

Exercises in Tracking & Detection

Exercise 1 AdaBoost

In this exercise we will implement the AdaBoost classifier for synthetic datasets.

- Download the synthetic datasets (**data1.mat**, **data2.mat**, **data3.mat**) from the website of the course. Each sample (1 positive and -1 negative) has two features (x and y position).
- Implement the Adaboost algorithm.
- The weak classifiers should be based on simple thresholding, applied in an axis.
- For every dataset, do the following:
 - Visualize the data samples before the classification (use different colors for the positive and the negative samples).
 - Train N weak classifiers and then test on the dataset.
 - Visualize the data samples after the classification (use again different colors for each class).
 - Visualize the classification error in comparison to the number of the weak classifiers.

Exercise 2 Face detector

In this exercise we will implement a Face Detector which is based on the Adaboost algorithm and the Haar-like features (Paul Viola, and Michael Jones, *Robust Real-Time Face Detection*. In International Journal of Computer Vision, 2004). At first, read carefully the publication and try to understand how the features are extracted and the training is done. It is not required to implement the training and the cascade part.

- Implement the feature extraction part of the Viola-Jones face detector.
 - Write a function for constructing the integral image from a gray scale image.
 - Write another function for extracting Haar-like features from an image patch.
 - The feature extraction function should be able to extract different kind of features (two, three and four-rectangle features is enough).
- Load the weak classifiers from the file **Classifiers.mat**. The file contains N weak classifiers.
- Each classifier has the following attributes:
 - upper left row (r) (classifier window)

- upper left column (c) (classifier window)
 - window width (winWidth)
 - window height (winHeight)
 - 1 - 5 denotes the classifier's number
 - mean of positive responses for this classifier (mean)
 - standard deviation of positive responses for this classifier
 - max positive value of the classifier response (maxPos)
 - min positive value of the classifier response (minPos)
 - iteration number (R out of n rounds)
 - alpha that should be multiplied chosen by Adaboost
 - error of this classifier
 - False negative error
 - False positive error
- There are 5 different types of weak classifiers, which are based on Haar-like responses. They have the following form:
 - Classifier 1
 - * Rectangle 1: $[r \quad c \quad ((winWidth/2) - 1) \quad (winHeight - 1)]$
 - * Rectangle 2: $[r \quad (c + winWidth/2) \quad ((winWidth/2) - 1) \quad (winHeight - 1)]$
 - * Feature response: $Rectangle1 + Rectangle2$
 - Classifier 2
 - * Rectangle 1: $[r \quad c \quad (winWidth - 1) \quad ((winHeight/2) - 1)]$
 - * Rectangle 2: $[(r + winHeight/2) \quad c \quad (winWidth - 1) \quad ((winHeight/2) - 1)]$
 - * Feature response: $Rectangle1 + Rectangle2$
 - Classifier 3
 - * Rectangle 1: $[r \quad c \quad ((winWidth/3) - 1) \quad (winHeight - 1)]$
 - * Rectangle 2: $[r \quad (c + (winWidth/3)) \quad ((winWidth/3) - 1) \quad (winHeight - 1)]$
 - * Rectangle 3: $[r \quad (c + ((2 * winWidth)/3)) \quad ((winWidth/3) - 1) \quad (winHeight - 1)]$
 - * Feature response: $Rectangle1 - Rectangle2 + Rectangle3$
 - Classifier 4
 - * Rectangle 1: $[r \quad c \quad (winWidth - 1) \quad ((winHeight/3) - 1)]$
 - * Rectangle 2: $[(r + (winHeight/3)) \quad c \quad (winWidth - 1) \quad ((winHeight/3) - 1)]$
 - * Rectangle 3: $[(r + ((2 * winHeight)/3)) \quad c \quad (winWidth - 1) \quad ((winHeight/3) - 1)]$
 - * Feature response: $Rectangle1 - Rectangle2 + Rectangle3$
 - Classifier 5
 - * Rectangle 1: $[r \quad c \quad (winWidth/2 - 1) \quad (winHeight/2 - 1)]$
 - * Rectangle 2: $[r \quad (c + winWidth/2) \quad (winWidth/2 - 1) \quad (winHeight/2 - 1)]$
 - * Rectangle 3: $[(r + winHeight/2) \quad c \quad (winWidth/2 - 1) \quad (winHeight/2 - 1)]$
 - * Rectangle 4: $[(r + winHeight/2) \quad (c + winWidth/2) \quad (winWidth/2 - 1) \quad (winHeight/2 - 1)]$
 - * Feature response: $Rectangle1 - Rectangle2 + Rectangle3 - Rectangle4$

The attribute *classifier's number* of each weak classifier indicates which is being used.

- Write a function which uses the loaded weak classifiers for detecting faces. Use the sliding window technique and detect faces in the test images. The classification output is based on thresholding in this exercise too.

- The default detector search window is 19×19 for current dataset.
- The rounds of the boosting algorithm during the training were 50.
- The threshold for a positive output t from a classifier is:
* $(mean - abs(mean - minPos) * (R - 5)/50) \leq t \leq (mean + abs(maxPos - mean) * (R - 5)/50)$.
- Use the pyramid model for detecting faces in different scales.