Quadraplegic Communicator for Spinal Cord Injury Patient

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Abstract— **Quadriplegic Communicator is designed to provide a communication tool between the quadriplegic patients and their care provider. The system is developed based on user-friendly concept and involved hardware and software integration. The acquisition circuit is able to capture rapid signal response from eye and send signal to the computer through a parallel port. The eye-blinking signal which was received in the reflective sensor will be amplified, filtered, generate a TTL signal to be acquired by the computer and able to be detected through Visual Basic program. Since this tool is expected to be used for Malaysia's citizen, the software GUI is designed in three languages selection. This system will be able to display the message that is selected from user and play the related message in sound.**

Keywords— **Quadriplegic, communicate, Visual Basic, parallel port, eye blink, sensor**

I. Introduction

Quadriplegia is caused by damage to the spinal cord (nerve damage). It is usually the result of an injury to the spinal cord. The most common causes of damage to the spinal cord are trauma's such as motor vehicle accidents, motor bike accidents, falls, sports injuries (particularly diving into shallow waters), gunshot wounds, assault and other injuries; and disease such as poliomyelitis [1].

Quadriplegics are limited in their motion and need some device to help them to communicate with the surrounding people [2]. The Quadriplegic Communicator will take input from the patient and make selection on Graphical User Interface provided. The aim of the Quadriplegics Communicator is serve as tool for quadriplegic care provider to understand the quadriplegics basic daily needs [3,4, 5].

The phototransistor reflective object sensor is used to detect the blinking eye signal from the user. The light will reflect to receiver of sensor when there is blinking eye signal from user and fed into passive high pass filter and voltage comparator. The transistor switching is connected to parallel port which will send the TTL signal to computer. The developed GUI program will respond to signal send from the hardware. The block diagram for project is defined as shown in Fig. 1

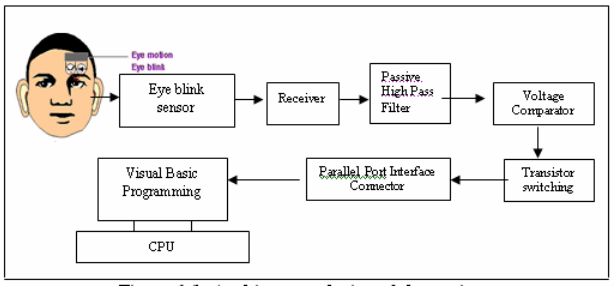


Fig. 1 Block diagram of the communicator

II. Methodology

A. Design specification

The Quadriplegic Communicator is developed based on user-friendly concept and involved hardware and software integration. It consists of eye blink sensor, hardware, parallel port connector and software. The Quadriplegic Communicator's specification is summarized in Table 1.

Table 1 The Quadriplegic Communicator Specification

Eye blink Sensor	o Phototransistor reflective object sensor which consists of infrared LED and phototransistor o The angle of sensor holder is approximately 35^0 from the spectacle
Hardware	o Capable to generate square wave to transmit through eye blink sensor o Capable to receive the signal and filter the signal o Consists of LED and buzzer to

	indicate the eye blink signal o Capable to send TTL signal to parallel port
Parallel Port Connector	o 25 pins o data pins :TTL level output o pin18-25 are ground o 5 input pins(10,11,12,13,15) o 8 output pins(2-9)
User interface	o User friendly o Provide 3 language version o Capable to provide option of the basic needs of quadriplegic patients o Capable of playing sound system

B. Sensor positioning

The angle of sensor holder from the spectacle is approximately 35^0. This angle is chosen due to the reason that this angle will not disturb the user vision and available for sensing eye blink signal. The small clip is used for fixing the adjustment of sensor as shown in Fig. 2.

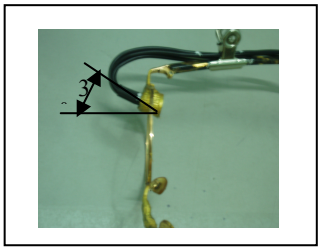


Fig. 2 The angle of sensing holder in Spectacle

The circuit block diagrams' functions in Fig. 3 will be explained as follow:

C. Sensor Driver Circuit

By referring to Fig. 1, the reflector sensor is actually driven by pulsating signal generated by a astable multivibrator. Trains of 137.9 Hz square wave from the non-symmetrical astable multivibrator is injected at the base of a transistor. The transistor can drive an infrared LED to transmit its pulsating light wave.

D. Receiving Part

Infrared beam detected by a sensitive phototransistor which is in one compact package of the sensor. The received signal needs to be conditioned before it can be send to PC. In the circuit, zener diode is applied to maintain constant voltage, regardless of varying current flow.

E. Passive High Pass Filter and Amplifier

Passive high-pass filter is used to filter the noise. The filter attenuates frequency below 159Hz and passes frequencies above that frequency. The amplifier is used to amplifier the receiving signal. A 560 gain in the inverting amplifier is multiplied to the received signal from the sensor. The output amplified signals is a clean square wave signal with minimum noise and distortion.

F. Voltage Comparator and Delay

There are two voltage comparators in the circuit. Voltage comparator is used to generate a difference voltage when there is a signal send from amplifier and passive high pass filter. The first voltage comparator will receive signal after filtering. The charging and discharging action of a capacitor is applied as a delay in this project. It is a need to have a 0.6 seconds delay between two voltage comparator because the eye-blinking signal is a fast signal response. When there is a voltage across the capacitor, it will take around 0.6 seconds to discharge the capacitor. While in the charging action of capacitor, capacitor will be charged instantly.

G. Alarm and Interface part

The buzzer will be activated and LED will be ON each time when there is an output from voltage comparator (eye blinking is detected). The signal from hardware will be send to computer through the parallel port.

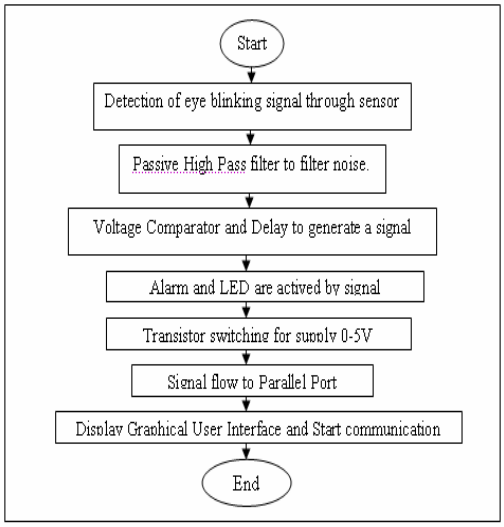


Fig. 3 Quadriplegic communicator hardware signal flow

H. Software Design

The program was written with Visual Basic program and it is divided into main menu and three submenus as shown in Fig. 4. Submenus are available in 3 languages; they are the language of the three main nations in Malaysia.

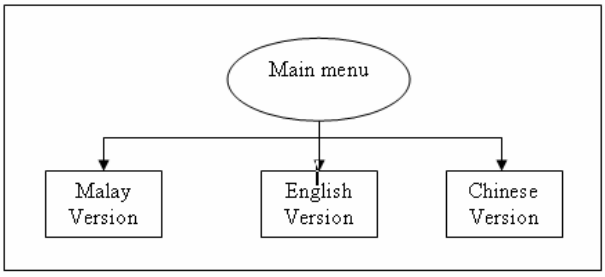


Fig. 4 Main menu and Submenu structure

a) Variable Declarations

The first part of source code for each menu is to declare the variables that will be used in the rest programming.

b) Programming of Checking Eye Blink Signal by Timer Check(TmrCheck)

Next, come to programming of checking eye blink signal which send from hardware. Due to pin 11 is the pin of parallel port which send the signal to computer, the logic AND operation is applied to 128 (the specific value for pin 11) and Inp (&H379)(input pin 11 which is at parallel port in hex) reading from hardware. When both conditions are fulfilling, it will run the following instruction.

c) Programming of Delay by Timer Message Delay(TmrMsgDly)

In order to keep the pre-programmed message to be display on the screen, one timer has to use for this purpose.

d) Programming of Sequence by Timer Sequence(TmrSeq)

It will control the sequence of pre-programmed message in submenu and running the selection of language in main menu.

e) Programming of Start and Stop button (cmdStop and cmdStart)

The start button will enabled the entire timer except timer delay and will clear the entire previous programmed message on the screen. The stop button will stop the entire timer and terminated all the programming

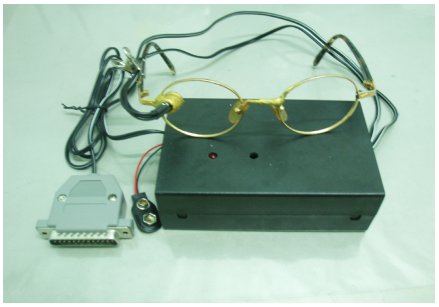
I. Setup program

In order to setup an application from the Visual Basic, the Visual Basic software has a good tool for this purpose: the Package and Deployment wizard.

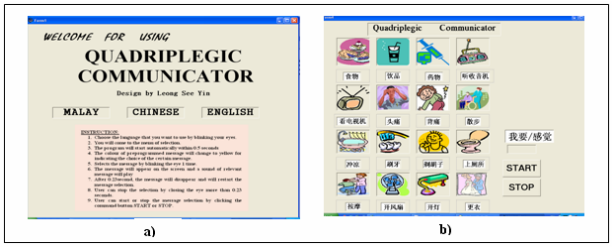
IV. Result and Analsysis

The user friendly Quadriplegic Communicator has a hardware and software as shown in Fig. 5. The timer activates the selection of each menu and the user is expected to blink when the running selection stops at the desired language on the computer screen. Then, this will lead user to the submenu. The submenu will run the preprogrammed message selection .After user make a selection, the message will be displayed and the message in sound will be played as well. Many trials has been made to find the best timer running speed to suit the responsiveness of a sick patient.

The software seems to be running well. However, the accuracy and efficiency of the hardware needs to be improved because the response of the sensor is rather slow and caused false selection. We will make a further study on the size of different patient forehead that requires adaptable sensor attachment for optimum sensor detection.



(a)



(b)

Fig. 5 (a) Prototype of the Communicator (b) Main and submenu of the GUI

III. Conclusions

This project has been successfully prototype with a software and hardware device powered by 9V battery. The visual Basic software will respond to signal send from the hardware. In addition, the installer of Quadriplegic Communicator program can be setup and distributed to various computers. Overall of the product is quite easy to be used as a plug-and-play device. Our future work is to further improve the sensing device design and conduct clinical trial in hospital.

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