Automatic Assessment of Cardiac Perfusion MRI

Hildur Ólafsdóttir[1], Mikkel B. Stegmann[1,2], and Henrik B.W. Larsson[2,3]

[1] Informatics and Mathematical Modelling, Technical University of Denmark
[2] Danish Research Centre for Magnetic Resonance, H:S Hvidovre Hospital, Denmark
[3] Dept. of Diagnostic Imaging, St. Olavs Hospital, Trondheim University, Norway

Abstract. In this paper, a method based on Active Appearance Models (AAM) is applied for automatic registration of myocardial perfusion MRI. A semi-quantitative perfusion assessment of the registered image sequences is presented. This includes the formation of perfusion maps for three parameters; maximum up-slope, peak and time-to-peak.
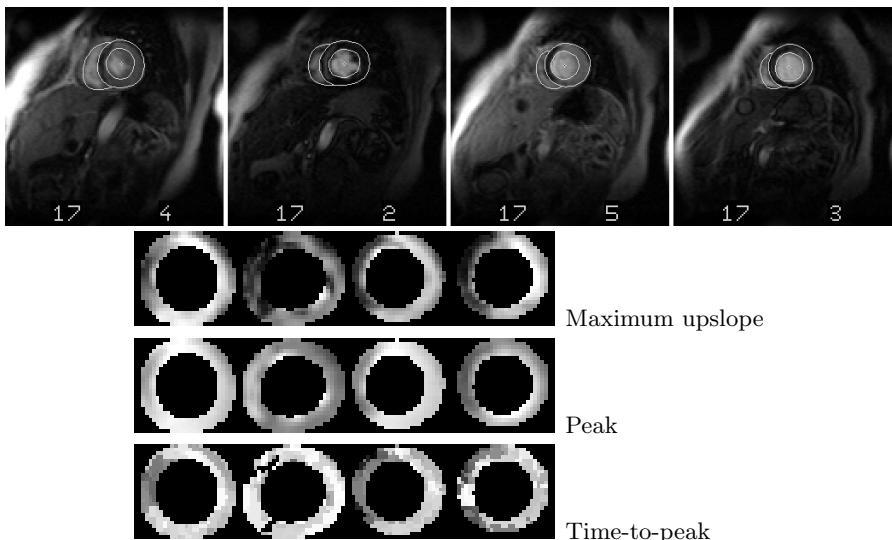
1 Introduction

Myocardial perfusion MRI has proven to be a powerful method to assess coronary artery diseases. The ultimate goal of the analysis is to obtain a full quantification of the perfusion in ml/(g·min), see e.g. [3]. A step towards this goal is a semi-quantitative perfusion assessment obtained by generating perfusion maps from a registered sequence of images, see e.g. [4]. This paper presents an automatic registration of multi-slice perfusion sequences and a preliminary clinical validation in terms of perfusion maps.

2 Methods and Results

The data material comprises 500 myocardial perfusion, multi-slice, short-axis, magnetic resonance images (MRI) obtained from ten freely breathing patients with acute myocardial infarction. Each image is composed of four spatial slices. The registration method is based on Active Appearance Models (AAMs) [1]. AAMs establish a compact parameterisation of object variability, as learned from a representative training set. Objects are defined by marking up each training example with points of correspondence, i.e. landmarks. Here, landmark positions are optimised by an MDL approach [2]. Subsequently, AAMs can be registered rapidly to unseen images. Modifications to the standard AAM framework include slice-coupled modelling, sequence priors and clustering of texture vectors. For further details, refer to [5].

Given the per-pixel point correspondences of each slice of the myocardium, a semi-quantitative perfusion assessment is carried out. Signal-intensity (SI) curves (plot of intensity vs. time frame) for each pixel position are generated and from those, three perfusion parameters are derived, the *maximum upslope*, *peak* and *time-to-peak*.

Registration of the perfusion data was carried out in a leave-one-out cross validation. Quantitative comparison to ground-truth (manual) registration showed

Fig. 1. Above: Registration of multi-slice time frame 17 from patient 8 (Slice 1–4 left to right). Below: Perfusion maps for patient 8 generated from the automatic registration.

a mean registration accuracy of 1.25 ± 0.36 pixels in terms of point to curve distance. Qualitative registration results and perfusion maps for patient 8 are given in Figure 1. The figure reveals a severe perfusion deficit at the anteroseptal and inferoseptal wall judged from the original multi-slice frame. This is confirmed by the perfusion maps for all slices for the maximum upslope parameter and slices 1, 3 and 4 for the remaining two parameters. Same regions were identified by the perfusion maps for the ground-truth registration.

Based on the preliminary clinical validation, it is concluded that the automatic registration method holds great promise for the automation of quantitative perfusion examinations.

References

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