ADVANCED COMMUNICATION FOR QUADRIPLEGIA

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Abstract - Accidents are common in all the countries and the affected faces trauma sometimes in the form of cervical injury, stroke, motor-neural syndrome. One such case is Quadriplegia, wherein the patient suffers from immobility due to the loss of control over his limbs sometimes also resulting in loss of speech leaving behind only the muscle movements of the head as a compliment. Many efforts to help such patients through the use of technology have been found and are in process, one such venture is "Advanced Communication For Quadriplegia''. Work based on embedded and software VB6.0 platform.

The main aim of the work is to provide the design and application of an efficient HCI helping a quadriplegic patient to establish an alternative communication path to self and outer world. Providing such a module would increase the quality of life of the patient.

Index Terms - Human-Computer-Interface (HCI), Visual Basics(VB), Graphical User Interface(GUI), Global System for Mobile Communication(GSM).

1. INTRODUCTION

Every year millions of people suffer from accidents around the globe, this may result in various maladies like loss of memory or amputation of hand or leg, amongst them paralysis is usually common as the patient experiences shock due to the disaster and one such paralysis is quadriplegia.

1.1 What is Quadriplegia?

Quadriplegia [5],[7],[9], also known as Tetraplegia, is a paralysis caused by illness or injury to a human that results in the partial or total loss of use of all their limbs and torso. It occurs when the brain, neck, or spinal cord is severely damaged, but it can also be the result of certain illnesses, including cancer, osteoporosis, and Multiple Sclerosis. The loss is usually sensory and motor, which means that both sensation and control are lost.

More than 250,000 Americans and 50,00,000 worldwide, have suffered debilitating spinal cord injuries, with 47 per cent being quadriplegic of which 82 per cent are male, and 56 per cent of these injuries are suffered by people of ages 16 to 30. The average age of a person who suffers this spinal injury is 31 years old.

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1.2 Causes

Road traffic accidents, domestic and work-related accidents, sports injuries, self- harm assault or complication surgeries. Spinal cord injury can also be caused by so-called 'non traumatic' cord injury. Examples include:

- Infection of spinal nerve cells (bacterial and viral).
- Cysts or tumors pressing on the spinal cord
- Interruption of the blood supply to the spinal cord (causing cord damage),
- Congenital medical conditions affect the structure of the spinal column.

1.3 Symptoms of Quadriplegia

Upon visual inspection of a quadriplegic patient, the first symptom of quadriplegia is impairment to the arms and legs. Function is also impaired in the torso. The loss of function in the torso usually results in a loss or impairment in controlling the bowel and bladder, sexual function, digestion, breathing and other autonomic functions.

Furthermore, sensation is usually impaired in affected areas. This can manifest as numbness, reduced sensation or sore burning neuropathic pain.

Quadriplegia is defined in different ways depending on the level of injury to the spinal cord, usually affects arm sensation and complete body system movement; however, all quadriplegics have or have had some kind of finger dysfunction.

Fig.1. Cross Sectional view of Spinal Cord injury resulting in Quadriplegia

As the affected person cannot talk or move his limbs the only option for him to communicate with the world is by his head movement. Using this cue many of them have formulated alternate methodologies and different techniques to help the quadriplegics to communicate, one such effort is "Advanced Communication For Quadriplegia", wherein a Human-Computer-Interface (HCI) [2], [3], [6] is successfully built to facilitate the cause.

1.4 Work based on Embedded

In this paper[16], [17] the emphasis is laid on building an effective interface i.e. a combination of hardware and software so as to assist the user with an 'ease-of-use' technology. The hardware is centered on the utilization of micro-controller by writing codes that effectively control the other hardware components like Analog to digital converter(ADC) [15], Accelerometer(MAX232) etc.

The software used is 'Visual basics 6.0',a GUI(graphic-user-interface) that uses 'drag and drop' option for creating the front end enabling the user to decide his needs depending on related images. The creation of the various modules is shown in screen shots and the method of creation using the available tools of VB 6.0.

1.5 Quadriplegia Institute Visit

AKHILA BHARATIYA VAKSHRAVANA SAMITHI located in Mysore is an institute set up by the Government of India to facilitate the specially abled people in negotiating with their everyday life .This institute has made a name for itself in the records for its unrelenting service to the visually impaired and the deaf.

Patients [4], [8] suffering from all kinds of problems ranging from spastic quadriplegia to Barrie's syndrome are treated here by the unique combination of therapies found by the doctors and electronic engineers working in unison. We had visited this place and have also obtained valuable inputs related to our research from doctors and engineers working there, which to a certain extent have been implemented in our project [1].

2. OUR MOTIVATION

Stephen William Hawking (born 8 January 1942) is a British theoretical physicist, cosmologist, and author. His key scientific works to date have included providing, with Roger Penrose, theorems regarding gravitational singularities in the framework of general relativity, and the theoretical prediction that black holes should emit radiation, which is today known as Hawking radiation.

Hawking has a motor neuron disease related to amyotrophic lateral sclerosis, a condition that has progressed over the years. He is now almost completely paralyzed and communicates through a speech generating device.

Fig.2. Stephen William Hawking

Though he sits on a wheel chair with inability to walk or even move a finger, his dedication, determination and perseverance has not withered even to the slightest extent as he has founded many a things and conceived many theories about space which was otherwise non decodable. In spite of being a quadriplegic his contributions have opened up the unknown 'universe' and his spirit always serves as an inspiration for all of us and the entire human race.

3. WORK OVERVIEW

Now a days accident are predominant and most of them lead to **Spinal cord injury**. Spinal cord injury causes information travelling along spinal nerves below level of injury will completely or partially cut off, this leads to paralysis. A type of paralysis is **quadriplegia**. It is derived from two words **quadric** means four and **plegia** stands for paralysis. These quadriplegic patients suffer with many problems such as the person cannot walk and could not even speak.

Some of these patients can only move their head. Establishing a new channel without speaking and hand/arm motions makes life easier for patients and therefore improves their life quality. To help these Quadriplegic patients to communicate we hereby propose a new mechanism where they will be able to communicate to anyone by various types of **head movements** as that is the only muscular movement available in their body. **Accelerometer** based **HCI** systems allow people to successfully and economically communicate with their environment just by their head movements.

4. STUDY APPROACH

With the conditions and constraints of the patients in hindsight the project is embedded designed in such a way

that utilizing the only possible muscular movement i.e. Head movement and efficient way of communication is implemented. The accelerometer, the selection tool device is programmed to a particular angle to respond to the head movement of the patient in selecting a couple of basic needs that is stacked up and made to toggle by programming using the visual basics software.

5. THE CHOICE OF VISUAL BASIC

The choice of visual basic software comes after evaluating along with comparing and contrasting it with its nearest competitor the C language. Listed below are a few advantages of visual basics and the reason as to why it was chosen over C language

- VB [10] is a GUI whereas C is a Character User Interface(CUI), i.e. the GUI provides the user with pictures as a mode of selection or in other words, the entire usage revolves around pictures in VB whereas the commands are used as parameters for all sorts of usage in C.
- VB can easily be designed to requirement using the 'drag and drop option' on the other hand C uses only command prompts and this usage fails, as the process of selection by the patient is extremely cumbersome.

5.1 Overcoming the bottlenecks faced in research work

- There existed a dilemma between the selection of software between visual basics and C language, both evaluated along their respective merits, VB was chosen for mentioned reasons.
- The coding part of the software was a setback as it involved certain 'know-how' of coding expertise, this issue was solved in programming skills.
- Positioning of the accelerometer to suit the x, y and z directions in accordance with the patient was initially a problem but was later rectified by restricting the rotations as minimum as possible and hence increasing the sensitivity of angle by changing the microcontroller code.

6. WORK LIMITATIONS

- The patient is to be instructed beforehand to the usage about the Quadriplegia system.
- The process is time consuming as to select a single letter, the keypad toggles 26 times.
- The components are inter-wired hence it is required by the patient to be in the vicinity of the device.

6.1 Application

- It is used as an alternate communication device by the patient to respond to his basic needs.
- Many medical researchers are using this platform to make similar equipments that aid the 'barre's syndrome'
- Using this prototype idea much advancement are being aided to track the emotions of the patient by the axon-neuron-dentrie connection that forms the basic chemicals to stimulate the 'response and stimulus' mechanism.
- It also comes in handy for those patients who suffer from speech and other vocal cord related problems
- It can even be applied to those children suffering from spastic quadriplegia, wherein the child suffers from loss of speech and temporary inability of locomotion.

6.2 Merits

- The module acts as an interface by bridging the communication gap between patient and the world.
- It boosts the morale of the patient by his effective communication with his environment.

7. DESIGN - BLOCK DIAGRAM

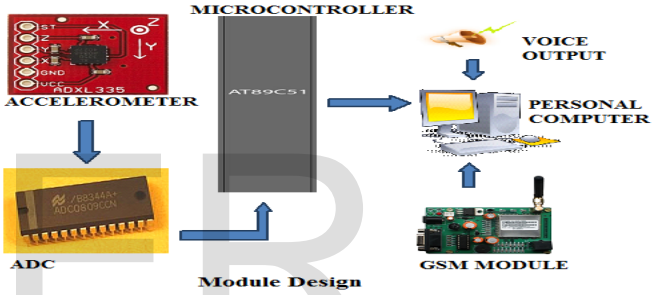

Fig.3. Design

As shown in Fig.(3), an accelerometer(ADXL335) is connected to the head of the quadriplegic patient. By the movement of his head, the tilt angle is calculated which is converted into voltage. The minimum power supply required to operate 5V for our experimental work, but depends upon the design module the input voltage may vary.

The voltage reading is then given to ADC(0809) [14], where the analog data is converted to digital; this digital data is given as input to the microcontroller(89C51), [11].

The coding for the microcontroller [12] is written such that, it assigns a number to each of the head movements; a number 1 to left position movement, 2 for middle position and 3 for the right position. These numbers are sent to the serial port of the personal computer were in the numbers can be used to select any of the menus and submenus that are created using visual basics 6.0.

The output obtained is in the form of voice from a loud speaker. This system will also be able to interface with a GSM [18] module and the user can send short messages to any mobile number.

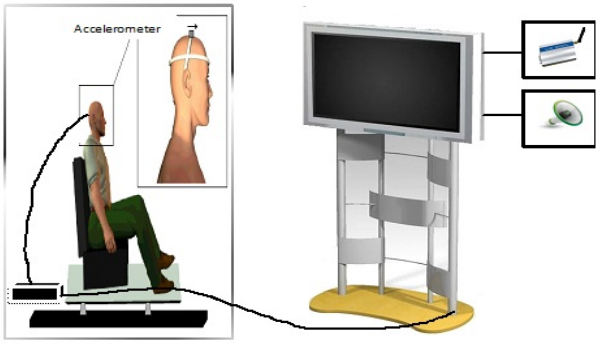

Fig.4.Quadriplegic System

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7.1 List of Components Used

COMPONENTS	APPLICATION
ACCELEROMETER(ADXL335)	SENSING OF HEAD MOVEMENT
ANALOG TO DIGITAL CONVERTER(0809)	SIGNAL CONVERSION
MICROCONTROLLER(89C51)	MASTER CONTROL
MAX232	LOGIC CONVERSION
GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS	SENDING SHORT MESSAGES
LOUD SPEAKER	AUDIO(VOICE)

8. DESIGN - ALGORITHM

Flow of the Module

Step 1: Accelerometer is connected to the head of the quadriplegic patient.

Step 2: The quadriplegic patient makes the choice of his/her needs through head movements which is sensed by the accelerometer.

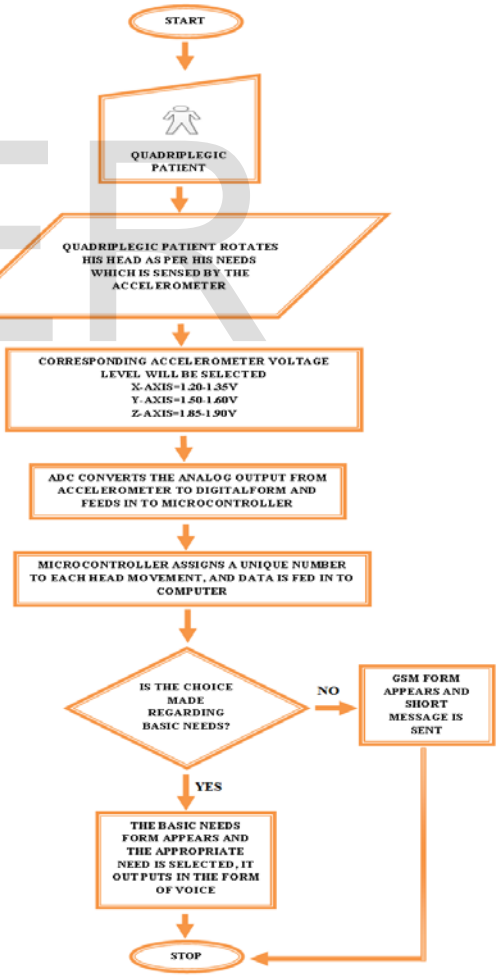
Step 3: The accelerometer now selects the corresponding voltage depending on the head movement.

Step 4: The output of the accelerometer is fed in to the ADC which converts the analog signal into digital signals and feeds the same to the microcontroller.

Step 5: Micro controller now assigns a unique code for the particular head movement.

Step 6: Now a decision needs to be made whether the patient has selected his basic needs or wants to send a message.

Step 7: Once the decision is made the appropriate form is selected and the requirement of the patient is served.

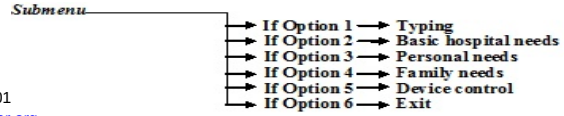


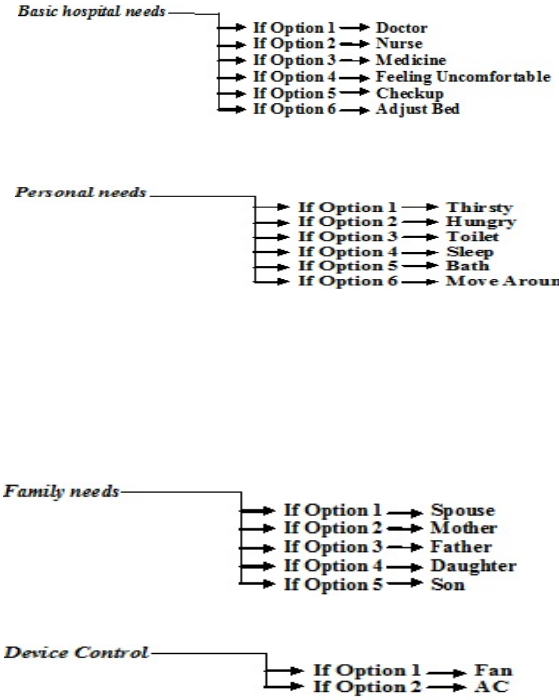
Flow Chart : PATH OF DATA FLOW

9. EXPERIMENTAL RESULTS

Process Flow:

Patient ➔Selects ➔Main menu ➔Sub menu





Example:

If the patient wants to adjust his/her bed then,

Patient➔Select➔Main menu➔Basic hospital needs ➔Adjust bed

Fig.5. Home Page

- This is the main window which opens first when executable VB file is run by the user.
- The initial setup consists of selecting the COM PORT number.
- The main application of this form is to make the patient select his/her basic needs.
- The cursor will be toggling from one need to the other which helps the patient to select the required need by his/her head movements.
- Once the patient selects the required need it is been heard through the loud speaker in the form of voice output.

Short Message Service(SMS)

Patient ➔Select➔Main Menu➔Typing ➔SMS ➔ Type Message ➔Virtual Keyboard ➔ Type Message➔Send Message

Example:

If the patient wants to send the message then to type a single letter it takes 38 seconds.

To type "HELLO" then it takes 38 X 5 = 190 seconds = 3 minutes and 10 seconds.

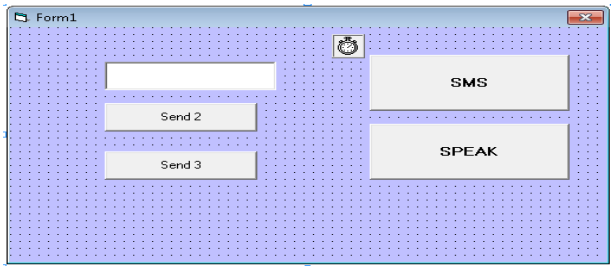


Fig.6. Short Message Selection Window

- This form will appear when the patient selects to send a short message.
- In order to type the message the following window appears.

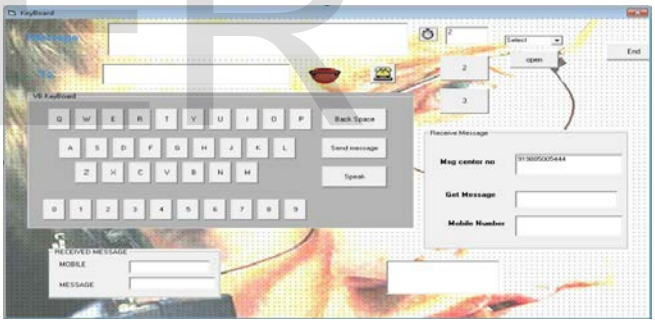


Fig.7.Virtual Keypad

- In order to help the patient type the message a virtual keypad is displayed as shown above in figure-7.
- The cursor toggles from A to Z and the patient can select the required alphabet to frame the sentence of his/her message.
- Once the message is ready to send the **"send message"** button has to be selected by the patient and the message is sent to concerned mobile number using the GSM technology.

Hardware View

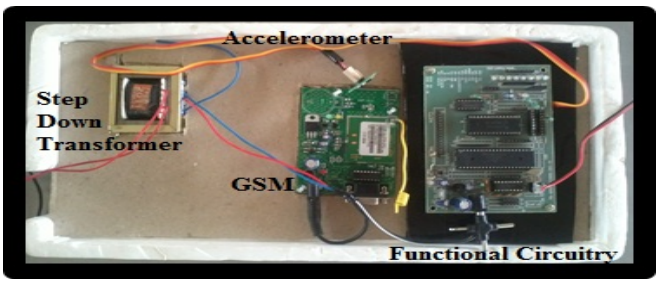


Fig.8. Front View of The Hardware

10. CONCLUSION

As stated in the introduction, an interface is successfully built which enables the diseased person to express himself through his various phases using a computer that uses hardware circuitry and software modules.

The implementation of hardware and software are well synchronized, resulting in successful demonstration of the project. Thereby helping the patient to communicate with his care takers and other people and hence raising his morale-standpoint.

The main motto is to reduce the time delay between Quadriplegia patient and the system to communicate. We achieved for some extend to have communication at faster comparing other methods implemented earlier.

It's a challenging project to carry out the research work in this field because economically very high.

" THE WORLD SHOULD BE SAFER FOR ALL, TO HAVE BETTER LIFE"

10.1 Future Enhancement

Wireless implementation: The inter connection between the accelerometer and the rest of the circuitry can be made wireless with help of blue tooth and other wireless technologies.

Image display for illiterates: It becomes difficult for illiterates to understand or to read the selections for their appropriate needs, this problem can be best solved by using image displays/pictures as the templates instead of text messages.

Speed enhancement: If Quadriplegic patient wants to type any text message it is going to be time consuming, as the toggling in the virtual key board allows to select only one alphabet at a time which results in time delay. To enhance the speed, technologies such as predictive text mechanism and others can be used and also algorithms can be written to speed up the process of selection.

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