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IR Sensor based Wearable Tongue Controlled Assistive Device

Er.Kunduru Umamaheswari[1],Er.Polepogu Rajesh[2]

[1, 2] Assistant Professor, E.I.E, V.R.Siddhartha Engineering College ,
Vijayawada , Andhra Pradesh, India

ABSTRACT

The study of WHO shows that globally, around 1 in 50 people are living with paralysis. Paralysis may also lead to mental depression. In this paper we proposed an Optical sensor based wearable tongue controlled assistive device that can aid a disabled person with a support to lead an easy life.The tongue movement is sensed using a small and low cost infrared (IR) sensor TCRT5000, mounted bilaterally near user's cheek. The user uses his/her tongue to change the reflection intensity of the sensor and this signal change is converted into user commands through signal processing. These commands are transmitted to Arduino Uno microcontroller, based on which the direction of the wheel chair can be controlled.

***Keywords*— Arduino Uno microcontroller, Infrared (IR) sensor.**

I. INTRODUCTION

Now-a-days People get partially or completely paralyzed mainly due to stroke and trauma to nervous systems or brain and spinal cord injuries (SCI) [1],[2]. A paralyzed person needs to depend on another person for carrying out their daily life task which makes their life miserable. Assistive Technology (AT) provides disabled people with independence by enabling them to perform their daily life tasks by themselves. It helps the user in various activities such as mobility, hearing, vision, self-care, safety etc [3]. One of the main areas in assistive technology is brain computer interface (BCI) where the EEG (Electroencephalography) signals are used to discern a user's intention. BCI technology requires concentration, consumes more set up time and it is not economical. Eye controlled assistive devices work on sensing eye movement by using cameras and measuring EOG (Electrooculography) [4], [5]. However, the disadvantage of this method is that as eye is used for watching purposes, and therefore requires much stress and concentration, on behalf of the user, in order to control the device [4].

The tongue is an organ, which is not influenced by other parts of the body as it is controlled by a cranial nerve. The movement of the tongue is usually not as affected by spinal cord injuries and minimally affected in nervous system damage. Thus tongue can be easily moved and used for recognizing a user's intention. OTCAD provides paralyzed people with a wireless tongue controlled assistive device.

Objectives of the paper

- To design an optical sensor based wearable tongue control assistive device to assist paralyzed patients.

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II. IMPLEMENTATION

A. Block diagram

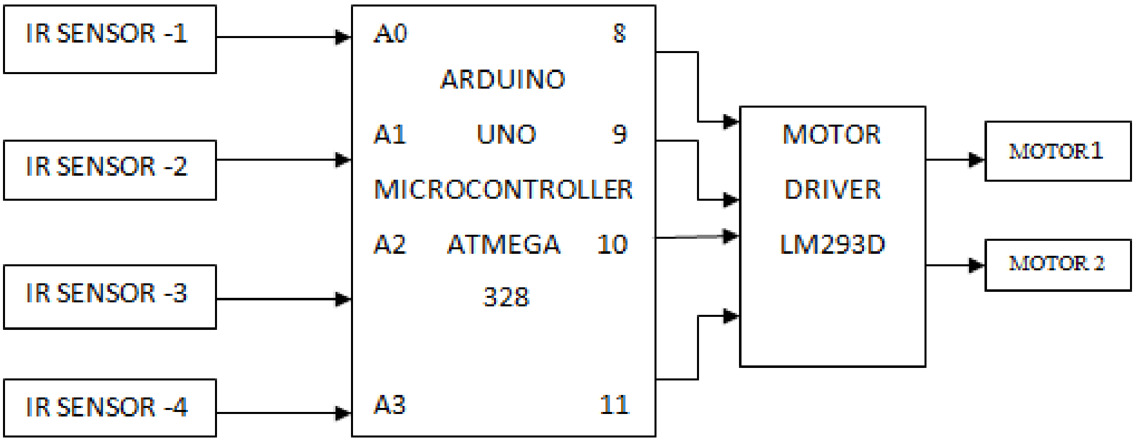

Fig.1 Block diagram

Fig.1 represents the block diagram of Optical Sensor based Tongue controlled assistive device .The sensing element used in this device, which tracks the tongue movement, is an IR reflective sensor consisting of an IR transmitter and receiver packed together. TCRT5000 is the IR optical sensor used and as the size of the sensor is very small, it is easy to mount on a headset and convenient for the user to operate [6], [8].The headset consists of four sensors, two on each side of the cheek as shown in Fig.2. On each side, one sensor is kept at the top and one at the bottom. These positions are chosen, as the tongue can be moved up and down without much strain. In order to provide more ease the placement of the sensors is fixed according to the user's preference i.e. according to where he/she can move their tongue. The outputs of the sensors are given to the Arduino Uno for signal processing. ATMEGA 328 is the microcontroller used and converts the sensor output into the user commands. User commands are in different letters indicating the user's intention through which they can move the cursor of the PC.

These commands are then provided to the device which transmits command to the assistive device, the control unit, consisting of the MCU. The IR sensors are fixed on the headset as shown in the overall architecture in Fig.2. A rechargeable battery is used to supply power to the system.

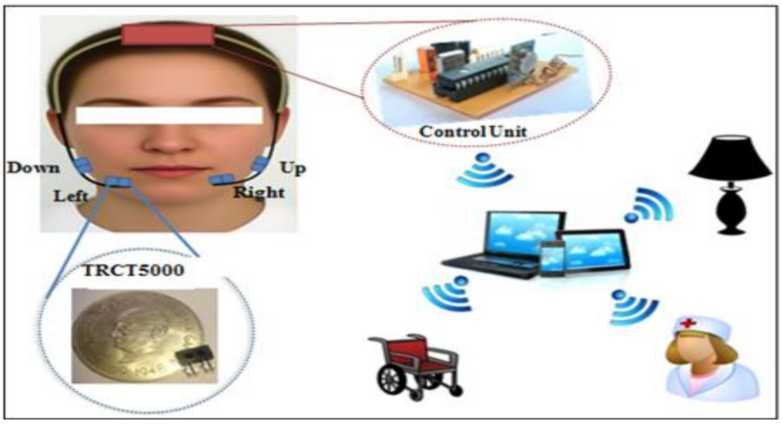

Fig..2 Overall architecture

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B. Arduino UNO Microcontroller

The Arduino UNO is a microcontroller board based on the ATmega328.Arduino is an open-source electronics prototyping platform and it is intended for designing, creating interactive objects or environment [7]. Arduino boards are relatively inexpensive compared to other microcontroller platforms.

Features

1. Cross-platform

The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems.

2. Simple, clear programming environment.

The Arduino programming environment is easy-to-use for beginners and flexible enough for the advanced users.

3. Source and extensible software.

The Arduino software is published as open source Open tools, available for extension by experienced programmers. The language can be expanded through C++ libraries.

4. Open source and extensible hardware.

C. TCRT 5000 Sensor

TCRT 5000 is an IR reflective sensor. The four IR sensors, two on each side, are used to track the tongue movement. An IR sensor module contains an IR transmitter and a receiver packed together. When an obstacle (reflective) comes in the path of the transmitted rays, the rays get reflected from the surface of the obstacle, and received by the receiver producing a corresponding output voltage [3]. This principle is used in the TCRT 5000sensor, where a photodiode acts as the transmitter and a phototransistor acts as the receiver [8]. According to the reflected light falling on the receiver, the sensor produces an output voltage. The sensors are fixed on the headset about 1cm away from the cheek and when the tongue is in its resting position, all the four sensors will produce an output voltage with respect to the IR rays reflected from each cheek. A supply voltage of 5V is provided to both the photodiode and the phototransistor through resistors and the output of the sensor is taken from the collector of the transistor.

When the tongue is in its resting position the IR reflections from the cheek fall on the photo transistor, of all of the sensors, switching it to a conducting state (ON state). This provides an output voltage, from all of the sensors, corresponding to the falling light and will be fixed as the threshold value. Thus, the threshold value from all sensors indicates the resting position of the tongue. When the user needs to perform an action he/she slightly pushes his/her cheek towards one of the sensors using their tongue. Thus this sensor gets blocked by the cheek, which is pushed using the tongue. This process cuts the IR transmission of that particular sensor and as the IR rays falling on the transistor are cut, the transistor switches into a non-conducting state (OFF state). This OFF state causes the output voltage of sensor to increase, in that particular sensor, as there is no conduction. Thus the voltage increases when the tongue blocks the sensor. Change in this signal is taken as the input to the user command. Thus whenever there is change in the sensor signal, i.e. cheek blocking one of the four sensors, the corresponding user command is generated with respect to which sensor is blocked. As the sensors are close to the cheek the user does not feel much strain in pushing the cheek to block the sensors.

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D. Signal Processing

The sensor output voltages are given to the MCU for further signal processing. An amplification section is provided in order to amplify the variation of voltages obtained when the sensor is blocked or not blocked. After amplification the signal is sent to an analog to digital converter (ADC) for digitizing, as shown in Fig.3. The resolution of the ADC is selected to be 10-bit which gives precise digital values for further processing. According to the digital values obtained, the user commands are generated by the Arithmetic Logic Unit (ALU). A comparison algorithm is used for command generation, which is explained in section E. Five user commands are created using four sensors, each sensor corresponding to each command. The position of the sensors in the headset with respect to each cheek and the corresponding user commands generated are given in Table .1. A "click" function can be performed using any of the four sensors. These commands are then provided to the RF module for wireless transmission. The transmitter is directly interfaced with the MCU and uses 434 MHz ISM band for transmission. These transmitted commands are received by microcontroller on the wheel chair and it moves according to the command received. Thus using these actions, not only the wheel chair he can operate and control tube lights, fan ON/OFF and can control the PC cursor also, they can control devices in their home environment [3].

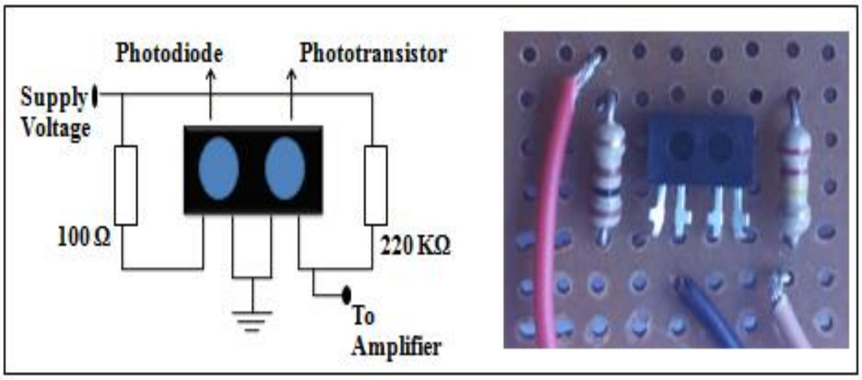

Fig.3 Hardware Implementation of sensor circuit

Table.1 Sensor command and wheel chair movement

Sensor position	User commands	Chair movements
Right bottom	**R**	**Right**
Right top	**U**	**Up**
Left Bottom	**L**	**Left**
Left Top	**D**	**Down**
Left Top	**C**	**Click**

Table.1 gives the information about user commands and wheel chair movement

E. Algorithm

➢ This section describes the algorithm used for generating user commands. A comparison approach is used for the conversion mechanism, where the values from each sensor are compared with a threshold value.

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- If the value is greater than the threshold value, then the corresponding command is generated and given to the wireless module for transmission.
- The sensor output voltages are given to the input channels of the PIC microcontroller. Outputs from ‘right’, ‘left’, ‘up’ and ‘down’ sensors are given to channel 1, 2, 3 and 4 respectively.
- The below algorithm is implemented in all sensors and shows the code for the ‘right’ sensor, which becomes the user command ‘R’, and also the ‘click’ action. An initialization phase is provided in order to fix the threshold value.
- This threshold value is not a preset value; instead it will be fixed in real time. Initially, for the first 10sec after the device is placed in position, the tongue should be in resting position so that the threshold value will be continuously read and fixed.
- After this 10sec the activation phase begins, where the user can start the tongue action by blocking the particular sensor according to which direction they want to move the cursor.
- The user will be informed of the start of the activation state by a ‘START’ command being displayed on the screen.
- Then the values, generated by blocking each sensor are read from the analog to digital converter (ADC) of the MCU, and are checked with the threshold value.
- If the read value is greater than the threshold value it indicates that the sensor is blocked and a corresponding command is send for transmission i.e. if it is from right sensor, ‘R’ is send.
- Now the unit waits for 5 sec after unblocking of that particular sensor is detected and if again the sensor is blocked i.e. read value is greater than the threshold value, then it is interpreted as click and the command ‘C’ is transmitted.
- Thus click function will be performed when blocking the sensor once again after unblocking. Apart from this if the tongue is in resting position for more than 5min then the MCU will change its state from active to sleep leading to power saving.

Steps for Algorithm

step- 1 : Starting the controller,

step- 2 : Initializing the set values of the sensor voltages

step- 3 : Giving the value r= read adc_channel1,

step- 4 : Ending up the for loop

step- 5 : Initializing is ended

step- 6 : Now applying the ‘IF’ condition,

IF(value > threshold_R) checking this condition and then
sends the R value to the controller.

Step-7 : Now here checking for condition of given time for
5Sec then entering in to or checks for IF condition

Step-8 : Verifying the IF condition for given threshold value

Step-9 : Sending the information to the command “c”.

Step-10: Closing the IF condition,

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Step-11: Ending of the for loop

Step-12: IF condition is Closed and the program is ended.

F. Interfacing of Hardware and Software

Fig.4 shows the IR sensor TCRT5000 is connected to the Anode (A) of the IR emitter to a 100 ohm resistor which has 5V applied, then connect the Cathode (C) of the IR Emitter to Ground (GND) on the arduino. Next we need to connect the Emitter (E) of the Photo Transistor to ground, then apply 5V to a 10,000 ohm resistor which connects to the Collector (C).To measure the voltage drop produced by the transistor we need to connect an analog pin from the Arduino to the Collector (C) of the Transistor. To interface the program in to arduino, we should download the arduino software in to the PC. In that we must go to analog read serial for the programming purpose. After downloading go to serial read monitor and write the program code. In this we can modify the program in the middle of the execution [6].

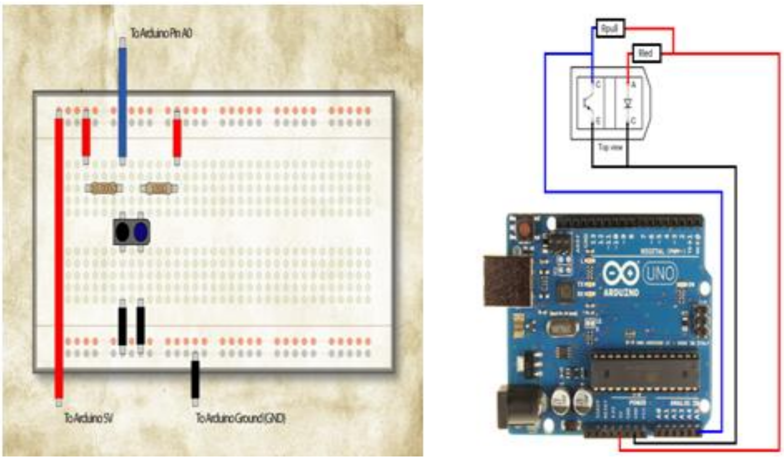

Fig.4 Connection diagram of sensor with ardunio

Motor driver ICL293D is a dual H-bridge motor driver IC,which can drive two motors simultaneously and capable to drive a dc motor in bidirectional. L293D IC is a current enhancing IC as the output from the sensor is not able to drive motors itself so L293D is used for this purpose.We insert motor driver in between motor and microcontroller. Motor driver take the input signals from microcontroller and generate corresponding output for motor.Fig.5 shows the Interfacing the Arduino with motor

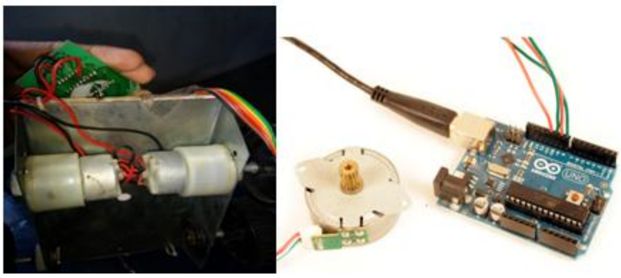

Fig.5 Interfacing the Arduino with motor

III. RESULTS

- Based on the tongue movement of the patient, the program is written and according to that the wheel chair will move. Table.2 shows Output of the sensor and the wheel chair movement.
- In table.2 the first figure shows the when the patient's tongue touches the respective Sensors, the following directions are followed:

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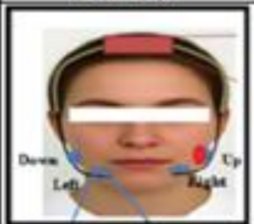
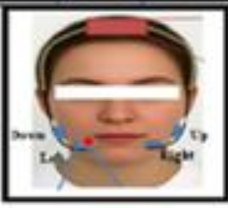
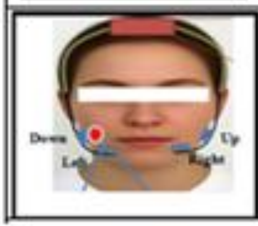
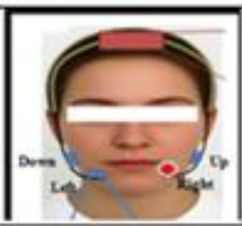
- Whenever the patient's tongue touches the 'UP' sensor the wheel moves forward direction, as shown in the figure-1, of the table.2.
- When the patient's tongue touches the second sensor i.e, 'LEFT' sensor then the wheel chair moves in left direction, as shown in the figure-2 of the table.2.
- And when the patient's tongue touches the third sensor i.e, 'DOWN' sensor, then the wheel chair will moves to the backward direction, as shown in the figure-3 of the table.2.
- And the fourth diagram represents, when the patient's tongue touches the fourth sensor i.e, 'RIGHT' sensor then the wheel chair will moves to the right direction, as shown in the figure-4 of the table.2.
- The fifth diagram will illustrates the when no command is passed i.e, there is sensing of the sensor by the tongue there is no movement in the it is constant, , as shown in the fig.5 of the table.2.
- And here we coded as the command passed by the sensor to the microcontroller it accepts the command up to certain period of time. That is given delay 1000 milli seconds, after 1000 milliseconds it will be neutral.

Table.2 Output based on the wheel chair movement

	Commands	Direction	Position of prototype
1		FORWARD	
2		LEFT	
3		BACKWARD	
4		RIGHT	
5		NEUTRAL	

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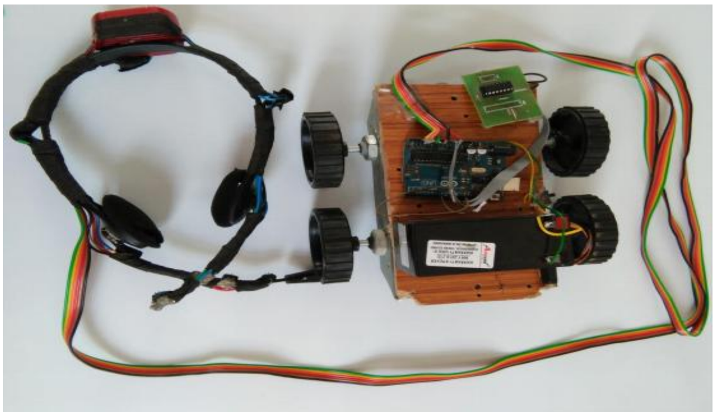

Fig.6 Proto type of the proposed model

IV. CONCLUSION

- In this paper we have designed a cost effective, low-power embedded system, "Optical Sensor Based Wearable Tongue Controlled Assistive Device" to control the movement of wheel chair.
- This proto type is very useful for paralysed patients for controlling the wheel chair in any direction. This will give more assistance for the patients in travelling, and making moments without the necessity of caretakers.

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AUTHOR'S BIOGRAPHY

Er.Kunduru Umamaheswari[1] was born in Nellore, Nellore district. A.P, On July 16th, 1977.She received her B.Tech Degree in Electronics and Instrumentation Engineering branch from Bapatla Engineering College, Bapatla, A.P in 1998 and M.Tech Degree in Digital Systems and Computer Electronics Specialization at Narayana Engineering College, Nellore, A.P in 2012. She has 9 years of teaching experience. She is at present working as an Assistant Professor, Department of EIE in V.R Siddhartha Engineering College, Vijayawada, A.P, India. She has authored over eleven research papers in refereed journals and over four papers in conference proceedings.

Er.Polepogu Rajesh[2] was born in Chejarla, Guntur district, A.P. On January 7th, 1985.He received his B.Tech Degree in Electronics and Instrumentation Engineering branch from Bapatla Engineering College, Bapatla, A.P in 2007 and M.Tech degree in Instrumentation and Control Systems Specialization from JNT University College of Engineering, JNTU Kakinada, Kakinada in 2010.He has 7 years of experience in teaching. He is at present working as an Assistant Professor, Department of EIE in V.R Siddhartha Engineering College, Vijayawada, A.P, India.He has authored over twelve research papers in refereed journals and over seven papers in conference proceedings.