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Finger Movement Based Wearable Communication & Navigation Aid for partially disabled

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Abstract

The FMBWCN Aid is a portable and wearable multi-purpose system for the partially disabled. The Aid is a glove-based system in which different trained finger movements leads to different modes of operation of the system such as APR Voice Module and Wheelchair Controller Module. The finger movements (bending movement) leads to the flexion of the flex sensor attached to the glove. Flexion leads to change in resistance of the flex sensors, which will be recorded via a microcontroller (Arduino Uno) and different sets of movement of the fingers will lead to different modules of operation as specified in the default settings of the FMBWCN Aid.

I. Introduction

A person requires a rehabilitation devices or assistive techniques to control their environment or to communicate with others due to many reasons. Disability is one of the main reasons. Rehabilitation devices enable persons with disabilities to live, work, play or study independently.in other words they increase the quality of life led by the disabled people and increase their self-esteem.

According to the 2001 census report around 6 million people in India are affected by movement disabilities [1]. Among them a majority persons are affected by paralysis. Paralysis can occur due to different reasons. It can be due to a spinal injury due to a road traffic accident or damage to the brain due to a brain hemorrhage or a tumor. Paralysis can also results from motor neuron diseases [2].

A common thought which haunts most of these people are that they are a burden to their families and society because to perform their day to day activities they need to depend on family even for basic needs like transport from one place to other, to communicate with someone, or using a computer etc. Most of the time the life led by these peoples are miserable. Different techniques by rehabilitation engineering help to improve the life of these people.

An ideal rehabilitation aid helps in collecting information from the surroundings, analyze this information, convey this information to the user and finally receive commands from user. With the advance in current research in image and signal processing, we can provide artificial intelligence to a system that can interpret the information automatically. The use of these rehabilitation aids aid the disabled person to do their day to day activities without depending on others. Rehabilitation devices are broadly classified in to two depending on whether they are biosignal based or non-biosignal based. Biosignal based rehabilitation devices mainly use biosignals like EEG, EOG or EMG as control signals. The advantage of using biosignal approach is that when patients become completely paralyzed only resources available to them are biosignals but it usually needs user training and have less accuracy than non biosignal approaches. The biosignal approach usually requires user calibrations because biosignals produced by each individual is unique due to difference in individual physiological properties and skin conductance. Non-biosignal rehabilitation aids provide 100% accuracy and less training for the patients but the usage of these devices limited to patients with partial or complete flexibility with their body parts.

II. Materials and Method.

2.1 System recquirements.

2.1.1. Flex Sensors:

Flex Sensors or Bend Sensors are a type of variable resisters which change their resistance when it is bent from one end. The resistance of the flex sensor changes when the metal pads are on the outside of the bend (text on inside of bend). The Flat

Resistance is around 10KΩ and the resistance increases as the bending of the sensor is increased. Fig 2.1 shows the Flex sensor 4.5'' and its working. If the flexion occurs towards the proximal end, it might result in faulty reading and damage of the sensor. So the flexion should occur towards the distal end. [3]

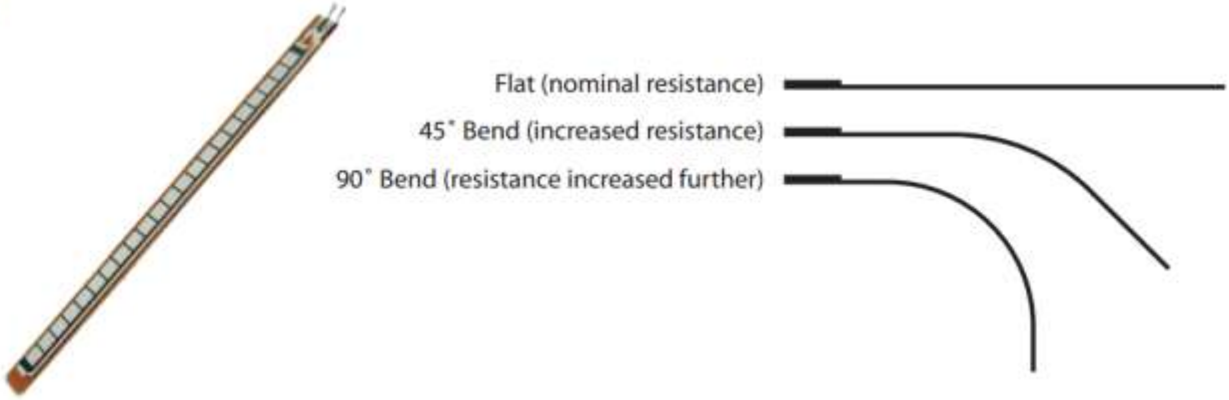

Fig 2.1 Flex sensor 4.5'' and its working. [3]

2.1.2 Arduino Uno:

Arduino Uno is a mini-size portable microcontroller board manufactured by Arduino Co. Significant features of this microcontroller include six analog input ports (A0 – A5), a 5V and 3.3V DC power supply ports and 14 Digital output ports. It can be interface with computer using the USB cord[5].

2.1.3 APR9600 Voice Module:

APR9600 is a low-cost high performance sound record/replay IC incorporating flash analogue storage technique. One salient feature is that the recorded sound is retained even after power supply is removed from the module. APR9600 pin diagram is shown in Fig. 2.3. Pins 1 through 6 and 8 and 9 are used to record 8 different audio messages (M1 – M8). So basically a single APR9600 IC has the capability to record and playback up to 8 messages [4].

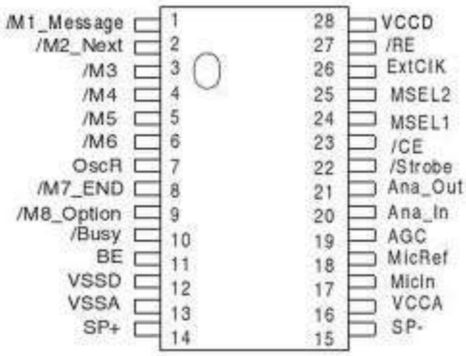

Fig. 2.2 APR9600 pin diagram [4]

2.2 Assembling and working of the FMBWCN Aid:

In the FMBWCN Aid, five Flex Sensors 4.5'' were used. They were mounted on 5 fingers of a glove as indicated in Fig. 2.4. They captured specific flexion movements of the fingers and based on the change of resistance of different sets of sensors, the system was trained to switch to different modes of operation. Arduino Uno was used to record the changes in resistance of the flex sensors on bending. The recording was done through 5 analog input ports. Based on the program ported on the microcontroller, signals were sent as digital output to either the APR6900 Voice Module, or the Wheelchair Control Module.

Fig. 2.4. Flex Sensors mounted glove and default unflexed state and flexed middle finger.

Assembling the whole system was done by first integrating the flex sensors onto the analog inputs of the Arduino Uno board, then integrating the digital output signaling mechanism from the board towards respective modules of operation. Fig. 2.5 shows the block diagram setup for integrating the flex sensors. Flex Sensor 1 mounted over the index finger is connected to Analog Input (AI) 1. Similar Sets are (Sensor 2, middle finger, AI 2), (Sensor 3, ring finger, AI 3), (Sensor 4, small finger, AI 4) and (Sensor 5, thumb, AI 5). Power Supply to the Arduino Uno board was given by a 5V Battery at the V_{in} port. Digital Output Ports 0 to 3 were connected to the wheelchair movement (forward, backward, left, right respectively). Ports 4 to 11 were connected to the APR 9600 Module for playing the respective recorded message among the 8 messages recorded. Similarly wheel chair also can be controlled by interfacing with the system itself.

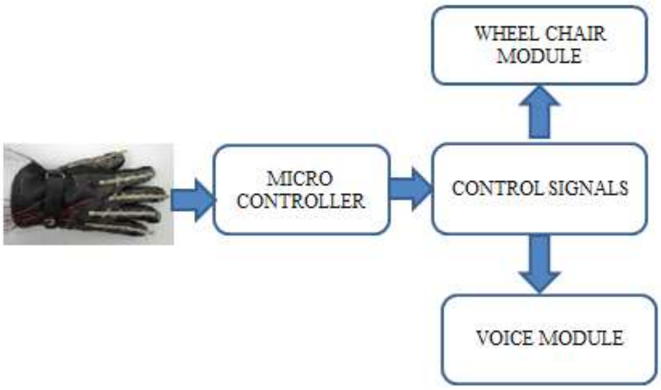

Fig 2.5 block diagram representation of FWCN

III. Result and discussion

The main input of the system was the five finger movements which would control the whole system setup. The mounting of the sensors on the glove was done by simply threading up the sensors onto the upper part of the glove fingers. The signals from the flex sensors are taken at an interval of 1 sec in real time. The flat resistance of flex sensors mounted on the glove was found to be around 9KΩ and the resistance on full flexion of the fingers was in the range 12KΩ - 13 KΩ. the equivalent electrical flowchart for FMBWCN Aid is given in Fig. 3.1

3.1 Main Module:

If one finger is flexed, the corresponding voltage goes below threshold voltage (Vth). Voltage variations across a single bend sensor while bending and releasing is shown in fig 3.1. If it is kept straight, the voltage lies above Vth.

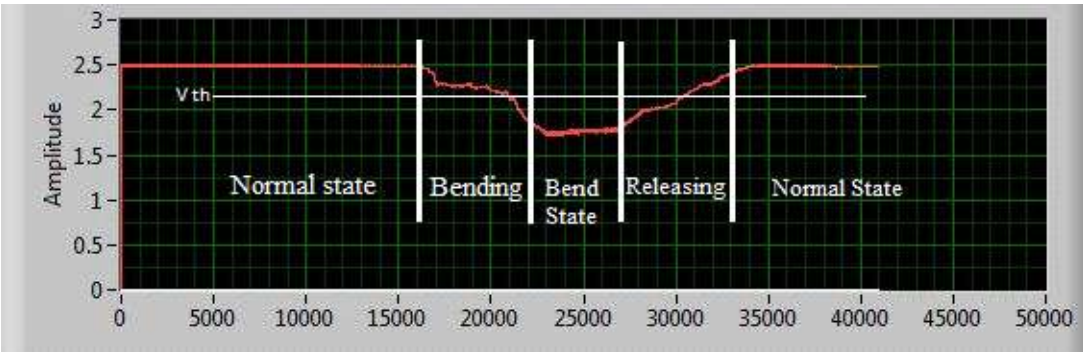

Fig. 3.1 Voltage variations across a single bend sensor while bending and releasing

Analog ports A1, A2, A3, A4, A0 respectively measure voltages v1, v2, v3, v4, v0 connected to index finger, middle finger, ring finger, small finger, and thumb respectively. If no finger is flexed, all values are above threshold, which means module has not changed. If v1 and v2 are below threshold and v3, v4 and v0 are above thresholds; APR Voice Module is activated (represented in Red). If v3 and v4 are below threshold, and v1, v2 and v0 are above thresholds; Wheelchair Module is activated. In any other condition, main module is not changed.

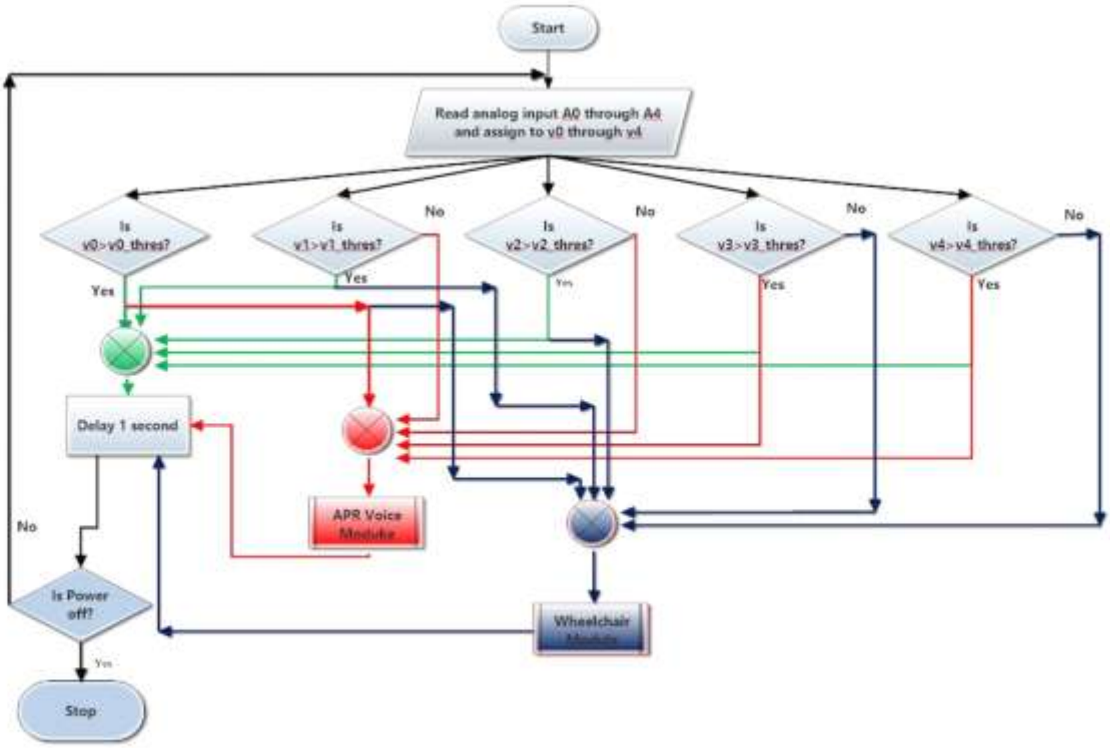

Fig. 3.2 Flowchart representing the operations of Main module.

Inside APR9600 Voice Module, different sets of flexion of different fingers would lead to different recorded voice slots to be played. Inside Wheelchair module, flexion of each finger would lead to respective movement of the wheelchair in a particular specified direction.

3.2 APR Voice Module

Once APR Voice Module is entered after flexing finger 1 and 2, the program does not move forward until all fingers are kept straight i.e. all voltages above the threshold. Then, APR Voice Module takes commands. If only finger 1 is flexed i.e. if only v1 is below threshold and all other above threshold, message 1 is played. Similar for fingers 2, 3, 4 & 0, the messages played are 2, 3, 4 & 5 respectively. The only way to exit APR Module and get back to main module is flexing all the fingers at once, which triggers the exit clause, followed by straightening all fingers at once which finally leads to exiting the voice module.

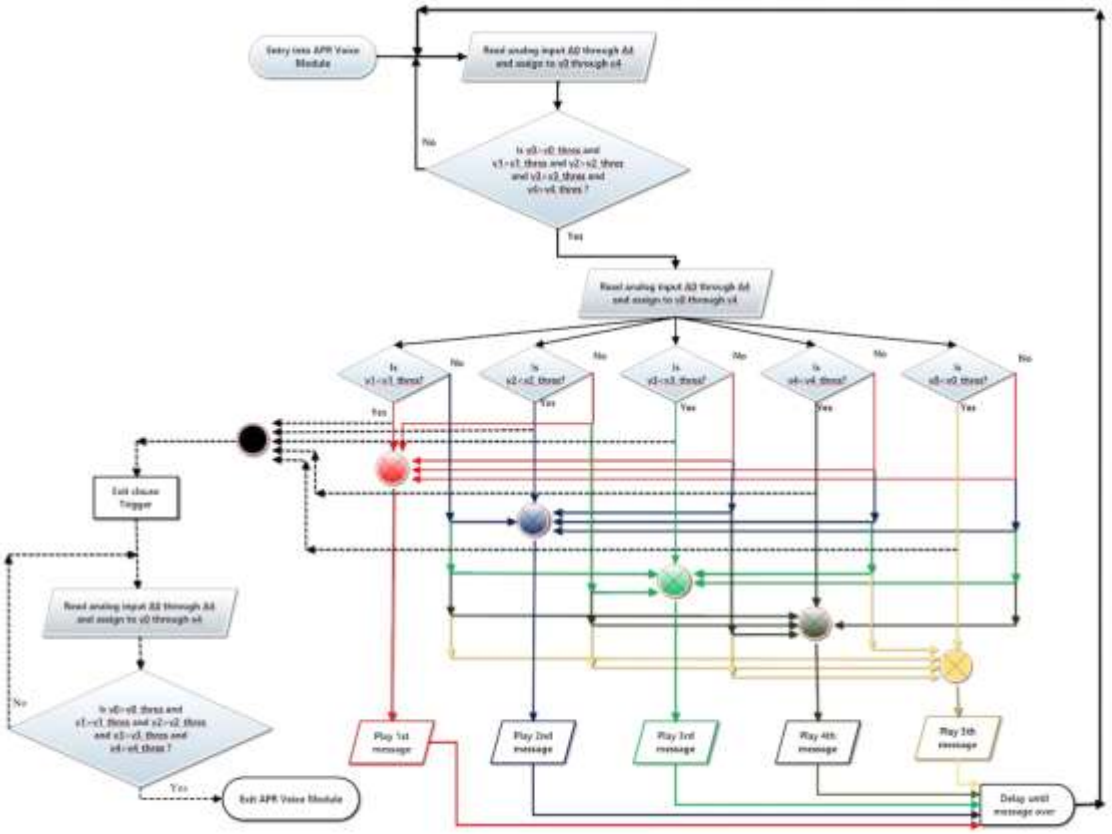

Fig. 3.3 flow chart representing operations of voice module.

3.3 Wheelchair Module:

Once Wheelchair Module is entered after flexing finger 3 and 4, the program does not move forward until all fingers are kept straight i.e. all voltages above the threshold. Then, Wheelchair Module takes commands. If only finger 1 is flexed i.e. if only v1 is below threshold and all other above threshold, command for forward motion is sent to transmitter. Similar for fingers 3 and 4, right and left motion commands are sent. For stopping the wheelchair, finger 2 is to be flexed. The only way to exit Wheelchair Module and get back to main module is flexing all the fingers at once, which triggers the exit clause, followed by straightening all fingers at once which finally leads to exiting the voice module.

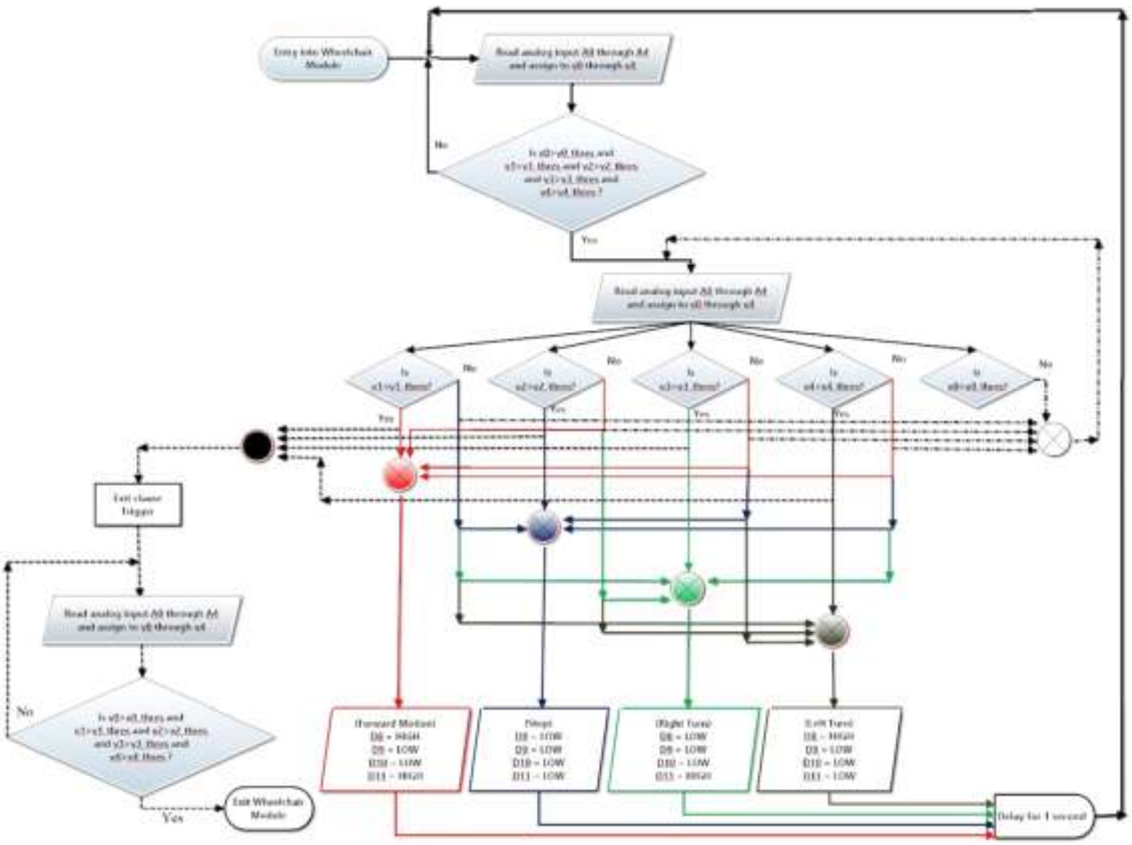

Fig. 3.4 flow chart representing operations of wheel chair module.

The fully-assembled FMBWCN Aid is shown in Fig. 3.5. Fig 3.6 shows the way FMBWCN can be implemented in real life. The FMBWCN Aid was checked thoroughly and all actions such as switching to modes, switching to specific actions, etc. were found to be performing as mentioned. Every set of flexing action of the fingers were checked and monitoring of the respective reaction of the system was also done.

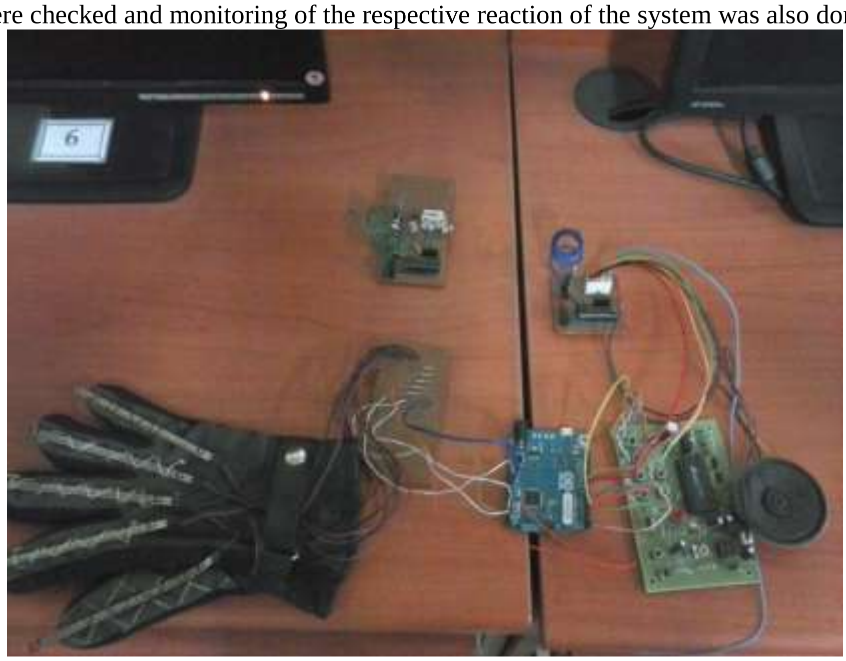

Fig. 3.5 fully implemented FMBWCN aid

Fig. 3.5 FMBWCN Aid implementation in real life

IV. Conclusion

The FMBWCN Aid is a very useful tool for people with partial disability to navigate around and communicate with the environment. The major advantage of this Aid is that it is wearable, cheap, all the parts and components are easily available and using flexion of only five fingers, a wide range of actions can be achieved. Hence it can be used as an effective rehabilitation system for those patients who have difficulties in moving around and expressing their basic needs.

Future prospects of this system can be seen in improvising and extending the range of actions. If we are able to incorporate image processing in the system, it can be a useful tool even for the navigation of the visually impaired persons.

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