Feasibility of Robot-Assisted Ultrasound System

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INTRODUCTION

Sonographers tend to develop musculoskeletal injuries over the years of work because of the repetitive motion and the physical demands of ultrasound scans [1]. This issue not only affects sonographers but also impacts care availability. To reduce sonographers' musculoskeletal strain, robot-assisted systems have been proposed in research studies as a means to address this issue by enhancing the ergonomics of scanning operations. Most of the prior studies were phantom-based. This study was conducted with 28 patient participants to show that it is feasible to perform ultrasound scans using a robot arm operated by sonographers.

MATERIALS AND METHODS

The system used in our study consists of a Universal Robots UR10e robot arm, Philips EPIQ 7C echocardiography scanner with X5-1 transducer, and a lightweight wireless OneStick controller. The system allows a sonographer to move the robot arm to one of the generalized apical or parasternal positions using a preprogrammed button on the OneStick controller. Using the OneStick controller, the sonographer can make minor adjustments to place the X5-1 transducer at the exact position for the best image quality. Using the Universal Robot's RTDE API, the arm keeps contact with the body of the patient by applying approximately 5N in the direction of the X5-1 transducer while remaining compliant only along the same axis, which prevents X5-1 from drifting from the target location. The forces applied by the robot arm onto the patients were continually recorded.

RESULTS AND DISCUSSION

The forces recorded during image acquisition are shown in Table 1. The force on the X-axis of the X5-1 transducer is the applied force by the robot, which doesn't exceed 9 N and assures safety and patient comfort. The forces recorded for other axes are forces applied by the patient to the robot since the robot force is constrained to the x-axis. A total of 1,629 DICOM images were acquired from 28 patient participants in this study, with a mean of 58.18 images per participant, a standard deviation of 19.64, a median of 56, and a maximum of 106 images. The visual assessment of the echocardiography images showed that robot-assisted scanning produced similar quality images to those acquired using standard manual scanning. Refer to Figure 1 for example images.

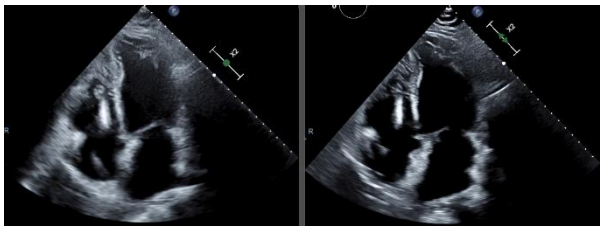

Fig 1: Shows the image capture manually in clinic (left), and image capture robot assistance (right)

CONCLUSIONS

This study demonstrated that using robot-assisted echocardiography scanning can enhance sonographers' comfort by providing a lightweight controller for them to perform the scan, thereby reducing musculoskeletal strain and injuries. The image quality of the robot-assisted echocardiography scans was comparable to the images acquired using manual scanning.

REFERENCES

[1] J. Alaniz and B. L. Veale, *J. Diagn. Med. Sonogr.*, vol. 29, no. 4, pp. 188–190, 2013.
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Table 1: Forces measured by UR10e integrated force sensor.

	Mean	Std	Median	Max
Force-X (N)	3.76	1.16	*3.69*	*9.43*
Force-Y (N)	1.24	0.94	*1.04*	*6.42*
Force-Z (N)	1.68	1.12	*1.55*	*7.08*