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Automatic Localization of the Heart in Cardiac MRI Series using RETROICOR

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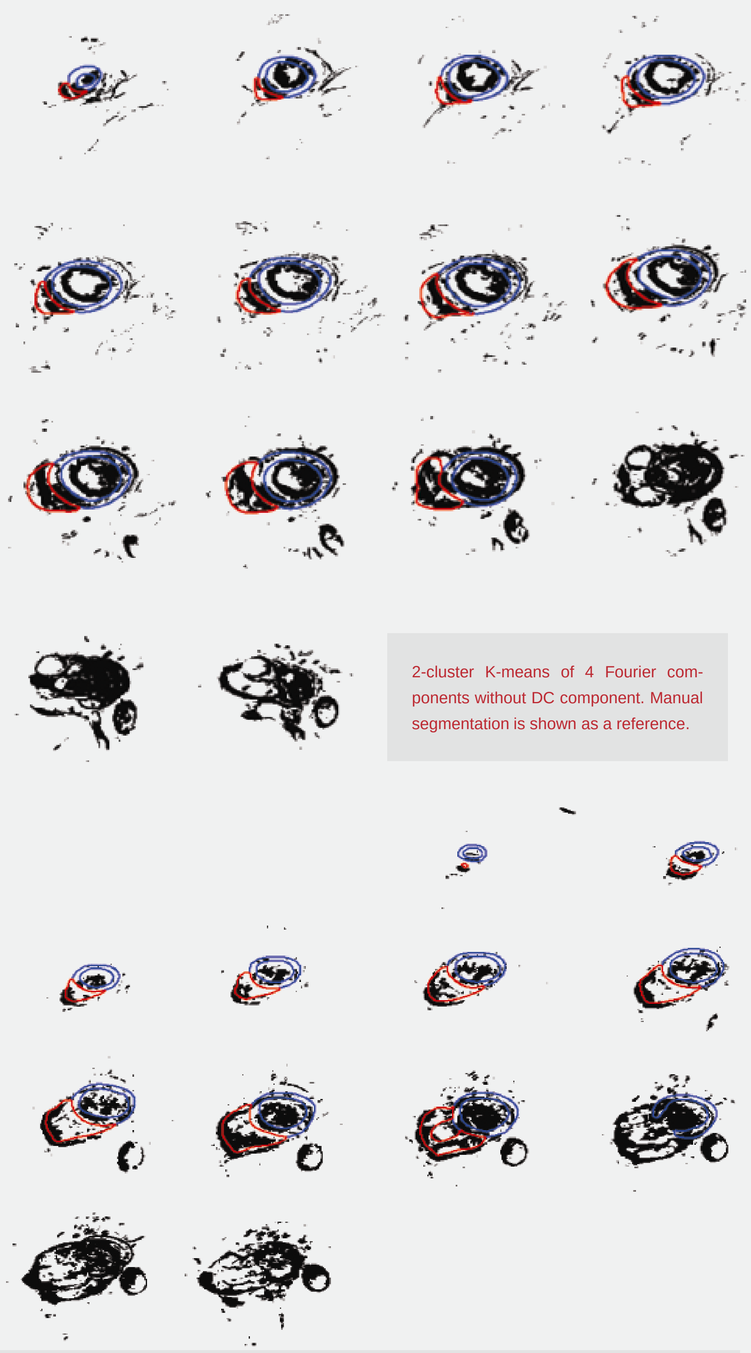
Abstract The heart can be located automatically by fitting Fourier series to pixel intensity variation across a heart cycle. Both unsupervised and supervised methods were successfully able to segment the heart.

Cardiac abnormalities can be evaluated and diagnosed non-invasively using X-ray, CT, ultrasound and MRI. The latter has high contrast and resolution and is considered to be harmless. Today, position and orientation of the scanning volume must be set manually by trained professionals, which prolongs the examination time considerably, thus automatic localization is desired.

The cardiac cycle can be simulated using RETROspective Image CORrection (RETROICOR) and can be used to reduce cardiac motion artifacts [1]. In this project harmonic functions are fitted to the temporal variation of the pixel intensities, which in this context will make the heart areas differentiate from other body segments.



2-cluster K-means of 4 Fourier components without DC component. Manual segmentation is shown as a reference.

The centroids from a 2-cluster K-means of 4 Fourier components is used as a model for segmentation. The model has been tested using an image time series. The result is shown above. Manual segmentation is shown as reference.

Methods and Materials

Multiple 4D MRI images recorded at Glostrup Hospital, each containing one heart cycle (20 images) in approx. 14 sagittal slices. The last image in the heart cycle was manually segmented and used as reference.

Unsupervised approach. Fourier series were fitted using FFT and clustered using the K-means with two clusters. [2], [3]
The centroids from the K-means, were applied to another patient's MRI data, to evaluate the heart/ not-heart discrimination across patients.

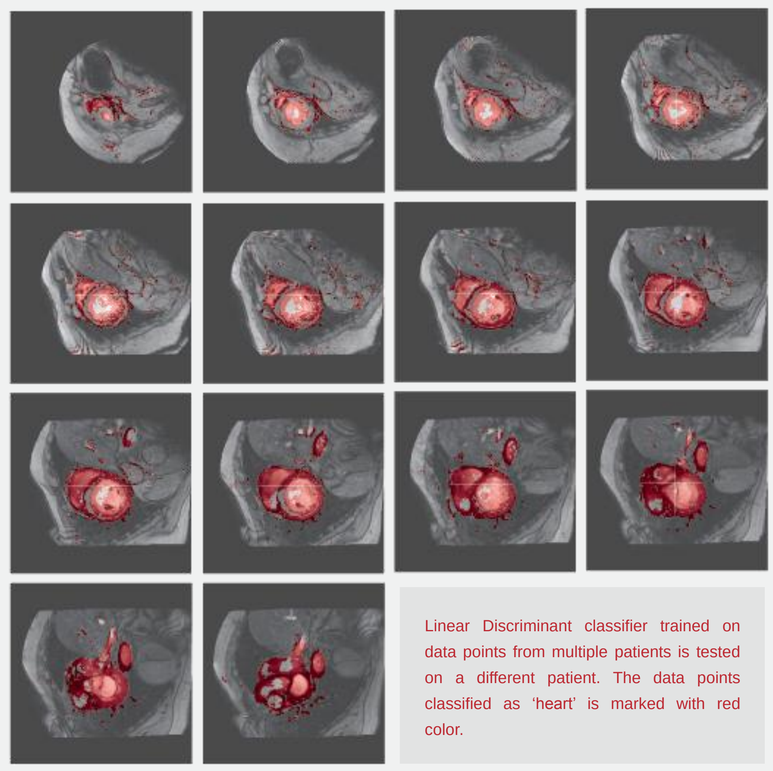
Supervised approach.
A two class Linear Discriminant classifier was applied to the same descriptors using the segmentations as response variables. Datapoints collected across several patiens were split into a training set (75%) and a validation set (25%). [2], [3]

Results

The upper left figure illustrates that the two clusters reflects heart and not-heart pixels. The corresponding reference is superposed.

The lower left figure suggest that the unsupervised model created from one or several patients, can be generalized to other patients.

The rightmost figure exemplifies how a supervised model trained from multiple .



Linear Discriminant classifier trained on data points from multiple patients is tested on a different patient. The data points classified as 'heart' is marked with red color.

patients manually segmented points can classify pixels in test-patient. The pixel-wise misclassification rate between classified and reference were less than 10%.

Future

The feature extraction, i.e. FFT and the two statistical methods: the K-means and Linear Discriminant classifier are computationally very efficient and thus attractive to implement in MRI scanner software. The methods seems to generalize across human variation. It may also generalize to other MRI scan weightings and sequences.

Reference

1. G.H. Glover, T.Q. Li and D. Ress, Image-based method for retrospective correction of physiological motion effects in fMRI: RETROICOR. Magnetic Resonance in Medicine: 44, 1, pp 162-167, 2000.
2. T. Hastie, R. Tibshirani and J. Friedman, The Elements of Statistical Learning, Strpinger, 2001.
3. C.M. Bishop, Pattern Recognition and Machine Learning, Springer-Verlag, 2008.