Development of Artificial Hand Gripper for Rehabilitation Process

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Abstract— **This paper focuses on the development of a robotic hand that imitates the movement of a human hand. The basic movement of the surgeon hand was limited from a wrist, elbow and shoulder degree of freedom during an operation. The artificial hand gripper system requires sensors for a smooth and accurate movement. This allows large movement from the surgeon hand to be corrected on a small scale with a perfect incision and without any vibration. Although such a system available in the market, the utilization of robotic hand particularly in Malaysia for medical application are still very minimum due to its expensive cost. Therefore, in this research we plan to develop a reasonably cheaper home built robotic hand which can perform the task of a hand gripper as a beginning step. The initial objective of this research is to analyze and develop artificial arm with a strength limit proportional to the weight. Next, followed by the attachment of a wireless system on the prosthetic gripper via Radio Frequency (RF) transceiver. The system development involves a Programming Interfacing Circuit (PIC) 16F877 as a core processing for the instrumentation, communication and controlling applications. A series of flex force sensors are fitted in a leather glove to get reading from the movement of human fingers. Microcontroller will further use this information to control multiple servo that act as a mechanical hand inside the prosthetic gripper.**

Keywords— **Artificial hand gripper, flex sensor, rehabilitation and medical robotic.**

I. INTRODUCTION

The term of “robot” comes from the Czechoslovakian word “Robota”, that means obligatory work or servitude. It was used firstly in a Czechoslovakian play called “R.U.R”. (Rossum’s Unversal Robots) [1]. The first prosthetic hand was done by a roman general who had his arm cut off and replaced with an iron hand in the 17th century [2]. In science, the definition of “gripper” is subsystems of handling mechanisms which provide temporary contact with the object to be grasped. They ensure the position and orientation when carrying and joining the object to the handling equipment. Prehension is achieved by force producing and form matching elements. The term “gripper” is also used in cases where no actual grasping, but rather holding of the object as in vacuum suction where the retention force can act on a point, line or surface [1].

Since then, prosthetic arm continues to evolve with variety of concept. For instance a “Myoelectric” prosthesis that uses electromyography signals or potentials from voluntarily contracted muscles to control the movements of the prosthesis arms. Here, a residual neuro-muscular system of the human body to control the functions of an electric powered prosthetic hand, wrist or elbow [2].

In another research the type of prosthetic arm are also called ‘Dermatos’ which has appearance as very close to that of the natural arm. In this research it was found that by movement of muscles back and forward, the system can send signals to the brain, which turns them into electrical messages that control motors inside the prosthesis. The prosthesis has three motors that open and close the joints [3].

In another study, a new prosthetic hand is being tested at the Orthopedic University Hospital in Heidelberg Grip which functions almost like a natural hand. It can hold a credit card, use a keyboard with the index finger, and lift a bag weighing up to 20 kg. It's the world's first commercially available prosthetic hand that can move each finger separately and has an outstanding range of grip configurations.

Touch Bionics is a leading developer of advanced upper-limb prosthetics (ULP). One of the two products now commercially available from this company, are the “i-LIMB Hand”, is a first to market prosthetic device with five individually powered digits[4]. This artificial limb looks and acts like a real human hand and represents a generational advance in bionics and patient care. The “i-LIMB Hand” is controlled by a unique, highly intuitive control system that uses a traditional two-input “Myoelectric” (muscle signal) to open and close the hand’s [5].

The German Aerospace Centre (DLR), in cooperation with the Harbin Institute of Technology (HIT), has already developed a robotic hand similar to a human hand with the aid of miniature actuators and high-performance bus technology. Constructing a robotic hand with the capabilities and dexterity of a human hand requires at least four fingers: three fingers to allow the robotic hand to grip conical parts, and a thumb used as a support [5]. This later concept will be followed as in this study for the development of a artificial hand gripper.

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The aim of this research is to assist handicap individual in providing them with an enhanced version prosthetics that is economical and affordable. The construction of the artificial hand gripper which is each individual powered finger can be quickly removed by simply removing one screw. Thus, the developed prosthetics can easily swap out fingers which require servicing and therefore patients can return to their everyday lives after a short visit to the clinic [6 - 8].

II. MATERIALS AND METHODS

In this section, we will start with demonstrating the operational flow chart for the proposed artificial hand gripper system as in this study (**refer Figure 1**).

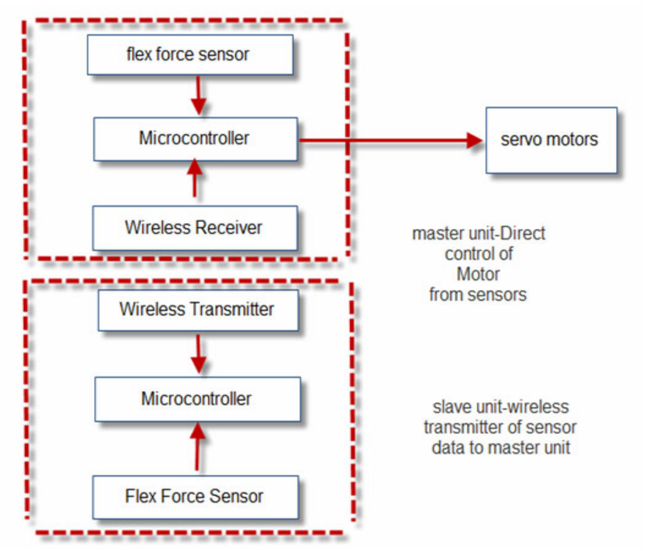


Fig. 1 Block diagram showing the operation of the Artificial Hand Gripper

III. RESULT AND DISCUSSION

A. Flex Sensor

In this section, we will start with demonstrating the operational/testing of flexible sensor for the artificial hand gripper system as in this experiment by using digital multi meter (**refer Figure 2**). In addition, **Figure 2** will also demonstrate the experiment performed on the flexible sensor by using oscilloscope (**refer Figure 2**).

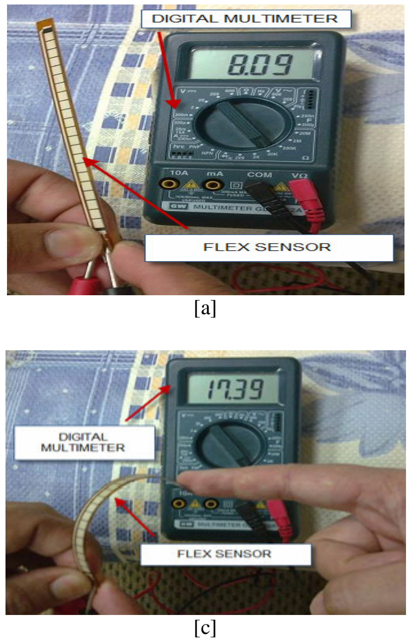


Fig. 2 Figures showing the experiment performed on the flexible sensor and the resistance output displayed via a digital multi meter a) when the sensor at 0º, by using Multi meter b) at 0º

The flexible-bend sensor or flexure sensor is designed in such a way that it can be bent easily. The sensor functions according to the changes in the resistance depending on the amount of bend introduced on the sensor. In other words, the flex sensor is a unique component which changes its resistance according to the amount of bent. An inflexed sensor has a nominal resistance of about 10,000 Ω (10KΩ). As the flex sensor bent the resistance gradually increases. When the sensor is bent at 90º its range will be between 10 KΩ - 14 KΩ ohms (**refer Figure 3**). The flex sensor could be bent up to 360º depending upon the radius of the curve. This will set the resistance value to increase further. The operating temperature of this sensor is 35ºC to 80ºC. It has a life cycle of more than 1 million bend.

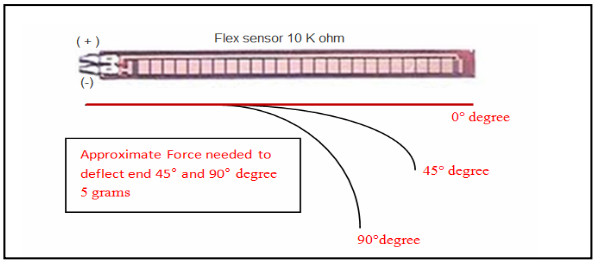


Fig. 3 Illustration of the flex sensor

B. Positional Servo Data

In this section, we will start with demonstrating the operational of servo motor by using PIC 16F877 for the proposed artificial hand gripper system as in this study (**refer Figure 4**).

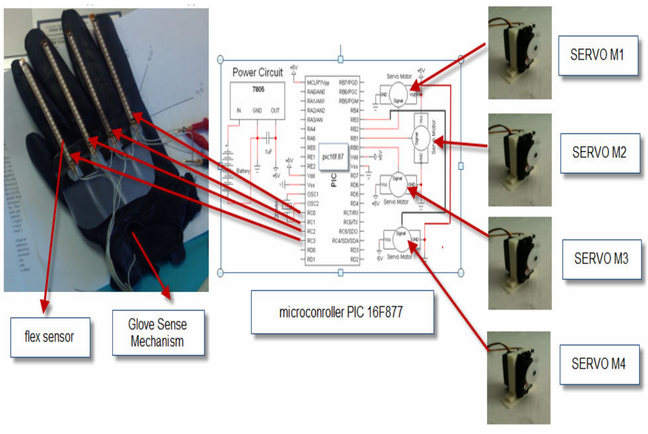


Fig. 4 Figures showing the proposed glove sense mechanism and servo motor connected to PIC16F877

A servo is a mechanical motorized device that can be instructed to move the output shaft attached to a servo wheel or arm to a specified position. Inside the servo box is a Direct Current (DC) motor mechanically linked to a positional feedback potentiometer, gearbox, electronic feedback control loop circuitry and motor drive electronic circuitry.

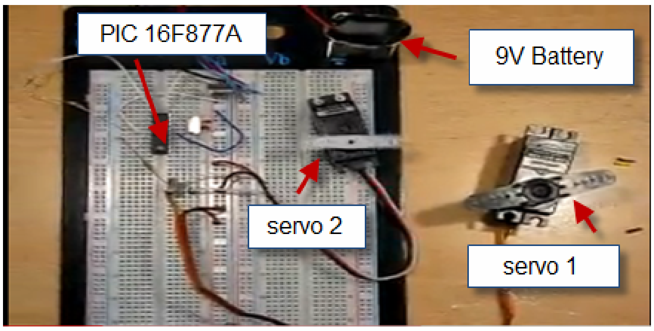


Fig. 5 Picture showing the experiment setup for the servo motor connected with the PIC 16F844 microcontroller

A Pulse Width Modulation (PWM) of approximately 1.5 ms (1500 us) is the “neutral” position for the servo. The servo, neutral is defined to be the point where the servomotor has exactly the same amount of potential rotation in counter clockwise direction as it does in the clockwise direction.[10] When the PWM sent to a servo is less than 1.5 ms, the servo moves few number degrees counterclockwise from the neutral point. When the pulse is greater than 1.5 ms the servo move few number of degrees clockwise from the neutral point. Generally the minimum pulse will be about 1.0 ms and the maximum pulse will be 2.0 ms with neutral (stop) movement at 1.5 ms. Servo speed was measured by the movement and the amount of time (in second) it takes an inch servo arm to sweep left or right through a 60 degree arc at either 4.8 or 6.0 volt.

C. Glove as Sensing Mechanism

In this section, we will demonstrate the measurements results for the mechanical part of the hand gripper by using flex sensor (**refer Figure 6**). Next, followed by the graphs produced for the bending analysis of the flex sensors positioned at the leather glove[9].

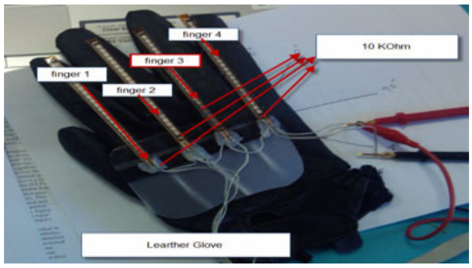
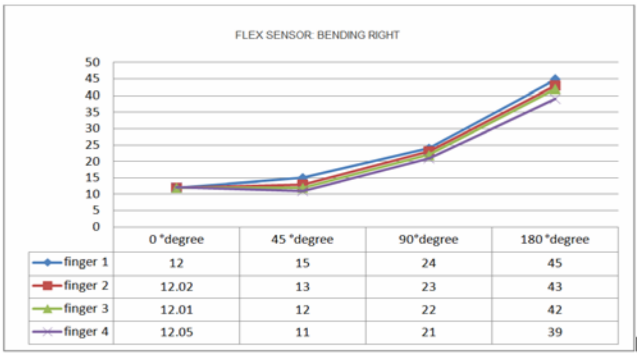


Fig. 6 Picture showing the glove sense mechanism, fingers and the flex sensors positions

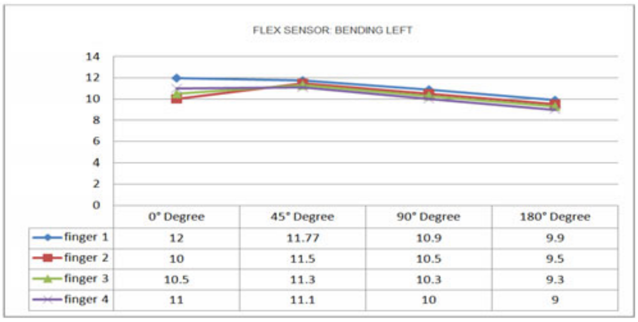
This project uses leather glove with flex sensors placed on the style of the four index fingers. The flex sensor will produce an output of 10KΩ at 0º and 9.56KΩ at 90º.

The outputs for the bending experiment were shown in Figure 7. The analysis indicates a high level of linearity with a dynamic response to changes in flex position. The outputs for the bending experiment were collected at 0º, 45º, 90º and 180º bent respectively in two directions which is left and right (refer Figure 7a and 7b). From the observation the output reading produced for both directions correlate with the bending level introduced to the four flex sensors.



	0 °degree	45 °degree	90°degree	180 °degree
finger 1	12	15	24	45
finger 2	12.02	13	23	43
finger 3	12.01	12	22	42
finger 4	12.05	11	21	39

[a]



	0° Degree	45° Degree	90° Degree	180° Degree
finger 1	12	11.77	10.9	9.9
finger 2	10	11.5	10.5	9.5
finger 3	10.5	11.3	10.3	9.3
finger 4	11	11.1	10	9

[b]

Fig. 7 Graphs showing the experimental data collected for the flexible sensor positioned in the sensing glove, a) bending right position and b) bending left position

IV. Conclusion

The robot was initially designed to assist handicap individual in providing them with an enhanced version of the normal prosthetics which are economical and affordable. It shows a lot of promise and was even applied in hands-on training with the application of visual basic interfacing software among university students with encouraging feedback. With support from the industries and government agencies, the artificial hand gripper could be better develop and achieved its intended target. Finally, the preliminary findings of this study cannot be understated.

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