Objective: This study aims at developing an automatic tool for left ventricular segmentation in 3D echocardiography, which is challenging but essential in providing anatomical and diagnostic information for functional analysis of myocardial dysfunctions.

Methods: We collected four sets of 3D echo images from four different patients with an iE33 Philips console fitted with a Philips X2-T Live 4D TEE probe. We set the volumes to be of size 224 x 208 x 208 (with a resolution of 0.7 x 0.7 x 0.6 mm per voxel), and use a 7 breath-hold cycle protocol to collect the intraoperative data. Given the data sets, we designed a novel level set method to segment the endocardium surface and epicardium surface. Specifically, two weighted surface-like models are initialized based on variational level set formulation and partial differential equations. The weighted endocardium surface and epicardium surface are then varying according to the local echo sampling density. To handle the noisy and non-uniform regions within the echo data, we used a regularization term to adaptively and continuously following the gradient descent of the topological change. Finally, the optimal the endocardium surface and epicardium surface are obtained by solving the minimal energy for the two weighted surfaces using a brief propagation algorithm.

Results: Even for the typically low signal-to-noise and small field-of-view in echo images, our method can successfully segment the left ventricle by robustly extracting the endocardium surface and epicardium surface. The proposed method achieves a mean accuracy of 6.1 ± 1.3% volume differences against the gold standard for MRI segmentation method and a mean accuracy of 14.5 ± 2.1% for segmentation of all four chambers.

Conclusions: Using a level set approach to segment left ventricle in 3D echocardiography provides a fully automatic tool for physicians to obtain the anatomical and diagnostic information for cardiac functional analysis, without requiring any user input or any other assistants. The ability of our method to automatically and accurately extract endocardium and epicardium from echo has promising clinical potential in further medical diagnosis and surgery planning.