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Multiscale Graph Convolutional Networks for Cardiac Motion Analysis

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smartheart

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Introduction

- Cardiac motion analysis plays an important role in the diagnosis of heart conditions. In diagnosis, displacement and strain are important biomarkers, which are sensitive to subtle changes in myocardial function and often indicate the early onset of cardiac disease.
- We propose to employ graph convolutional neural networks (GCN) to model cardiac motion in the geometry space of the GCN which can take advantage of a sparse representation of the cardiac myocadium using contours instead of images.
- We demonstrate that multiscale spatio-temporal patterns achieve good performance for cardiac motion estimation and regional analysis of left ventricular function.

Methods

Multiscale Cardiac Graph Construction

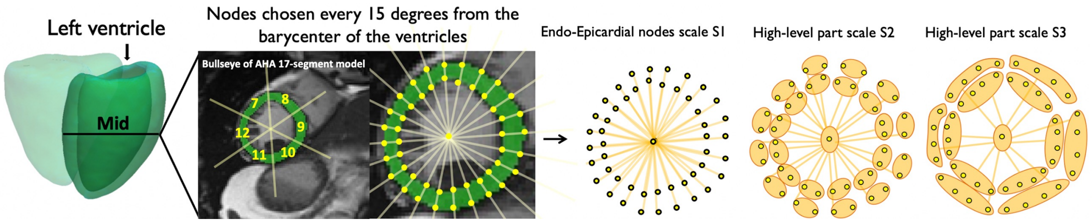

Fig.1: Overview of the proposed framework for the three scale cardiac structure graph construction in the mid-ventricular of short-axis view cardiac MR image sequences. *At scale S1, the barycenter of the left ventricle (LV) and the 48 node locations from both the endocardium and epicardium are considered as cardiac structure graphs. At scale S2 and S3, 25 and 13 parts are considered respectively.*

Multiscale Spatio-Temporal Graph Convolutional Neural Network

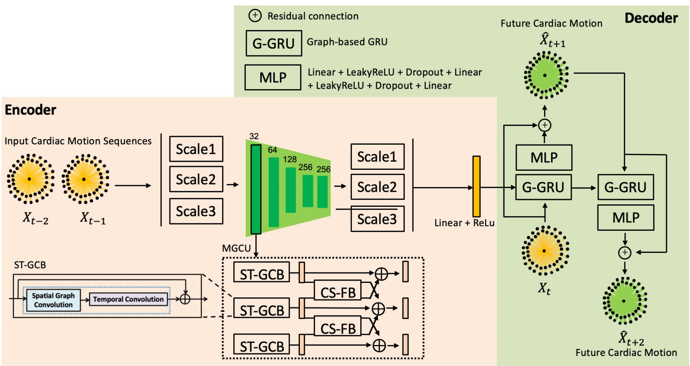

Fig. 2: Network overview. *The cardiac motion sequence is given as input to the MST-GCN encoder-decoder framework. In the encoder, each MGCU layer extracts spatio-temporal feature by multiscale graphs. The sum of the output of the decoder and the previous motion status represents the output future cardiac motion trajectory (predicted node locations), which is used in regional analysis of left ventricular function. ⊕ denotes the element-wise addition.*

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Results

Quantitative Results

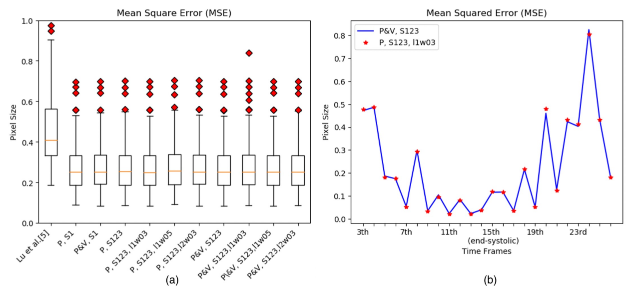

Fig. 3: (a) Using the proposed method *- with ten different architectures and parameter settings - and the baseline, a comparison was made between the MSE on the predicted node locations on the endo-epicardial borders in the MRI sequences with the ground truth.* ***(b) Comparison of the mean squared error (MSE)*** *for the best two performing architectures and parameter settings using the proposed method in each MRI frame.*

Left Ventricular Function Evaluation

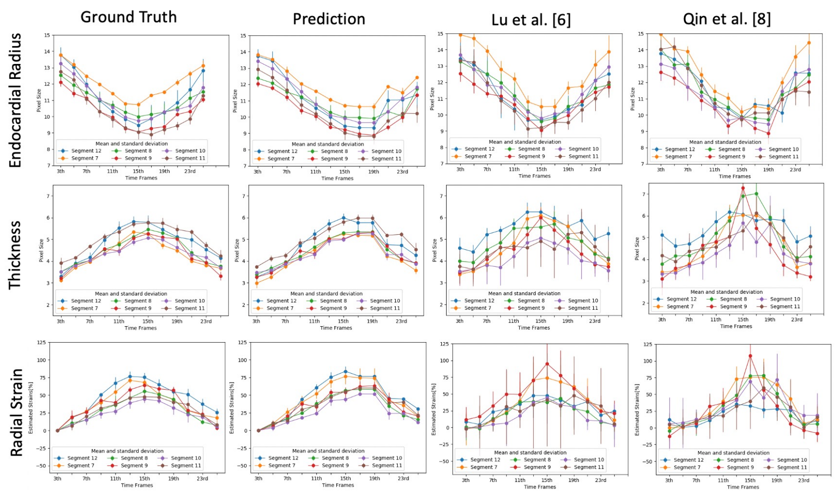

Fig. 4: Example results *of the estimated endocardial radius (mean and standard deviation shown), thickness (mean and standard deviation shown) and radial strain (mean and standard deviation shown) for cardiac segments (7-12) plotted on frames 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25 over a cardiac cycle. Results(left to right) for ground truth, prediction, methods from Lu et al. [7] and Qin et al. [9] in a healthy volunteer.*