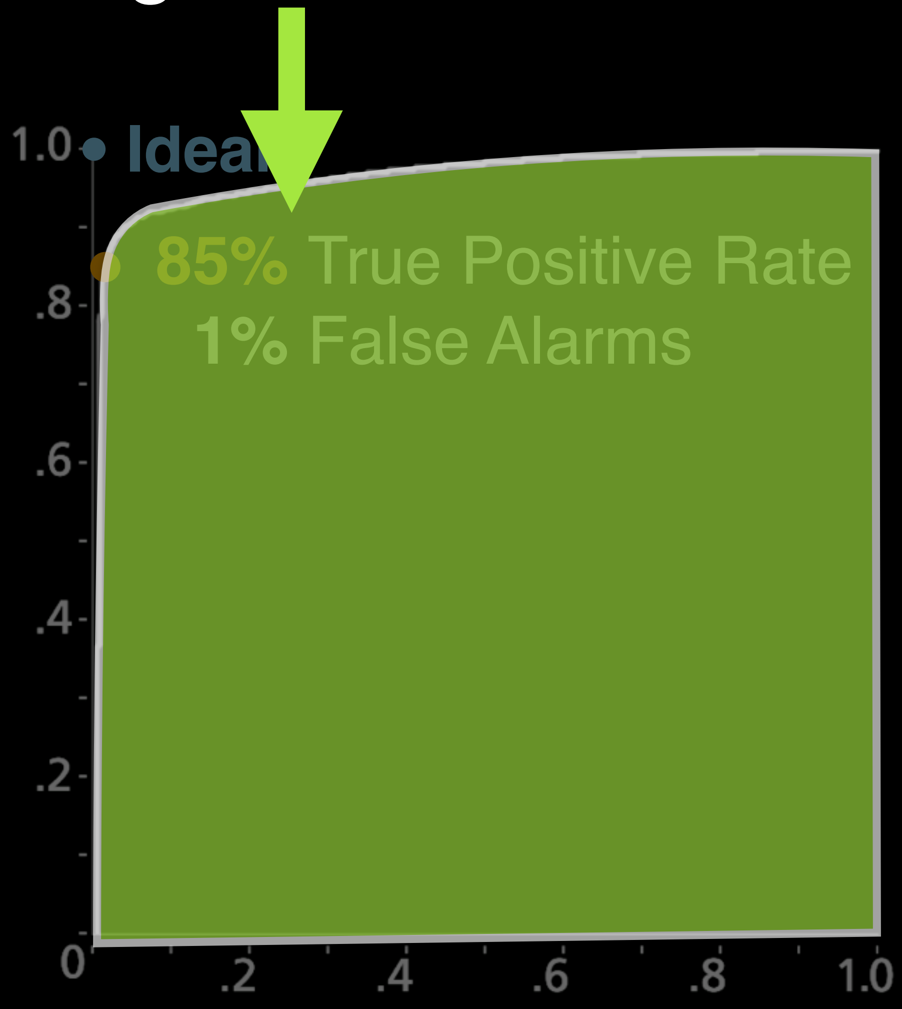
% of **bad** correctly labeled



False Positive Rate (False Alarms)

% of **good** labeled as **bad**

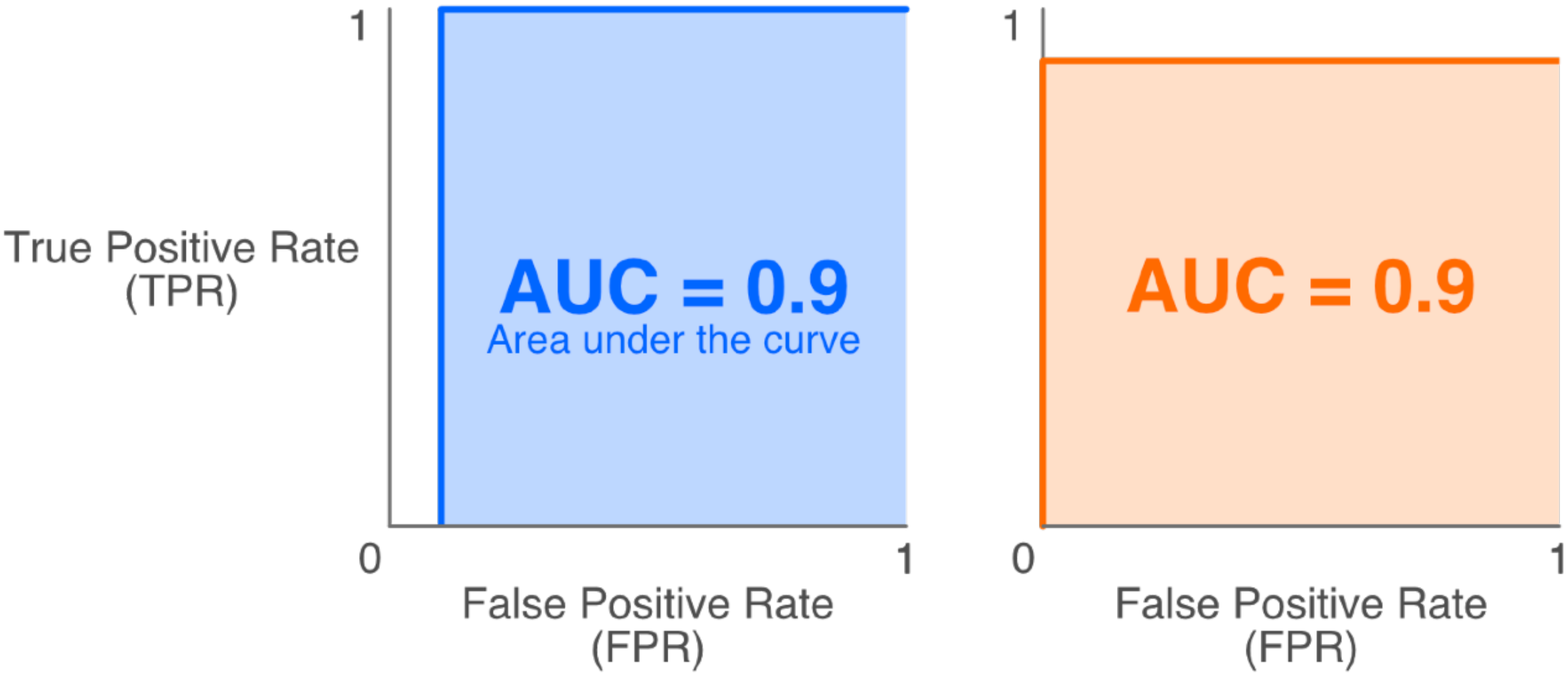
Measuring Classification Performance
using **AUC** (Area under the curve)



If a machine learning algorithm achieves **0.9 AUC** (out of 1.0),

that’s a great algorithm, right?

Be Careful with AUC!



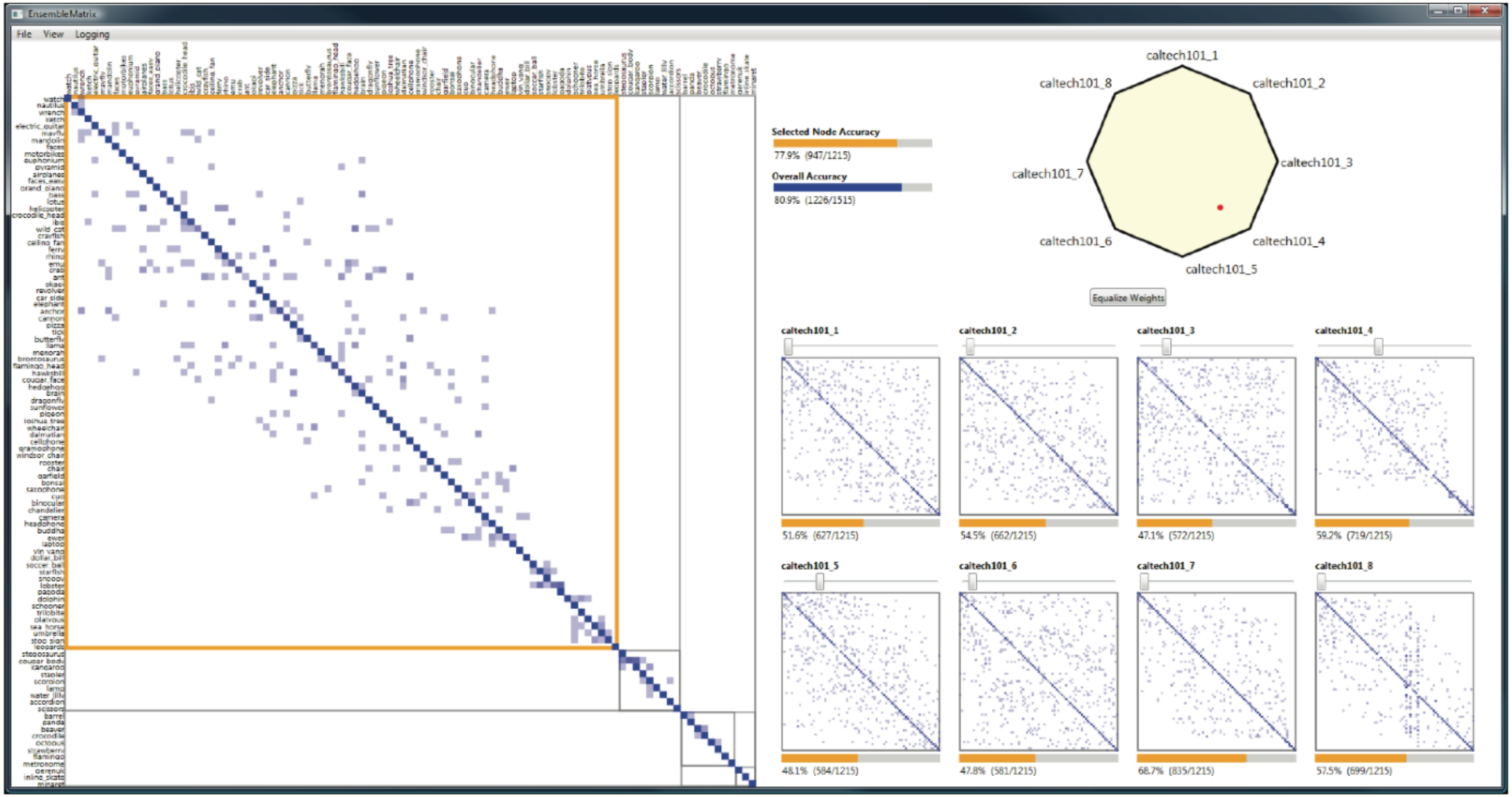
Weights in combined models

Bagging / Random forests

- Majority voting

Let people play with the weights?

EnsembleMatrix



Selected Node Accuracy
77.9% (947/1215)

Overall Accuracy
80.9% (1226/1515)

caltech101_1
51.6% (627/1215)

caltech101_2
54.5% (662/1215)

caltech101_3
47.1% (572/1215)

caltech101_4
59.2% (719/1215)

caltech101_5
48.1% (584/1215)

caltech101_6
47.8% (581/1215)

caltech101_7
68.7% (835/1215)

caltech101_8
57.5% (699/1215)

Figure 1. Primary view in EnsembleMatrix. Confusion matrices of component classifiers are shown in thumbnails on the right. The matrix on the left shows the confusion matrix of the current ensemble classifier built by the user.

http://research.microsoft.com/en-us/um/redmond/groups/cue/publications/CHI2009-EnsembleMatrix.pdf

Improving performance

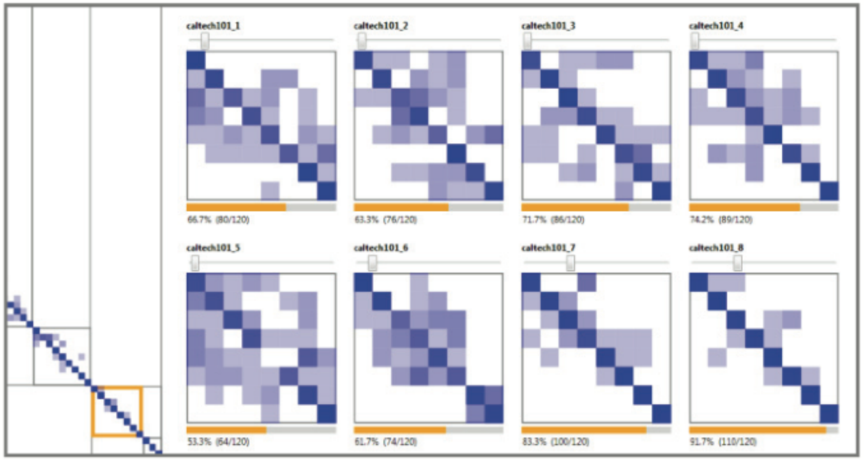


Figure 3. After partitioning the matrix, selecting a partition, outlined in orange, causes the thumbnails to display only the data instances in that partition. The component classifiers demonstrate very different behavior in this partition, including clustering and large differences in accuracy.

- Adjust the weights of the individual classifiers
- Data partition to separate problem areas
  - Adjust weights just for these individual parts
- Caveat: evaluation used one dataset

http://research.microsoft.com/en-us/um/redmond/groups/cue/publications/CHI2009-EnsembleMatrix.pdf