Ultrasound Guided Robot for Minimally Invasive Surgery

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One of the difficulties of guiding a medical robot with an ultrasound is the need to be in the imaging area of the ultrasound. Our solution to this problem is to locate the ultrasonic sensor at the tip of the tool driven by the medical robot. By using a miniature ultrasonic sensor, it is possible to achieve high precision localized measurements.

Our goal is to create a robotic system which will enable autonomous scanning of a selected area in a biopsy surgery, identification and sampling of the suspected tissue guided by the ultrasound (US) signal. Several systems suggest integrating a US with a medical robot [1-3] although in all of them the tool and the US are not collocated or work in a closed loop. Our medical robotic system for MIRS contains the following components (Fig 1):

6 DOF Robotic Arm Type Denso VP-G; Open architecture controller manufactured by Quanser; An Ultrasonic sensor manufactured by Vermon, France. The sensor installed in a Perspex rod that represents a standard laparoscopic tool; Force sensor type Nano 17; Phantom-Haptic Device type Omni manufactured by SensAble; Pulser/Receiver made by Lecoeur Electronique called USBox.

Fig. 1. Image of the ultrasound guided robotic system for MIRS

Fig. 3. Echo’s peak amplitude as a function of angle for different distances.

Fig. 2. Decay of the echo’s peak amplitude as a function of distance.
In order to estimate the ability of the US probe to measure features in the body we did some calibration measurements in a water filled vessel from Perspex, presented at figure 2 and figure 3.

In addition we have performed localization and tracking experiment (figure 4 and figure 5) by exploiting the data from the ultrasound sensor to close the loop in real time (with update rate of 10 Hz) control of the location of the tip of the laparoscopic tool using the standard controller and the Matlab environment. We have performed surface scanning while maintaining a constant distance from the surface of the objects, 2 flat metal discs on top of each other. Fig. 5 shows that the robot follows accurately the surface contour.

We intend to incorporate in the system a user interface using the Phantom as a guiding tool for the robot. The user will guide the robot manually to reach a point of interest and will be able to receive through the Omni and the NANO17 tactile information during the process. We present here a medical robotic system using US in real time for guidance. In future work we will apply image processing for identification of the suspicious malformations in the measured organ and add trajectory planning to them using the ultrasound and force sensor as feedback.

References: