EchoQuan-Net: Direct Quantification of Echo Sequence for Left Ventricle Multidimensional Indices via Global-Local Learning, Geometric Adjustment and Multi-target Relation Learning

Rongjun Ge[1,2,4,7], Guanyu Yang[1,2,4], Chenchu Xu[7], Jiulou Zhang[1,2,4], Yang Chen[1,2,3,4], Limin Luo[1,2,4], Cheng Feng[5], Heye Zhang[6], Shuo Li[7]

1. Laboratory of Image Science and Technology (LIST), School of Computer Science and Engineering, Southeast University, Nanjing, P.R. China
2. Key Laboratory of Computer Network and Information Integration, Southeast University, Ministry of Education, Nanjing, P.R. China
3. School of Cyber Science and Engineering, Southeast University, Nanjing, P.R. China
4. Centre de Recherche en Information Biomédicale Sino-français (CRIBS), Rennes, France
5. Department of Ultrasound, The 3rd People's Hospital of Shenzhen, Shenzhen, P.R. China
6. School of Biomedical Engineering, Sun Yat-Sen University, Guangzhou, P.R. China
7. Department of Medical Imaging, Western University, London, Canada

✉: {gerj16,chenyang.list}@seu.edu.cn

Objectives

To directly quantify left ventricle from echocardiography (echo) sequence without segmentation

Figure 1: Multidimensional indicesof LV: length and width of 1D, area of 2D, and volume of 3D.

Challenges

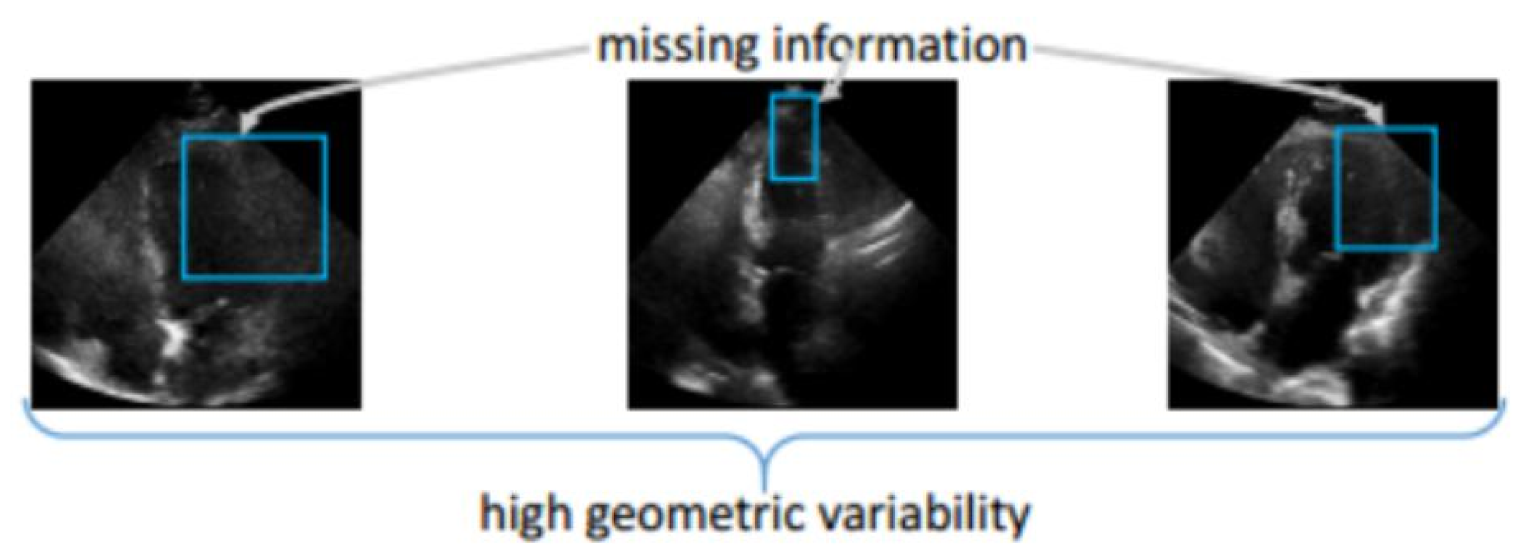

Figure 2: Frequently missing information in box due to ultrasound imaging modality, and high geometric variability caused by subjective imaging acquisition.

Methods

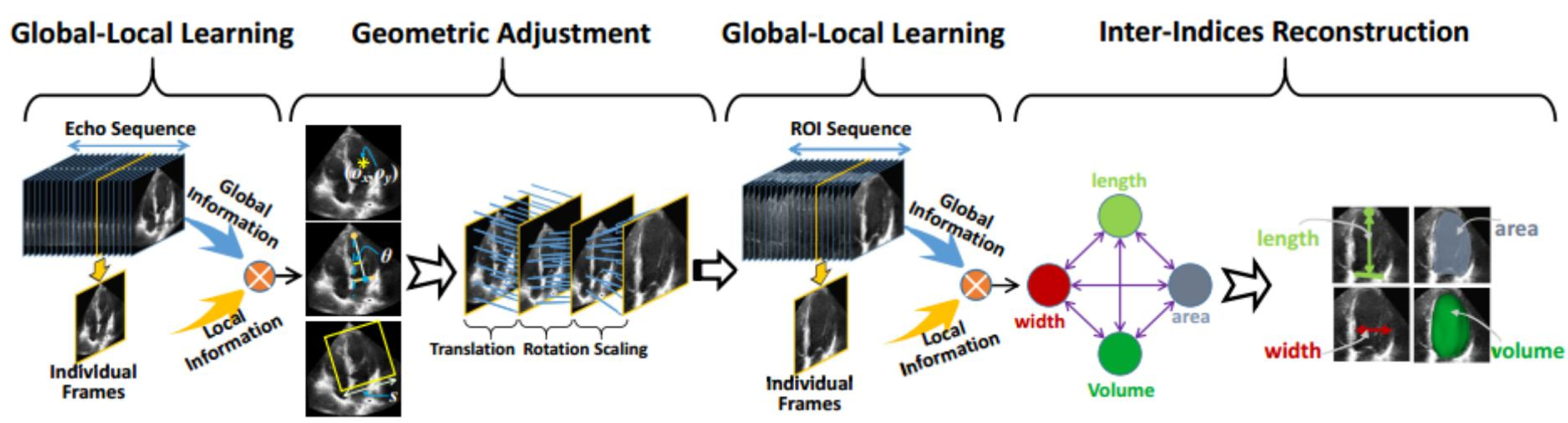

Figure 3: The EchoQuan-Net directly achieves multidimensional quantification for LV in echo sequence, with composed of three effective components: (1) Global-Local Learning for contextual information in the cardiac cycle, (2) Geometric Adjustment for translation, rotation and scale invariant, (3) Multi-target relation learning for joint quantification of LV multidimensional indices.

Results

The performance of the network is measured by calculating the mean absolute error (MAE):

$$MAE = \frac{1}{50 \times 20} \sum_{sub=1}^{50} \sum_{f=1}^{20} \left| \hat{y}_{sub,f}^{t} - y_{sub,f}^{t} \right|$$

Table 1: The proposed method achieves best quantification performance compared to the existing methods, with the lowest MAE for each index.

	Length (mm)	Width (mm)	Area (mm^2)	Volume (ml)
Multi-features+RF[1]	3.86 ± 3.48	3.23 ± 2.91	323 ± 266	18.4 ± 15.7
SDL+AKRF[2]	3.73 ± 3.05	3.21 ± 2.82	280 ± 236	18.9 ± 15.2
MCDBN+RF[3]	3.93 ± 3.38	3.18 ± 3.00	312 ± 255	17.6 ± 14.9
Indices-Net[4]	3.29 ± 2.42	4.27 ± 3.37	354 ± 338	16.1 ± 14.4
U-Net[5]	N/A	N/A	387 ± 296	N/A
Proposed method	$\mathbf{3.14 \pm 2.69}$	$\mathbf{3.10 \pm 2.76}$	$\mathbf{276 \pm 245}$	$\mathbf{13.5 \pm 11.6}$

Data set: A data set of 1000 2D echos of 50 subjecys from 2 hospitals is used to evaluate the performance. Each subject provides 20 frames in a cardiac cycle.

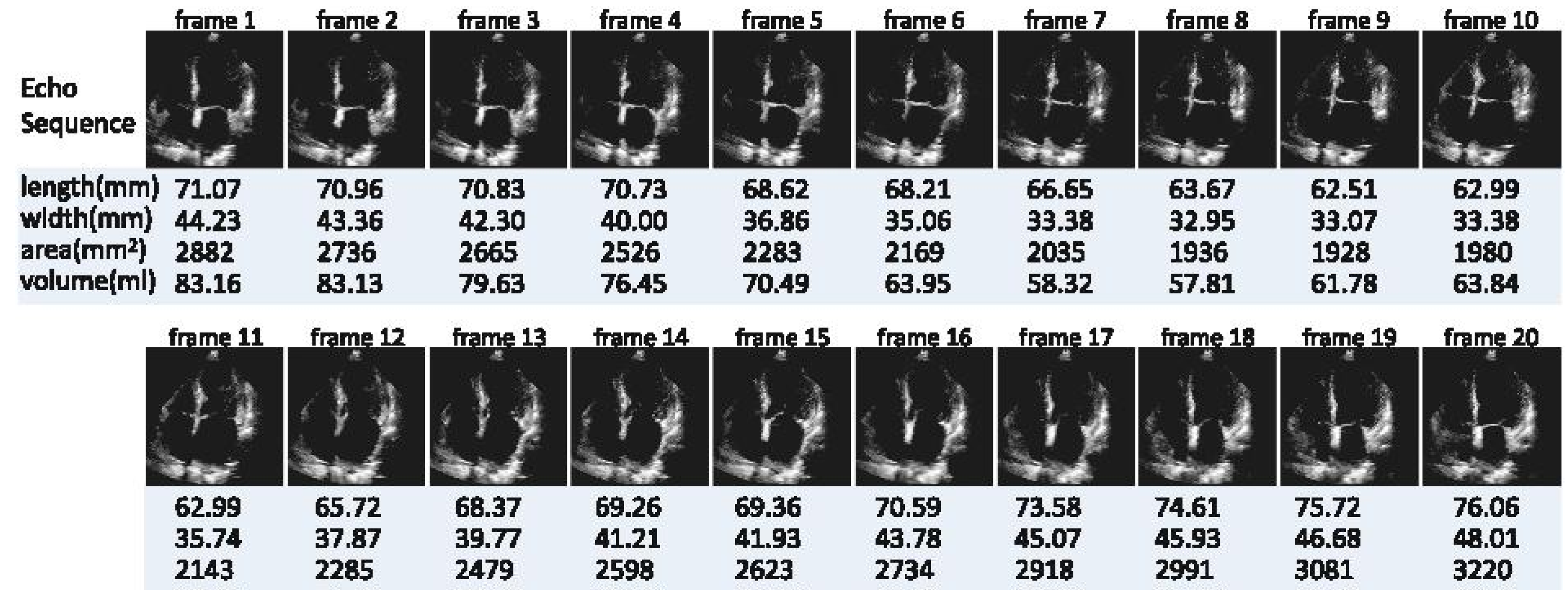

Figure 4: The proposed EchoQuan-Net is able to effectively, multidimensionally and continually quantifies the cardiac changes across the cardiac cycle.

Reference.

[1] Zhen, X., Wang, Z., Islam, A., Bhaduri, M., Chan, I., Li, S.: Direct estimation of cardiac bi-ventricular volumes with regression forests. In: MICCAI 2014, pp. 586–593.
[2] Zhen, X., Islam, A., Bhaduri, M., Chan, I., Li, S.: Direct and simultaneous fourchamber volume estimation by multi-output regression. In:MICCAI 2015, pp. 669–676.
[3] Zhen, X., Wang, Z., Islam, A., Bhaduri, M., Chan, I., Li, S.: Multi-scale deep networks and regression forests for direct bi-ventricular volume estimation. Med. Image Anal. 30, 120–129 (2016).
[4] Xue, W., Islam, A., Bhaduri, M., Li, S.: Direct multitype cardiac indices estimation via joint representation and regression learning. IEEE Trans. Med. Imaging 36(10), 2057–2067 (2017).
[5] Ronneberger, O., Fischer, P., Brox, T.: U-Net: convolutional networks for biomedical image segmentation. In: MICCAI 2015, pp. 234–241.

28th International Conference on Artificial Neural Networks Sep 17, 2019 - Sep 19, 2019 Munich, Germany