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Ultrasound Imaging Based on Robotic System

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Abstract

Recently, many researchers have shown interest in robots and their applications in various medical applications (Invasive and Non-Invasive Diagnostic Testing).This paper introduces developing of master and slave robots that aid radiologists perform ultrasound tests on the human body. Three degrees of freedom Movements for ultrasound imaging are provided for master device and slave robot. The probe of ultrasound machine is fixed in the slave and touches human body through the end of design to decrease the volume of the slave. The master is depended on linear actuators to be controlled in real-time. The master and slave robotic system was developed and a movement tracking test was shown with the introduced system.

Keywords: Ultrasound examination, Medical robot, Real-time system

1. Introduction

Echography is a difficult exam depends totally on specialized skills. The radiologist doing the diagnosis moves the transducer at the affected Patients to collect bi-dimensional images. It may also carry out its diagnosis through constant measurements of these photos and / or the evaluation of the dynamic behavior of the organs as an example depending on the pressure exerted by the probe on the patient. A lot of these skills may not be particularly available in a few health care centers or in emergency situations.

Recently, a robotic ultrasound diagnosis system was introduced in many researches. An ultrasound robot has been developed to decrease joint fatigue of ultrasound technician [1], A robot designed and manufactured for tele-echography that depends on the humans body through the examinations [2], Developed an automated ultrasound scan system containing of orbicular guides related to serialization with floating actuator [3, 4], the development of a hybrid mechanism to manipulate the ultrasound transducer [5]. Robotic arm has been developed four degree of freedom had been presented in [6], A robotic hybrid arm was designed for 3D medical imaging [7].

A mechanical arm was designed to aid ultrasound technician during the ultrasound imaging had been introduced in [8], A robotic device was designed with 6-degree of freedom to move the transducer in a three-dimensional area and measure the contact strength between the transducer and the patient[9]. Development of four degree of freedom robotic system for remote ultrasound imaging [10,11].

In this article we present the design and fabrication of an integrated hardware and software system that is cost-effective, easy to use, and maintains manual technology.

2. Materials and methods

2.1 System overview

Figure 1 shows the Flow diagrams for Master-Slave Robotic System for ultrasound diagnoses [12]. Usually, in ultrasound imaging, a radiologist controls ultrasound machine using a master device similar to an ultrasound probe. Master control circuit transmits a signal to slave robot via microcontroller. Pc controller showed the motion track of master and slave robot using MPU-6050 (Gyro + Accelerometer) MEMS Motion Tracking sensor. In the development system, a radiologist assistant is required to put the slave on patients and emergencies.

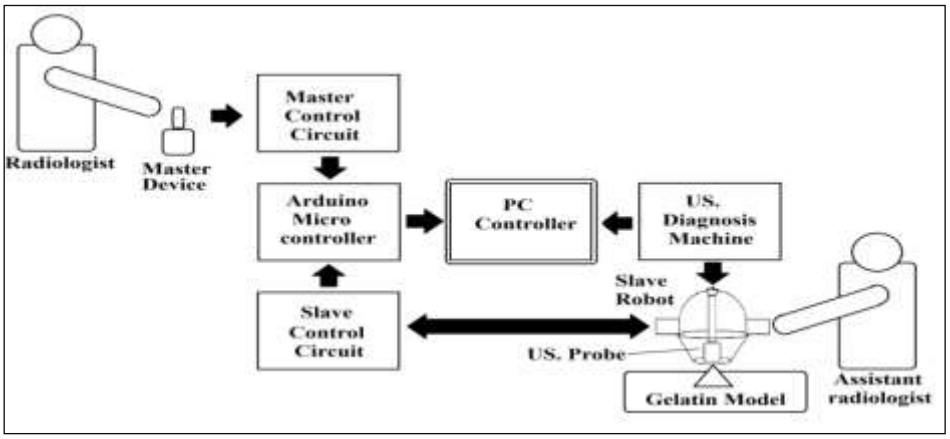

Figure 1. Robotic System diagram

2.2 Master device

Figure 2 shows movement of the master and how to record the results using the MPU sensor installed on the master, these movements are pitch, roll and yaw. The master control circuit contains of electronic components that convert the master's motion to an electric signals, Arduino reads these values and send it to the servo motors in the slave.

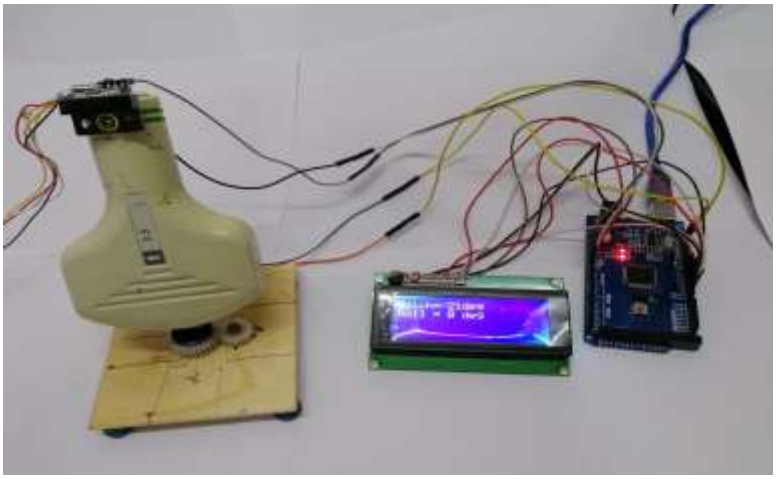

Figure 2. Master Device

2.3 Slave architecture

As the development system in [12], The slave robot architecture was designed depend on the motion of the ultrasound convex probe during examination. In particular, the convex probe movement was used to ensure enough movement

when using any type of other probes such as linear or sector probes, because these probes need a fewer movements than the convex Probe, this will be presented in the results for using another probe with the system. Figure 3 shows the parts of the slave robot that were designed on the AutoCAD program, where each part displays the motion angle. Based on this design concept, the size and weight of the robot are reduced so that the assistant can carry it without any additional loads

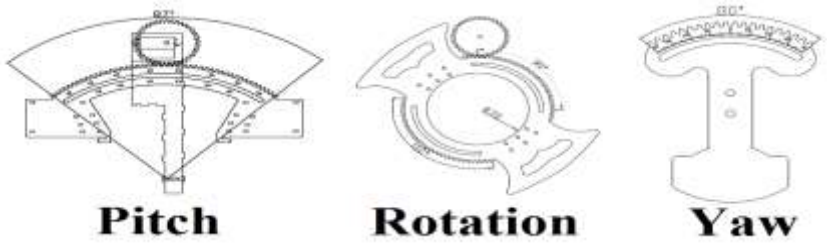

Figure 3. Slave robot architecture

3. Results and Discussion

3.1 Ultrasound imaging gelatin Model

Experiments were performed with the robotic system on gelatin Model to display its ability to perform ultrasound imaging; the model includes a plastic doll as shown in figure 4. The model was examined using a Mindray ultrasound device, and the ultrasound probe was used convex probe.

Figure 4. Ultrasound imaging for gelatin model

3.2 ultrasound robotic system

Figure 5 shows the ultrasound robotic system. The overview configuration of the introduced ultrasound robotic system is characterized in Figure 4. The ultrasound

diagnostic machine (acuson cypress) is used and the echo transducer was fixed in the slave. In this article, the newly master device was developed to provide convenient and efficient movement. The assistant radiologist is wanted for placement of slave to patient and to manage the emergency. Ultrasound diagnostic motion of three degree of freedom was obtained via master and sent to the slave robot to control a fine movement of ultrasound probe.

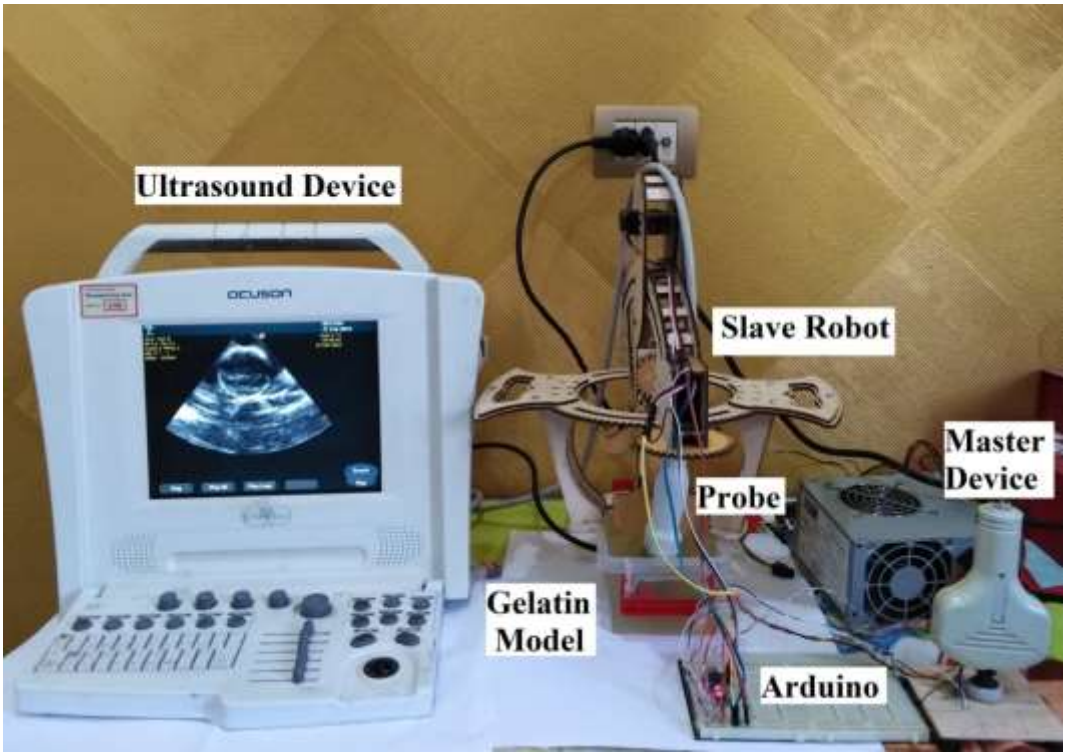

Figure 5. Master - Slave robotic system.

3.3 Tracking evaluation

Movement tracking between master and slave robot was obtained. The arbitrary motion of master was recorded in the pc control program by MPU-6050; simultaneously the movement of the slave was acquired by MPU-6050 Six-Axis (Gyro + Accelerometer) MEMS Motion Tracking™ Device. The tracking results are shown in the Figure 6.

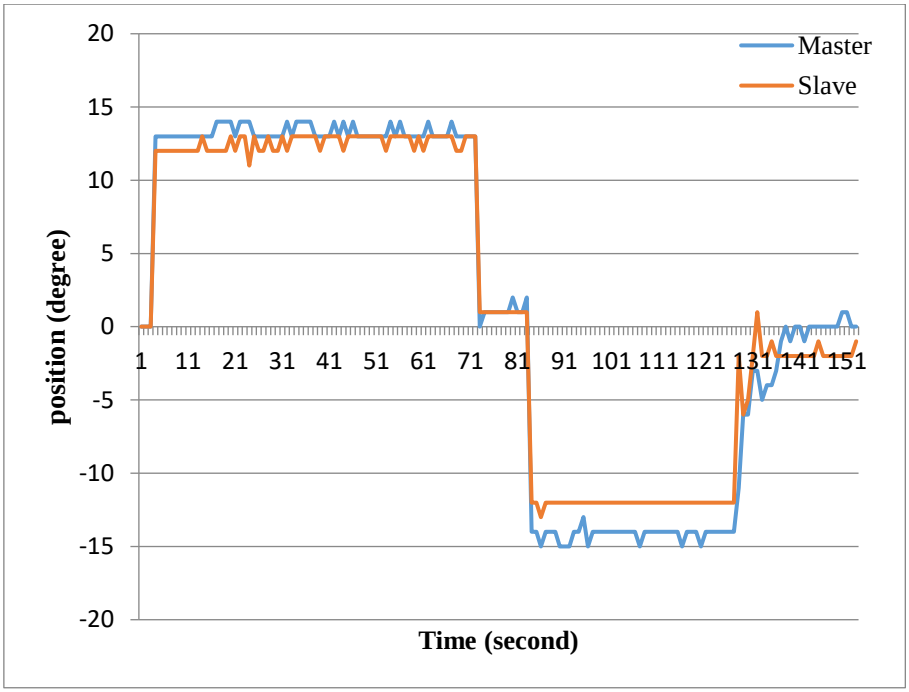

Figure 6. Movement tracking for master-slave robots

4. Conclusions

The ultrasound scan provides a quick and reliable non-surgical examination. However, the main drawback of current ultrasound techniques is that the quality of the examination is highly dependent on operator skills, which are often lacking in small medical centers and isolated areas. As a solution to this problem, a complete robotic ultrasound imaging system has been developed in this paper to aid radiologists perform examination on patients. The system consists of a 3-DoF robot and a 3-DoF manual controller. From the robotic point of view, this is the most complete system for conducting ultrasound imaging. The master device and slave robot for the operator were useful and enabled him to preserve contact between the probe and the patient and to obtain continuous ultrasound images.

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