Eye Gaze Contingent Ultrasound Interfaces for the *da Vinci*® Surgical System

Zhaoshuo Li[1], Irene Tong[1], and Septimiu E. Salcudean[1]

***Abstract*— Current practice of intra-operative ultrasound requires an assistant due to the fact that surgeon's hands are occupied with surgical tools. This process can be tedious and prone to error. This work presents three novel designs in one common framework to provide surgeons with further autonomy in using ultrasound. Leveraging the *da Vinci* Research Kit, the interfaces incorporate eye gaze and voice recognition into the *da Vinci*® Surgical System for ultrasound machine control.**

I. INTRODUCTION

Robot-assisted laparoscopic surgery is widely adopted with a prominent example being the *da Vinci*® Surgical System (Intuitive Surgical Inc., Sunnyvale, CA). The *da Vinci*® features a stereo endoscope, motion scaling, and hand tremor-filtering to improve the surgeon's capabilities. The benefits of robot-assisted surgeries for patients include faster recovery times and fewer surgery complications [1].

While ultrasound imaging is often used intra-operatively during robot-assisted surgery, in part due to its real time and non-ionizing nature, there is a challenge in performing it efficiently. Surgeons usually instruct their assistants to adjust the ultrasound parameters to obtain the optimal images, because their hands are occupied with surgical tools. This process can be tedious and prone to error due to miscommunication and non-intuitive control [3].

Eye gaze control has shown to be a promising modality in robot-assisted surgery, such as actively for instrument control [6] or passively for camera scene stabilization [5]. A retro-fit eye gaze tracker [7] has been designed for the *da Vinci*® Surgical System. Improvements upon previous design include a new hardware configuration and the adaptation of the *ExCuse* pupil detection algorithm and a glint detection algorithm [2], [4].

This work aims to integrate eye gaze tracking with ultrasound control to increase the surgeon's autonomy in the operating room and increase the use of ultrasound imaging in a robot-assisted setting.

II. MATERIALS AND METHODS

A. System Setup

The proposed system is composed of a ultrasound control application software, the *da Vinci* Research Kit (dVRK) developed by Johns Hopkins University, a SonixTouch ultrasound machine (BK Ultrasound, Peabody, MA), a custom eye gaze tracker [7], and a microphone. The control application interfaces with the *dVRK* through Robot Operating System (ROS) for motor control and sensor reading. It sends commands to the ultrasound machine, and acquires a stream of ultrasound images. It uses the eye gaze tracker to obtain eye gaze position and the microphone for voice recognition. The ultrasound control application containing ultrasound image stream and parameters is displayed within the *da Vinci* surgeon console real-time.

[1]Zhaoshuo Li, Irene Tong and Septimiu E. Salcudean are with Faculty of Electrical Engineering and Computer Engineering, University of British Columbia, 2332 Main Mall, Vancouver, BC, Canada V6T 1Z4 maxwellli@ece.ubc.ca

B. Graphical User Interface (GUI)

A GUI incorporating four commonly used ultrasound parameters (zoom, gain, depth and Doppler mode including color gain) is designed. The ultrasound image is displayed prominently. The four parameters are in a circular layout to maximize the space for ultrasound images and decrease the difficulty for eye gaze selection [8]. One increase button and one decrease button are designed to adjust ultrasound parameters. A position input is used for pointing and a confirmation input is used to confirm or cancel a selection of a button. The GUI occupies the full display screen inside the surgeon console with endoscopic views hidden.

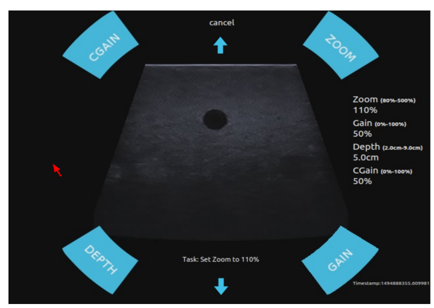

Fig. 1: GUI layout with parameter buttons and increase/decrease buttons shown in blue.

C. Interfaces

Three novel interfaces for remote ultrasound control based on *dVRK* and *ROS* are designed.

Master tool manipulator (MTM) mode: this interface is designed to be similar to the normal operation of the *MTMs*. The 2D planar position offset of the *MTM* from the initial position when the application starts is used for the position input. A dominant *MTM* gripper is set based on the user's dominant hand. The click of the dominant *MTM* gripper is for confirmation and the click of the other gripper is for cancellation. A spring-damper haptic feedback model is built around both *MTMs* with $F = k(x) \cdot \vec{x} + c \cdot \dot{\vec{x}}$,