WIR BEGEISTERN UNSERE KUNDEN MIT
EMOTIONALEN FAHRERLEBNISSEN.

PRÄZISE - CHARAKTERSTARK - INNOVATIV

MACHINE LEARNING AS A EXAMPLE FOR OVERRIDE DETECTION

SUPERVISED MACHINE LEARNING WITH MATLAB.

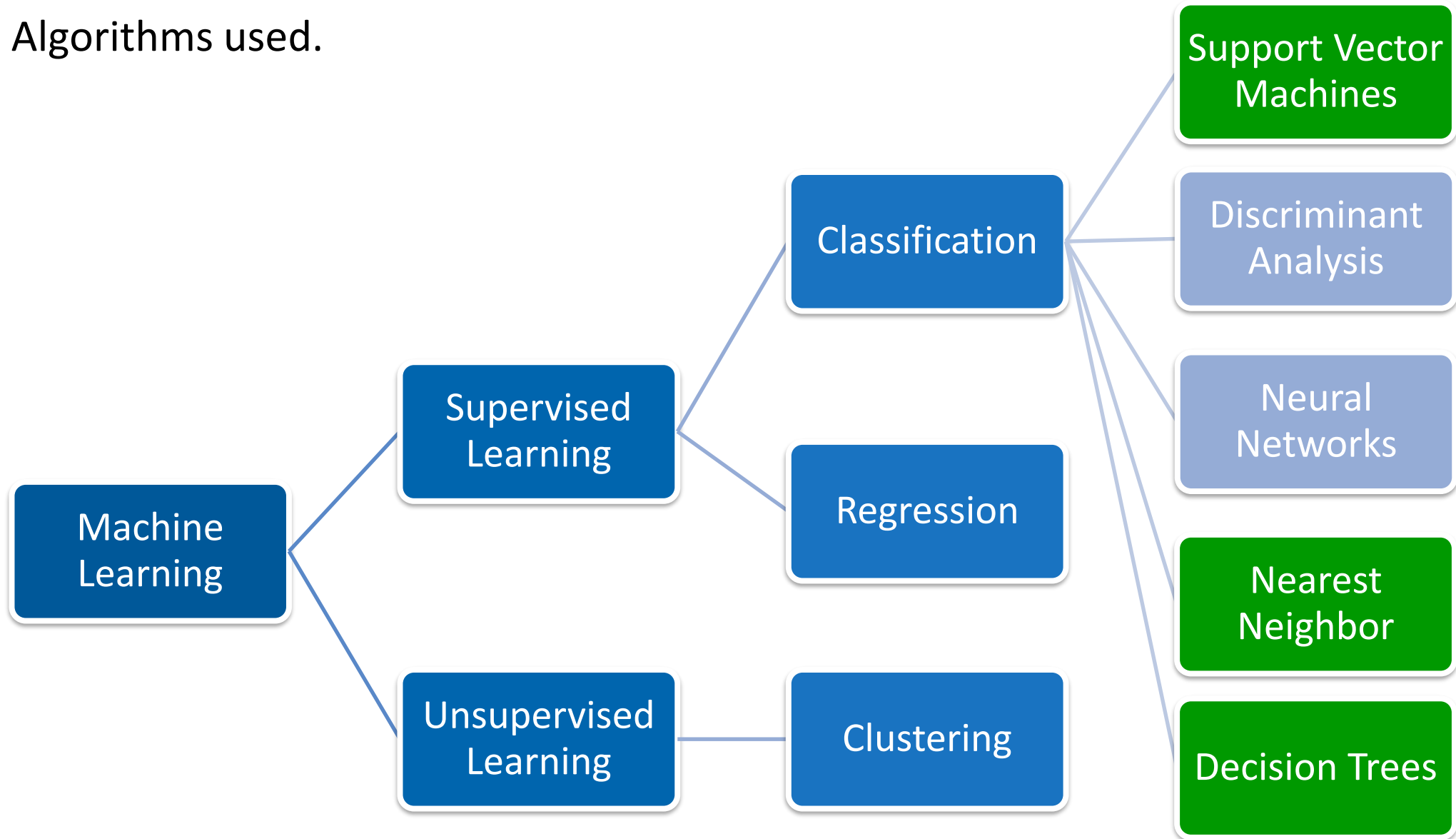BMW GROUP

BMW   MINI   Rolls-Royce Motor Cars Limited

MOTIVATION.

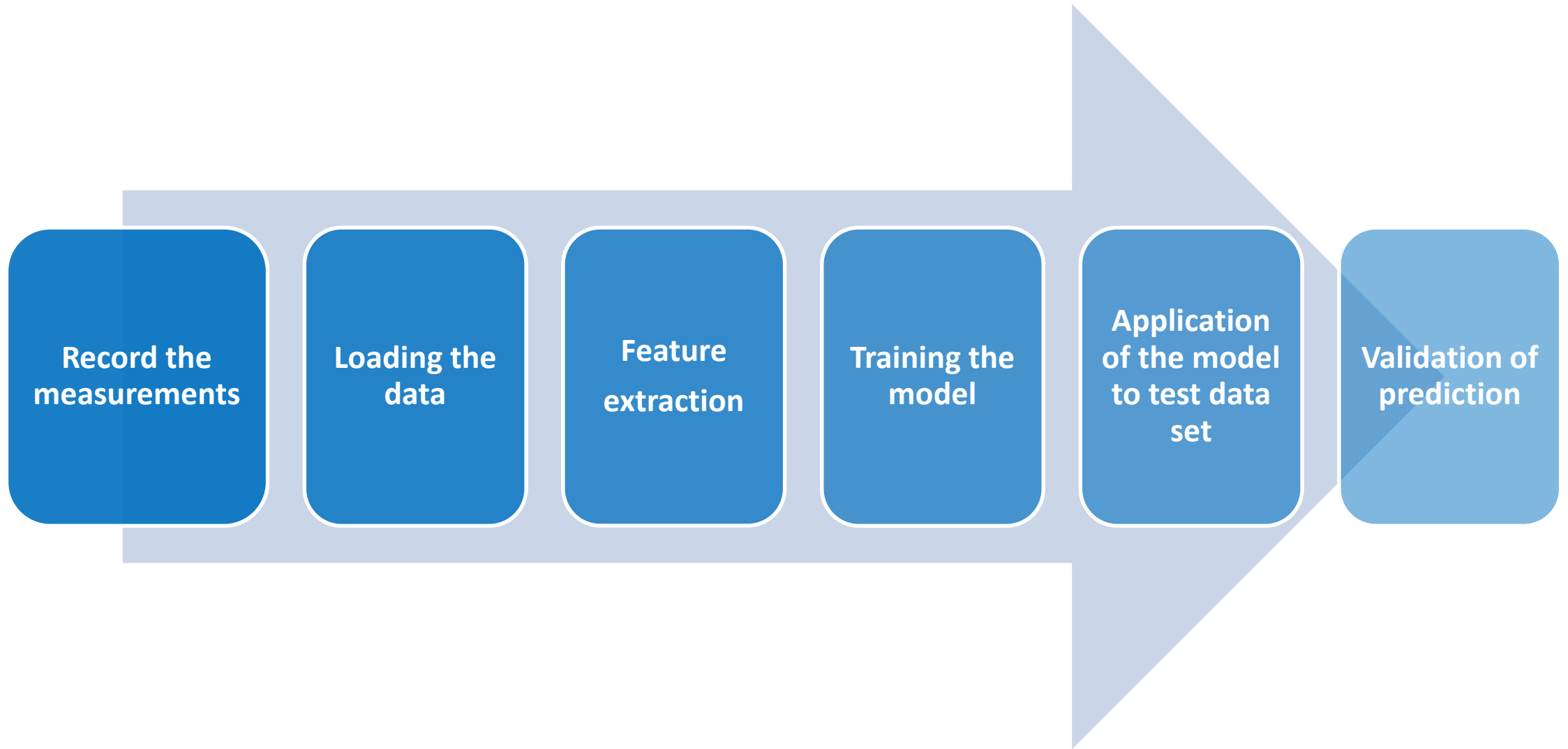Evaluation of the "Statistics and Machine Learning" Toolbox from MATLAB

Large number of recorded vehicle measurements (unlabeled) available
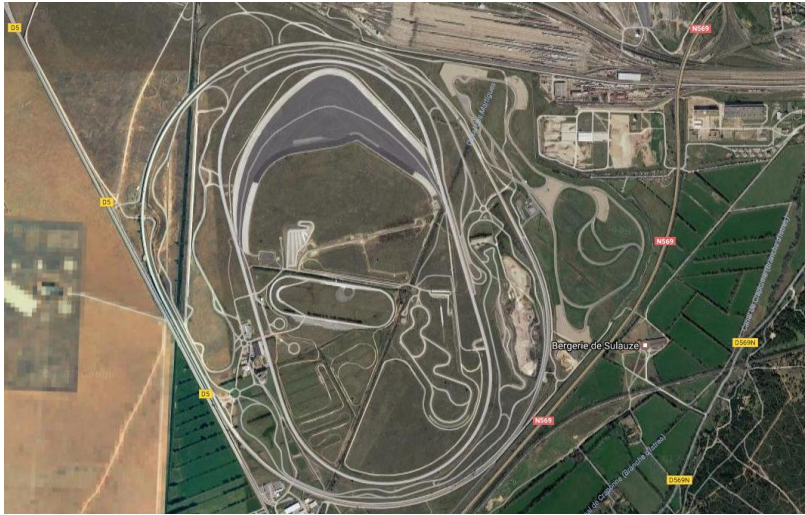
MACHINE LEARNING.

Algorithms used.

```
Machine
Learning
├── Supervised
│   Learning
│   ├── Classification
│   │   ├── Support Vector Machines
│   │   ├── Discriminant Analysis
│   │   ├── Neural Networks
│   │   ├── Nearest Neighbor
│   │   └── Decision Trees
│   └── Regression
└── Unsupervised
    Learning
    └── Clustering
```

WORKFLOW.

| Record the measurements | Loading the data | Feature extraction | Training the model | Application of the model to test data set | Validation of prediction |

GENERATION OF THE MEASURED DATA. TRACK

Train a model →

Training data set:

- Handling course Miramas

- 259.000 data points

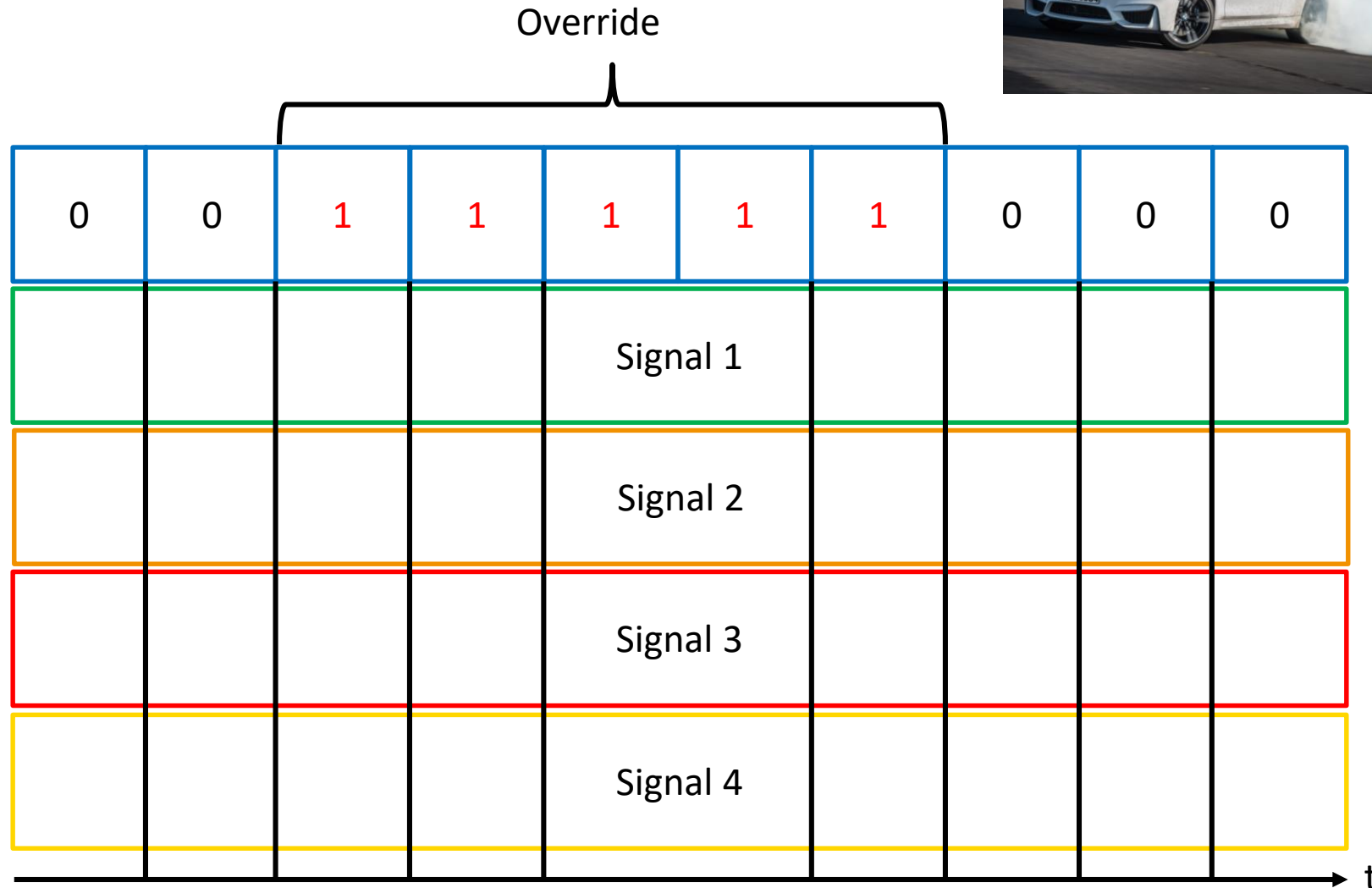≙ 43 minutes

Test the trained model →

Test data set:

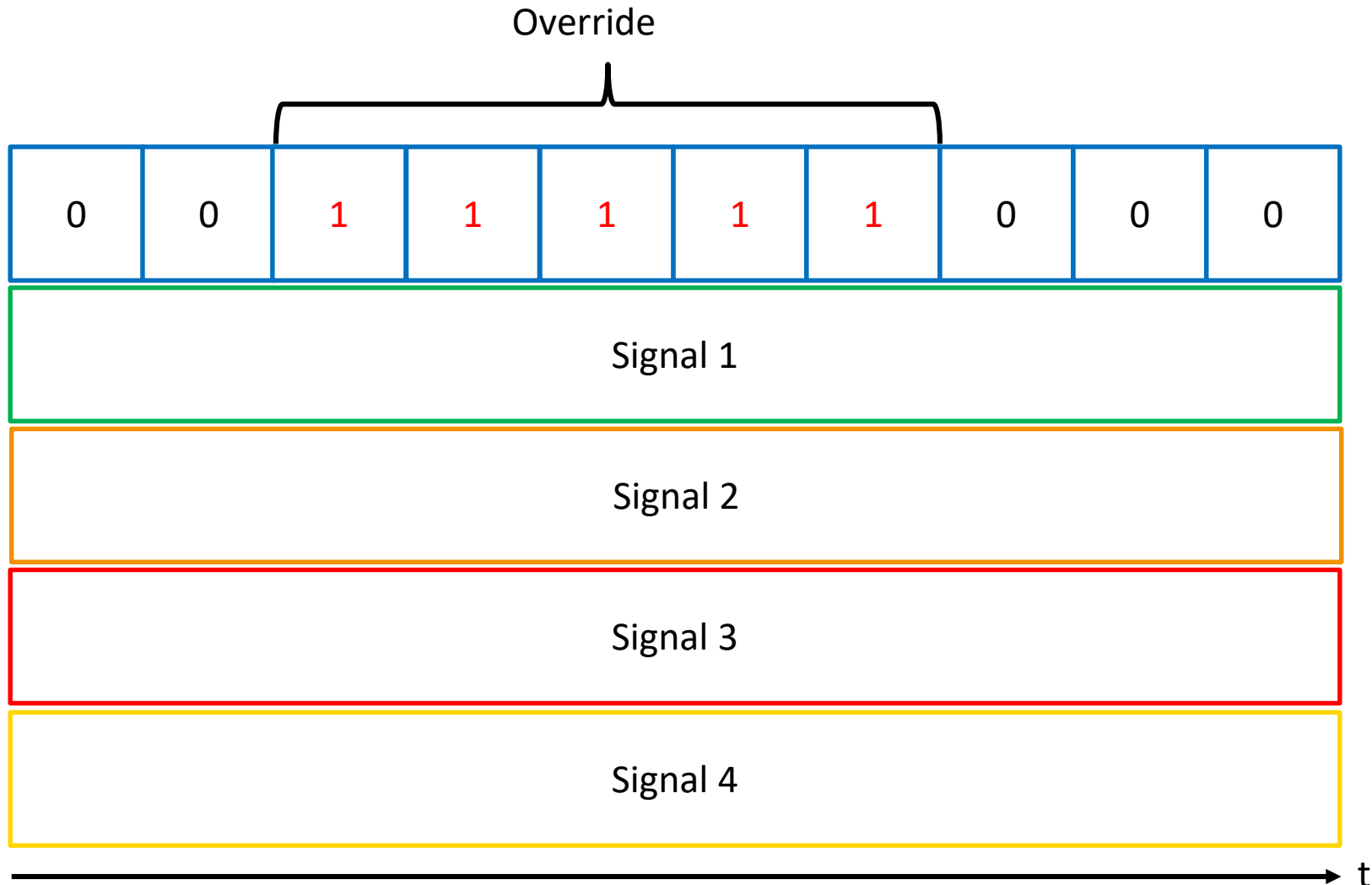- Handling course Aschheim

- 150.000 data points

≙ 25 minutes

GENERATION OF THE MEASURED DATA.

Insert a trigger signal.

Override

0	0	1	1	1	1	1	0	0	0
				Signal 1					
				Signal 2					
				Signal 3					
				Signal 4					

t

GENERATION OF THE MEASURED DATA.

Insert a trigger signal.

FEATURE EXTRACTION.

Filter.

Signal des Radwinkels
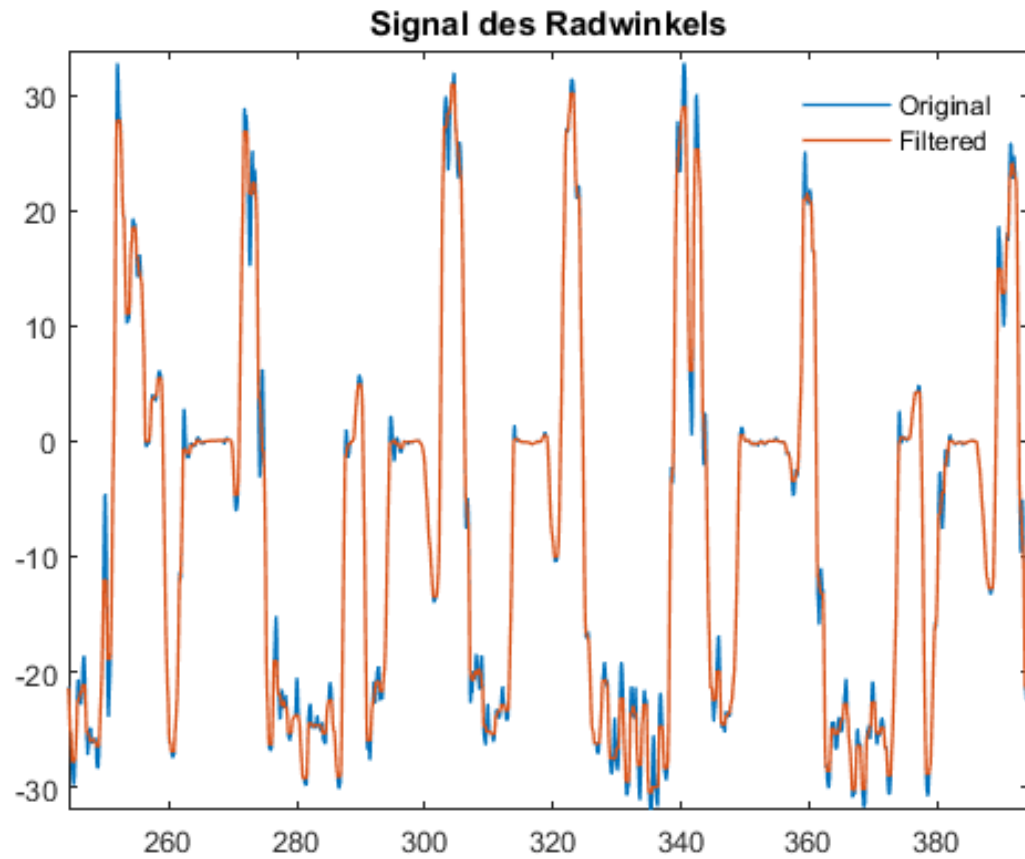
Suppress signal noise

Training and test data sets have to filter in the same way
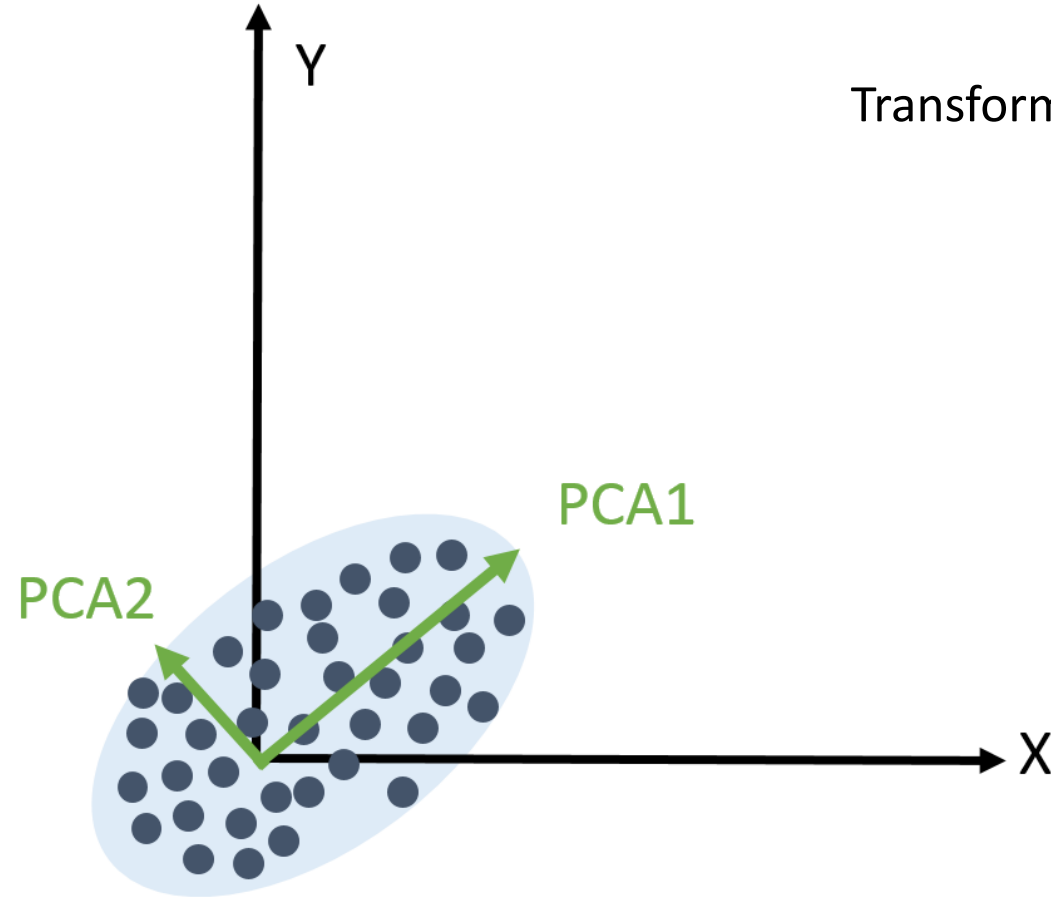
FEATURE EXTRACTION.

Peak Analysis.
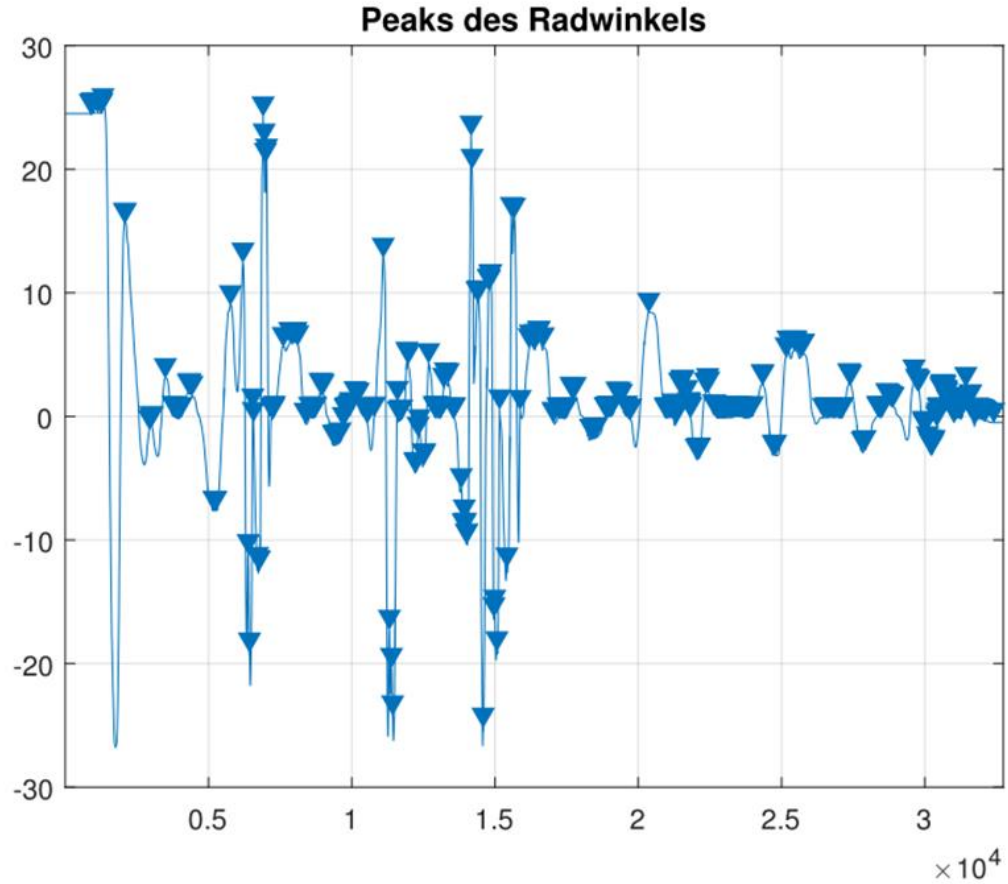
- Use the FindPeaks function

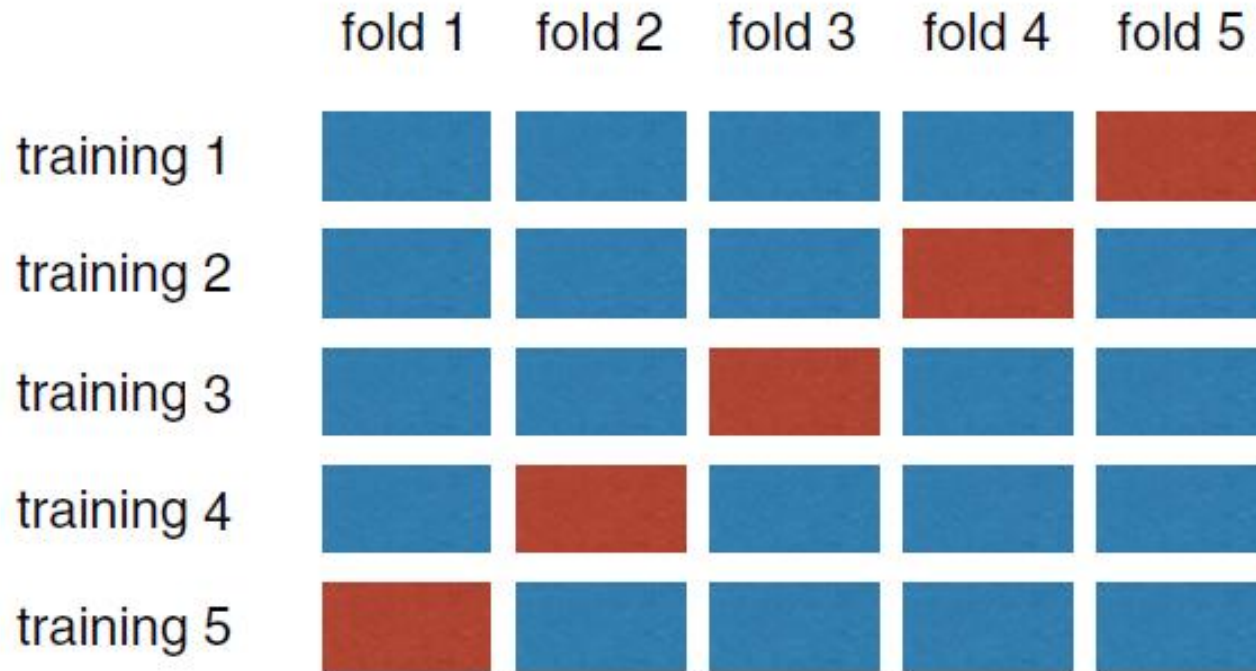- Minimum distance between the peaks

FEATURE EXTRACTION.

Principal Component Analysis (PCA).

Transformation in the directions of Principal Components

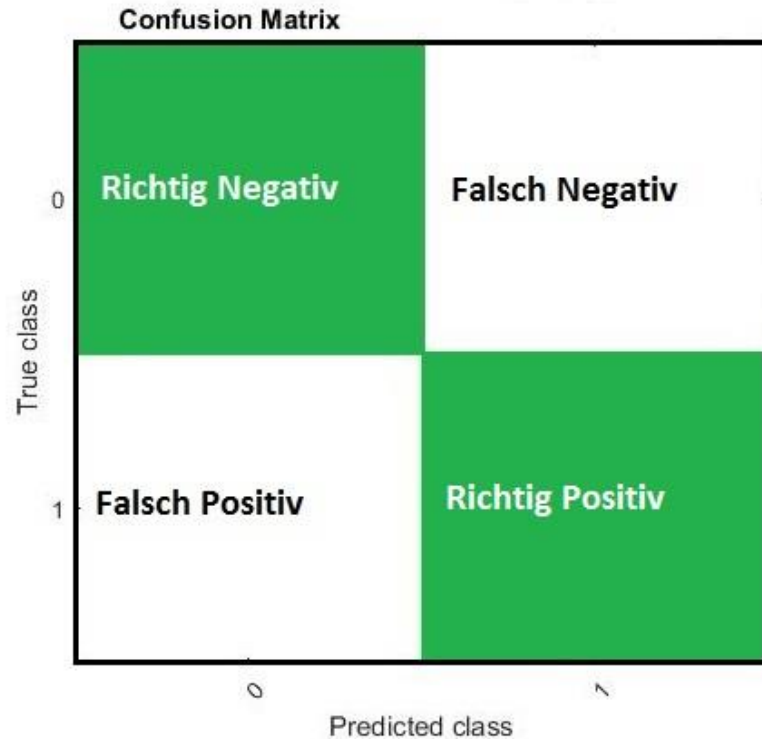# MODEL SELECTION.

K-Fold Crossvalidation.

	fold 1	fold 2	fold 3	fold 4	fold 5
training 1					
training 2					
training 3					
training 4					
training 5					

Blue= Training data set
Red= Test data set

Results: Average error

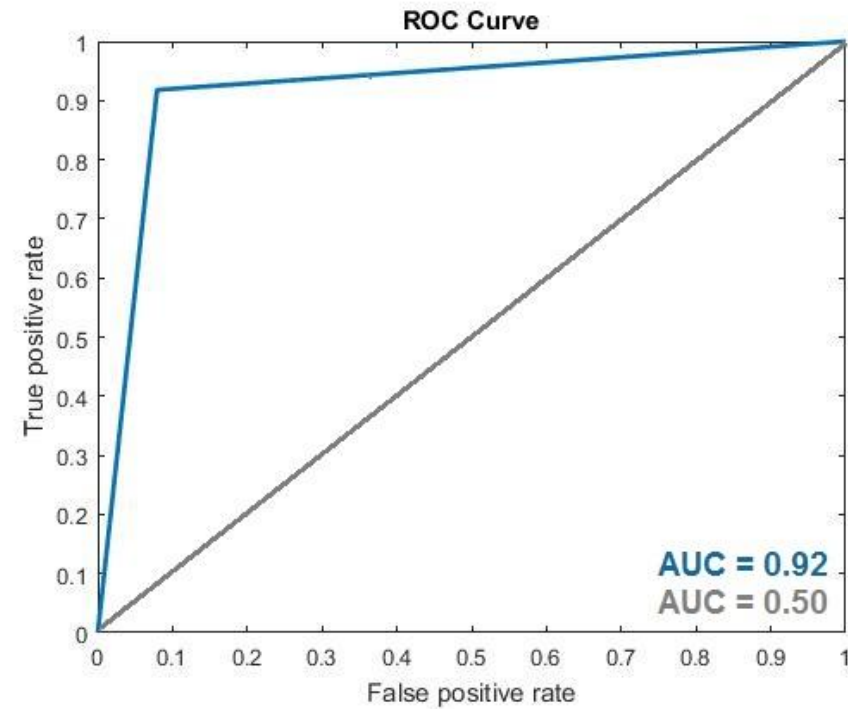Source: Machine Learning for Evolution Strategies, Kramer, 2016, S.39
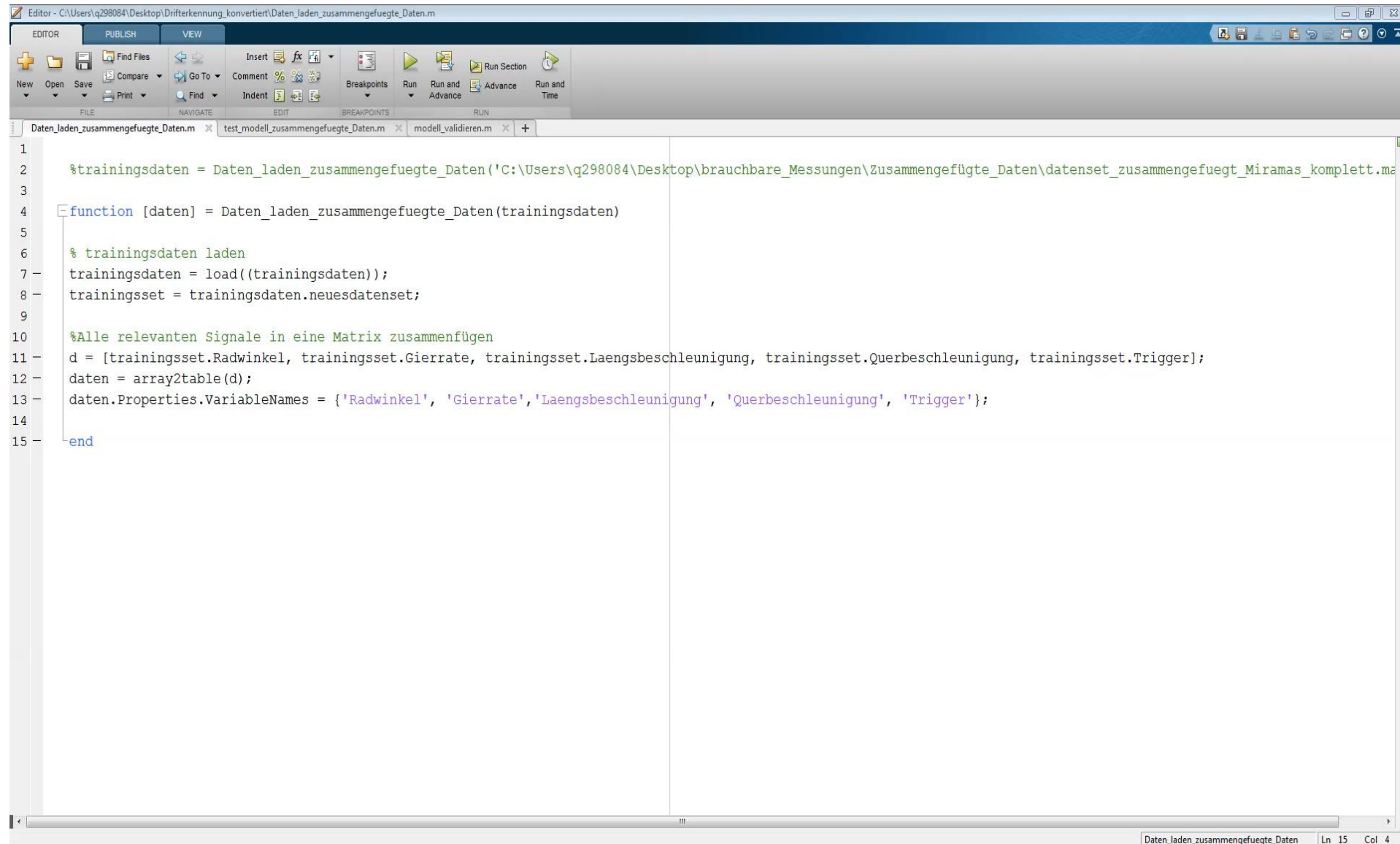
MODEL SELECTION.

confusion matrix.

Receiver-Operating-Characteristic-Curve.

Goal:
100 % on the green diagonal

Goal :
AUC = 1

VIDEO: PROCEDURE.

RESULTS.

confusion matrix: K-Nearest Neighbor & PCA Feature Extraktion

Confusion Matrix for K-Nearest Neighbor
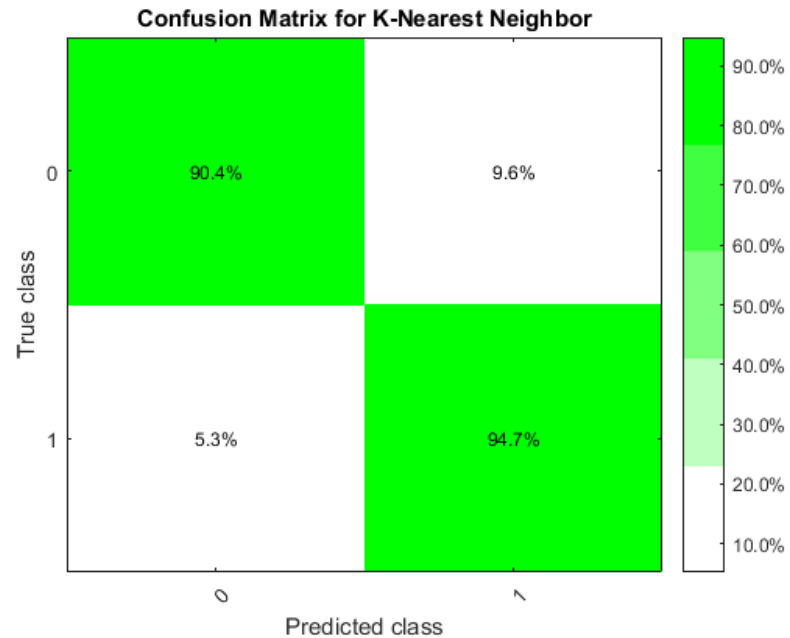
```
Performance of model :
                Predicted 0        Predicted 1
    Actual 0    90.35% (82943)      9.65% (8856)
    Actual 1     5.26% (3162)      94.74% (57004)
```
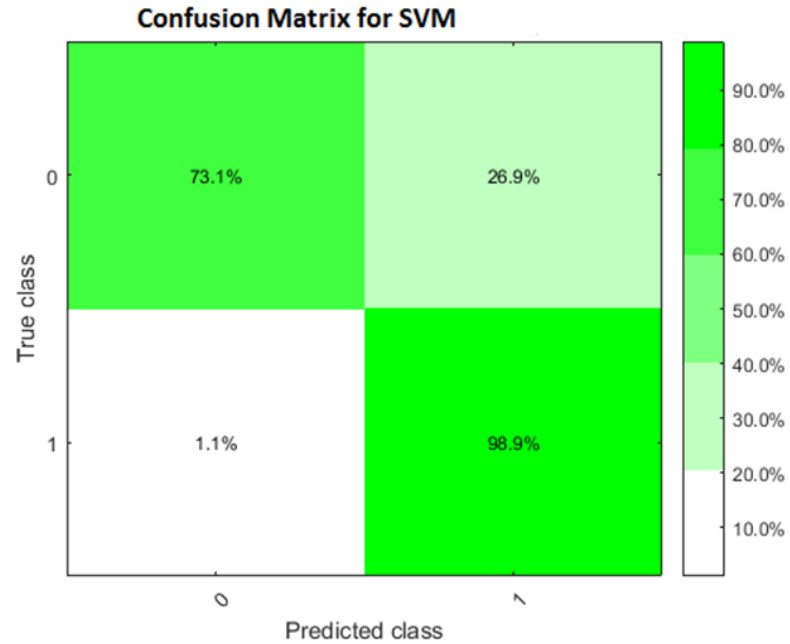

ROC Curve
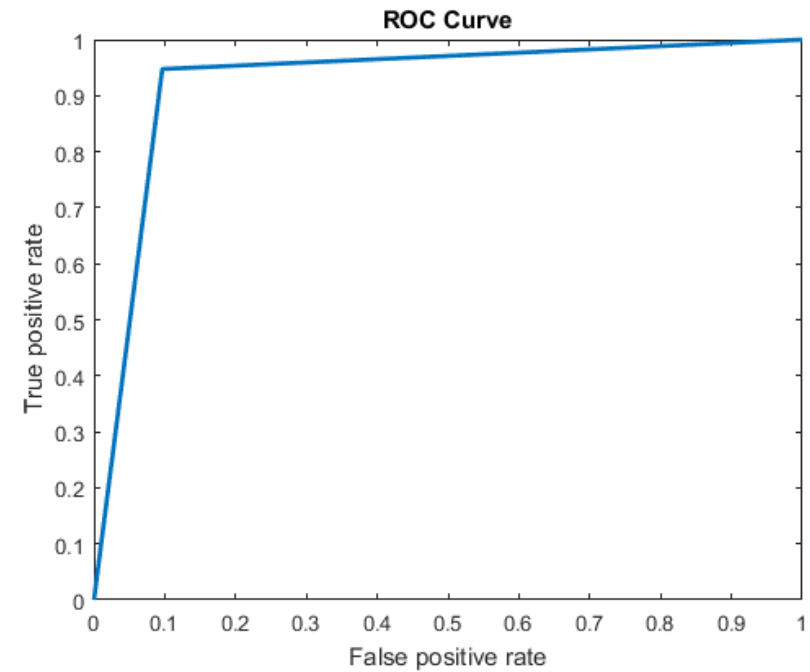
RESULTS.

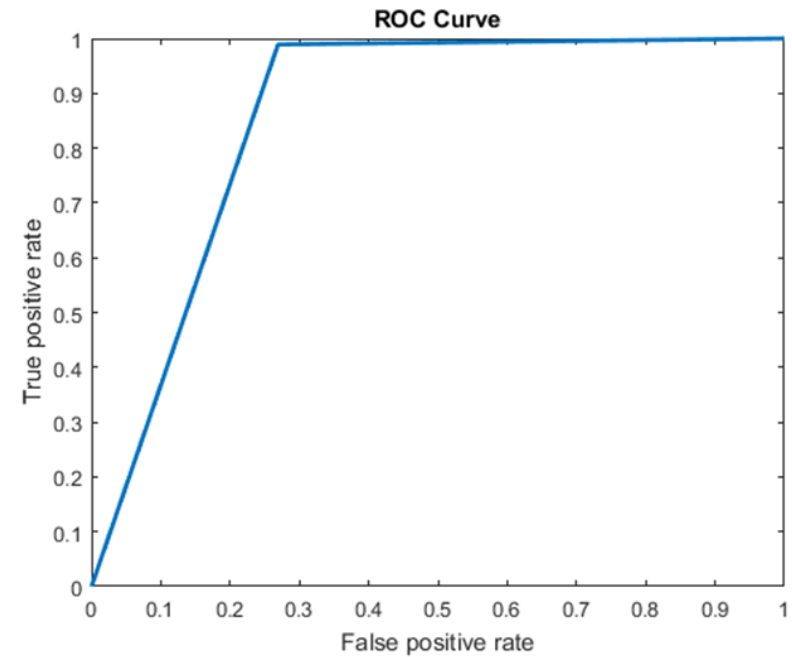## confusion matrix: Support Vector Machine

Confusion Matrix for SVM

```
Performance of model :
                    Predicted 0          Predicted 1
    Actual 0      73.07% (67078)       26.93% (24721)
    Actual 1       1.08% (650)         98.92% (59516)
```
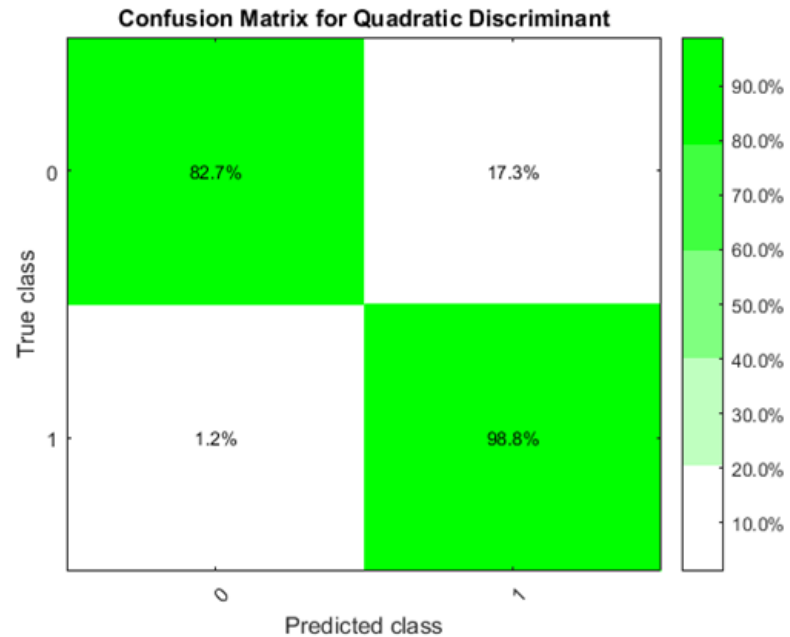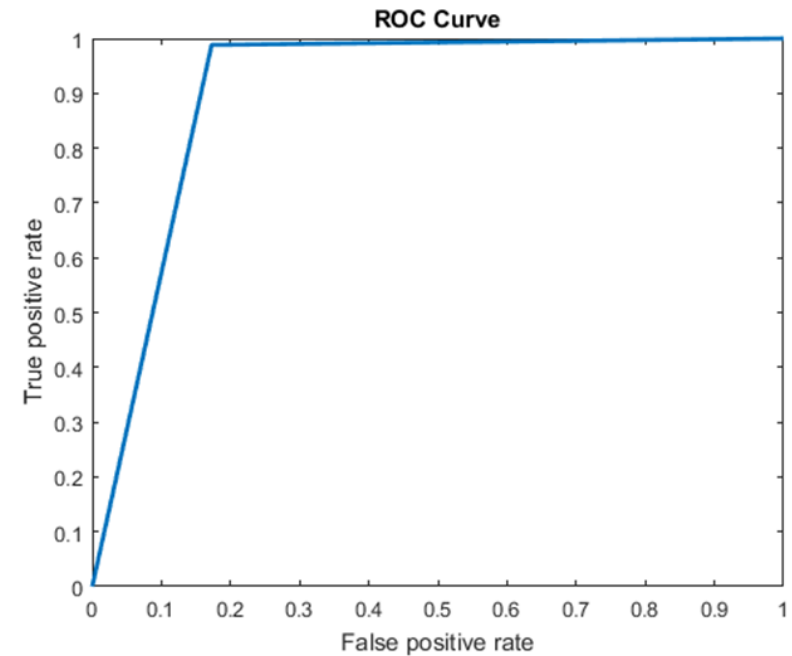

ROC Curve

RESULTS.

confusion matrix: Quadratic Discriminant analysis model

Confusion Matrix for Quadratic Discriminant

0	82.7%	17.3%
1	1.2%	98.8%

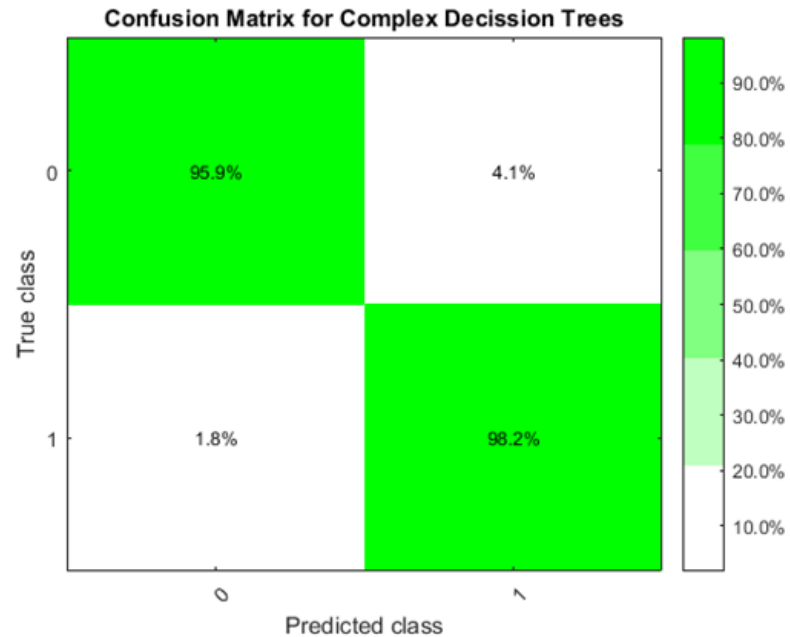True class / Predicted class

```
Performance of model :
               Predicted 0        Predicted 1
Actual 0     82.73% (75946)     17.27% (15853)
Actual 1      1.17% (701)       98.83% (59465)
```
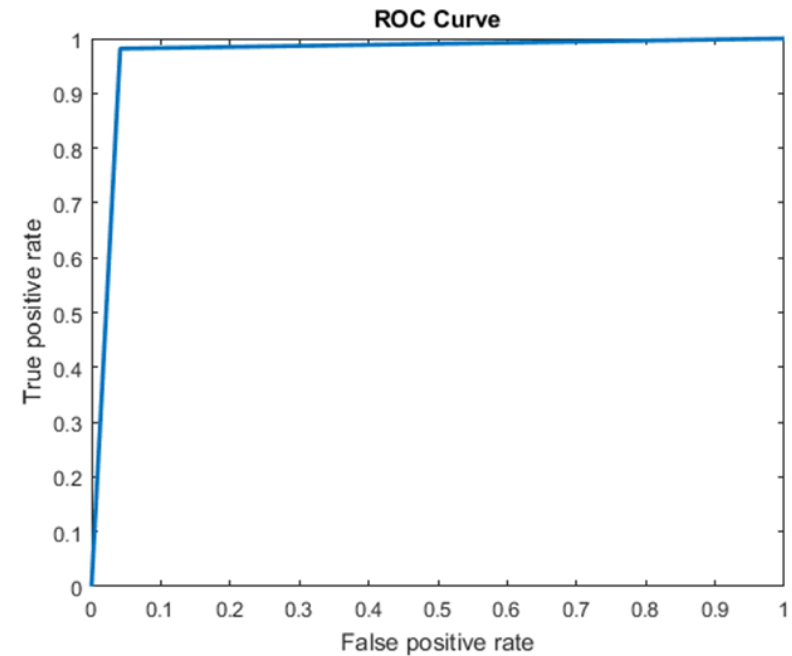
ROC Curve

RESULTS.

confusion matrix: Complex Decision Trees

Confusion Matrix for Complex Decission Trees

	Predicted 0	Predicted 1
True class 0	95.9%	4.1%
True class 1	1.8%	98.2%

```
Performance of model :
                Predicted 0       Predicted 1
Actual 0      95.86% (87996)     4.14% (3803)
Actual 1       1.84% (1109)     98.16% (59057)
```


ROC Curve

SUMMARY.

Learning must always be carried out from the beginning of the measurements, no adaptive learning

Generate C code from the learned algorithm possible

Fast results with little previous knowledge