2nd Exercise on Medical Image Processing

LU 183.630 – 2024 SoSe

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Disclaimer: for performance reasons the Run.m script in the uploaded coding MEDBV23_UE1_codedata.zip file is working with the saved optimized parameters (optimization takes a long time and has been uncommented in U2T4.m).

Shape Model

In the 2nd exercise part 1 the generateShape function has been extended to allow rotation, scaling and translation of Shapes. Figure 1 shows examples for rotating shapes.

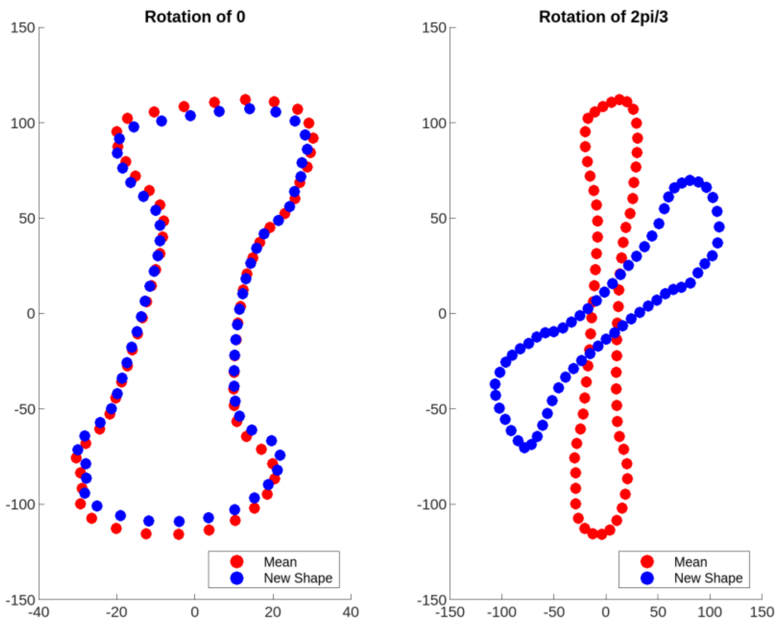

Figure 1: Shape Model Rotation

Figure 2 shows examples for scaling these previously rotated shape.

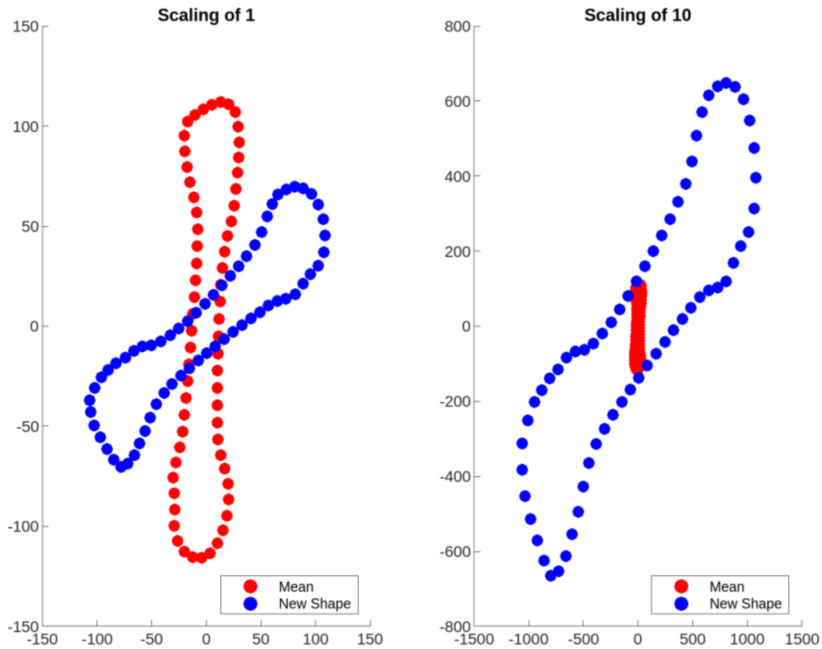

Figure 2: Shape Model Scaling

Figure 3 shows examples for adding first x-translation only and then also y-translation.

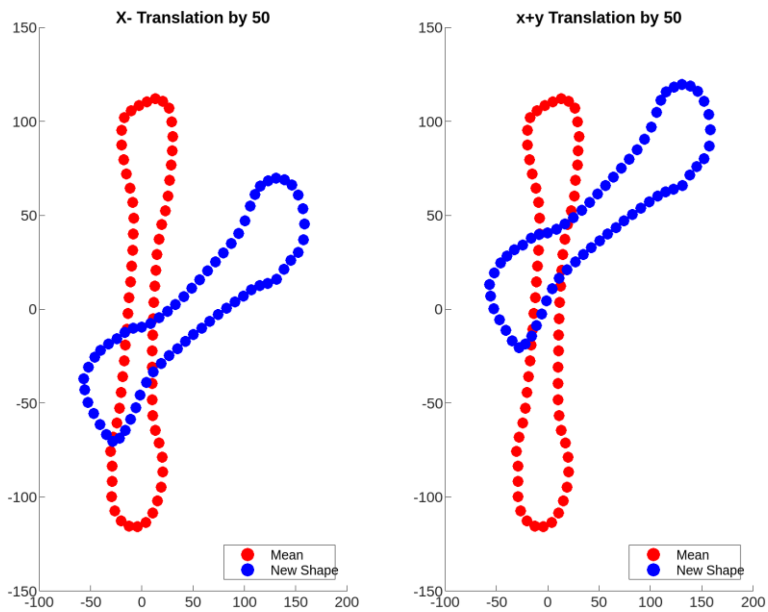

Figure 3: Shape Model Translation

Feature Extraction

In part 2, the feature matrix for an image is calculated, by creating a feature vector for each pixel. The feature vector consists of the following features: grey value itself, of the gradients in x- and y-direction, the magnitude of the gradient, Haar-like features based on gray value and bases on gradient magnitudes plus the x- and y-coordinates of a pixel.

The following plots visualize the features for image 1.

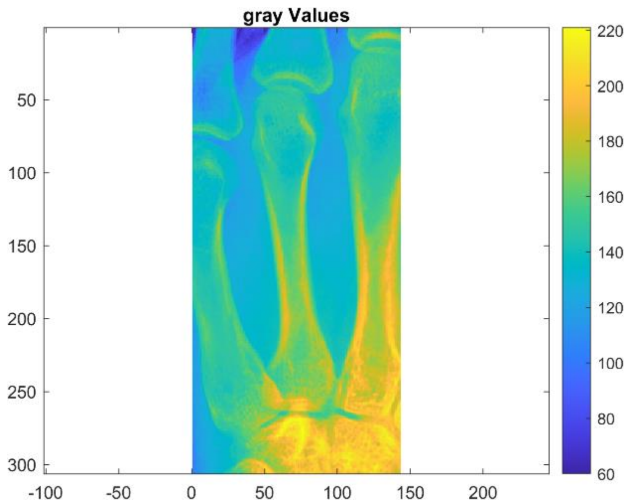

Figure 4: Image1 Gray Values

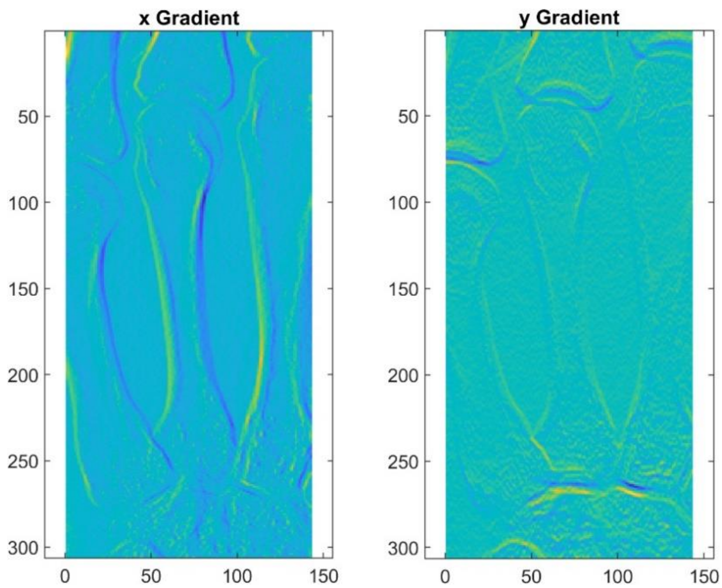

Figure 5: Image 1 Y and Y Gradients

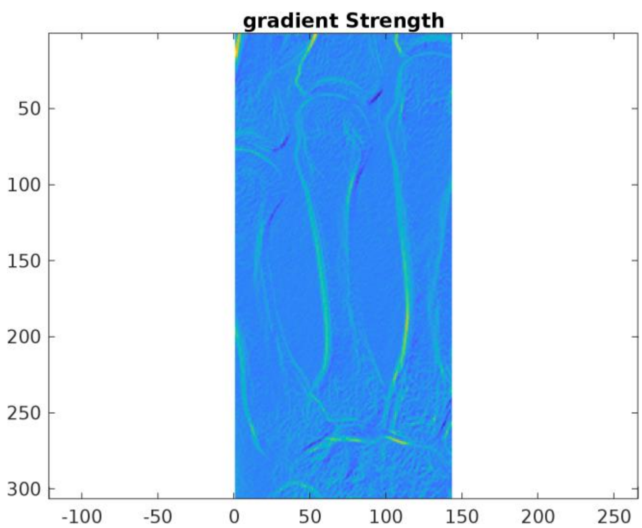

Figure 6: Image 1 Gradient Strength

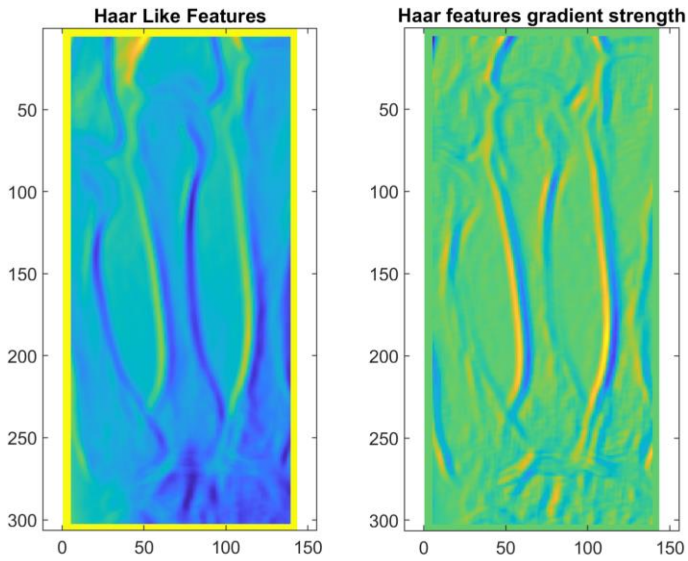

Figure 7: Image 1 Haar like

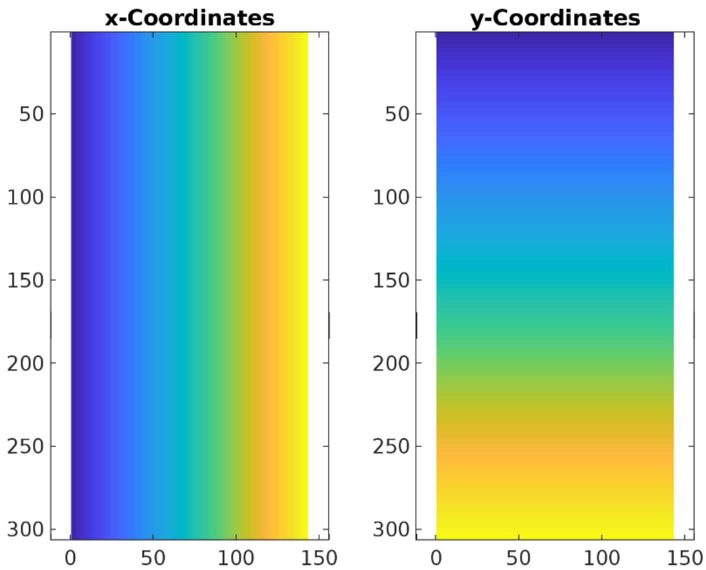

Figure 8: Image 1 X and Y Coordinates

Classification & Feature Selection

The Random Forest Classifier was trained for 100 Estimators. In Figure 9 it is visible that after around 20 trees the error does not decrease significantly anymore. Additionally, figure 4 highlights in the lower half that the features Y-*Coordinate* and *Haar Like based on Gradient Magnitude* have a higher importance for the classification than the other features.

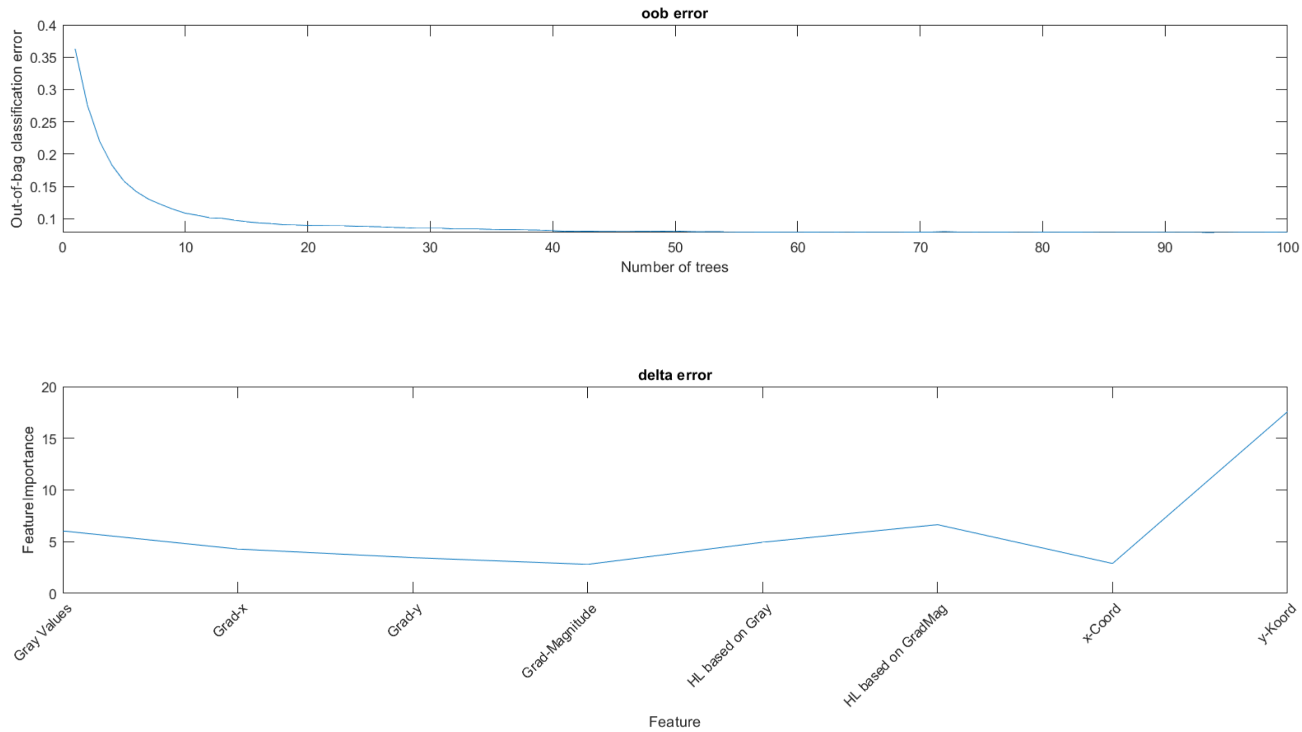

Figure 9: OOB Error and Feature Importance

Shape Particle Filters

The train function provides a RandomForest Classifier model with 20 trees as determined by the OOB Error evaluation in the previous paragraph. The feature vector has not been adjusted feature importance, the assumption is that the bootstrapping in the random forest will take care of this.

The Cost Function determines the probability if a pixel is in the background of the picture, the higher the probability that the picture is in the background the higher the costs added. As input the cost function receive the mean PCA Shape of the training examples, the predicted score (probability of the pixel being in background) from the predict segmentation method and the p Vector with an initialization of the transformation values to be optimized (scaling 1, rotation 0, x and y translation 0). As output the cost function determines a cost value, the more likely the value is in background the higher the cost value assigned.

Segmentation Prediction is using the MATLAB predict function to generate a mask out of the provided image and also assigns scores if a pixel is in background or foreground

The p-Vector parameters are optimized by the optimizeSegmentationCost Function for each of the test set images (31-50). The optimizations is running between the min and max boundaries [0.85;-3.2;-300;-300] and `[1.15;3.2;300;300].`

Visualization

From the saved set of optimized parameters, sample visualizations can be generated to better understand the segmentation results.

On the original picture the 'true' annotated landmarks, the mean PCA shape landmarks and the 'optimized' predicted landmarks are plotted. For image 31 the segmentations work quite well already as visualized in Figure 10: Image 31.

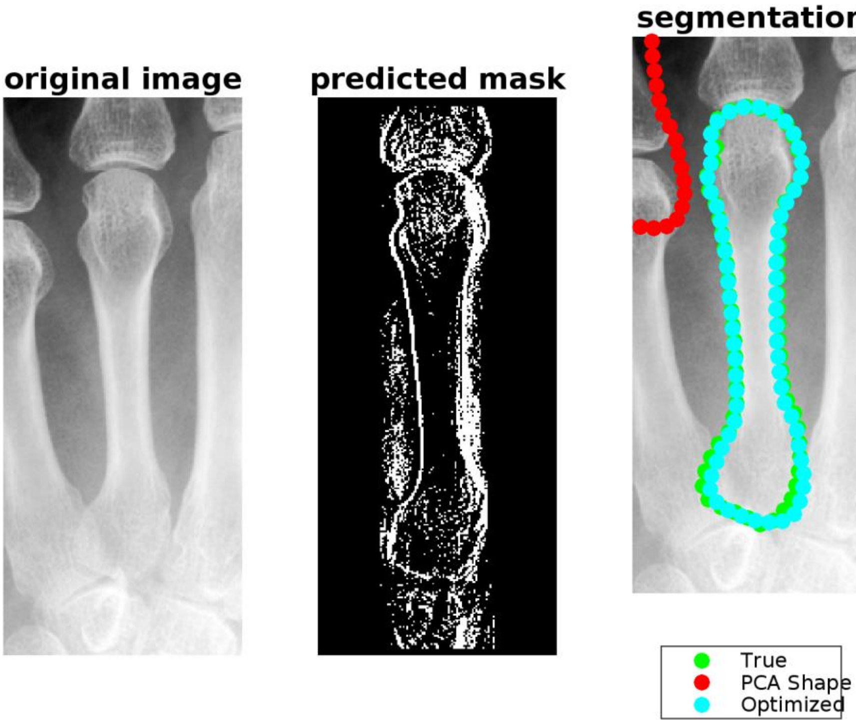

Figure 10: Image 31

However, for the visualization in images 41 (Figure 11: Image 41) and 45 (Figure 12: Image 45) the scaling would still go a bit too small, either initialization or optimization boundaries could be adapted for better outcomes

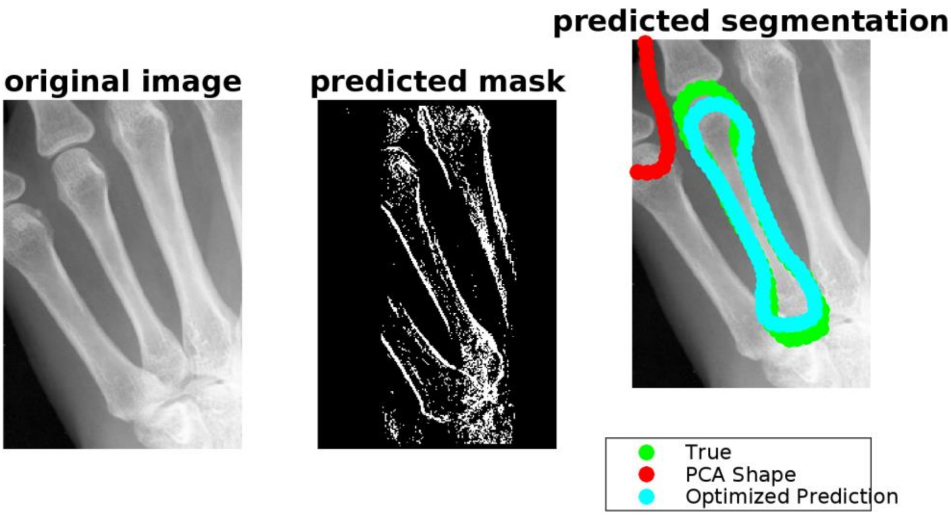

Figure 11: Image 41

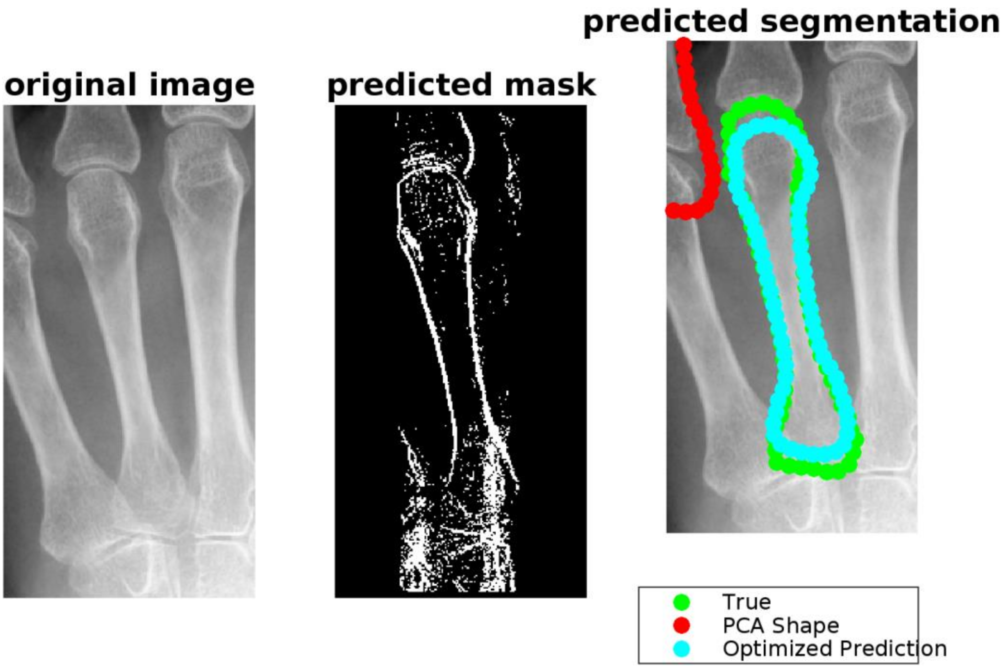

Figure 12: Image 45

List of Illustrations