ML Exercise 1

Classification

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Datasets

- Heart disease
- Amazon
- Congressional voting
- Polish company bankruptcy

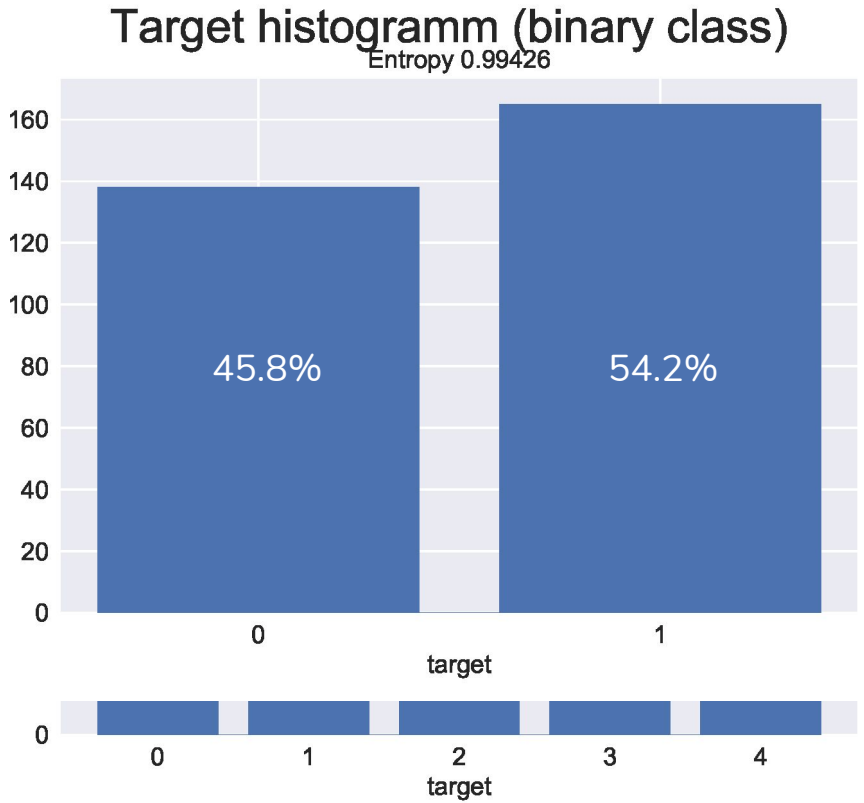
Classifiers

- K-Nearest Neighbors (KNN)
- Random Forest (RF or RFC)
- Multilayer Perceptron (MLP)

Dataset	samples	dimensions	Nominal/ordinal	# of classes	missing values
Heart Disease	303	14	mixed	5	very few
Amazon	750	10000	ordinal	50	no
Companies	6k	64	ordinal	binary	~1,5%
Congress	218	17	nominal/binary	binary	no

Heart Disease

Heart Disease



Small + low dimensional:

- Samples: 303
- Features: 13 + 1 target
- Target (5 classes):
  - 0… no disease
  - 1,2,3,4… different diseases
  - Uneven target distribution
- Evaluation: Accuracy + F1-score (balanced model)
  - Custom cost matrix: domain expert needed

Data preparation

Features			
numerical		categorical	
name	range	name	range
age	29 - 77	sex	0, 1
trestbps	94 - 200	cp	0, 1, 2, 3
chol	126 - 564	fbs	0, 1, 2
thalach	71 - 202	restecg	0, 1, 2
oldpeak	0 - 6.2	exang	0, 1
-	-	slope	0, 1, 2
-	-	ca	0, 1, 2, 3, 4
-	-	thal	3, 6, 7 → 0, 2, 1

Features:

- 5 numerical
  - different ranges → scale
- 8 categorical
  - 2 - 5 encoded categories per feature
- 5 samples with missing values in “ca” or “thal” (entry “?” in csv → hard to spot)
  - 1.5% of samples: no gain if imputed → simply drop samples

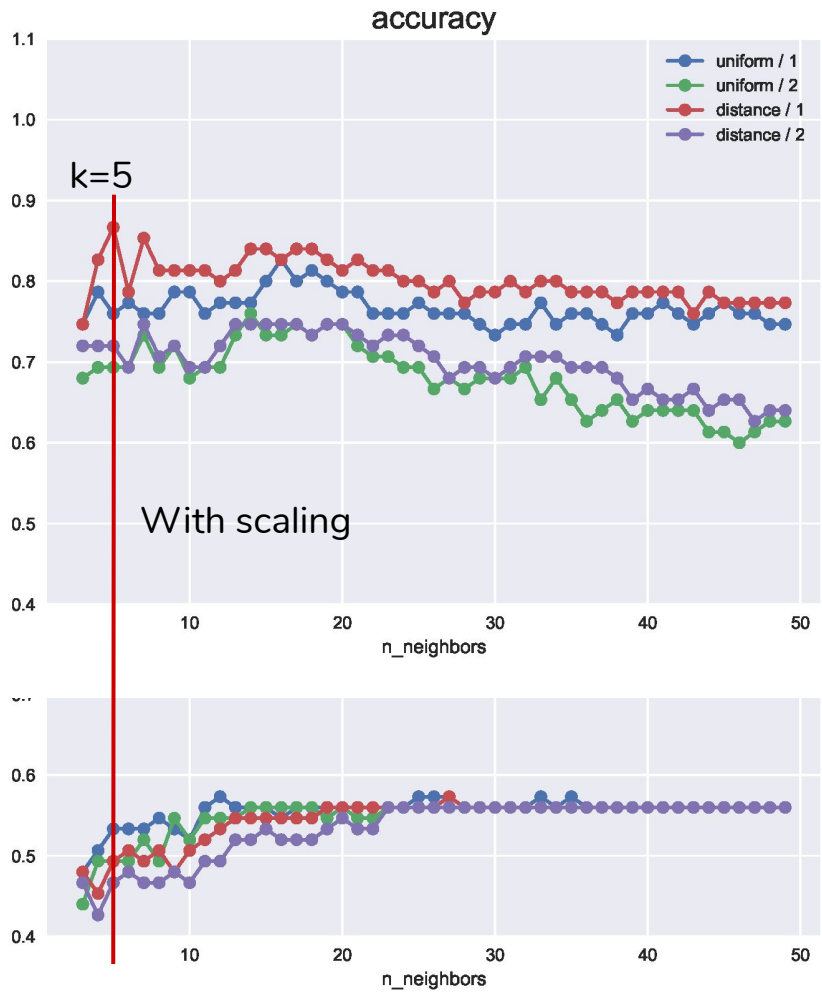
KNN Classifier

Results:

- Unscaled: BAD
  - CM: only guesses 0
- Scaled: OKAY
- norm:

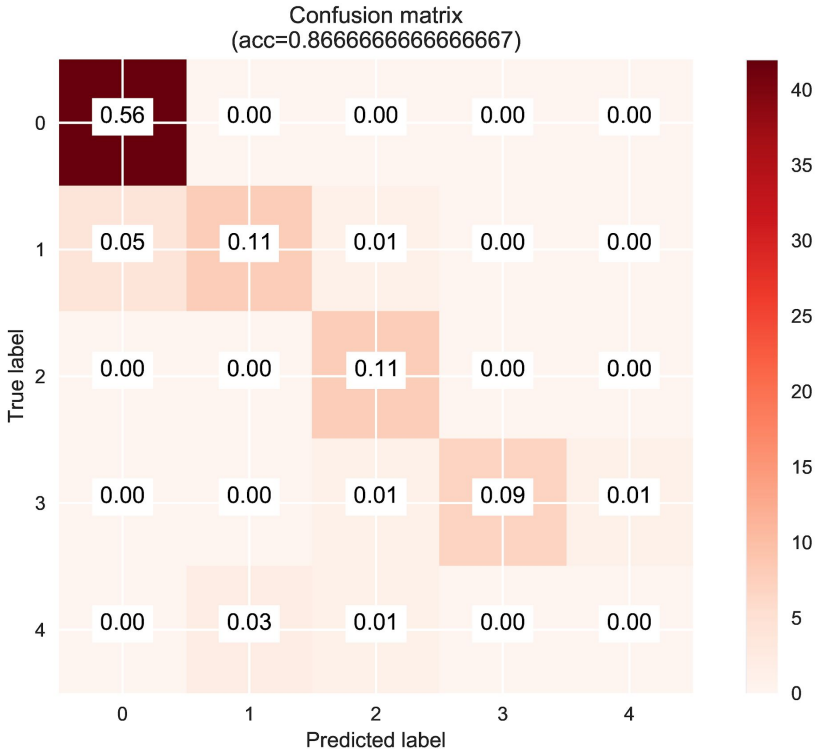
  Manhattan (p=1) > Euclidean (p=2)
- weights:

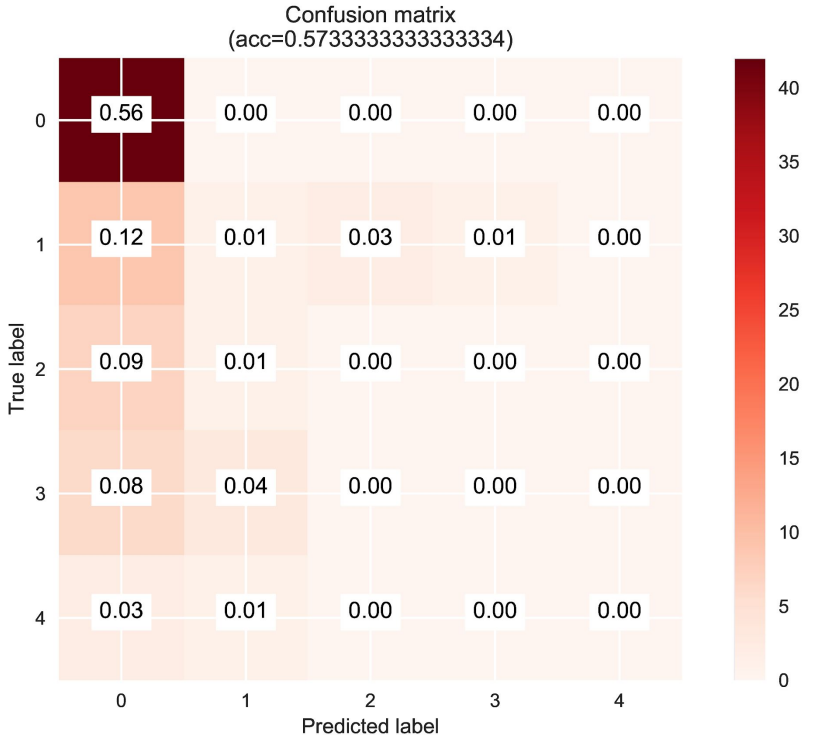
  distance > uniform



KNN Classifier - Confusion Matrices (BONUS)

Scaled vs. unscaled

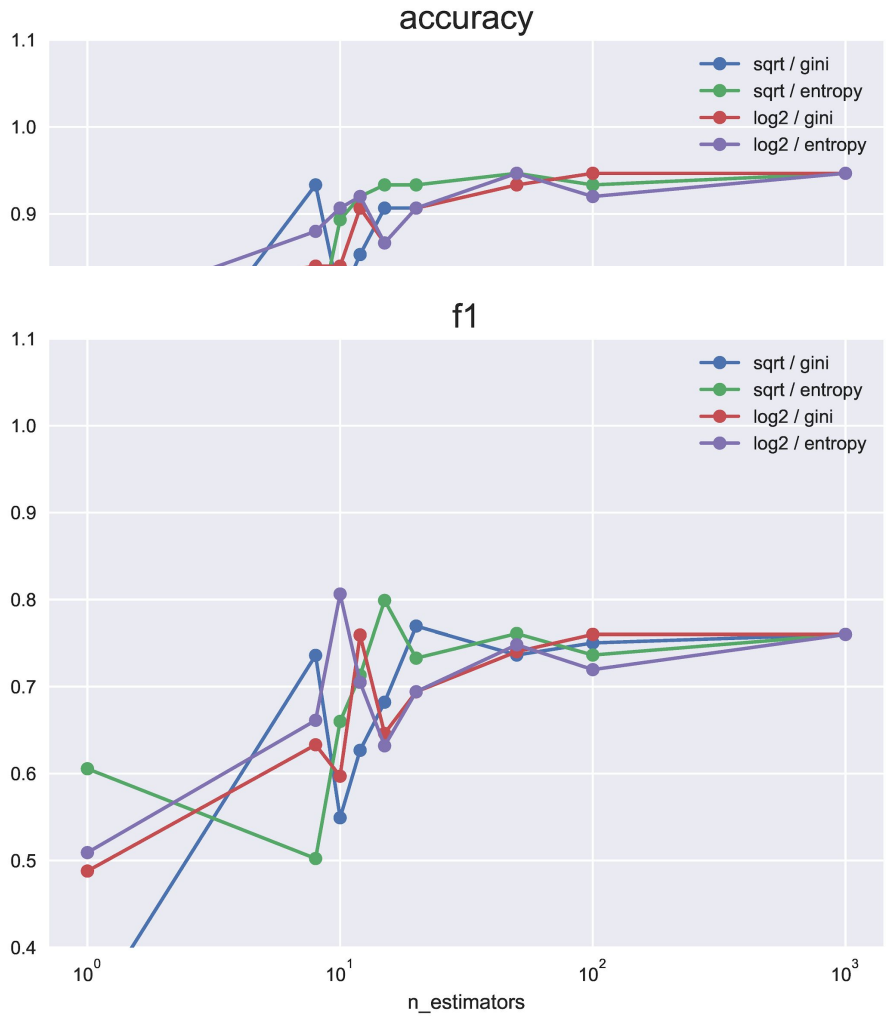




RF Classifier (BONUS)

Results:

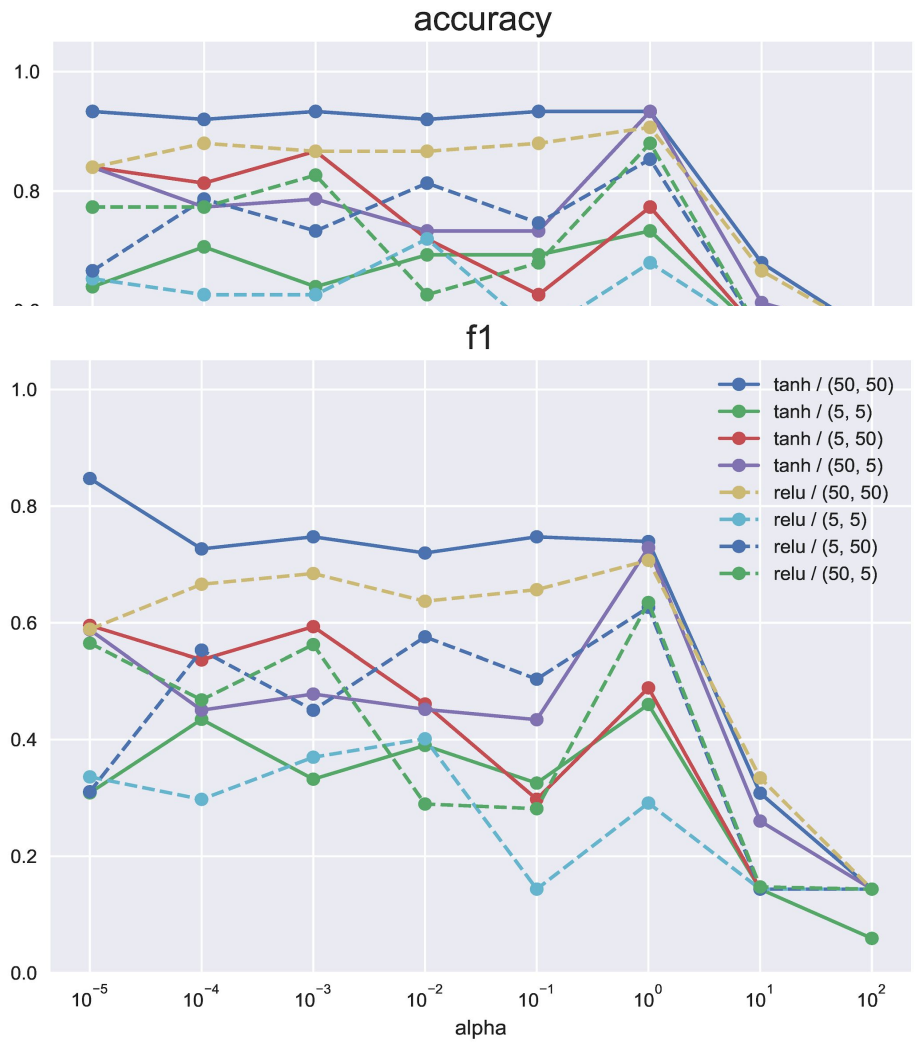
- scaled, unscaled: no difference
- n_estimators:
  - 10 - 20 best
- criterion:
  - entropy > gini
- max features (per split):
  - no difference



MLP Classifier

Results:

- scaled > unscaled data
  - right side: scaled
- Regularization alpha:
  - 1e-5 best (even smaller?)
- activation:
  - mostly relu > tanh
  - BUT: tanh has best
- hidden layers:
  - bigger = better



Final decision

RF

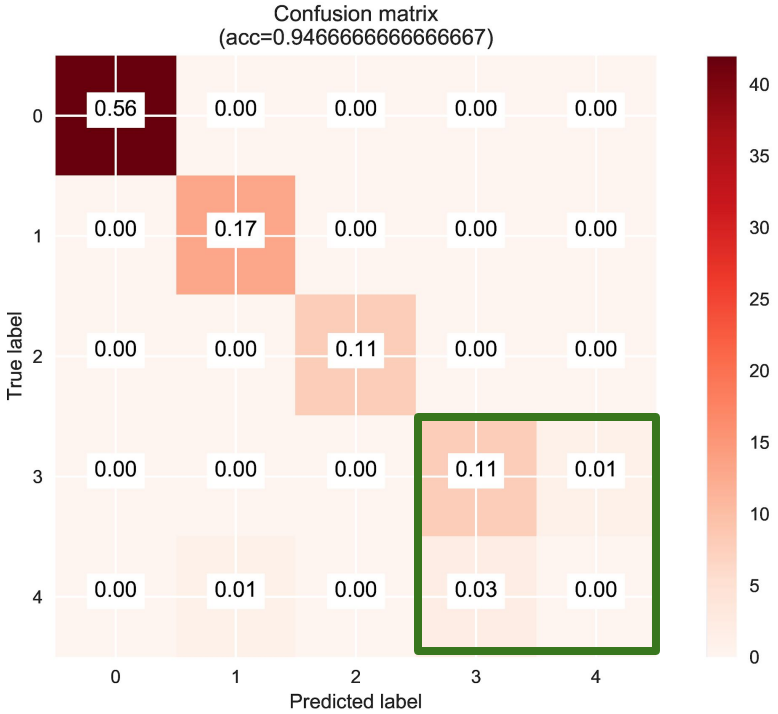
F1=0.801

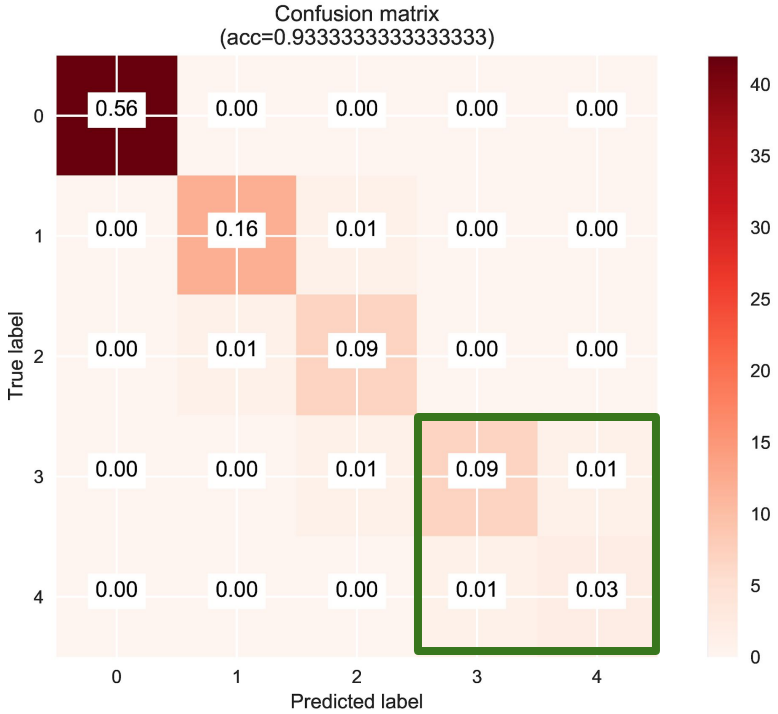
vs

WINNER

MLP

F1=0.847





Amazon

Amazon

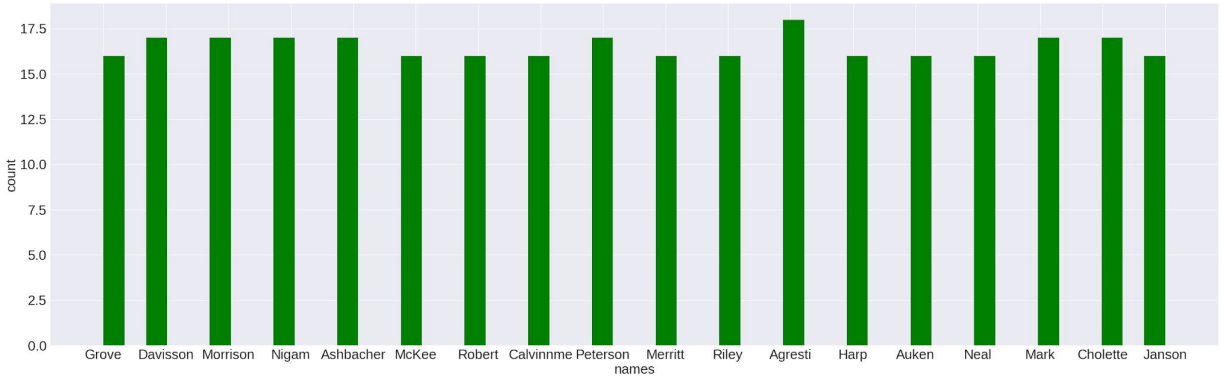
Description:

Class: 50 different names

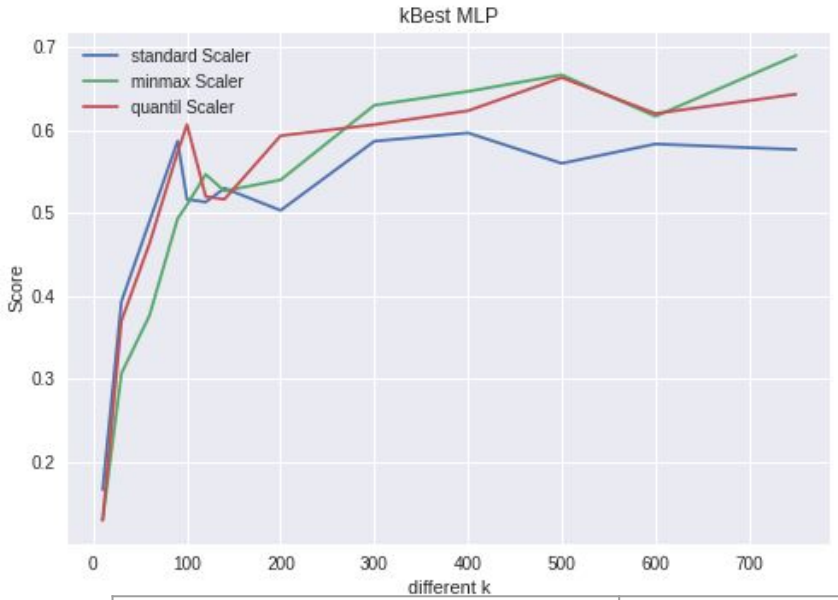
features: numeric values

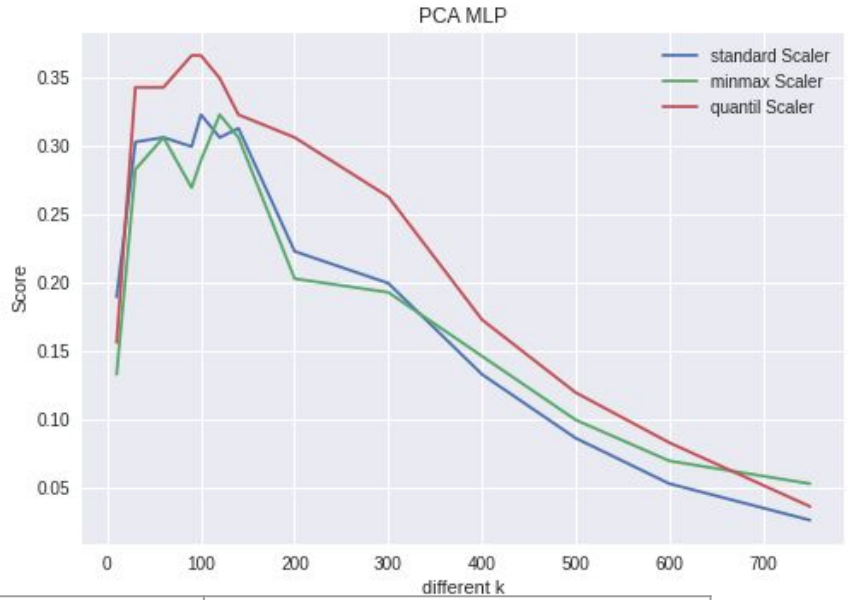
Preparation:

feature selection: kBest or PCA



Feature Selection





Classifier	k-value	scaler
Knn	500	quantil
RFC	300	quantil
MLP	750	MinMax

Results

parameter:

KNN n_neighbors = 8; weights = distance; algorithm = auto

RFC n_estimators = 1000; max_features = sqart; criterion = gini

MLP alpha = 0.01; layers = (100,100); solver = lbfgs; activation = tanh

Classifier	score	F1 score	recall	precision	runtime
Knn	0.477	0.453	0.489	0.537	0.059s
RFC	0.593	0.572	0.612	0.627	6.558s
MLP	0.616	0.608	0.636	0.622	10.969s

Congressional Voting

Congressional Voting

Description:

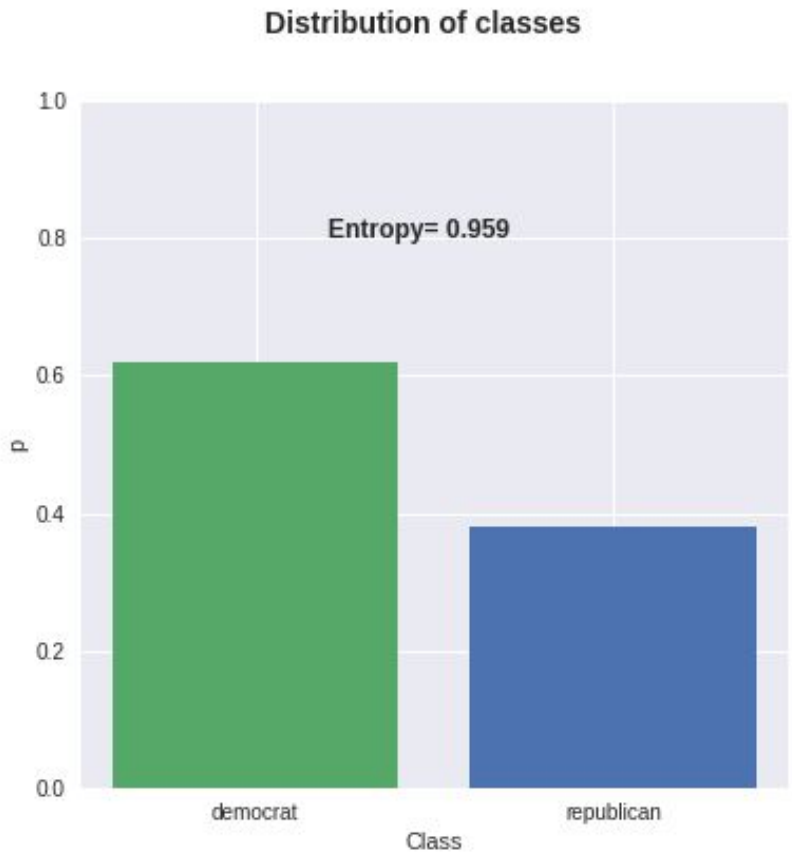
Class: Republicans or Democrats

features: nominal values “y”, “n” and “unknown”

Preparation:

write “n” -> -1; “y” -> 1; “unknown” -> 0

even distributed -> prevent scaling



Results KNN

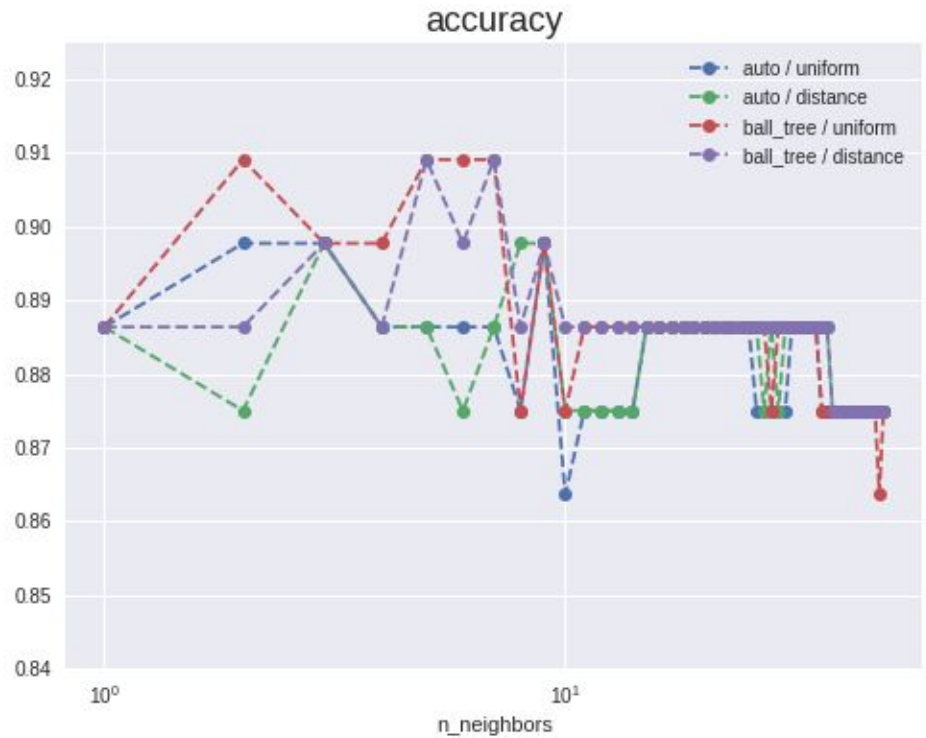
parameter:

auto/ball_free or uniform/distance

results:

very short time

a good score



score	F1 score	precision	recall	runtime
0.915909	0.915368	0.916842	0.914155	2.082ms

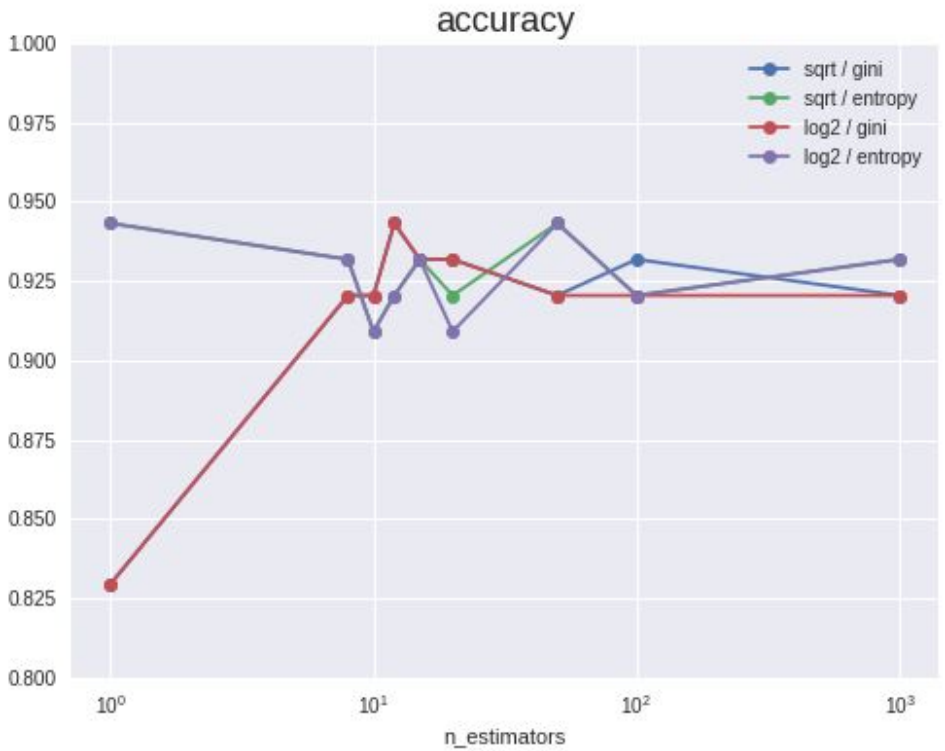
Results RFC

parameter:

sqrt/log2 or gini/entropy

results:

better score than the KNN



score	F1 score	precision	recall	runtime
0.9476	0.9296	0.9276	0.92445	4.402s

Results MLP

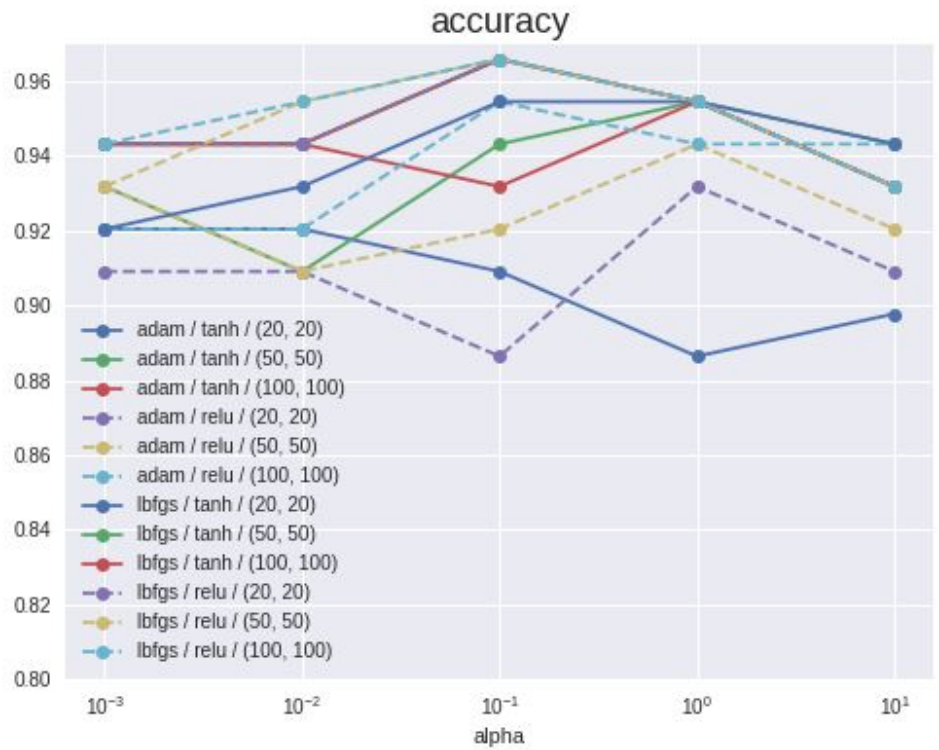
parameter:

adam/lbfgs or tanh/relu

results:

best score

200 times more intensive

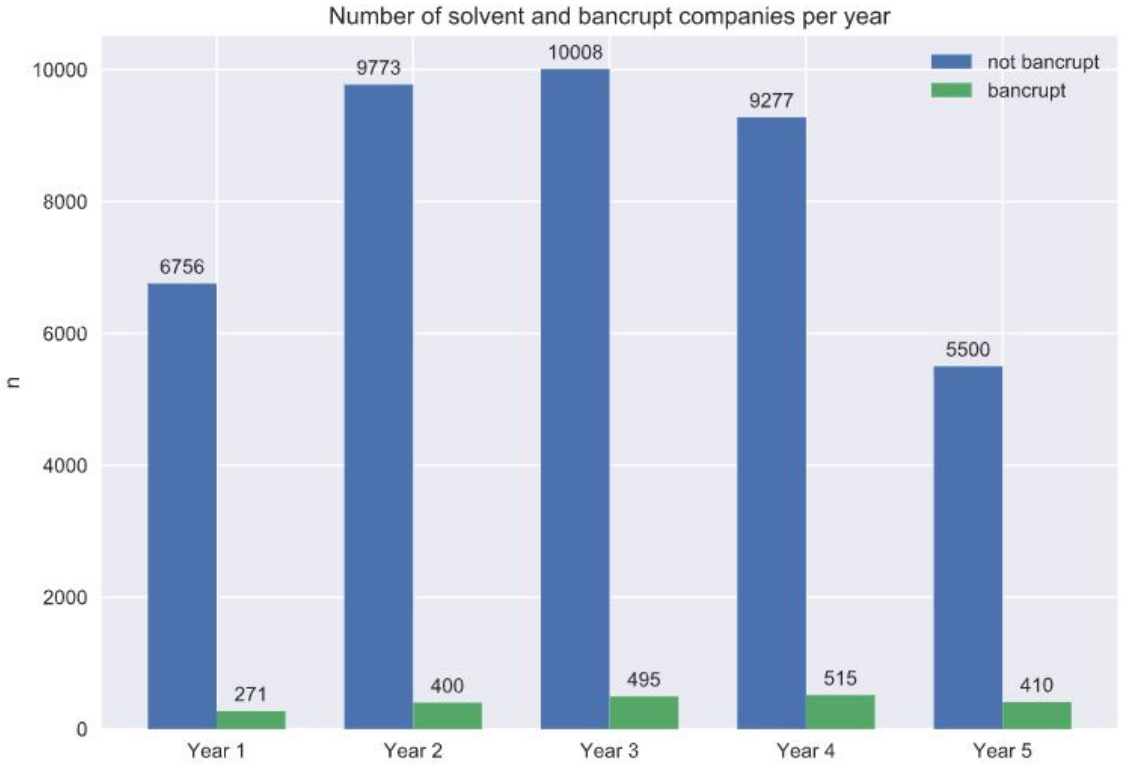


score	F1 score	precision	recall	runtime
0.965	0.9653	0.9641	0.9668	487.08s

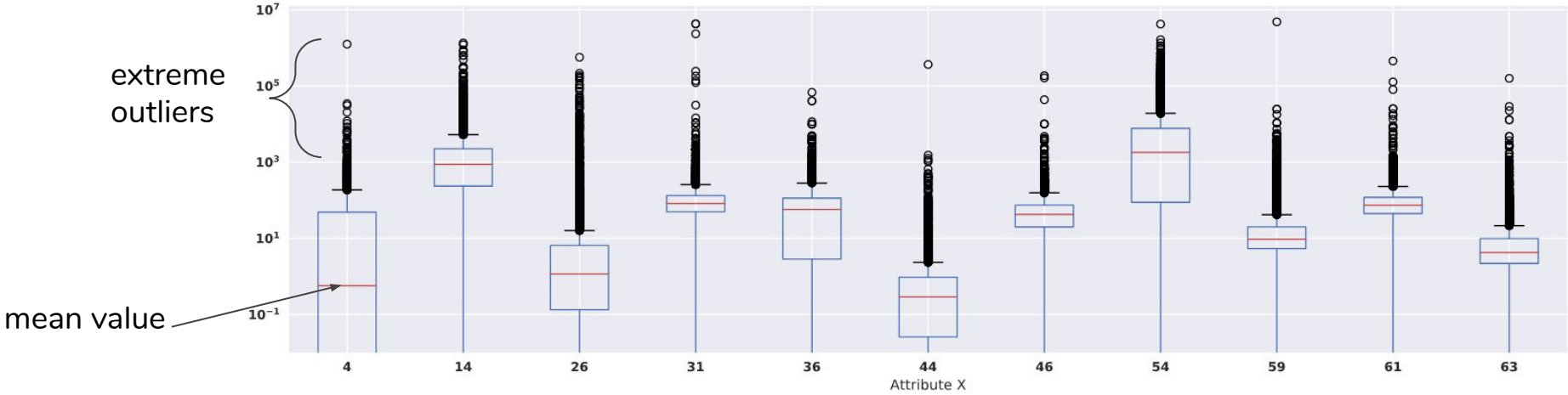
Polish Company Bankruptcy

Polish company bankruptcy

- 5 data sets
- 5k-10k samples / year
- 64 dimensions
- 2 different classes
- high imbalance of class distribution ~15:1



Preprocessing



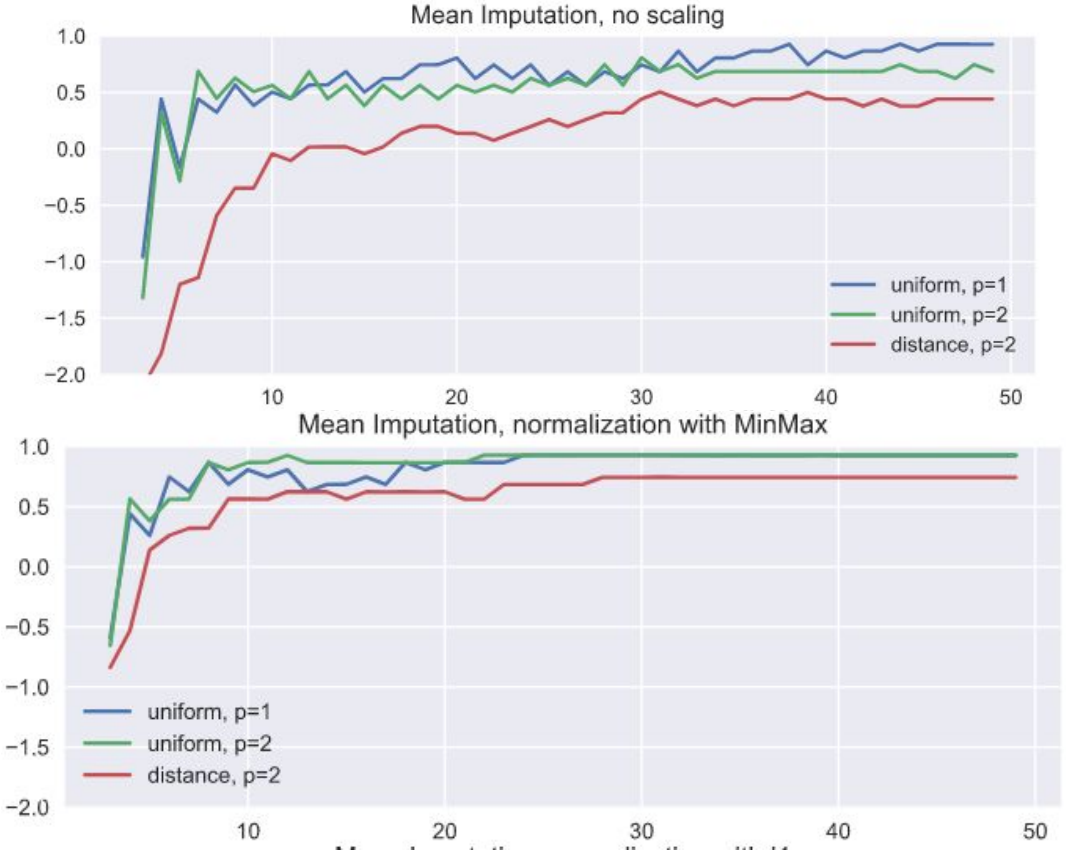
-> Normalization expected to have a positive impact

Rating classifiers / Cost Matrix

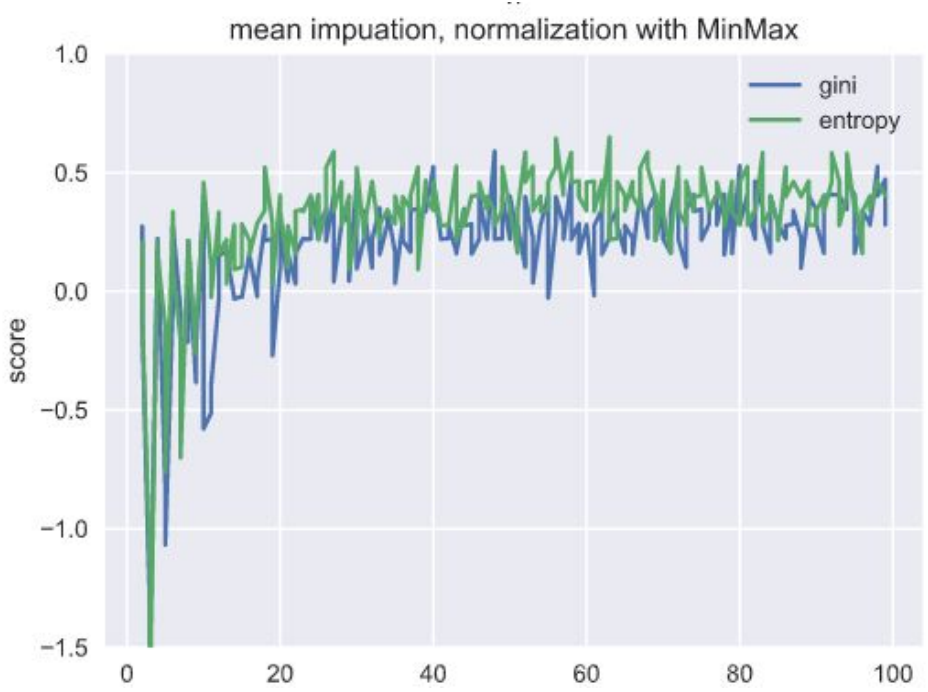
- FP is much worse than FN
- Rating based on normalized cost
    - 1: perfect prediction
    - 0 -1: good model
    - < 0: bad model

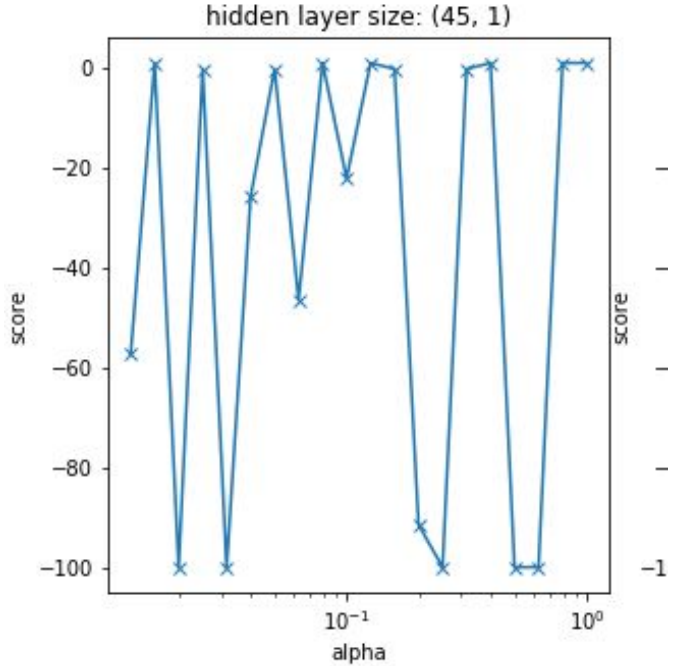
Cost Matrix		actual	
		solvent	**bankrupt**
pred.	**solvent**	-1 (TP)	100 (FP)
	bankrupt	1 (FN)	0 (TN)

Findings - KNN



Findings - RFC and MLP





Findings - Conclusion

Cost Matrix		actual	
		solvent	**bankrupt**
pred.	**solvent**	-1 (TP)	100 (FP)
	bankrupt	1 (FN)	0 (TN)

- KNN reached the highest score consistently
- Classifiers with few FP are favored due to cost matrix
- No model with high recall AND precision was found
- => best models have low recall / high precision

	accuracy	score	F1 score	precision	recall	runtime
k-nearest neighbors	0.9362	0,9303	0,1374	0.9000	0.0743	0,142s
random forest	0.9334	0.6864	0.1060	0.6363	0.0578	0,664s
multi-layer perceptron	0.9328	0.8674	0.0480	0.7500	0.0247	3,811s

Scores

$$\text{ACC} := \frac{\text{TP} + \text{TN}}{\text{n\_samples}}$$

$$\text{Recall} := \frac{\text{TP}}{\text{TP} + \text{FN}}$$

punishes false negatives
ability to find all positive samples

$$\text{F1} := \frac{2 \cdot \text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}}$$

$$\text{Precision} := \frac{\text{TP}}{\text{TP} + \text{FP}}$$

punishes false positives
ability to not mislable negative samples