Program Digest, 2019 IEEE International Ultrasonics Symposium (IUS)
Glasgow, Scotland, October 6-9, 2019

Adapting deep learning based motion estimation for myocardial function imaging

Andreas Østvik, Ivar Mjåland Salte, Erik Smistad, and Lasse Lovstakken

Background, Motivation and Objective

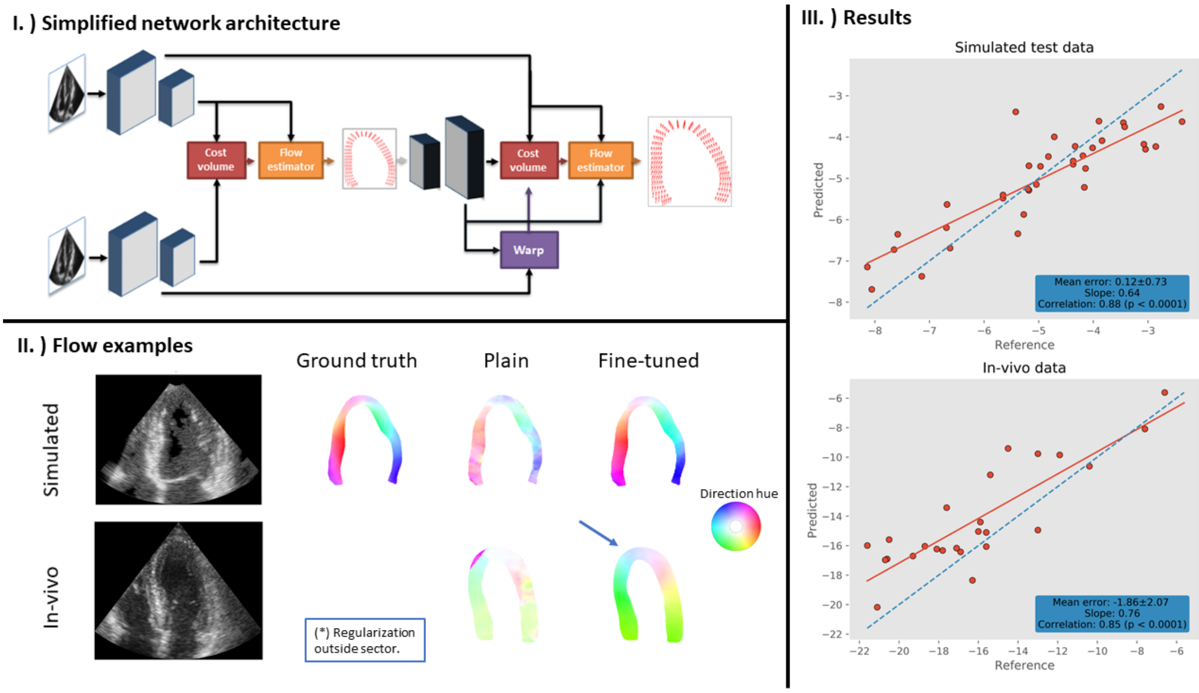
Motion estimation using convolutional neural networks have shown promising results for general optical flow problems. Their design and training regime facilitate correlation between global image features, and optimization for rigid motion patterns. This is not optimal for myocardial function imaging, where local coherent speckle is used to track tissue motion, and deformation occurs through the cardiac cycle. Here, we modified the PWC-Net for ultrasound (US), and developed a training method with fine-tuning on simulated US data to improve the aforementioned.

Statement of Contribution/Methods

A PWC-Net with six feature levels, warping and cost volumes with normalized cross-correlation was employed. Pretraining was performed on publicly available datasets (FlyingThings3D and FlyingChairs2D) of everyday objects moving on arbitrary backgrounds. To reduce the feature space and adapt for US, we converted this data to grayscale. Further, fine-tuning was performed on an open database of simulated US created for quality assurance of speckle tracking algorithms[1]. Due to limited data, we added relevant augmentations such as shadowing, resolution deterioration, and more. The simulated data is highly unbalanced, with known motion only within the myocardium. To address this issue, we used a custom regional multiscale-loss function to restrict optimization to this region.

Results/Discussion

Cross-validation was performed on the simulated data by dividing into folds by vendor and different motion patterns, to avoid potential overfitting. We achieved a mean error of (0.1 ± 0.7) calculating global longitudinal strain (GLS) on the test data with a correlation coefficient of 0.88 ($p < 0.0001$). Further, we tested the trained model in vivo using our previously reported pipeline (IUS2018) for measuring GLS, for 25 patients with pathology compared with a clinical software (GE EchoPAC). The mean deviation was $(-1.9 \pm 2.1)\%$, and within limits of agreement of previously published studies. In comparison, without fine-tuning, an adjustment of 29% (bias) and 10% (standard deviation) was measured. The underestimation of strain values may partially be explained by a limitation of the motion model used to generate the simulations, and we thus believe enhancing the training data further can improve results.



[1] M. Alessandrini et al., "Realistic Vendor-Specific Synthetic Ultrasound Data for Quality Assurance of 2-D Speckle Tracking Echocardiography: Simulation Pipeline and Open Access Database". IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, 2018.