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# Smart Glove

**P. Ganesh Babu[1], S. Nivedha Ramalakshmi[2], D. Nisha[3]**

[1]Assistant Professor, Department of Biomedical Engineering, Adhiyamaan College of Engineering (Autonomous), Dr. M. G. R. Nagar, Hosur, Tamil Nadu, India

[2-3]Student, Department of Biomedical Engineering, Adhiyamaan College of Engineering (Autonomous), Dr. M. G. R. Nagar, Hosur, Tamil Nadu, India

## ABSTRACT

The Smart Glove is a feedback system designed for upper extremity rehabilitation after stroke. It includes a glove shaped exoskeleton as sensory hardware device and a software application. The sensor device tracks the movement and position of the user's distal limb and recognizes functional gesture, such as forearm pronation /supination, wrist flexion/extension, radial/ ulnar deviation, and finger flexion/extension. An accelerometer sensor in the device measures the 3-dimensional orientation of the hand, and 5 flex sensors estimate the angle of motion of the fingers. The acquired sensing data is transmitted and received via USB portal connected to the computer. According to the movement of the hand the data are sensed and transmitted to the software application which changes the visuals of the game. In addition, this device can analyze the active and passive range of motion for each functional gesture.

**Keywords :** Rehabilitation, Range of motion, visual feedback, Gaming, Exercise

## I. INTRODUCTION

Stroke accounts for high rates of mortality and disability. It imposes great Physical burden and mental stress on the affected subjects, their family and the society at large. Motor impairments after stroke mainly involve hemiplegic or hemiparesis in the upper and lower limbs. The recovery of the motor impairments is not consistent and does not follow a fixed pattern but it can be improved by repeating the motion of the affected area. Proper intensity of this movement repetition can retrieve the functioning of the impaired part. The therapy can be improved by assistive devices that can ease the recovery by repeating exercises bot at home and clinic. This thesis aims to develop a Smart Glove and a software that can retrieve the motor movements of the upper extremity by visual feedback to the patient on hand movements (wrist and finger gestures) performed during treatment. The design implements resistive flex sensors for detecting the extensions and scan the information using the Arduino Uno mounted on the wrist.

## II. METHODS AND MATERIAL

### BACKGROUND

The proper functional movements of the upper extremity are very much of importance since for leading a normal life involves the functioning of this part, but retrieving the functioning of this part is of much difficulty for the stroke survivors. The fingers

and wrist joint involves the most number of joints in the motor impairments of the stroke patients hence it took a long period and continuous repetition of exercises to regain the function. About half of the stroke survivors leads the life with impaired hand. Since it is the last part to recover after stroke the stroke patients often lose hope to continue exercises.
The function of upper extremity is very much essential for doing daily activities such as writing, eating, lifting objects, and it is also involved in doing most personal activities of daily living so it is of primary importance to enhance the upper limb functionality

DESIGN OF GLOVE

The sensory device is a glove that is made of plastic on to which the sensors are placed. The glove is made of plastic to overcome the spasticity of the hand. Spasticity refers to the condition in which the muscles tend to contract continuously causing stiffness and restiveness to the movements of the muscles that is the result of the loss of control of the brain over the motor nerves in the hand due to stroke. The stroke patients also suffer from edema resulting after the hemiparesis which is swelling of the extremity due to fluid collection. This is result of improper fluid motion caused by nerve damage. This is often associated with pain stiffness and weak extremity in stroke patients. The plastic frame of the gloves provides support for extension of the muscles and positions the hand and wrist correctly. It provides support and protection for the swollen or weak joints in hand. This acts as splint and keeps the wrist in neutral position to eliminate muscle contracture and increases extensibility of the wrist and fingers.

BLOCK DIAGRAM DESCRIPTION

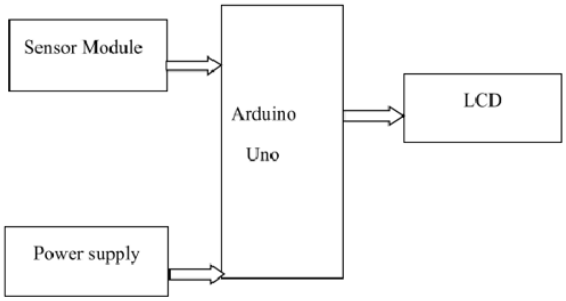


**Fig 1.** Block Diagram of Sensing Glove

Sensors are used for sensing each movement of hand during motion. Intended movements as follows:

- forearm pronation/ supination
- wrist flexion/extension,
- finger flexion / extension

The sensory module is fixed to the glove. The sensors used for recognizing the movements are the Bending sensors and the accelerometer. Bending sensors are used for sensing the vertical motion of the fingers and the accelerometer is used for sensing the orientation of the hand. the microcontroller board Arduino Uno is used for gathering the data from the sensory module process and transfer it to computer software. In addition, a voltage regulator is used to get a constant voltage of 5V. The power supply acquired from the computer to which the glove is connected for running software application.

CIRCUIT DIAGRAM DESCRIPTION

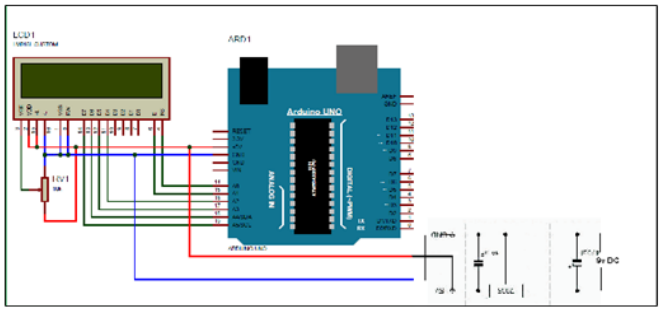

**Fig 2.** Circuit Diagram

Microcontroller

The Arduino Uno is the heart of the device. It used as a platform for creating the smart gloves. It consists of 14 digital input/output, 6 analog inputs pins for interfacing the board with various hardware of the glove and software gaming programs. The inputs are acquired from the various sensors connected to the microcontroller and the output of the board gives the compatible signal for running the software. Thus microcontroller board helps in the interfacing of the hardware and the software. The Arduino Uno is a microcontroller board based on ATmega328 microcontroller. It has Integrated Development Environment for programming software in computer. Both the power supply connection and data transmission can be done via the type 2 USB cable. Ceramic resonator in the board is the source of 16MHz Clock signal. It also contains an ICSP header which provides In-Circuit Serial Programming. The Atmega16U2 microcontroller present in the Arduino Uno acts as a USB-to-serial converter for speed transmission of data for visual feedback.

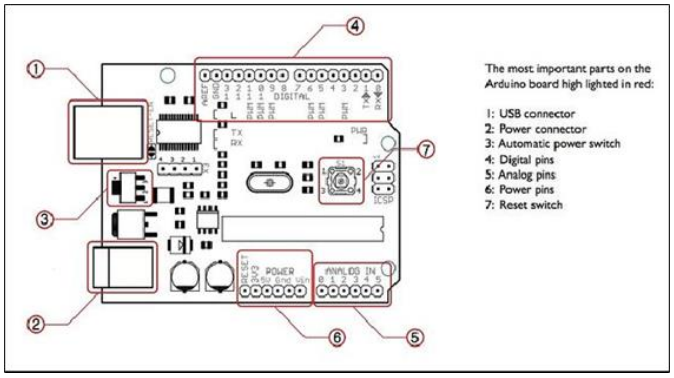


**Fig 3**. Pin Diagram of Arduino Uno

Voltage regulator

The LM7805 monolithic is a 3-terminal positive voltage regulators. It is used to get constant voltage. Regulator is used for stabilizing the voltage utilized by the processor and other modules of the system. It looks like a transistor and it contains three terminals, one input and one output and ground. Depends on the output voltage we choose regulators. The output required in this device is 5V, so 7805-5V regulator is used.

Bending sensor

Bending sensor or flex sensor is used for measuring the bending angle of the fingers. This sensor is basically a thin conducting layer whose resistance changes with change in dimensions of the conductive layer. Hence it can be called as variable resistor. It is applied on the device based on the principle that whenever the finger is bent the sensor is flexed, this decreases the width and increases the length of the sensor, thus the resistance increases. This change in resistance is measured and transmitted to device for predicting the movement of fingers.

Accelerometer

Accelerator is a device used to detect the orientation of the hand and to sense the movement. It basically measures the acceleration exerted upon the sensor. Acceleration is the measurement of the change in velocity, or speed divided by time. It is utilized for axis- based motion sensing of the glove.

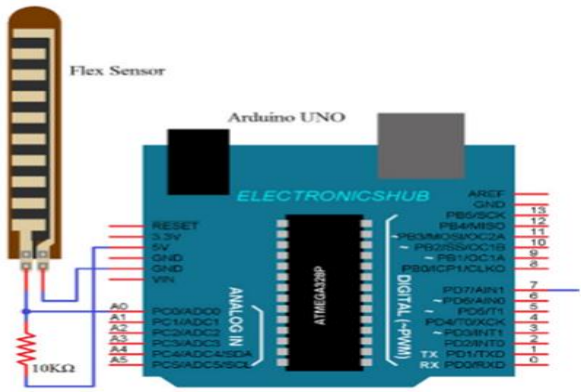


**Fig 4.** Circuit Diagram of Flex Sensor with Arduino Uno

Display

LCD display is used temporarily to display the data sensed by the sensor, it will be removed on further development of the device in which glove will be interfaced with the software.

SOFTWARE

Game is developed in which the user has to finish the task for continuous repetition of motion. Each game involves the task for the specific rehabilitation exercise movement. By successfully performing in each level the user can increase the repetition and range of motion of particular movement.

The orientation and motion of the hand is updated at immediately forming a visual feedback system. The performance of the user is determined based on the range of motion but it can also be determined by the speed of motion for some tasks. Based on adequate repetition of a movement and on the performance the difficulty level is increased. The motion of each joint is analyzed. The improvement and the percentage of motor function recovered is shown at each level. This helps the user to see the progress visually and continue gaming.

## III.RESULTS AND DISCUSSION

The sensors are interfaced with the microcontroller. The wrist and finger extension and flexion are sensed. During the hand movement, the data from the sensor is displayed on LCD. The smart glove and PC software have to be designed further.

## IV.CONCLUSION

Smart glove can bring rehabilitation to home in a comfortable environment and at low cost. It is novel rehabilitation device that helps to increase the repetition of the exercise movements of the upper extremity to improve the functioning of the wrist and fingers. It will be great solution after stroke to help stroke patients to stay motivated by engaging exercises in fun games. It can be used as a home rehabilitation device. It eliminates the stiffness of the hand and increases the functional capability.

## V. FUTURE SCOPE

Future scope of this work can be the further effective rehabilitation by creating more effective exercises, more accurate data analysis on movement and designing even more interesting games.

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