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A Wireless Implementation of a Prosthetic Animatronic Hand

Abhiram M.V.[1], Jayanth Kumar H.S.[1], Krishna Prasad M.J.[1], M.S. Mallikarjunaswamy[2]

Student, Dept. of I.T., Sri Jayachamarajendra College of Engineering, Mysuru, Karnataka, India[1]

Assistant Professor, Dept. of I.T., Sri Jayachamarajendra College of Engineering, Mysuru, Karnataka, India[2]

ABSTRACT:The Prosthetic Animatronic Hand is a mechanically constructed hand that senses the actions of a human hand and is controlled with the help of a microcontroller. The intention of this device is to imitate the actions performed by the human hand in order to help minimise the requirement of physical presence of a human being in places where human intervention is minimally required. This paper contains the algorithm used to sense the actions of the human hand, the actuation system of the hand and the communication technique employed. The communication technique employed enables the module to be used wirelessly. Wireless communication between the sensing sub-system and the control sub-system opens up a myriad of applications, and is implemented using the UART protocol.

KEYWORDS: Robotic Hand, XBee, Flex Sensors, Servo Motor.

I.INTRODUCTION

There are certain applications where a human hand is plays a significant role in a task, but pose life threatening risks when humans are subject to exposure. The objective of this work is to develop a robotic hand controlled by a human, in order to obviate human intervention in certain deleterious applications.The Prosthetic Animatronic Hand is a mechanical hand that is controlled with the help of an Arduino board. For instance, the device can be put to use in nuclear industries where hazardous substances that may pose a threat to his/her life, are handled. Also, the device can be employed in remote medical assistance wherein doctors can perform surgeries from a distant location, obviating the need of physical presence. The Prosthetic Animatronic Hand can also be helpful to physically disabled patients who have limited locomotory capabilities, thereby reducing the dependency on another person. According to a survey conducted in the United States, it is found that approximately 1 in 50 people or 5,596,000 people suffer from paralysis [8].Consider a patient who wants to operate a light or a fan switch, but cannot do so due to his disability.The robotic hand helps to augment the abilities of such patients hand and thereby helps in operating the electrical switch. Hence, the motive of the robotic hand is to make the lives of individuals across various walks of life including paralytic patients, simpler and easier.Figure 1 shows an overview of the module.

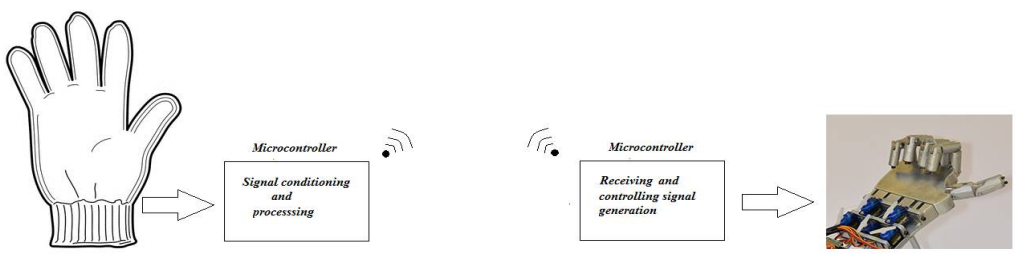

Fig. 1 - Overview of The The Prosthetic Animatronic Hand

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II.LITERATURE REVIEW

N. Carbonaro et al. propose an innovative multisensor controlled The Prosthetic Animatronic Hand [1]. An ad-hoc sensing architecture has been designed, developed and tested. In particular, traditional EMG system has been considered together with in socket force sensing and inertial sensing. In socket pressure sensing has been included to monitor the so called Force Myography (FMG). FMG uses a set of force sensors to measure the pressure on the forearm caused by the muscular activity. FMG signal has been used in few pilot works to extract the hand neuromuscular volition. In the present work in socket force distribution and conventional EMG have been used at the same time to encode subject/patient movement intention. The advantage of the FMG is that the reduced sensor cost and complexity with respect to EMG and the possibility to spread the sensor in redundant configuration in order to reduce the personalisation effort of the prosthesis. The inertial sensor on the forearm has been included to enable the patient to select different hand grips in relation to the forearm orientation in space. Musa Hakan Asyali et al. presented a voice-controlled The Prosthetic Animatronic Hand [2]. A novel multi fingered The Prosthetic Animatronic Hand was designed with the ability of picking up and releasing objects. The Prosthetic Animatronic Hand employs 3 DC motors and gears to transfer motion to the linked parts of the fingers. They used flexible thin-film resistive force sensors at the fingertips of The Prosthetic Animatronic Hand to adjust the grip force at the fingers. The control circuit that they designed consisted of an HM2007 speech recognition IC and a PIC microcontroller to drive the DC motors moving the fingers.Tejashree Dhamapurkar et al. propose a wirelessly controlled animatronic hand [3]. Theydiscuss the design and implementation of a wireless animatronic hand using XBee-S2 and Arduino- UNO board. The module is composed of two parts namely, Transmitter and Receiver.The transmitterhas an Arduino-UNO and an XBee-S2. This part known as the control glove, contains flex sensors. These flex sensors are connected to the input pins of the Arduino board. This voltage value was serially sent to the XBee transmitter pin. This data is then wirelessly sent to the another XBee-S2 (which is there in the receiver part). XBee at the receiver side receives the voltage value and this value would be sent serially to the second Arduino board. Thereby, the motors connected to the second Arduino will start rotating.Aaisha Parveen S and Rohitha.U.M propose a microcontroller based hand recognition [4]. Themodule consists of sensor glove which consists of a microcontroller,accelerometer sensors or flex sensors that are positioned on fingers of the glove. The glove designing and gesture decoding are studied. Theacceleration values of a hand motion are transmitted to the microcontroller and these acceleration values in threeperpendicular directions are detected by accelerometers. Analgorithm of automatic gesture recognition is developed to identify all gestures in a sequence. Agrawal A.D. and Chandak M.A. propose an animatronic hand [5]. The paper presents an acquisition method that comprehensively looks for the mimic configurations of the human hand. The data obtained in this process is further analyzed, transformed, and then used to synthesize a reduced configuration space of a robot anthropomorphic hand. The method relies on a dimensionality reduction technique that provides a new basis of the full configuration space, from which one can select a subset of the vectors forming that basis, and finally obtaining a simpler configuration subspace. These vectors represent the coordinated motions captured by a sensitized glove on a human hand and transferred to the robot hand.Dr. Shreenivas Jog et al. propose an animatronic hand that uses wireless technology [6]. This paper intends to implement an affordable electronicproduct known as wireless animatronic hand based onwirelesstechnologybasedonXbee moduleaswellasArduinoUNOboard. There are two main parts of this project i.e.transmitter (Control glove) and receiver (mechanical-electronicrobotichand).Both parts interact with each other usingwireless communication.

After reviewing the numerous methods in which a robotic hand could be controlled, the objectives were set so as to control the robotic hand using flex sensors and servo motors due to their inexpensive nature and ease of interface with the microcontrollers. In order to effectively interface the input and output modules and program the algorithm on the Arduino boards, a book titled “Arduino Programming in 24 Hours” [7] was referred.

III.METHODOLOGY

The algorithm used to sense the actions of the human hand, the actuation system of the hand and the communication technique employed are proposed. The sensing part of the device takes place with the help of flex sensors. Flex sensors are devices whose resistance varies when the sensor is subjected to a bending force. The resistance increases with the increase in bend angle and remains at a nominal value when there is no force acting on it [9]. The resistances of the flex sensors act as the measurand, which is constantly read by the Arduino. The microcontroller in the Arduino, converts the analog resistance value into a digital count with the help of an Analog To Digital Converter. The digital count value is a direct indication of the resistance of the flex sensor, and hence represents the bend angle. The digital count that is

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obtained is used as an intermediate value and is communicated to another microcontroller board that in programs routines to help proportionally rotate the servo motors. Servo motors are a special kind of motors, that have a 180 degree sweep angle and run on pulse width modulated signals [10]. The Arduino produces the pulse width modulated signals required by the servo motors in order to produce an appropriate degree of rotation. The servo motors are mechanically coupled to the fingers of the robot hand, which leads to the movement of the fingers in response to the positional change of the servo motors.

The Prosthetic Animatronic Hand consists of both hardware and software systems.The description of various functional blocks in order to meet the objective of the module is presented.The Prosthetic Animatronic Hand makes use of flex sensors, an Arduino Boards, XBee modules used for communication and servo motors that are mechanically linked to the robotic hand. The locomotory actions of each of the fingers is picked up by the flex sensors mounted on each of the fingers of the control glove. The flex sensor plays a pivotal role in sensing, whose one side is printed with a polymer ink with conductive particles embedded in it.When each finger bends, the corresponding flex sensor bends, thereby varying the resistance. A voltage divider is used to convert the resistance of each of the flex sensors into a corresponding analog voltage, and is read by the Arduino Leonardo. The Arduino Leonardo uses an in-built Analog To Digital Converter to transform the analog voltage into a digital count which is used by the program running on the processor [11]. The digital count obtained on the Arduino Leonardo is transmitted using ZigBee module using UART protocol. The digital count values are initially converted into bytes, that are stored in an array. The array is communicated to the Arduino Mega ADK board using the Zigbee module [12].The received values are manipulated so as to achieve rotation of the Servo Motors. Servo Motors are primarily used to control the movement of the mechanically constructed hand. Servo Motors are a unique kind of motors which have a maximum rotation of 180 degrees. The servo motor actuation system is linked to the fingers of the robotic hand using nylon stings, thereby enabling the fingers to move in accordance with the sensed actions of the human hand.Figure 2 shows the functional block diagram of the system.

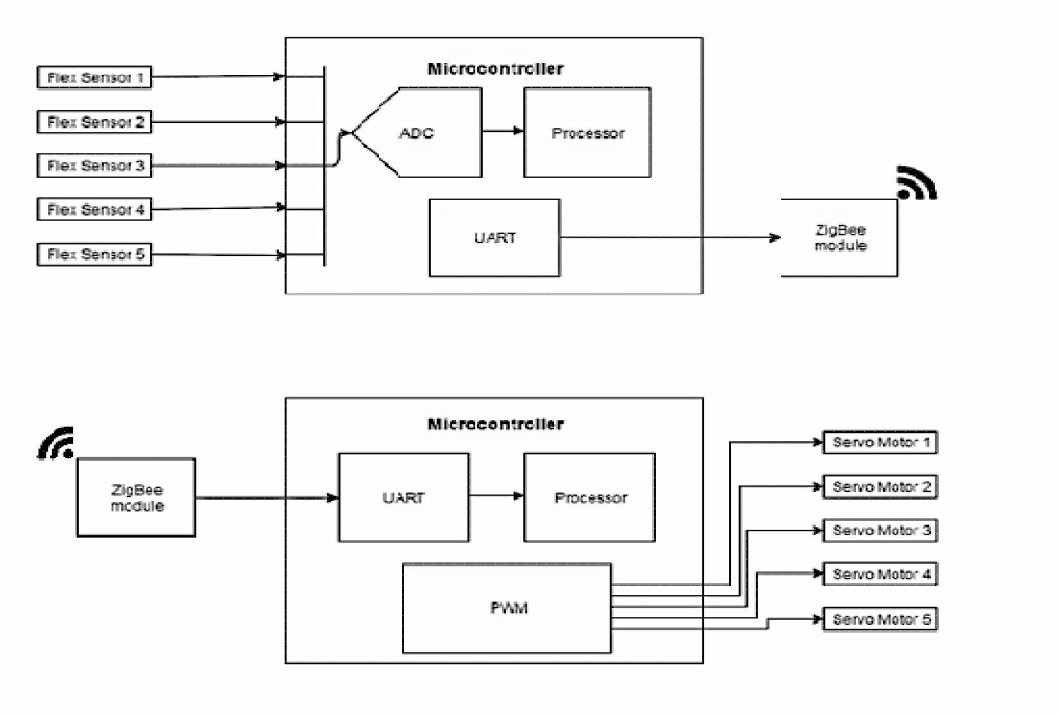

Fig. 2 - Functional block diagram of The Prosthetic Animatronic Hand

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IV.RESULTS

Each of the flex sensors were initially checked for their nominal resistance values, when not subjected to any stress. Accordingly, resistors with similar were chosen to be connected along with the flex sensors as a part of the voltage divider circuit. The digital count values obtained from the Analog To Digital Converter, for each of the sensors, under both straight and bent conditions, were noted using the Serial Monitor and tabulated. Table 1 shows the ADC digital count values obtained for each flex sensor used in the module.A servo motor, was used to set the sensitivity of the flex sensors and the corresponding digital count values of each of the flex sensors to be included in the program, so as to avoid the motion of the robotic fingers due interferences resulting from minuscule movement of the flex sensors.

Table 1 – ADC Count Values of Flex Sensors

	Min ADC Count	Max ADC Count	Nominal ADC Count
Sensor 1	448	800	506
Sensor 2	480	800	528
Sensor 3	450	845	500
Sensor 4	439	750	476
Sensor 5	440	803	475

Table 2 shows the variation of the angle of servo motor with the degree of bend of flex sensor. As the degree of bend increases, the Arduino board outputs a proportional PWM signal to the servo motor, thereby enabling it to rotate to a desired angle.

Table 2 – Variation of Servo Motor Angle w.r.t the Angle of Flex Sensor Bend

Sensor Angle in degree	Output of Servo in degree
0	0
10	8
20	19
45	45
60	56
90	89

A photograph of the module is shown in Figure 3. The robotic hand mounted along with servo motors and the control glove along on which flex sensors are placed can be seen in the picture.

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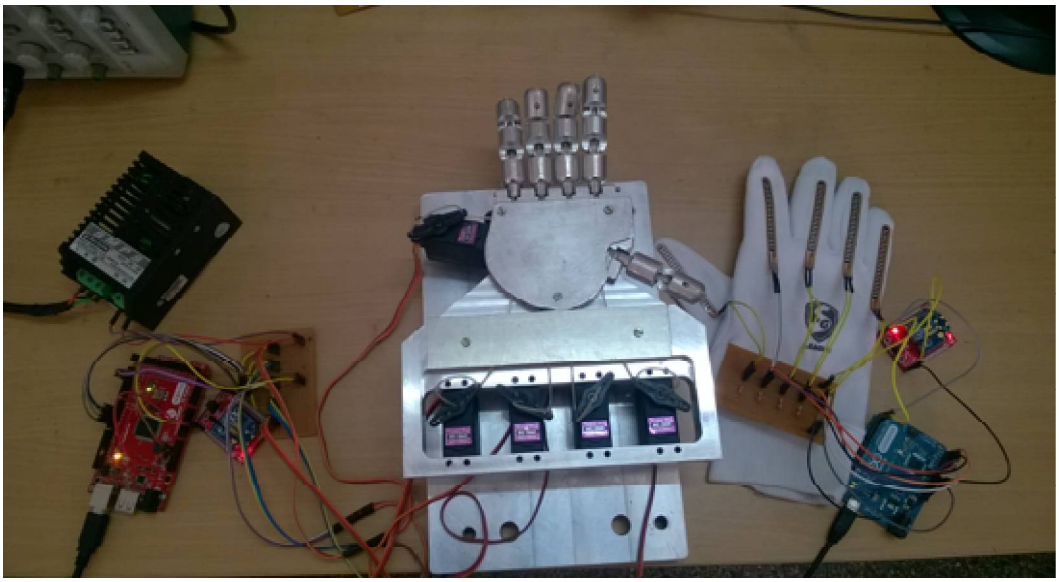

Fig. 3 - Aphotograph of the module

VI.CONCLUSION

The Prosthetic Animatronic Hand , analyses the actions of a human hand, and synchronously controls a robotic hand. The work was successfully tested and was found to operate in a hassle free manner. The problems faced during the execution were rectified and was made sure to not repeat under any conditions. During testing each module, a certain amount of problems were faced that included erratic behaviour of the servo motor that resulted from intermittent changes in the voltage. Also, due to higher sensitivity of the flex sensor, the digital count value of the Analog To Digital Converter turned out to be inconsistent and varying rapidly. The high sensitivity of flex sensors also resulted in the unstable functioning of servo motors. The problems faced were corrected and the module was hence found to be operating without any error. The system can be made ambidextrous and also can be combined with virtual reality technology thereby augmenting the capabilities and hence opening a wide range of global medical applications.

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