Navigation Assistance Device for Visually Impaired People

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Abstract: *Visual impairment reduces quality of life if not aided. This paper takes a cursory look at the statistics of blindness around the world and in Nigeria. The paper then looked at the financial implication of aiding the visually impaired in some countries as well as the impact blindness have on the economy of countries based loss of manpower. Various assistive technologies were looked at and then a design for hand held aid that uses ultrasonic sensor was designed.*

Keywords:*Visual Impairment, Navigation Assistance, Blindness, Blind Aid, Visual Acuity.*

I. INTRODUCTION

Blindness is a condition in which vision is totally lost. The word however is a relative term usually used to describe conditions in which vision is impaired. Vision impairment can range from mild to severe. However for the purpose of this paper, blindness and vision impairment would refer to the inability to easily move around without some sort of aid.

Blindness is a condition that reduces the quality of life of the person suffering from it if the person is not aided. Aiding a blind person to navigate and interact with his immediate environment comes with the help of assistive technology. Assistive technology is an umbrella term used to describe technologies that offer services (devices and appliances) that can help people with visual impairment. The use of technology can be helpful with visual impairment, learning, communicating and for interacting with the immediate environment. By using a computer and ultrasonic sensors with appropriate software and hardware, the visually impaired can be given access to standard resources. For instance, speech synthesizers can be used to read to a blind person without having to translate it into Braille.

Developing visual assistive technology that could improve the mobility and navigation of blind people would increase their quality of life and their independence.Visual assistive technologies are basically divided into three; vision enhancement, vision substitution, and vision replacement. Of the three categories vision replacement is not common because its implementation has to do with medicine and technology - it has to do with presenting visual information straight to the visual cortex of the brain. The other two methods are similar but different in the presentation of information. While vison enhancement has to do with visual display of information vison substitution is a non-visual display like hearing and body sensing like vibrations. [1]

II. STATISTICAL OVERVIEW OF BLINDNESS

In the early days, babies that were born blind were considered incomplete and then left to die[1]. There are many causes of blindness and they depend on the socioeconomic condition of the country plays a major role in the causes.In developed nations; the leading causes of blindness include ocular complication of diabetes, macular degeneration, and traumatic injuries. In third-world nation where 90% of the world visually impaired population lives, the principal causes are infections, cataracts, glaucoma, injury, and inability to obtain any glasses [2].

Infection causes in underdeveloped areas of the world include trachoma, onchocercaisis (river blindness) and leprosy. The most common infectious causes of blindness in developed nation are herpes simplex [3].The most common causes of visual impairment globally are glaucoma (2%), refractive errors include near sighted, far sighted, presbyopia and astigmatism.Cataracts are the most common causes of blindness. Infections, corneal clouding, childhood blindness, diabetic retinopathy and macular degeneration are the other disorders that causes visual problem [4]. Self-navigation in an unfamiliar environment poses a great challenge people with complete blindness or low vision.In fact, physical movement is one of the biggest challenges for the blind, travelling or even taking a walk down a street that is crowded could pose a great difficulty. Because of this, many people with low vision will bring a sighted friend or family member to help navigate unknown environment [5].The ability to move with ease, speed and safety throughout his environment independently is essential.

Statistics of Blindness in the World

It is estimated that about 1.3 billion people live with some form of vision impairment. When distance is considered, then about 188.5 million people suffer from mild vision impairment, another 217 million have moderate to severe vision impairment while the blind sum up to 36 million people. Regarding near vision impairment 826 million people are suffering from that condition. Uncorrected refractive errors and cataracts are the leading causes of vision impairment globally and approximately about four in five of all vision impairment is considered avoidable [4].

Statistics of Blindness in Nigeria

Reference [6] carried out a study on 15,122 persons aged 40 and above. It was observed that of the 90 percent of those examined, the prevalence of blindness 20/400 in the better eye was 4.2 percent while severe visual impairment (20/200-20/400) was 1.5 percent. They were also able to conclude that blindness was associated with increasing age, being female, poor literacy and residence in the north. It was estimated that 4.25 million adults aged 40 years and above have moderate to severe impairment or blindness(20/63) in the better eye.

III. IMPORTANCE OF BLIND AID

Reference [7]estimated that there were 12,995 blind individuals in Ireland in 2010 and in 2020 there will be 17,997. They estimate that the financial and total economic costs of blindness in the Republic of Ireland in 2010 were 276.6 million and 809 million, respectively, and will increase in 2020 to 367 million and 1.1 billion, respectively.

Sight loss and blindness from age-related macular degeneration (AMD), cataract, diabetic retinopathy, glaucoma and under-corrected refractive error are estimated to affect 1.93 (1.58 to 2.31) million people in the UK. Direct health care system costs were £3.0 billion, with inpatient and day care costs comprising £735 million (24.6%) and outpatient costs comprising £771 million (25.8%). Indirect costs is estimated to be between £5.12 and 6.22 billion. The value of the loss of healthy life associated with sight loss and blindness was estimated to be £19.5 (15.9 to 23.3) billion or £7.2 (5.9 to 8.6) billion, depending on the set of disability weights used. If 2004 disability weight and 2008 estimates were used in comparison with other published results, then the total economic cost of sight loss and total blindness in estimates came to be £28.1 (24.0 to 32.5) billion in 2013. Using 2010 disability weights, the estimated economic cost of sight loss and blindness was estimated to be £15.8 (13.5 to 18.3) billion in 2013 [3].In the United States, reference [9] estimated the direct cost on economic burden to be over 66 billion dollars and the indirect total cost on economic burden to be over 72 billion dollars per year.

The global economic cost of visual impairment was carried out by [10]. The results of the research shows that about 733 million people have one form of visually impaired or the other in 2010. The direct health carecosts of VI total

$2.3 trillion in 2010, with an expected DWL of $238 billion, productivity loss of$168 billion and an estimated informal care burden of $246 billion. In total the global cost ofVI is estimated as $3.0 trillion. As population increases, there is a great possibility of increase in the burden of disease

IV. NAVIGATION ASSISTANCE DEVICE DESIGN.

Developing visual assistive technology that could improve the mobility and navigation of blind people would increase their quality of life and their independence. Visual assistive technologies are basically divided into three; vision enhancement, vision substitution, and vision replacement. Of the three categories vision replacement is not common because its implementation has to do with medicine and technology - it has to do with presenting visual information straight to the visual cortex of the brain. The other two methods are similar but different in the presentation of information. While vison enhancement has to do with visual display of information vison substitution is a non-visual display like hearing and body sensing like vibrations[1].

The vision substitution method has three subcategories, namely:

1. Electronic Travel Aids (ETAs): These are devices that are in contact with the immediate environment. They obtain firsthand information and transfer same to the user.
2. Electronic Orientation Aids (EOAs) these are the aids that provide people with visual impairment with guidance in unfamiliar places.
3. Position Locator Devices (PLD):these devices obtain the precise location of the bearer. They often use GPS technology.

The navigation assistance device can be placed under the Electronic travel aids, which are devices that gather information and transmit them to the holder in order to make decisions based on the information received.

In this project, two sensors are needed, one sensor as transmitter, the other as receiver, both of them are placed beside each other. The different sections of the design include:

i. Ultrasonic sensor transmitter
ii. Ultrasonic receiver
iii. Ultrasonic amplifier.
iv. Signal condition
v. Micro controller
vi. Sound amplifier

This device will point forward, the ultrasonic transmitter send out signal and echo is received at the ultrasonic receiver. It is amplified and sent out to the micro controller unit (MCU) for analysis. The MCU calculate the difference between the time when the signal is sent and the time the echo is received at the receiver, the calculated time is used to calculate the distance from 2s/time where the speed of sound which is 330m/s approximately. The device aim at conveying information (typically via an auditory channel) about the environment to visual impaired individual so that they can exploit part of their bodies to gather information that sighted individuals would normally use to have a feel and understanding of their immediate environment and explore it. The device receives through ultrasonic receiver and transmits an audio in response to any nearby object. The intensity of the sound is proportional to the proximity of the detected object.

Ultrasonic Transmitter and Receiver:The circuit has two transducers, one for emission and the other one for reception, these are ultrasonic sensors. The audible range of sound is between 20Hz to 20KHz. These sensors are designed to transmit and receive sound wave at 20KHz and above. Because ultrasonic is being used, it reduces interference with other sound signal.

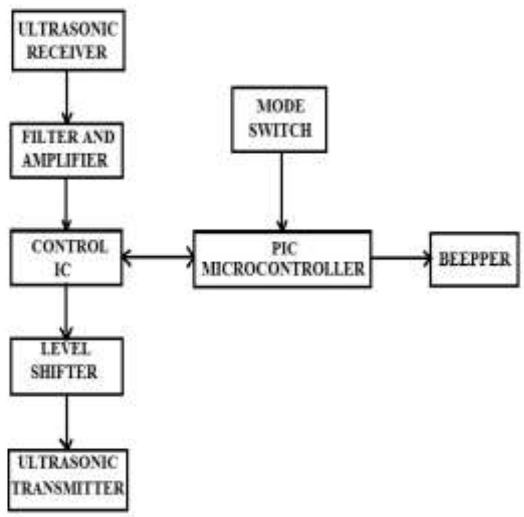

FIGURE 1: BLOCK DIAGRAM OF A BLIND AID

Level Shifter:The supply voltage implemented in the design is just 5V; meanwhile, to transmit an ultrasonic pulse requires a high voltage. So the level shifter increases the 5V to the necessary amount of voltage needed by the ultrasonic transmitter. A MAX232 (U3) IC is used to produce +/-10V from 5V. The transducer is connected to the two outputs. Power is only applied to this circuit through Q2 sometime before and during the pulse emission.

Filter and Amplifier:The receiver side uses LM324 which contains 4 op-amps. U2D is just a times 6 amplifier, U2C is a multiple feedback (1st order) pass band filter which is followed by another 8 times amplifier (U2B). The last op-amp (U2A) is used together with Q1 as a hysteresis comparator. The pass band filter response is centered at 40 KHz.

The Control IC:The receiver and emitter circuit are controlled by an EM78P153S Chinese microcontroller running at 27MHz. The IC is specially designed for this application. It is an OTP IC which means it cannot be reprogrammed. This IC communicates with the PIC microcontroller (up) digitally. It serves as an intermediary between the analog transducer circuit and the digital microcontroller. It initiates a valid 40KHz ultrasonic transmission burst after it have received the command from the up, it then wait for an echo to be received.

Pic Microcontroller:The PIC18F4620 is Peripheral Interface Controller (PIC) family of microcontroller used for embedded applications. It's a 8-bit microcontroller with many features like ADC, Timers, Interrupt etc.This part of the circuit is the central control unit of the circuit. It performs the major calculations and the necessary actions needed in the circuit. It commands the control IC to initiate transmission and it then calculate the difference in time between the time of transmission and the time an echo is received back.

Mode Switch:The mode switch is a SPDT (Single Pole Double Touch), NOMP (Normally Open Momentary Push) button switch. The switch is used to power on, or put the device in sleep mode. This kind of switch is used for easy accessibility by the end user. The switch is directly connected to the microcontroller.

Beeper:The beeper is a small piezo-electric transducer. Piezo-electric effect is when a crystal is exposed to physical stress, voltage is generated across it and also if voltage is applied across the crystal plates, the plates are stressed there by producing vibration, these vibrations are converted to sound by the aid of a flexible diaphragm.The beeper is responsible for notify the user of hindrances right before him. It produces beeping sound at certain frequency and the frequency of beep changes as the proximity to the object increases.

DESIGN FLOWCHART

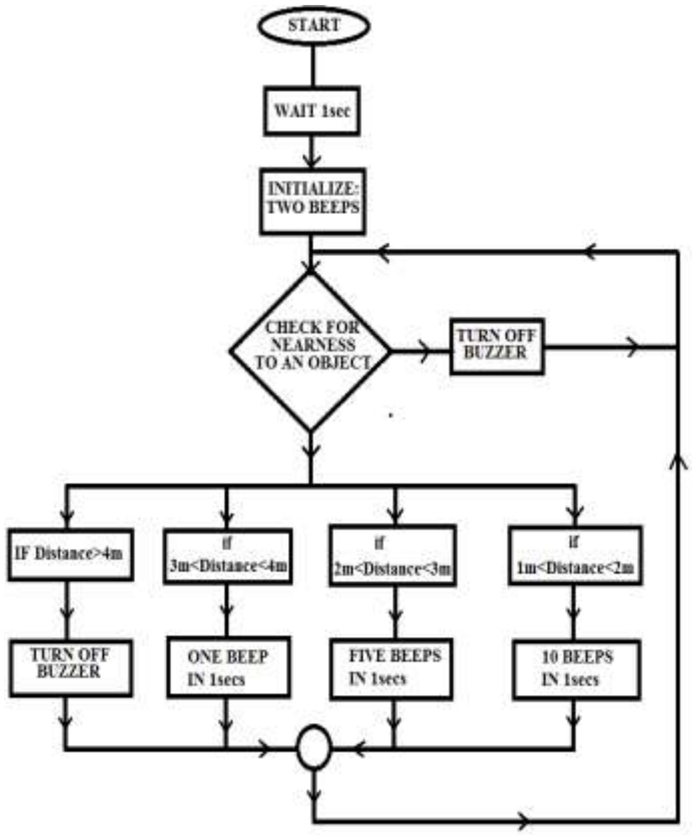

FIGURE 2: DESIGN FLOWCHART OF THE BLIND AID

When the device is first powered on, it delays for one minute to set up, after which it produces two short beeps (0.5 seconds each) to indicate that the device is powered on. It then proceeds to test if the device is very near to an object directly in front of it. If there is an object indeed, it starts to produce a beeping sound with certain rate, the rate of this beep notifies the user of his/her closeness to the obstruction so that he/she can avoid it. However, if the power button is suddenly pressed, and the device was previously on, it switch the device off and it produce two long beep (1 seconds each) to notify the user that the device is off. Whenever the device is off, it is in its ultra-low power mode where virtually no power is drawn from the battery.

Design Calculations

$$Given\ that\ F_{osc} = 8MHz$$

$$Time = \frac{(TMR1H\!:\!TMR1L)}{Internal\ Clock} \times Prescaler$$

Where F_{OSC} is the clock frequency of the PIC18F4620 MCU

TMR1H:TMR1L = the time between the transmission and reception

$$Internal\ Clock = \frac{F_{osc}}{4} = \frac{8MHz}{4} = 2MHz$$

$$Therefore, \qquad Time = \frac{(TMR1H{:}TMR1L) \times 2}{2000000}$$

$$= \frac{(TMR1H{:}TMR1L)}{1000000} \dots\dots\dots\dots\dots\dots\dots\dots (*)$$

Distance Calculation

$$Distance(d) = Speed(s) \times Time(t)$$

Let d = the distance between the ultrasonic sensors and the target.

The total distance traveled by the ultrasonic burst = 2d (forward and backward).

Speed of sound in air = 340m/s = 34000cm/s

$$Thus, d = \frac{34000 \times Time}{2}$$

By substituting eq(*)

$$d = \frac{34000 \times (TMR1H{:}TMR1L)}{4}$$

$$= \frac{(TMR1H{:}TMR1L) \times 2}{58.82}$$

V. DISCUSSION

If everybody were blind, quality of life for the blind would definitely be better than presently obtainable. Obviously attention would be given to the design of various facilities, processes and equipment for ease of access, communication and use. The visually impaired are in the minority so considerations for them are low. If every blind person can easily do what the non-blind can do and have the same quality of life then, then their contributions to the society would be immeasurable. The design of the navigation assistive technology is to help aid the visually impaired and harness what they can contribute to the society.

VI. CONCLUSION

Visual impairment cost a lot of losses in human capital, quality of life, economic loss to states and individuals. Any means that would enhance or improve the quality of life and assist such people contribute their quota to the development of humanity should be highly encouraged. The visual assistance aid designed in these paper has explored a very cheap way of helping the visually impaired have the ability to easily navigate his immediate environment instead of being rendered immobile and very dependent on other people that could be doing other useful things.

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