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"iVIN"; Interactive Navigation for Visual Impaired Person

Zuhairah Ariff Abd Ghadas, Syed Abdullah Fadzli, Azrul Amri Jamal, Mohd Fadzrul Hanif Fadzilah, Hadri Omar and Norsyahira Jano

University Sultan Zainal Abidin, Malaysia

Abstract: Visual impaired persons normally require assistance to move around such as the guide cane. In this research, an innovation in navigation equipment for visual impaired, named iVIN is proposed. iVIN is actually a headgear introduced as a tool to replace and/or compliment the guide cane. The prototype is equipped with sensor which wil notify the user if there is any obstacle nearby the persons who are wearing the headgear. The sensor will give signal to the micro-controller. The data from it will warn the vibrator if there is obstruction around the user

Key words: Visual Impaired · Interactive Navigation

INTRODUCTION

According to the World Health Organization (WHO), it is estimated that 253 million peoples are visually impaired worldwide and 217 million have moderate to severe vision impairment [1]. According to Malaysia Department of Social Welfare 2015 report, there are 32, 807 people who are having visual impairment.

Visual impairment is the functional limitation of the eye or eyes to see to a degree that causes problems not fixable by usual means such as glasses. This issue is not unknown in Malaysia as a high number of people in the country suffer from visual impairment. There is no age range as visual impairment can have effect from birth up to old age. In most cases, the visually impaired depends on using a guide cane to move around because it is considered cheap and easy to use. Nonetheless, a guide cane has certain limitations and its user needs some time to get familiar with the tools. Generally, a guide cane is useful but it could only cover the lower limb area and cannot detect an object from above the waist such as obstacles close to the head.

This paper introduce an innovation in Interactive Navigation, named as Interactive Visual Impairment Navigator (iViN) which has a bigger function than a guide cane. The primary objective to develop iVIN is to assist people who are visually impaired to navigate easily. iVIN is equipped with sensor that will notify its user if there are nearby obstacles. The sensor will give a signal to the micro-controller and the data from it will warn the user by using vibrations if there is any obstruction around the user.

Rights of Persons with Diabilities: The Convention on the Rights of Persons with Disabilities, which is an international human rights treaty of the United Nationscame, came into force on 3 May 2008. The Convention was adopted by the UN General Assembly on 13 December 2006 and opened for signature on 30 March 2007. The Convention is intended to protect the rights and dignity of persons with disabilities. This Convention is also the first human rights treaty of the third millennium and acted as a major catalyst in the global movement towards viewing persons with disabilities as a full and equal members of society with human rights. Parties to the Convention on the Rights of Persons with Disabilities are required to promote, protect and ensure the full enjoyment of human rights by persons with disabilities and ensure that they enjoy full equality under the law. There are eight guiding principles that underlie the Convention, namely [2]:

- Respect for inherent dignity, individual autonomy including the freedom to make one's own choices and independence of persons
- Non-discrimination
- Full and effective participation and inclusion in society

Corresponding Author: Zuhairah Ariff Abd Ghadas, Universiti Sultan Zainal Abidin, Gong Badak Campus, 21300, Kuala Nerus, Terengganu, Malaysia. Tel: +609 6688460.

- Respect for difference and acceptance of persons with disabilities as part of human diversity and humanity
- Equality of opportunity
- Accessibility
- Equality between men and women
- Respect for the evolving capacities of children with disabilities and respect for the right of children with disabilities to preserve their identities

It is obderved that one of the principles emphasized under the Convention is full and effective participation and inclusion in society. One of the ways to galvanize this principle is to provide the disable persons with assitances and facilities, which enable them to blend easily and effectively in the society

Visual Impairment: The International Classification of Diseases (Update and Revision 2006) report states that vision function is classified into four broad categories, namely normal vision, moderate vision impairment, severe vision impairment and blindness.

According to Ananya Mandal [3] visual impairment is the functional limitation of the eye or eyes or the vision system which may leads to loss of visual acuity and inability of the person to see objects as clearly as a healthy person, loss of visual field meaning inability of an individual to see as wide an area as the average person without moving the eyes or turning the head, photophobia (inability to look at light), diplopia (double vision), visual distortion or distortion of images, visual perceptual difficulties or difficulties of perception or any combination of the above features.

WHO report 2017 highlighted that chronic eye diseases are the main cause of vision loss with uncorrected refractive errors and then un-operated cataract are the top two causes of vision impairment with un-operated cataract remains the leading cause of blindness in low- and middle-income countries. Diseases such as diabetic retinopathy, age-related macular degeneration and raised pressure within the eyes leading to glaucoma may also caused visual impairment [4].

Assitive Technology for Visual Impaired Person: People with visual impairment often have diffuculties self-navigating and physical movement is one of the biggest challenges them. Traveling or simply walking down a crowded street may pose great difficulty and many people with low vision needs assitances to help them navigate especially in unknown environments [5].

According to Marti L. Riemer-Reiss and Robbyn R. Wacker [6], assistive technology devices enable individuals with disabilities to participate in society as contributing members. These devices are also credited with helping individuals with disabilities achieve optimal functional ability and independence [7]. A system that assists visually impaired persons' navigation and orientation in real time will be of great benefit to achieve this demanding task [8].

Proposed Interactive Navigation for Visual Impaired Person (iVIN): Many animals utilize echolocation method to scan their environment. The most popular animal that uses this technique is bat, who uses ultrasonic echolocation to detect the size, distance and characteristics of their prey. The same method can be applied by humans who are blind or those who have problems in viewing their surroundings using normal senses. With the use of technology, those who are blind may be able to navigate around their surroundings more efficiently using ultrasonic echolocation method to produce haptic feedback [9].

This paper discusses an innovation in interactive navigation, named as Interactive Visual Impairment Navigator (iViN) which has a bigger function than a guide cane. iVIN is a conceptual intelligent helmet that uses rangefinders to detect objects in the environment. iVIN is equipped with sensor that will notify its user if there are nearby obstacles. The sensor will give a signal to the micro-controller and the data from it will warn the user by using vibrations if there is any obstruction around the user.

The device uses haptic language, a non-verbal form of communication, to alert the user about obstacles detected in the environment by producing vibrations. The intensity of the vibration will indicate the distance of the obstacles from the user. iVIN lets the user 'feel the area' via the vibrations, allowing them to have an added sense. It provides a hands-free experience, without requiring any graphical user interface or touchscreen to navigate.

The Framework of iVIN: iVIN is a conceptual intelligent helmet that uses rangefinders to detect objects in the environment. The device uses haptic language, a non-verbal form of communication, to alert the user about obstacles detected in the environment by producing vibrations. The intensity of the vibration will indicate the distance of the obstacles from the user. iVIN lets the user 'feel the area' via the vibrations, allowing them to have an added sense. It provides a hands-free experience, without requiring any graphical user interface or touchscreen to navigate. iVIN consist of series of rangefinders that would take input from sensors and output feedback to pulse vibration motors placed on a person's head. If a region was lacking feedback, then it would be safe to proceed in that direction.

There are four (4) rangefinder modules which uses ultrasonic waves to detect an obstacle. Each module is located at the four angle of the helmet; front, right, back and left (Fig. 1). This will allow the user to have a 360 degree obstacle scan.

The rangefinder module is controlled and managed by Arduino Nano, a small yet powerful microcontroller board based on the ATmega328 connected with a HC-SR04 ultrasonic sensor and a 3 volt vibration motor (Fig. 2). The module automatically sends out a high-frequency sound pulse and detect whether there is a pulse signal back. If the signal is back, the duration taken between sending and receiving the signal is measured to calculate the distance of the obstacles (Fig. 3). The speed of sound is approximately 341 meters per second in the air, therefore the distance is calculated using the following formula [1]:

Distance = (time x speed of sound) / 2 [1]

where, time is the duration between sending and receiving and divide by 2 is used considering the sound wave have to travel from and to the sensor. If the distance meets a certain threshold, the module will pulse the vibration motor with appropriate intensity according to the distance. The stronger the vibration means the obstacle is closed to user.

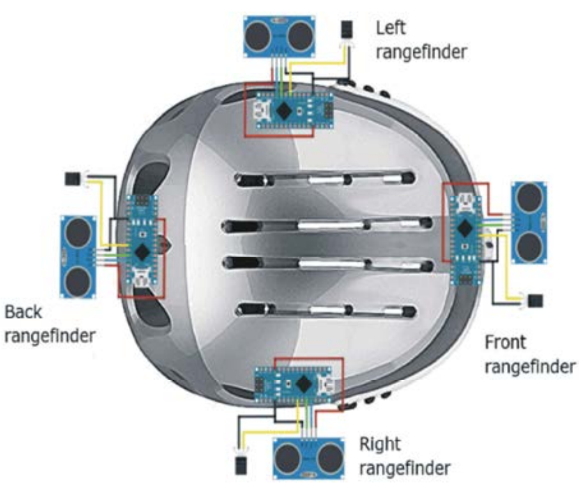

Fig. 1: Illustration of the rangefinders location

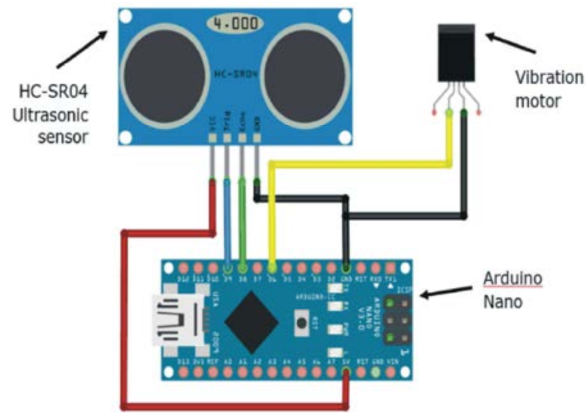

Fig. 2: Rangefinder module sketch

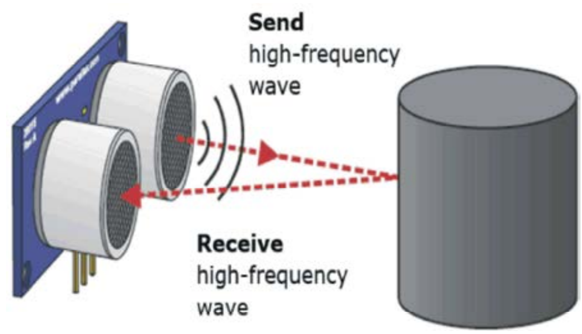

Fig. 3: Ultrasonic rangefinder procedures

The core of the system is based around three software interrupt service routines (ISRs). The first ISR is used to receive echoes and record their arrival times and durations. The second ISR is used to signal a consistent echo pulse train to the transmitter. It will then reset the system time if it is appropriate. The third ISR increments the system time. The main loop of the program then updates the value used to control the haptic feedback vibration motor.

In this system, the hardware is closely associated with the software. The transmitter consists of an oscillator circuit that drives the ultrasonic transmitting speaker at 40 kHz. The transmitter is controlled by a single TTL pin which is controlled by a microcontroller port. This creates a continuous short electronic pulses which hit the ultrasonic receiver, reflect off the nearest object and return to the receiver. The receiver circuitry filters and amplifies the signal and trigger the microcontroller to tell when there is a wave present. As was stated previously, the time between the initial pulse and the reflected pulse at the receiver, as well as the duration of the two pulses, is recorded by the microcontroller and be calculated as the distance between the receiver and the object.

Recommendation: For future developments, iVIN can be connected to mobile apps like Google Maps or Waze to safely guide the blind or those with poor vision safely navigate to their desired destination. iVIN can also be utilized by not just the visually impaired, but other people such as fireman who could vavigate through a smoked environment or soldiers who could receive silent vibrations instead of radio messages. This could help the soldiers to navigate silently in their mission.

iVIN has been tested at the Kuala Terengganu Blind Association and received positive feedback from the potential users. It recommded for iVIN prototype to be develop until it ready to be commercialized so that it could be fully utilized by the public

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