THE IMPORTANCE OF SHAPE TO ECHOCARDIOGRAM SEGMENTATION

Stebbing R. - University of Oxford
richard.stebbing@sjc.ox.ac.uk

Abstract

Echocardiography is an important tool in the diagnosis of heart-disease. Automatic segmentation of the endocardium is desirable to provide physicians with a fast method for measuring various parameters of heart function. While the segmentation problem appears straightforward, methods relying only on local image features perform poorly because of the variation in patient anatomy and acquisition variables. Incorporating global shape information is therefore required.

The Problem

Segmenting the endocardium from echo images is challenging for the following reasons:

- Lack of visual cues such as colour.
- The boundary of the blood-pool does not exactly delineate the endocardium due to the presence of the papillary muscles, shadowing, and imaging artifacts.
- Appearance variation along sections of the endocardium.

As a result of these challenges segmentation methods driven by low-level features (edges) can be easily misled and perform poorly.

Initial Solutions

Active Shape Models (ASMs) have been applied to the segmentation of the left ventricle in echo and MR images [1]. ASMs and its derivatives, however, still rely on very strong low-level features such as edges for boundary detection. Appearance based models that do not explicitly rely on boundary detection have been shown to provide improved performance as the local features can be learned for different sections of the endocardium [2].

References

[1] Cootes TF., Hill A., Taylor CJ., Haslam J., Use of active shape models for locating structures in medical images, in *Image and Vision Computing*, 1994

[2] Lekadir K., Keenan NG., Pennell DJ., Yang GZ., An inter-landmark approach for 4-D shape extraction and interpretation: application to myocardial motion assessment in MRI, in *IEEE Transactions in Medical Imaging*, Accepted for publication

[3] Orderud F., Rabben SI., Real-time 3D segmentation of the left ventricle using deformable subdivision surfaces, in *CVPR*, 2008

Example: Deformable Mesh + Kalman Filter

A deformable mesh of 24 controls points modelling the left ventricle and updated using a **Kalman filter** has been implemented [3]. The Doo-Sabin subdivision process has been used to create the basis functions for the surface points (**Figure 1**). The echo image is sampled along the normal vectors (**Figure 2**) at each surface point and the local displacement is determined. The output covariance matrix is set according to the strength of the edge responses.

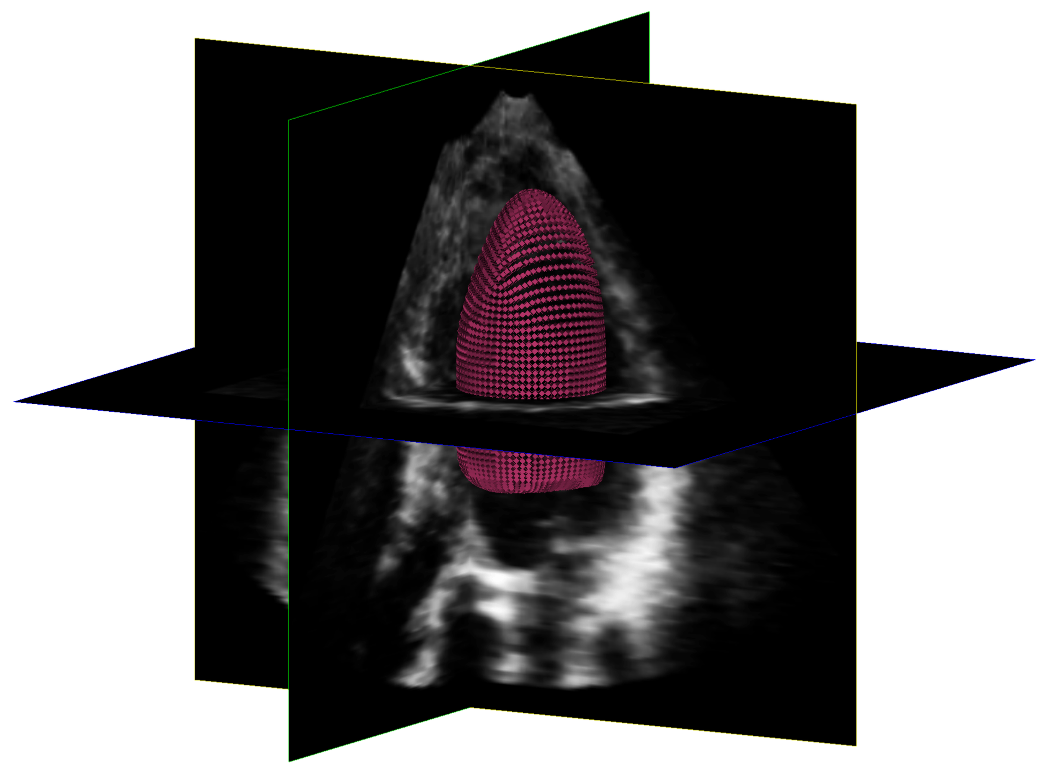

Figure 1: Deformable surface initialisation.

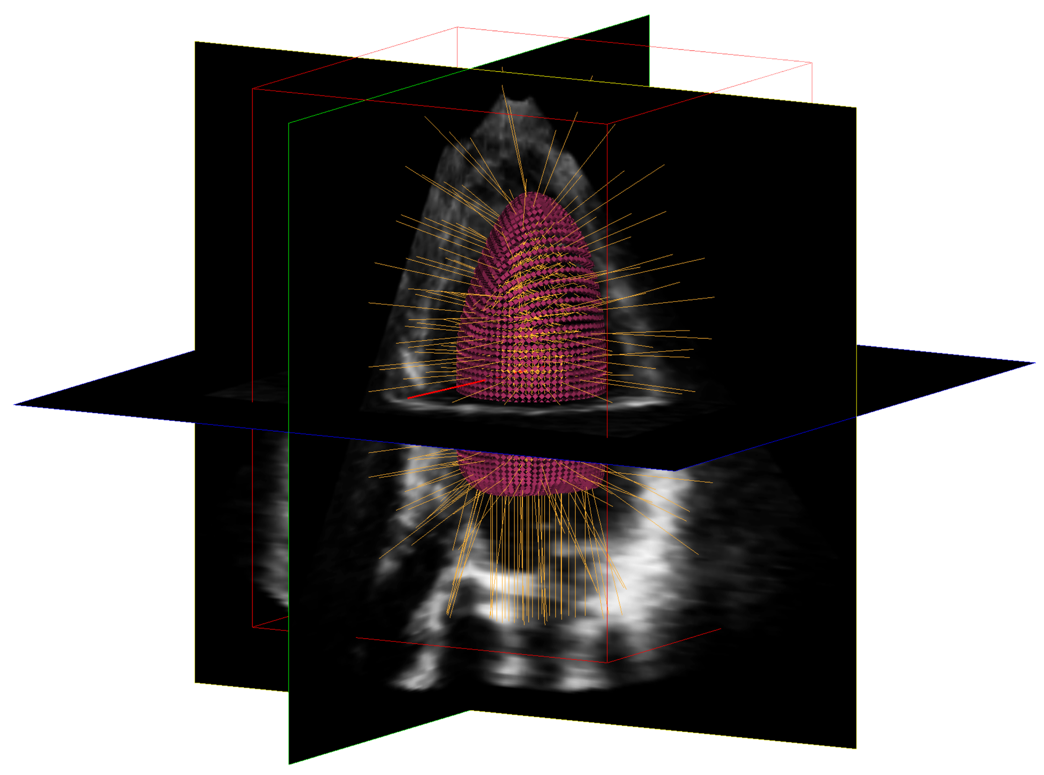

Figure 2: Sampling performed along lines normal to the surface.

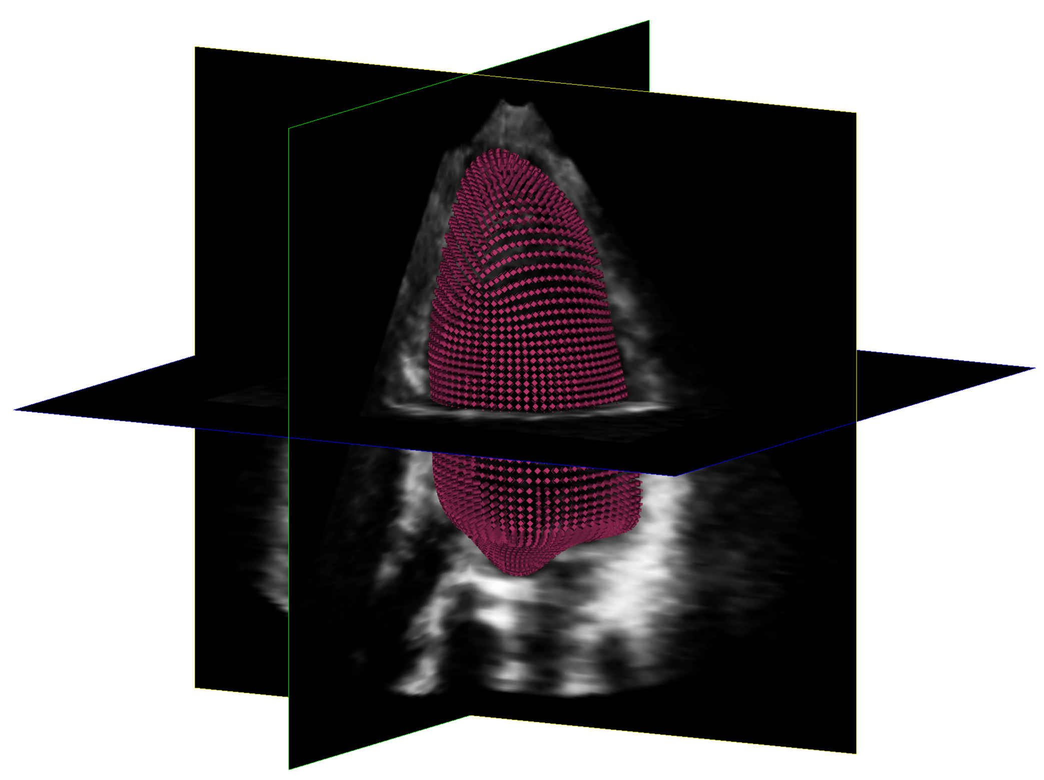

Figure 3: Updated surface.

Figure 3 shows that the updated surface is accurate near the mitral valve as a result of the strong edges. However, closer to the apex the edge features are weaker and the surface has extended past the endocardium. **Global shape information can be used to constrain the surface evolution and improve the use of these edge features**.