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Hand Finger Flexion Measurement for Rehabilitation Process using Sensorized Glove

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ABSTRACT: In our ordinary life our association with the world is through our hands. We perform most of the task with them. They use them to hold and control things and to connect with basically clear gestural and non-verbal communication. In numerous engineering applications which are extending from the exploration of gestures to the biomedical sciences the hand movement data attainment is utilized. For obtaining hand movement information the Glove-based systems imply a standout amongst the most imperative endeavors. For more than three decades, they are attracting the interest of researchers from progressively miscellaneous arenas. As researchers have taken interest for hand movement information accomplishment there is an investigative and innovative advance in the advancement of medicinal gadgets. The diseased person (trauma, stroke like diseases) that implies the person who requires hand exercise, robotic frameworks can be an aid for fast patient recapturing. So in this paper we are presenting a moderate system. This system will be helpful in medial field for doctors and also for users. This system involves a glove where sensors are suitably arranged. This sensorized glove will sense the position of hand fingers and will send this data to the doctor utilizing wireless communication. For sensing the position of fingers we have utilized flex sensors, which is only a little strip. This system will be significant in rehabilitation process.

KEYWORDS: Rehabilitation; signal conditioning; Degrees of Freedom; wireless communication; flex sensors; Graphical User Interface; sensorized glove

I. INTRODUCTION

In our regular life we utilize hands for interacting with and taking care of our surroundings in an enormous number of tasks. So to create advancements for studying interaction and control some research effort has been committed. The advancement of the most widely recognized devices for hand movement attainment that is glove-based systems began around 30 years back. This glove-based system keeps on including a developing number of specialists. So this hand movement data attainment is used in many engineering applications like robotics, design/manufacturing, arts/entertainment, information visualization, sign language understanding, medicine/health care etc.

From survey we can see that consistently, millions of people overall experience issues on account of traumatic brain injuries, degenerative diseases, and articulation traumas. Stroke, among the distinctive sorts of brain trauma, is the real reason for disability in adulthood and the rate of this injury is growing consistently, so there is a growing need of rehabilitation treatment. The reason of rehabilitation is to restore patients' physical, sensory and mental capacities influenced by injuries, diseases and disorders, and to backing the patient to recompense the deficit that is not medicinally treatable. Notwithstanding surgery, patients with stroke and muscular disorders need rehabilitation to recover mobility.

These days we are helping to a change of temperaments. General keyword and mouse are being exchanged by different sorts of information equipment. For instance in Xbox utilizes the Kinect to catch humman movement and submit it to acknowledgment, iPad uses fingers to touch the screen or in Wii that we utilize Wiimote to create movement that is caught by the accelerometer and then converted into commands. However these arrangements don't offer reactions like the stimulus that we get when we interface with real objects. Accordingly in the previous 30 years, various advances were created to help researchers to proceed with their studies [1]. Those innovations are named as data glove based system. They are basically gloves instrumented with sensors used to perform data attainment.

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However all the presented technologies have a few liabilities since none satisfy the accompanying necessities like good resolution, parallel data acquisition, low cost and wireless communication.

Understanding the control of human finger movements is crucial for the translation of deficits after injuries to the focal sensory system and the improvement of rehabilitation procedure. While trying to achieve this understanding, sensor gloves have been utilized to record and examine deliberate human finger movements in sound subjects and patients [2]. The system needs a sensorized unit, like a glove with suitable sensors. Due to its daintiness and versatility, a sensorized glove grants to measure the position of every finger, but simultaneously, to perform the required movement. The glove based system is characterized as a collection of electronic sensors to be utilized for hand information achievement, handling and a provision for the sensors which can be worn on hand. For the most part glove is a fabric glove where sensors will be sewn or stuck. Human hand is described for having Degrees of Freedom (DoF) to characterize hand movements. A glove prepared with one sensor for each DoF may appear to be the most obvious configuration decision.

II. RELATED WORK

The first glove base system was produced amid the 70s. From that point forward some glove based systems have been proposed. This glove based system protypes were created at Massachusetts Institute of Technology (MIT) and were assigned as MIT-LED and Digital Entry Data Glove. In 1977 Thomas de Fanti and Daniel Sandin built up the Sayre glove model in Rich Sayre proposal. This glove was made utilizing light as source that is directed through exible tube, mounted along every finger, that as photocell to quantify light varieties. Right on time in the 80s MIT added to another version that utilized a LED system which was camera-based to track body movement in real time processing [3]. Later in 1983, Gary Crimes created and patented the Digital Entry Data Glove that had sensors installed on material to recognize if thumb is touching any piece of the hand or fingers, measure the thumbs joint exion, hand tilt and the twisting /exing of the lower arm [4].

Zimmermam built up a data glove utilizing exible plastic tubes and detectors installed on a material to catch joint points. Late in 1987, Visual Programming Language Research, Inc. showed up with another adaptation utilizing fiber optics. This new form came outfitted with 5 to 15 sensors to gauge exion, abduction and adduction [5]. In 1989 Mattel Toy Company produced a minimal effort control gadget, the Power Glove, for the Nintendo video games. This glove has utilized resistive ink imprinted on flexible plastic bends which takes after the movements of every finger to quantify the general flexion of the fingers [6]. Nissho Electronics in 1995 developed and commercialized the Super Glove. This glove came with 10 to 16 sensors and used resistive ink printed on boards sewn on the glove cloth [7]. In 2002 Super Glove was updated for Power Glove, the P5 Glove [8]. The data gloves then improved using the force sensors. Which are widely used in many applications such as virtual reality applications, robotics, telecheric applications, and biomechanics. This new data glove will have all information of finger position as well as the force the fingers apply on an object. The force sensor was made of a steel plate substrate where the commercial strain gauges are attached [9].

In [10], they had an aim to create and test an arrangement of five virtual activities on top of a system, which is intended for the determination and restoration of patients with hand debilitations. They have actualized assignment arranged activities taking into account entrenched and basic activities, specifically the Jebsen Test of Hand Function and the Box and Block Test. In [11], they have introduced a wearable sensing glove with installed heterocore fiber-optic nerve sensors that identify finger flexion to accomplish unconstrained hand movement observing. This wearable detecting glove innovation has gone for decreasing the quantity of sensors for minimal effort and long haul observing without aggravating characteristic action. Artificial Neural Network (ANN) can be utilized for aligning the sensors on the Cyber Glove. There are three principle purposes behind picking ANNs for the adjustment of the CyberGlove. To begin with, ANNs have been effectively sought the alignments of numerous frameworks in a wide range of designing fields. Second, they have seen that there are some immediate and reliable connections between the human-hands portion size and the reporter sensors readings through the test. Third, once the last NNs are found for every sensor, the era of alignment information for any new subject is straightforward and quick [12].

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The glove system can also use for the speechless person. In [13], it described an electronic talking glove, intended to encourage a simple correspondence through incorporated discourse for the advantage of speechless patients. Gestures of fingers of a client of this glove will be changed over into incorporated discourse to pass on a perceptible message to others, for instance in a discriminating correspondence with specialists. This project is a helpful device for discourse hindered and halfway deadened patients which fill the correspondence hole between patients, specialists and relatives. The glove system which is useful in restoration is given in [14]. This paper concentrates on mulling over and actualizing a framework for measuring the finger position of one hand with the point of offering criticism to the restoration framework. It comprises of a glove where sensors are mounted suitably designed and joined with an electronic molding and obtaining unit. The data in regards to the position is then sent to a remote framework. The goal of this paper is to give a sensorized glove to observing the recovery exercises of the hand.

In [15] Giancarlo Orengo et.al introduced another system. In this system the sensor and their extracted models were connected to register the human knee revolution amid a stride cycle, either at moderate pace for a mobile and at high velocity for a running, lastly the finger joint pivots at their most extreme precise speed. Paper [16], presents an inventive wearable kinaesthetic glove acknowledged with knitted piezoresistive fabric (KPF) sensor innovation. The glove is considered to catch hand movement and gesture by utilizing KPF as a part of a twofold layer setup filling in as angular sensors (electrogoniometers). Nizan Friedman et.al proposed a gadget called "The Manumeter". It is a gadget that logs total angular distance went by wrist and finger joints utilizing magnetic ring worn on the index finger and two triaxial magnetometers mounted in a watch-like unit [17]. In paper [18], a wearable detecting glove for measuring the movement of the fingers is proposed. The system comprises of linear potentiometers, flexible wires, and linear springs, which makes it smaller and lightweight so it doesn't meddle with the normal movement of the fingers. A flexible wire is connected to the back of every finger. As the flexible wire moves due to the movement of the finger, the joint angles are ascertained by measuring the change in length of wire.

III. SYSTEM DESCRIPTION

This system concentrates on study and execution of a system for measuring the finger position of hand with the point of offering solace to do the activity and to the recovery treatment. The design flow for this system is shown in below Fig.1. As per the design flow, the sensors are attached on the glove to sense the position of each finger and then this data is forwarded to the PC.

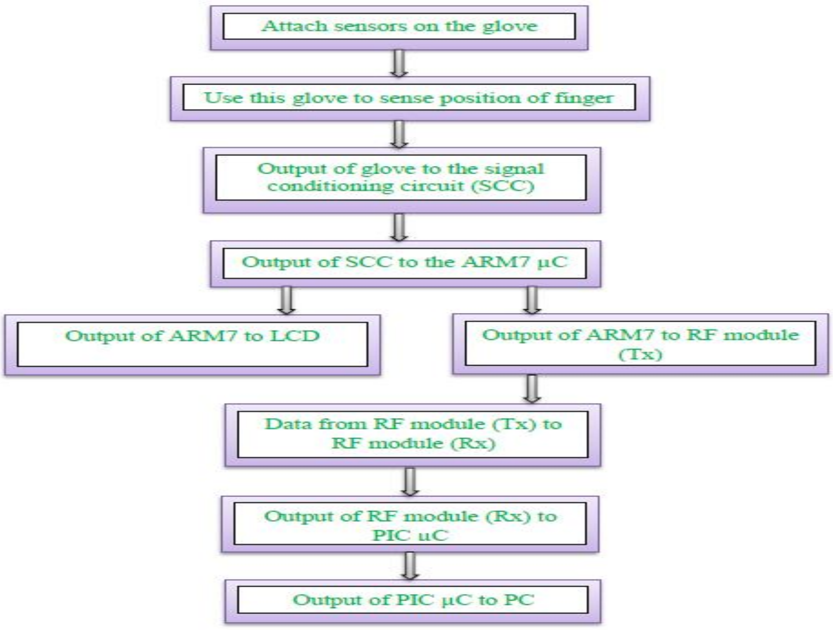

Fig.1. Design flow for the system

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The block diagram for transmitting section and receiving section is given in Fig.2. and Fig.3. respectively. It comprises of a glove where sensors are mounted suitably arranged and associated with an electronic conditioning circuit. The data in regards to the position is then sent to a receiving section, means PC, utilizing the wireless communication.

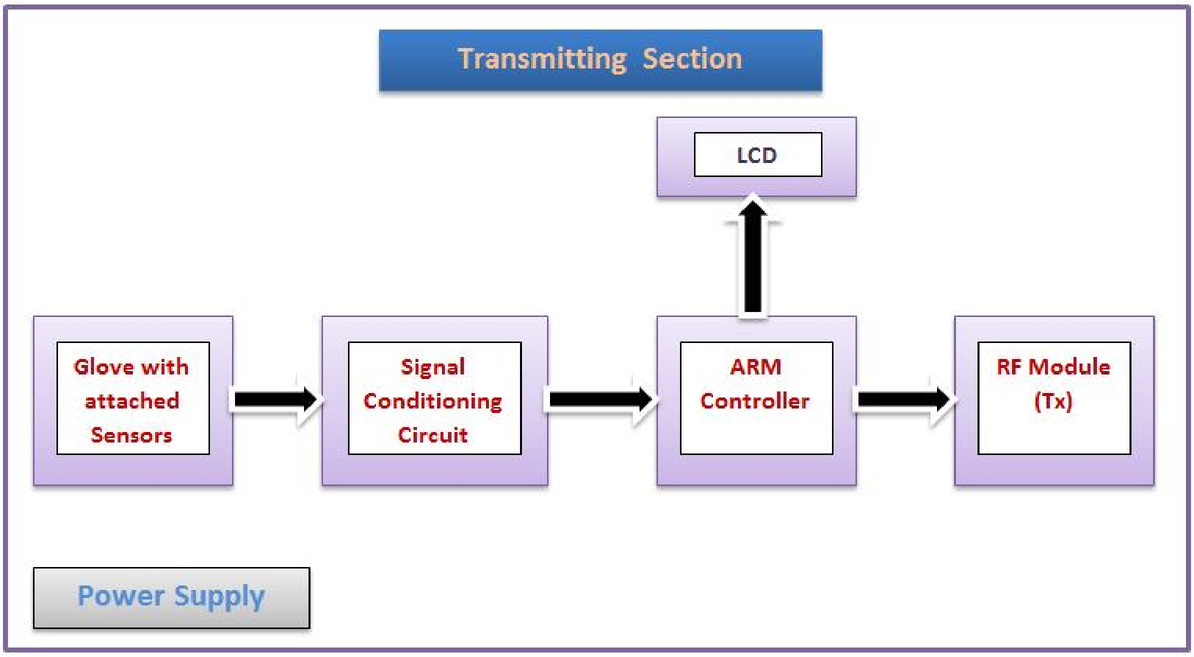

Fig.2. Block diagram of transmitting section

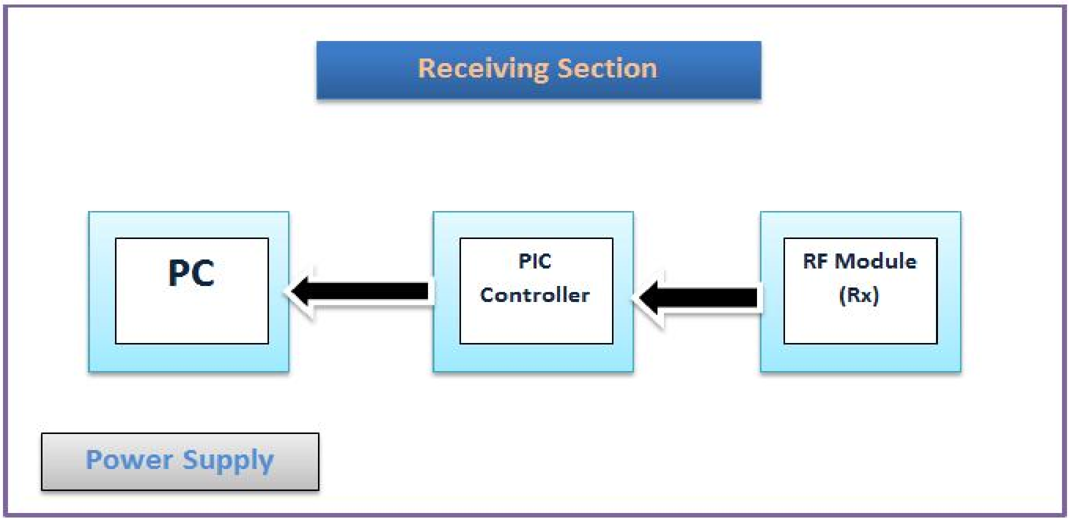

Fig.3. Block diagram of receiving section

The system is made out of a transmitting section and a receiving section. The transmitting section is the transduction system and comprises of a glove including 5 flex sensors (one for every finger and number of sensors may change) joined with a microcontroller through front-end hardware. The management of the sensor estimation is allotted to the ARM microcontroller that performs a few capacities: interfacing and conditioning of signals from the sensor block and

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information transmission. Amid the operation, the receiving section which is comprised of a beneficiary and a PC, changes over, records, and showcases the got measures of joint deflection.

IV. Experimental System

The experimental set up for transmitting section and receiving section is shown in Fig.4. and Fig.5. respectively.

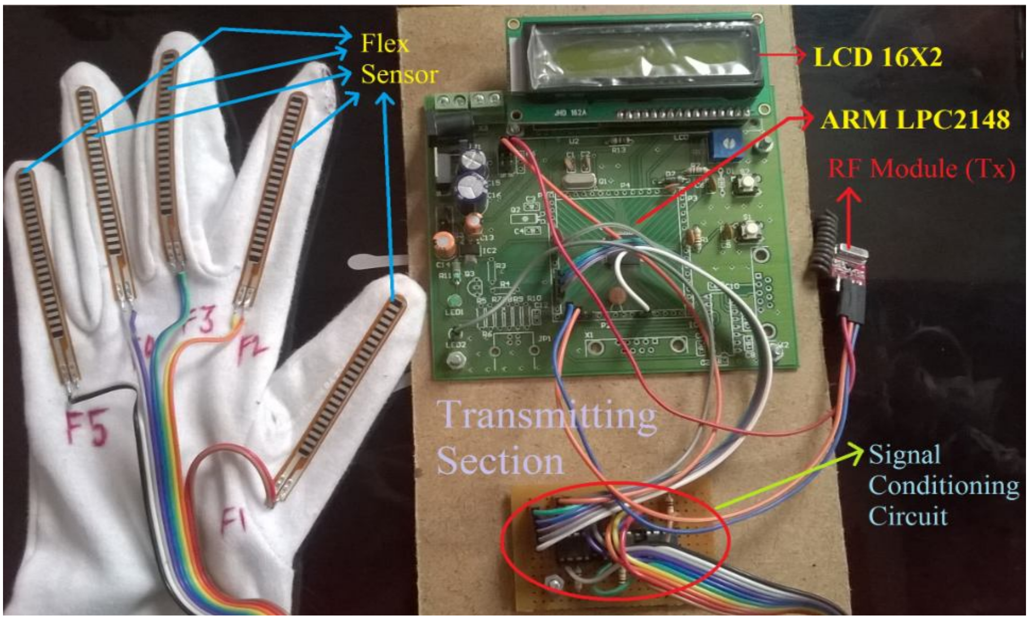

Fig.4. Transmitting section set up

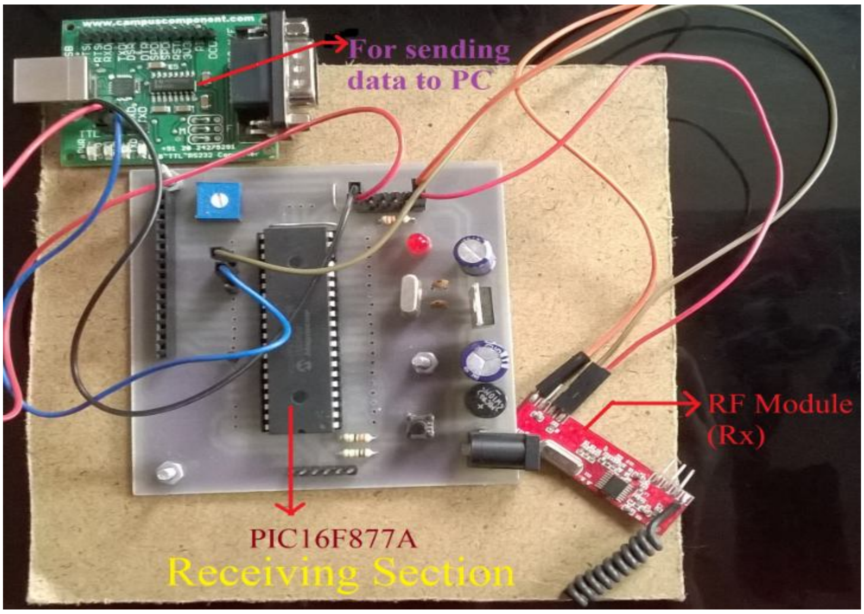

Fig.5. Receiving section set up

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In the transmitting section, we have sensors which are attached with the glove. From these sensors we will get output in the form of resistance. In the signal conditioning circuit we will convert this resistance into voltage using voltage divider circuit. The interfacing and conditioning of signals will be done by ARM LPC2148 controller. The output of the controller is then transmitted using the RF module which operates on 433 MHz frequency. The finger movements are detected or not will be displayed on LCD on transmitter side. In this system 16X2 LCD is used. The transmitted data will be received using RF module in receiving section. The received data will be displayed on PC using any MATLAB software. The ARM7 means LPC2148 is used for the processing of the data. As it is 32-bit microcontroller it is very useful in this system. On the receiver side PIC16F877A is used. The flex sensor bends and flexes physically with motion device. The flat resistance (at 0° angle) of this sensor is 10KΩ and when its bend at 90° angle then its resistance will be 50KΩ. It has a power rating of 0.5 Watts continuous. The temperature ranges from -35°C to $+80^{\circ}$C. The signal conditioning circuit in transmitting section is shown in below Fig.6.

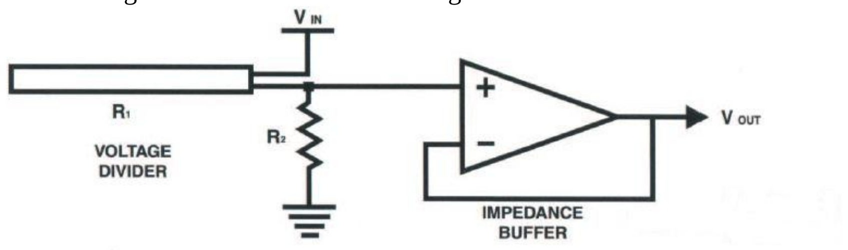

Fig.6. Signal conditioning circuit

The R_1 resistor is nothing but the variable resistance of flex sensor. This resistor is connected serially to R_2 resistor,which is a fix value resistor. Using this circuit the flex sensors output, variable resistance, is converted into the voltag. Each sensor requires its separate voltage divider circuit. The impedance buffer is, a single sided operational amplifier, utilized with these sensors because the low bias current of the op amp reduces error due to source impedance of the flex sensor as voltage divider. Suggested operation amps are the LM358 or LM324.

V. EXPERIMENTAL RESULTS

The data received by the receiver of the RF module need to be displayed. For displaying this data from RF module receiver we have used the PC. For displaying data on PC we have used the MATLAB software. There are different tools in MATLAB software for displaying any data. In this system we have used Graphical User Interface (GUI) tool. Using this tool we have created a one GUI. This GUI is shown in below Fig.7. This GUI is used to show the angle of each finger in the form of degree as well as the image of hand.

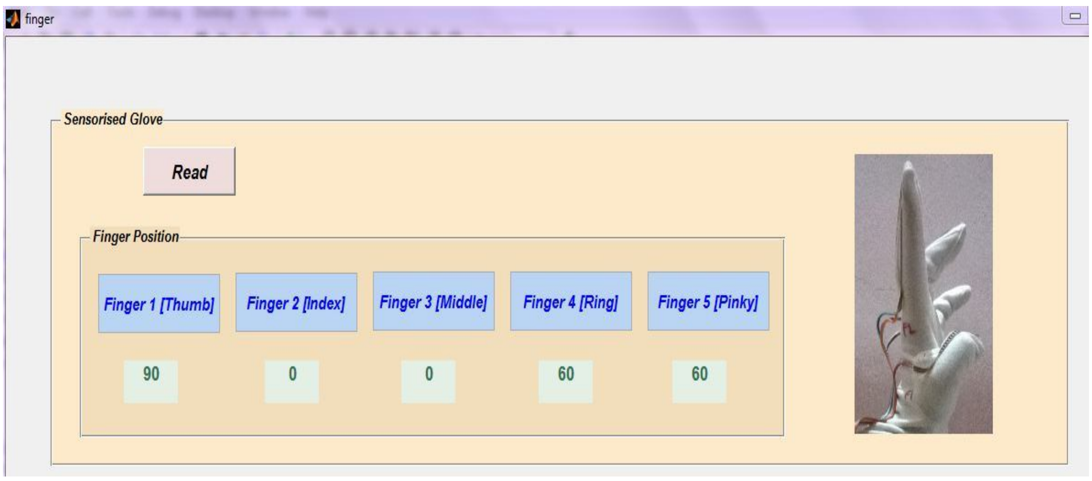

Fig.7. Result on PC

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VI. CONCLUSION AND FUTURE WORK

The system discussed in this paper measures the position of each finger of hand. This system will sense and measure the position of the fingers using flex sensors and it will be displayed on PC using MATLAB software. The application of this system is in biomedical field. This system will be useful for patients who have traumatic brain injuries, degenerative diseases or articulation traumas to do exercise. It will have ability to perform the exercise at home which will reduce cost and difficulties of transport to hospital. In future we can make this device portable by using the battery as a means of power supply and weight also can be reduced.

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