Basal Strain Estimation using Deep Learning based Deformable Image Registration

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Background
• Patients undergoing cardiac surgery run the risk of serious complications due to reduced cardiac function
• Continuous monitoring of cardiac function is desirable, but requires manual effort with current methods
• Strain/strain rate require manual annotation and large inter-vendor variations cause issues

Method
• Continuation of the work of De Vos et al.[1]
• Fully convolutional network estimate low-resolution displacements in x and y directions
• Number of alternating convolutional and pooling layers can be adjusted to achieve desired downsampling
• B-spline interpolation used to upsample and achieve full-resolution displacement field estimates

Results and Discussion
• Inspection of the warped grids shows that the displacement estimates are reasonable in most cases
• Strain estimation achieves a mean difference of 7.25% (± 4.56%) when compared to expert annotations performed with standard clinical software (GE Echopac 202.53)
• High degree of underestimation indicates too much downsampling or regularization
• Noisy samples give unpredictable estimates
• Out-of-plane movement and air bubbles “traps” tracker leading to bad estimates
• Filtering approaches (Kalman, Exponential moving average) did not improve robustness
• Robustness could be improved by daisy-chaining networks, incrementally estimating displacements (work in progress)
• Inference time is slow, ~230ms between frame pairs
• Moving processing currently done in Python to the Tensorflow runtime could decrease inference time
• To fully automate the procedure, automatic detection of the landmarks must be implemented

Conclusion
• A fully convolutional network was implemented to estimate frame-to-frame displacements
• Unsupervised training makes data gathering less time-consuming
• Displacement and strain estimation works as expected in low noise samples, but more noise degrades performance
• Remaining work includes automatic detection of landmarks and improving robustness

References