Prototype Model of Robotic Arm using telemetry for Surgery

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ABSTRACT
Now-a-days, robots are being used to perform surgery**.** The main advantages they provide are precision, miniaturization, smaller incisions, decreased blood loss, less pain, and quicker healing time. Robotic assistance decreases the fatigue that doctors experience during surgeries that can last several hours. Telesurgery is the ability for a doctor to perform surgery on a patient even though they are not physically in the same location. The paper deals with design and development of a prototype model of a basic robotic arm for telesurgery in remote locations. The movement of the user's arm along with haptic technology is used to control the movements of the robotic arm. The processing of the raw data from the potentiometric sensors attached to the hand was carried out by microcontroller. The telemetry system comprised of a RF transmitter and receiver were used for sending and receiving the data.

General terms—Robotic Arm, Haptics, Telesurgery**.**
Keywords--- Robots, telesurgery, telemetry system.

INTRODUCTION
A multifunctional manipulator that can be reprogrammed to move material, parts, tools, or specialized devices s defined as a robot [7]. A robotic arm consists of several sections connected together by linkages that help the arm to travel specifically in a designed pattern, with sensors ensuring that all movements are exactly of the similar pattern. They are endowed with several degrees-of-freedom, giving them the flexibility to move in many directions through multiple angles with utmost ease and agility.

Haptic technology or haptics is called a tactile feedback technology as it takes an advantage of a user's sense of touch for the enhancement of the remote control of machines and devices [2]. Devices that enable manual interactions with virtual environments or teleoperated remote systems are called haptic interfaces. In general, they receive motor action commands from the human user [10]. Tele-hapticscan be defined as the use of haptics in a network context. It is the science of transmitting computer generated tactile sensations over networks, between physically distant users [9].

Medical robots are managed by physicians through computerized consoles. The shape and dimensions of the arm depends upon the type of surgery being performed [12]. Remote surgery promises to allow the expertise of specialized surgeons to be available to patients worldwide, without the need for patients to travel beyond their local hospital [11]. Some of the advantages that robotic surgery provides us are that incisions are smaller as compared to conventional methods, the risk of infection is less, hospital stays are shorter so therefore people can return faster to their workplace and hence the healing followed is significantly reduced. It has been observed that laparoscopic procedures have lessened the pain and the cosmesis and the postoperative immune function is better [13].

Currently many robotic surgical systems are being developed. A master-slave manipulator system known as ARTEMIS (consisting of 2 robotic arms controlled at the console) was developed by Schurr et al at EberhardKarls University's section [14] for minimally invasive surgery. Also, a prototype miniature robotic system for computer-enhanced colonoscopy was developed by Dario et al [15]. This system allows the endoscopist to directly supervise the endoscope. The system is integrated with endoscopic tools. The Zeus system and the Da Vinci system are most commonly used for the laparoscopic surgeries. The most notable application of robotic surgery is in total endoscopic coronary artery grafting, which is not possible by any laparoscopic technology [13].

The objective of the paper is to design a fundamental robotic arm. The arm is designed to have three degrees of freedom, one at the wrist, one at the elbow and two claws that emulate the movements made by the thumb and the first finger. Three servo motors are attached at the required positions to imitate the movements. On the transmitter side the potentiometers attached at the above three specified locations respectively help to transmit the desired data. The analog voltage obtained from the potentiometers is converted into a digital signal by the micro-controller. The transmitter then transmits this digital data which is received by the receiver of the same frequency. The data is then used to operate the servo motor connected to the robotic arm. As the arm is intended to be used for telesurgery, the robotic arm is wireless and works on the principle of telemetry

1.SYSTEM DESIGN:

The designed robotic arm has 3 degrees of freedom. One each for the elbow, wrist and the claws respectively and for each degree of freedom a servo motor is provided. The degree of freedom is used to manipulate the robot workspace which is highly dependent on the robot configuration. The end-effecter is the tool, gripper, or other device mounted at the end of a manipulator. It is an electromechanical device for accomplishing tasks such as picking up objects.

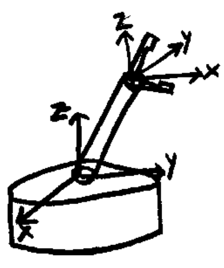

Figure 1: Schematic diagram of the robotic arm showing the moving axis.

A mechanism which provides signals for the control of equipment is called an actuator[7]. There are two main types of actuators commonly used in robotic arms:

Stepper motors and Servo motors

.Stepper motors is a kind of brushless motor which moves in small discrete steps [7]. It provides both analog and digital feedback signals. But, servo motors are used in automatic control systems. Servomechanism is a system whose objective is to control the position of an object. Servomotors convert an electric signal (control voltage) applied to them into an angular displacement of the shaft. They can operate in continuous duty or step duty depending on the construction.

The following figure explains how the internal circuitry of a servo motor works.

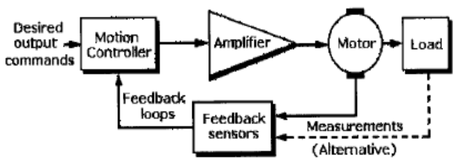

Figure 2: Block diagram of the servo motor

Motor selection criteria are:

Rated speed: The maximum operating speed that can be sustained by a data-processing device or communications line, not allowing for periodic pauses

Peak torque: The maximum torque a motor can exert.

Two types of servo motors were used in the project. Two of similar types were attached between the disc and the base and between the claws. The other type was attached between the disc and the arm so that it could hold the weight of the arm.

The AT-Mega 16L AVR development board was used to convert the analog voltage signal to a digital signal. The microcontroller was then interfaced with the transmitter to transmit the signal. Another microcontroller was interfaced with the receiver so that the signal transmitted could be received at the same frequency. This board was then used to operate the servomotors. A pair of wireless transceiver was used as the transmitter and receiver module.

On the AT Mega board, PORT C is from pin number 22 to 29 on the right side of the notch followed by PORT A from pin number 33 to 40. And on the left side of the notch PORT B is from pin number 1 to 8. On the transmitter side the LCD is connected on PORT C while the transmitter is connected on PORT B. The potentiometer assembly is connected on PORT A. While on the receiver side, LCD is connected on PORT C and the receiver is connected on PORT B. The servo motors are connected on PORT A.

1.1 Transmitter section

The following block diagram explains the working of the transmitter side.

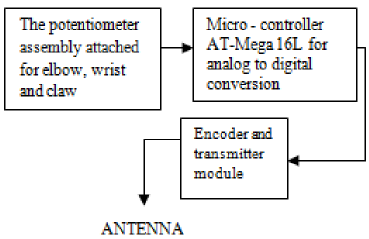

Figure 3: Block diagram of the transmitter section

The first block explains the potentiometer assembly which is attached to the elbow, wrist and between the first finger and thumb. The shaft of the potentiometer is attached to the hand assembly. Thus its position is constantly altered due to the changing hand movements. Due to the voltage supply given to the potentiometers, when the position changes there is also a voltage change. This changing analog voltage signal is fed to the micro controller for its digital conversion. Servo control is done by sending a pulse width modulation or PWM signal to the PWM input pin.

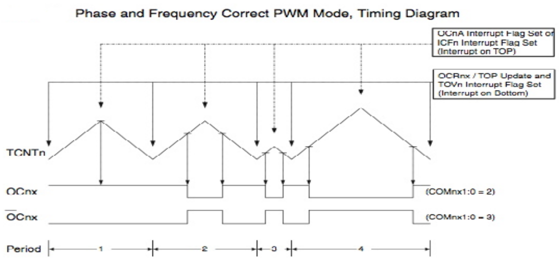

Figure 4: Pulse Width Modulation Signal

The potentiometer is connected on Port A and Port B is the output port where the transmitter is connected. The digital data from PORTB is then transmitted through the encoder and the transmitter module. To ensure the digital data being transmitted an LCD was connected at Port C.

1.2Receiver section

The following block diagram explains the working of the receiver side.

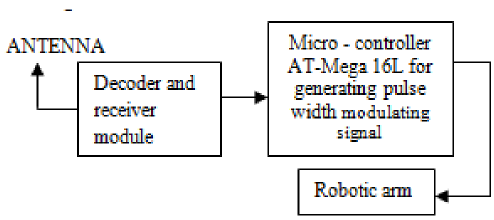

Figure 5: Block Diagram of the receiver section

On the receiver side, the data is first received by the receiver module and then by the decoder. The servo compares the received pulse width modulation signal to the actual position of the servo and adjusts the servo accordingly. The internal circuitry of the servo expects a constant 50Hz PWM signal (a 50 Hz signal is one that repeats every 20 ms). The motors are connected on port B on the receiver side. These motors thereby control the working of the robotic arm. To ensure the digital data received an LCD was connected at Port C on the receiver board as well.

Three servomotors were attached to mimic the three hand movements of the wrist, the elbow and the fingers.

2.RESULTS :

The LCD attached on the transmitter board displayed the data being transmitted. The same data was displayed on the LCD attached on the receiver board.The initial and final positions of the claws, arm and the base as obtained are shown by the figures below. These were mimicked hand movements.

Figure 6(a) below shows the shortest distance between the two claws. This is the mimicked position of the first figure and the thumb closed at the tip.
Figure 6(b) below shows the maximum distance to which the two claws can be stretched. At this position the first finger and the thumb are also the maximum distance apart.

Figure 6 (a): mimicked minimum distance between the first finger and the thumb.
Finger 6 (b): mimicked maximum distance between the first finger and the thumb.

The movement shown in the above two figures was obtained due the data transmitted by the movement of the potentiometers attached on the hand of the user. Therefore, as the two fingers moved away and closer to each other the corresponding movements were mimicked by the two claws.

Figure 7(a) below shows the starting position of the revolving disc. This position corresponds to the extreme left position of the user's hand.
Figure 7(b) below shows the final position of the revolving disc. This position corresponds to the extreme right position of the user's hand.

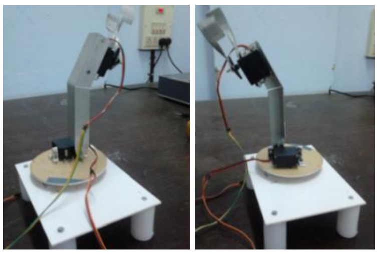

Figure 7 (a): mimicked extreme left position of the elbow.
Figure 7 (b): mimicked extreme right position of the elbow.

The above two movements were obtained due to the potentiometers attached at the elbow of the user's hand. Therefore as the elbow completed the 180 degree movement, the disc rotated and mimicked the same.
Figure 8(a) below shows the upward movement of the wrist. This position corresponds to when the user's wrist is in the upward position.
Figure 8(b) below shows the downward movement of the user's wrist.. This position corresponds to when the user's wrist points in the downward direction.

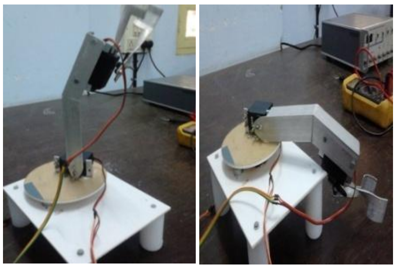

Figure 8 (a): mimicked upward position of user's wrist.
Figure 8(b): mimicked lower position of user's wrist.

The above two movements were obtained due to the movement of the potentiometers attached at the wrist of the user. Therefore as the wrist moved up and down the corresponding movements were mimicked.

As a result, owing to the above explanation and diagrams, the arm mimicked three basic hand movements. The opening and closing claw movement, the 180 degree elbow movement in the horizontal plane and the 180 degree wrist movement in the vertical plane.

3.CONCLUSION:

Since many decades the main subject of concern has been the human safety and the trauma caused to the patient during surgery. With the advent of robotics in medicine more accuracy and precision can be achieved during surgery.
Though telesurgery is still under debate whether it would replace conventional surgery altogether. But, it would be extremely useful in remote areas or war-affected areas where medical help is not easily available. Doctors can perform operations in rural communities or dangerous settings without having to be present. In this project a prototype model of a robotic arm using haptics has been implemented. Haptics is an emerging trend which will have a tremendous impact of the field of robotics and telemedicine in the near future.

FURTHER SCOPE:

Robotics and telemedicine are both extremely vast fields and a number of advancements can be made to the current project. A camera system can be mounted on the robotic arm to enable robotic vision. Adding a camera system would assist a person to manipulate the arm in order to move in a well co-ordinated manner. Various transducers like displacement sensors, to measure the distance of the robotic arm from the patient's body or pressure sensors, to measure the amount of pressure applied to the patient and give a feedback back to the robotic arm to limit it if it exceeds a certain preset value could be attached. The arm's degrees of freedom can be increased as it will increase the precision and accuracy of the robotic arm. Complicated movements can be then performed by the arm.

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