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# A Collaborative Robotic System with Autonomous In-Plane Orientation Adjustment for Lung Ultrasonography

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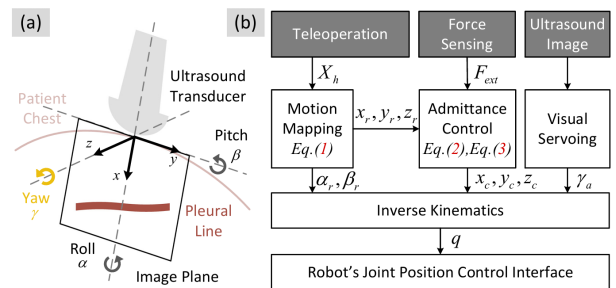
Introduction

This poster presents a collaborative robotic system that can autonomously horizontalize pleural lines in ultrasound images during teleoperated lung ultrasonography. The system deploys a shared control strategy that exposes the out-of-plane pose of the robot-held ultrasound transducer to human teleoperation and autonomously adjusts the in-plane orientation of the transducer with visual servoing technique. Preclinical tests show that the system successfully works in the restricted autonomous manner as designed.
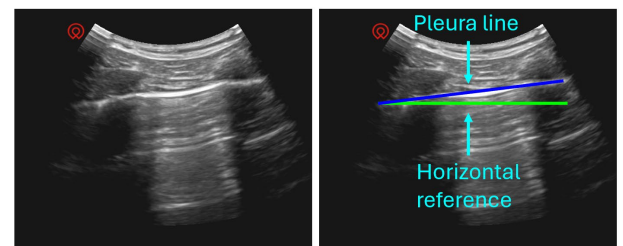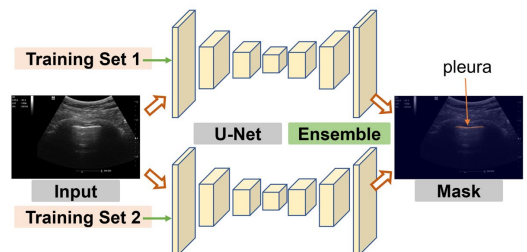
System
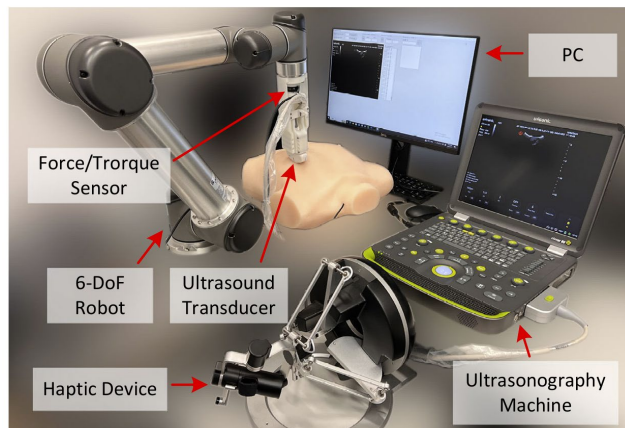
Methods

Shared control scheme

$$X_r = [x_r, y_r, z_r, \alpha_r, \beta_r, \gamma_r]^\top = \lambda X_h \qquad (1)$$

$$e = X_c - [\mathbf{1}^{1\times3}, \mathbf{0}^{1\times3}]^\top X_r \qquad (2)$$

$$M\ddot{e} + D\dot{e} + Ke = F_{ext} \qquad (3)$$

$$X = [x_c, y_c, z_c, \alpha_r, \beta_r, \gamma_a]^\top \qquad (4)$$

Ensemble U-Net model for ultrasound image processing

Results

We validated our system on phantoms (see videos via QR code at right top corner of the poster) and volunteers. Images below are snapshots taken (a) before and (b) after the autonomous in plane orientation adjustment during teleoperated lung ultrasonography on a volunteer. The blue line in the ultrasound image marks the pleural line and the green line marks the horizontal reference. The results show that our system succeeded in adjusting the in-plane image orientation autonomously during the teleoperated lung ultrasonography.