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Master's Thesis
Title: Two Methods for Rotation-Invariant Landmark Classification and their Application to 3D Heart Images

A robust algorithm for anatomical, rotation-invariant landmark detection is desirable e.g. for segmentation of ultrasound images where organ orientation inside the imaged volume is not known beforehand. The main difficulty on developing an algorithm for these images is within the estimation of the unknown spatial orientation. There are approaches providing a solution for 2D images like for finding objects with unknown orientation as in [8] as well as other landmark detection methods (e.g. [6]). However, these not provide a robust and reliable solution for 3D images.
This work focus on the estimation of the image orientation in combination with the identification of detected landmarks. For this aim, two different approaches are implemented, tested, and compared. First one is taking usage of the eigenvectors of the structure tensor [1], [4], [5] to estimate the orientation. The second method is based on histogram of oriented gradients [2]. Both are estimating the orientation by definition of new images axes and use these to transform the image patch and into the new, normalised coordinate system. For the second approach histograms are normalised as well. The identification of a landmark is performed via six image similarity measures [3], [7] by comparison with a set of training data.
For testing the two approaches 3D CT images of the human heart is used, since this aims only in testing the feasibility and comparison of both approaches. 220 datasets, consisting of three images (original image and two artificial rotations), are used to perform three different experimental set-ups. First the accuracy of rotation estimation is tested. In the second one a landmark is extracted from original image and sought in the two artificial rotation (intra-patient). For the last set-up training data out of 35 datasets is used to classify landmarks in all three image of a dataset (inter-patient).
The results show that both approaches lead to satisfying accuracy in rotation estimation. But in comparison, Histogram of oriented gradients performs a little better, however, this approach has higher number of outliers which are prone to misclassification. Outliers and misclassification interaction is visible for intra-patient experiment. For aortic valve there is a difference in number of outliers differs as well as for hit ratio for both approaches. For pulmonary valve both are nearly identical. For inter-patient experiment structure tensor approach is emphasized. Nevertheless, the hit ratio is not sufficient for directly transcription from CT to ultrasound images.

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