Manual Control of Robotic Arm for Long Distance Applications

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Abstract—In recent times, field of advanced robotics has witnessed a major boom among the researchers around the world. They are involved in research including the features of controlled robotics such as robotic arm etc. These arm can be used as a prostatic for disabled person or can be used in controlled environment where human presence may not be possible. In this paper, a 4 Degree of freedom (DOF) Robotic arm model is proposed that is secured in an ace slave setup with human. It can be controlled manually from distance via Radio Frequency (RF) module incorporated with the glove. The automated arm comprises of an arrangement of the DC Servo engines by which it will rotate or move around its axis. The ARDUINO board implemented at the robotic arm or receiving end follow the PID control algorithm in order to reduce the generated error. The applied PID controller tracked the input .signal with 83% accuracy and with minimum error

Keywords—Radio Frequency (RF) module, wireless communication, gyro sensor, robotic arm, PID controller

INTRODUCTION

As the technology advances, it becomes much easier for the disabled people to interact physically using prosthetic arms. In such regard, field of robotics have made some major breakthrough in the past two decades. Many researchers around the world are involved in improving the prosthetic technology in order to provide better quality of life for the disabled people [1-3]. Such technology can also be used wirelessly in the place where human presence is at risk such as contaminated areas or in industrial production, processing and manufacturing. They can be used as a firefighting drone [4] or a medical bot to provide some basic medical treatments [5-8]. Many researchers utilized robotic arm for medical applications are introduce them for clinical trials [9-13]. Chronic stroke patients may have difficulty to grasp physical objects, robotic arm can help support such patients to grasp objects [14]. Technology based on electrical brain signals to control the prosthetic limb is also introduced by Tang, Jingsheng, Zongtan Zhou, and Yadong Liu [15].

Robotic arm are also controlled using image processing by gesture manipulation and recognition [16-17]. Artificial neural network is also used to control robotic arm by many researchers [18]. Machine learning algorithm further enhances the object identification and grabbing process of robotic arm, a voice command can be used for identification of an object [19]. Gesture control robotic arm can also perform critical work like bomb and mine defusing to prevent workers from dangerous tasks. [20-22].

In the recent years the technology for development of rehabilitation robots has rapidly increased. For a comfortable and harmless rehabilitation process, a fuzzy logic-based system has been introduced to monitor the pain level [23]. Fuzzy Logic was also applied on the robot arm to control objects using Flex sensor, and hand gestures [24].

In this paper, a model of robotic arm is proposed which can be operated wirelessly with precision using a real time feedback loop for positions sensing using Gyro and flex sensors. Two sensor are used to measure the full scale movement of the robotic arm. For a base controller ARDUINO Mega is utilized for robotic arm and ARDUINO Uno is used for the transmission from the devised glove and the interfaced sensors. The arm can be controlled wirelessly or it can be wired if used as a prosthetic because in that case it is mounted on the disabled person and wireless communication is unnecessary.

MATERIAL INFORMATION AND IMPLEMENTATION

System Hardware Model

Proposed system is composed of a glove and a robotic arm as given in Fig. 1. An ARDUINO Uno is utilized as a core processor to accept input from the glove. One gyro and one flex sensor are embedded with the glove, gyro sensor is placed for the elbow joint to move along x and y axis and flex sensor is placed on the fingertip to control the gripper used to grab objects. The Gyro sensor provide the present angular position of a human arm wearing the glove in degrees. Glove can communicate with the robotic arm wirelessly using RF-Transceiver or it can be wired if used in close proximity.

Robotic arm is composed of four servo motors controlling all the basic movements as shown in Fig 1. For the movement of elbow joint two servos are used to rotate it from 0o to 180o along the X-axis and from 0o to 90o along the Y-axis. Third servo is used for the movement of wrist, it only moves along Y-axis from 0o to 180o. Fourth servo is for the gripper, it only moves from 0o to 90o. This robotic arm behaves as a receiver and on the other, although both ends are incorporated with transceivers as robotic arm will receive instruction wirelessly and also transmit the current angular position of the arm using gyro sensor interfaced with the elbow joint of robotic arm as

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well, which will be received by the glove. Gyro sensors are also used to identify the position of an arm joint. In ARDUINO Mega, a PID control algorithm is implemented in order to reduce the error between the reading acquired by the glove and robotic arm. Fig.2 represents the glove fabricated to control the robotic arm. Gyro sensor is placed of the top of the hand and flex sensor is used for the gripper to grab objects. Fig. 3 displays the robotic arm that is controlled by the glove.

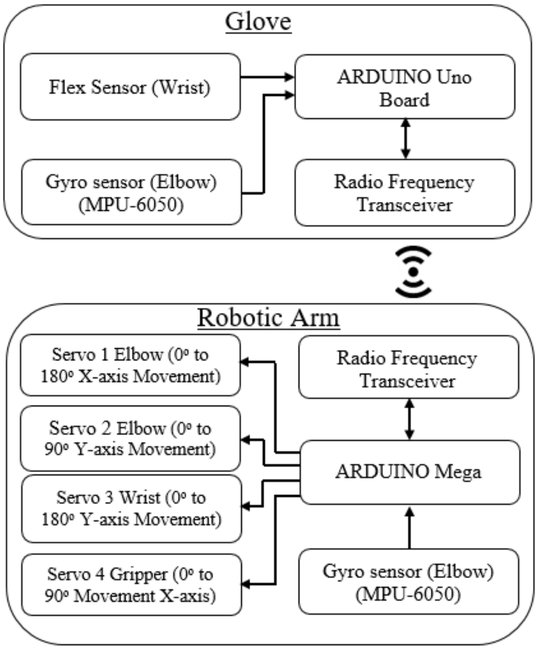

Fig. 1. Basic Block Diagram of the System

Fig. 2. Glove to control robotic arm

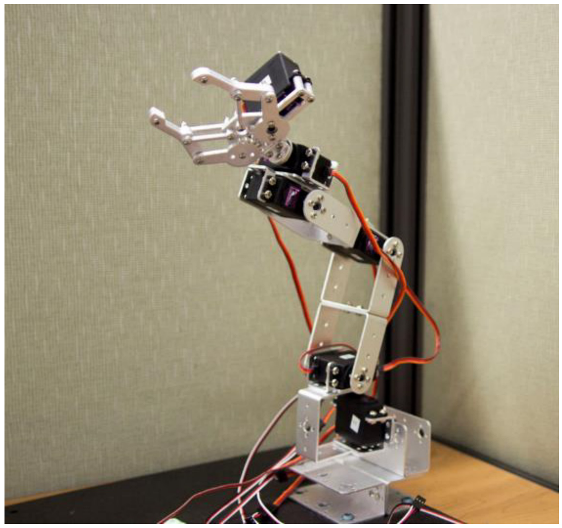

Fig. 3. 4 DOF Robotic arm Physical Model

PID Based Software Implementation

Software flow control is given in Fig. 4, representing the proper control algorithm in sequential order. As soon as the system initialize, the glove acquires the current angular position of the human arm from the gyro sensor embedded with the ARDUINO-Uno board and transmit that information to the receiver bard that is ARDUNIO Mega that actually control the robotic arm. The transmitted information is processed while ARDUINO Mega implemented as a base controller for the robotic arm will acquired the current angular position of the robotic arm. The acquired information is processed and the PID control algorithm implemented will tend to reduce the error response accumulated.

When the corresponding angular position is acquired by the robotic arm, the system will acquire the next angular position form the glove. The whole process will repeat for the new information. Position of the glove can be tricky because of the angular movement that can vary and another factor that may reduce the accuracy is the movement speed of the glove. If the glove move fast then it will become a tedious task for the robotic arm to track and follow the movement. For such application the movement of the controlling object has to be reduced in order for the controlled object to properly track and follow its movement.

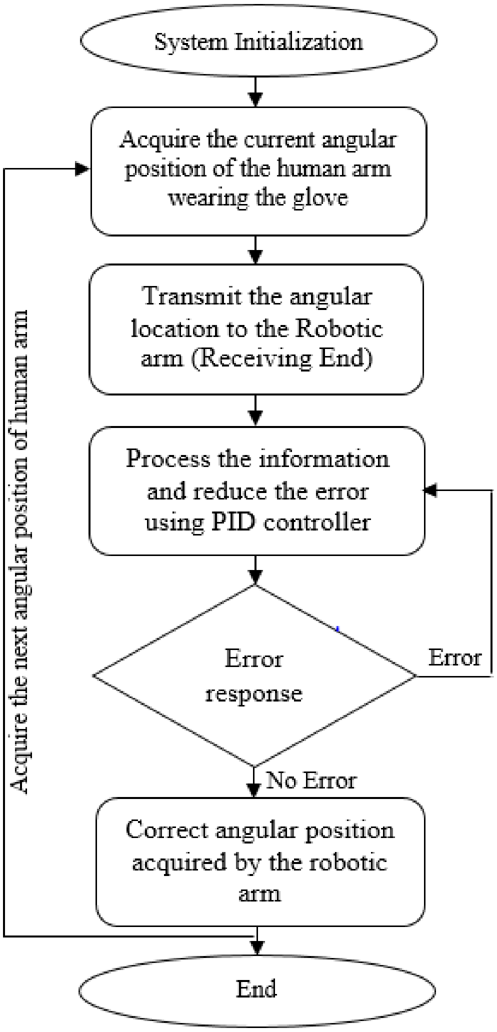

Fig. 4. Software flow control

RESULTS

Fig.5 is the representation of the signals involved in tracing and controlling the robotic arm along x-axis. It displays the angular input which actually is the desired output and the actual output response that the robot is tracking. This is done by reducing the error signal using the PID controller. Fig.6 represents the signal involving the movement of the robotic arm along y-axis. For x-axis the input signal is generated by the glove and the output signal in blue color is generated by the movement of the robotic arm. Red color dotted line represent the control signal generated by the PID controller to reduce the error signal in green. In Fig. 5, the input signal has a sudden drop at the time scale of 2 sec from 80 to 40 and even then it does not require a lot from an actuator to properly track the desired response and in Fig. 6 the movement of glove is increasing steadily rather than rapidly, thus in this case it still tracks the input with precision with minimum error.

Signal tracking of the PID controller is auto tuned to perform at optimal precision. This means that it track the input signal and reduce the error without using much of the resources. It will require minimal input signal in order to track the signal which can be easily provided by the actuator. If it was set for the robust tracking then it will put a lot of strain in the actuator to perform the task.

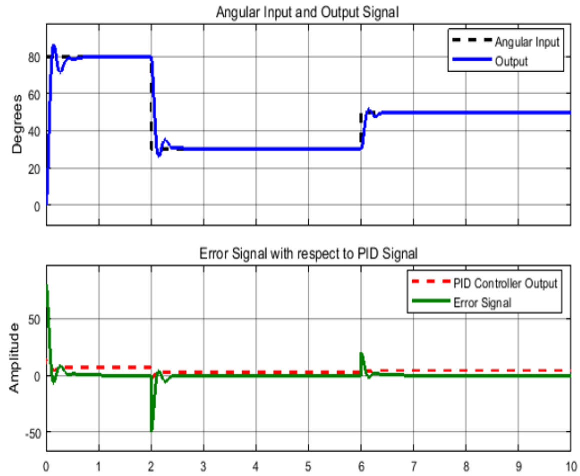

Fig. 5. Position Control along x-axis in degrees

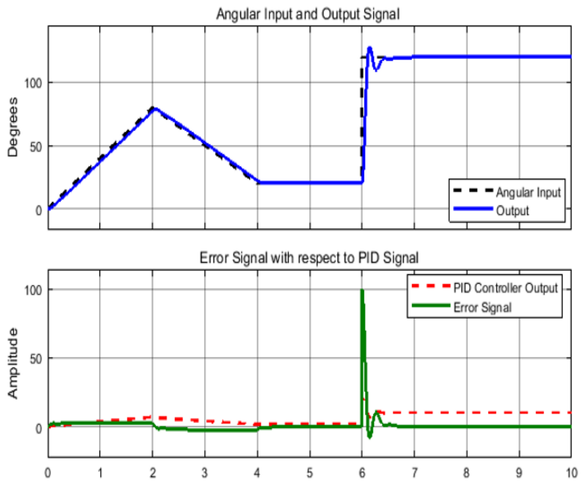

Fig. 6. Position Control along y-axis in degrees

CONCLUSION

The proposed model of a robotic arm controlled with the glove is based on the angular movement of the human arm. The implemented PID controller incorporated in an ARDUINO board at robotic arm end will reduces the error between the acquired angular movement from the glove and actual angular position of the robotic arm. The purpose of the designed model is to track the movement of the human arm via glove and make the robotic arm to mimic the angular movement along x and y-axis. The performance of the complete system in a controlled environment was successful and yield positive results in tracking the input angular movement with precision and minimum error. The proposed model us easy to use, cheap and can also be used to replace a limb of a disabled person.

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