

using the passivity of the wave variables properties of [9,10].



Fig. 2: 4 DOF PROSIT-0 prototype, the prismatic z axis carries the ultrasound probe and maintains it in contact with the patient's skin and is based on the PRISME patent [10]

The development of these schemes as well as of the haptic device is based on the users requirements defined by INSEM390 partner using developed robotic mechanical architecture [6].

RESULTS

The first PROSIT prototype has been built. It is a 4-DOF serial type robot with a remote centre of motion. This RCM corresponds to the contact of the ultrasound probe tip with the patient's skin. The prismatic z-axis enables to exert a maximum force of about 20N on the patient's body. One of the main characteristics is that it can hold any type of ultrasound probes used in the medical radiology department; it is under technical and clinical tests with Tours university hospital. This prototype is teleoperated via any communication links and using a passive input device with a flock of bird (FOB) position sensor from ascension technology. However, to satisfy the users requirements and improve the system transparency, a new hand-free haptic device for PROSIT has been designed; it has a similar appearance as of a standard ultrasound probe; it is a light and easily transportable, active haptic system.



Fig. 3: Haptic probe CAD providing the environment impedance variations to the operator

It integrates inertial sensors and an accelerometer in order to obtain angular and displacement variations in order to register the expert's hand movements; these sensors are an alternative to the FOB system as they are not sensitive to electromagnetic fields. This ergonomic haptic probe integrates a force sensor and an actuator to provide, a good rendering of the environment impedance variations during the tele-echography act. The position accuracies have been assessed using the Vicon Nexus motion capture system. A force sensor at the slave system provides the force applied by the ultrasound sensor on the patient's skin and sends the information in real time to the master site.

DISCUSSION

On the clinical aspect, the tele-echography robotised system performance is evaluated by comparing it to a conventional echography done on the same patient. The medical team evaluates a score expressed as a percentage of the number of patients for whom the organs could be visualised using the robot with respect to the number of patients for whom all organs could be visualised using conventional echography. With this prototype, 87% of abdominal robotic echographies were successful in visualising all the set of organs needed to provide a reliable diagnosis. These preliminary results show the need of such a system in comparable emergency situations. In order to improve these results, visual servoing will be added to the system to track a region of interest of the ultrasound image to compensate for mechanical defaults or data loss in the communication link.

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