Automated walk-in assistant for the blinds

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Automated Walk-in Assistant for the Blinds

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Abstract—**This paper aims to provide a solution for the blind people to walk safely by detecting obstacle and generating corresponding alert signal according to the distance of the obstacle. The solution is provided by developing a walking assistant embedded in a spectacle glass with an obstacle detection module and an alarm generator. There is only one ultrasonic sensor in the obstacle detection module which can cover 3 meter distance and 60 degree angle to detect the obstacles. The obstacle detection module generates high frequency signal through the ultrasonic sensor and evaluate the echo which is received back by the sensor. Then the distance of the obstacle is measured and this information about the obstacle is delivered to a blind using the alarm generator which generates alarm corresponding to the distance. Experimental studies show that the proposed methodology provides a more cost effective, lesser weighty, simpler walk-in assistant for the blinds than existing dominant work.**

***Keywords**—Walk-in Assistant, Ultrasonic Sensor, Obstacle Detection, Blinds*

I. INTRODUCTION

There are more than 285 million people who are visually impaired all over the world. Among them 39 million people are blind and 246 million people have some visual impairments like low vision. The number of these kind of people is growing day by day. The incidence and demographics of blindness vary greatly in different parts of the world. 90% of these people live in the developing countries [1].The number of people who are blind or visually impaired from condition related to longer life expectancies is increasing significantly. The major portion of visually impaired people is aged 60 or older. Birth defects and uncorrected refractive errors cause blindness and visual impairment in younger groups. A statistics of World Health Organization shows that the total number of visually impaired and blind people will be double by the year 2020.With the general population living longer due to advances in medical technology, more people are being affected by Age-related Macular Degeneration (AMD). This is a leading cause of blindness on the developed countries with an estimated 25 – 30 million people affected worldwide. This number is expected to triple in the coming 25 years.

Among all sensations perceived through human senses, those received through sight have by far the greatest influence on perception. Sight combined with the other senses, mainly hearing, allow us to have a global perception and to perform actions upon it. For the blind, the lack of sight is a major barrier in daily living: information access, mobility, way finding, interaction with the environment and with other people, are challenging issues.

For the blind, research on supportive systems has traditionally focused on two main areas: information transmission and mobility assistance. Problems related to information transmission concern reading, character recognition and rendering graphic information about 2D and 3D scenes. Problems those are related to the mobility assistant are very sophisticated and challenging. They comprise spatial information of the immediate environment orientation and obstacle avoidance [2].The complexities of the existing solutions flag a great need of research on supportive systems for the blinds.

This paper proposes the design and implementation issues of an automated walk-in assistant for the blinds. The device receives any reflected waves, and produces an audio in response to any nearby object. The intensity of the sound is proportional to the proximity of the detected object. The reduced cost, lesser weight and simpler design of the proposed system prove the effectiveness over existing work.

The organization of this paper is as follows: Section 2 describes the related work of the proposed system. Section 3explains the construction and operation of the proposed system. The experimental analysis and comparison of specification and accuracy are shown in Section 4. Finally, concluding remarks are drawn in Section 5.

II. RELATEDWORK

Recently, many electronic travel aids (ETAs) devices with advanced technology and computer vision system are introduced to assist the blind for safe and independent walking [3]. Some of those devices are NavBelt [4], Guidecane [5],VA-PAMAID [6], Laser cane [7], Guide Dog Robot [7], Mowat sensor [8], KASPA [9].The NavBelt [4]consists of a belt with a small computer, ultrasonic and other sensors. Signals from these sensors will be processed by a unique algorithm and relayed to the user via headphones.This device will enable a blind user to walk safely and quickly through unknown, obstacle-cluttered environments. The main limitation of this device is that it is exceedingly difficult for the user to comprehend the guide signal in time to allow fast walking.Guide cane [5] is a shorter cane generally extending from the floor to the user's waist. It is used to scan for kerbs and steps. The guide cane can also be used diagonally across the body for protection. But its mobility function is limited and needs hands interaction. VA-PAMAID [6], Veterans Administration Personal Adaptive Mobility Aid (VA-PAMAID) Mowat sensor [8] is a light Wight, hand held device which uses high frequency ultrasound to detect nearby object and generates vibration to guide the user.The Veterans Affairs Personal Adaptive Mobility Aid (VA-PAMAID), is a robotic walker, can scan the environment and detect obstacles and landmarks. The walker is equipped with a laser and ultrasonic sensors, which are mounted on the front, left and right sides of the device. A computer controls the motors that guide the direction of the front wheels, while the sensors detect obstacles and landmark features. This device is also costly and large in size. The Guide Dog Robot [7] is a robotic ETAthat utilizes a Kinect sensor to visualize its environment and navigate its owner around obstacles.Advanced control and measurement technologies like ultrasonic sensor, radar, and robot and so on are used in these types of devices. The basic operations of these devices are to detect the obstacle which is in front of the blind using ultrasonic senor or laser scan and to send the guide information to the blind for correct and safe moving. But its performance becomes very low if the surface is very rough. The price of this device is also very high. Mowat Sensor [8] is another hand-held device that informs the user of the distance to detected objects by means of tactile vibration where frequency of the vibration is inversely proportional to the distance. This device cannot be used as the primary aid but used as secondary aid in conjunction with Long Cane of Guide Dog Robot [7] for the blind. Over the years, the Sonic Guide undergone continuous enhancements and one of its latest version is called KASPA [9].KASPA [9] is worn as a headband and creates an auditory representation of the objects ahead of the user. With sufficient training, it allows users to distinguish different objects and even different surfaces in the environment. The bulk weight, performance and cost has raised a question on the effectiveness of the approaches.

III. PROPOSED WALK-IN ASSISTANT

The walk-in assistant uses a spectacle glass which has very light weight and hands free interaction. This spectacle glass is imported with an ultrasonic sensor which can detect object hanging from top or lies on the ground. This device can detect object of 3cm width (diameter) or above. Our proposed system is very light and inexpensive with respect to other devices but its performance is very laudable and excellent.

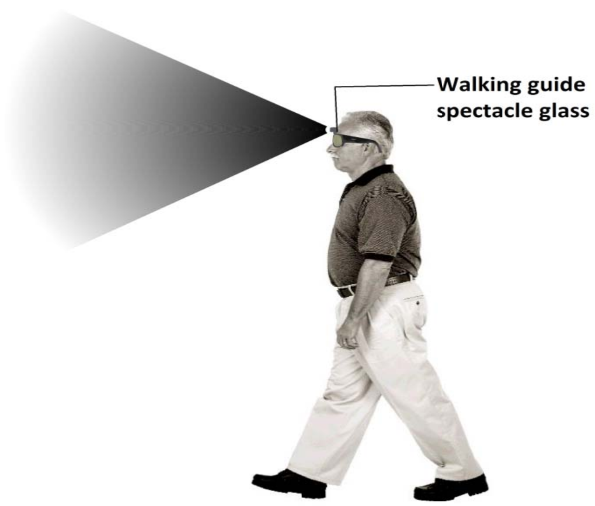

Fig.1. How to use the proposed walk-in assistant

The design methodology of the proposed system is shown as follows.

A. The Design Methodology of the Proposed System

The proposed system consists of three main components. These are: i) Ultrasonic sensor ii) Microcontroller iii) Alarm Generator. The block diagram of the proposed system is shown in Fig. 2.

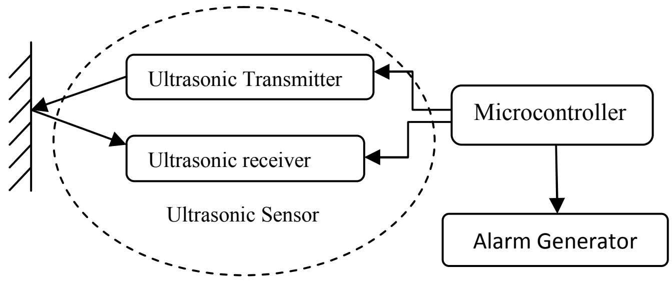

Fig. 2. The block diagram of the proposed system

The ultrasonic sensor has been used for detecting objects. Once the ultrasonic sensor is triggered, it will generate and transmit ultrasound in the forward direction. This ultrasound will be reflected back to the sensor if any object is present within 3 meter range. Then the microcontroller measures the distance by calculating the time taken by the ultrasound to travel to and back from. For continuous distance measurement the ultrasonic sensor is triggered at a regular time interval and the counter inside the microcontroller is reset accordingly. If the obstacle is detected, then the counter output of microcontroller is analyzed for measuring the distance of the obstacle and then corresponding signal is sent to the alarm generator. The alarm generator generates alarm according to the signal received from the microcontroller. The flow chart of the proposed system is presented by following figure.

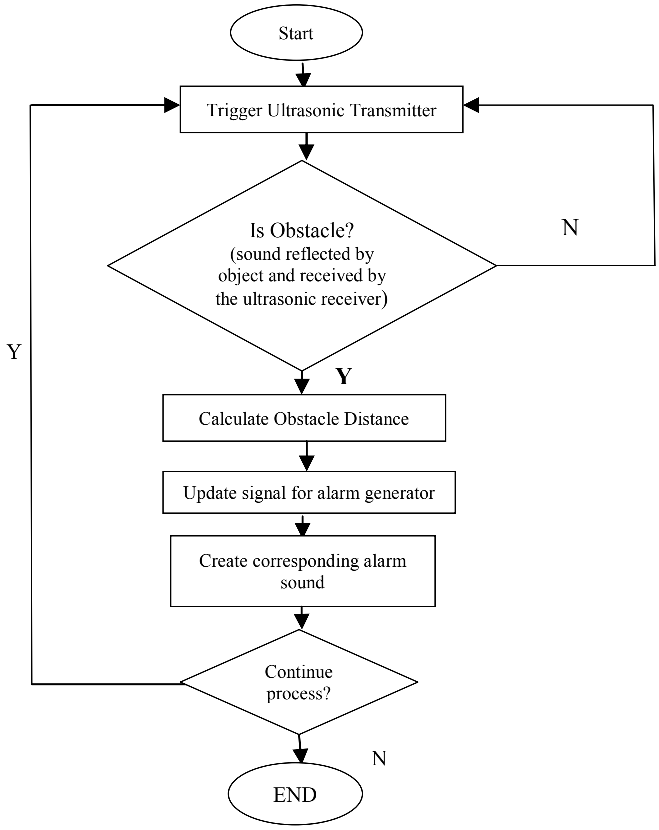

Fig. 3. The flowchart of the proposed system

B. *The Obstacle Detection*

The scan angle of the proposed system is set to 60˚ because people who are blind need the obstacle information in more narrow range for walking. Ultrasonic signal transmitter and receiver are used for detecting the obstacles in this system. Ultrasonic sensor is located at the middle of the spectacle glass as shown in Figure 4. The transmitter emits the ultrasonic wave simultaneously and the receivers get the reflected wave. From the wave the only closest obstacle is calculated using TOF (time of flight) and ITD (inter-aural time difference) method. The detecting range and angle of the proposed system is are 0.1 – 3 meters and 60˚ respectively. In this system, the ultrasonic sensor is triggered regularly at a specified time interval for continuous distance measurement. The preferred walking speed of human is 5 km/h. With respect to this speed, in this system it is considered that the walking speed of a blind person in an unknown place 1.5 km/hour and the time taken to travel 1 meter is 2.4 seconds. If no obstacle is found then the sensor is triggered at the time interval of 2.4 seconds. If any obstacle is found then the system triggers the ultrasonic sensor repeatedly at 1second interval.

C. *Warning and Guiding Sound Generation*

When an obstacle is found, the system sends a signal to the alarm generator according to the distance. The sound generator increases intensity as it is approaching to the obstacle. This intensity is indicated at four levels. The first level covers the region between 2-3 meters from the proposed system. Within this level, the volume of the sound is lowest so that the information to the blind is "You are going to face an obstacle". The second level covers 1.5-2 meters distance and within this range, the volume of sound is more than first level. So information to the user is "Be aware". Similarly the third level covers 1-1.5 meter distance and volume is more than the second level. So the warning message to the user is be very careful. Fourth level, the most important level covers less than 1 meter distance. Within this level volume of sound is maximum and the sound generator generates continuous sound. So the warning message is "You are at dangerous area". The properties used for the several distances between the blind and the obstacle are shown in Table I.

TABLE I. THE PROPERTIES USED FOR THE SEVERAL DISTANCES BETWEEN THE BLIND AND THE OBSTACLE.

Distance of the obstacle	Duration of the sound	Time interval	Volume of the sound
2m-3m	1s	1s	40
1.5m-2m	.8s	.8s	45
1m-1.5m	.5s	.5s	50
< 1m	.3s	.3s	55

Table I. shows that when the distance is maximum then sound duration and interval is maximum but volume is minimum. But when the distance is minimum then duration and time interval is minimum and volume of sound is maximum.

IV. EXPERIMENTALANALYSIS

This section describes the construction, specification and experimental results of the prototype of the system.

A. *The Prototypeof the System*

The prototype of the system is implemented as shown in Fig. 4. according to the specification. An ultrasonic sensor is fixed at centre part of the spectacle glass. A microcontroller, an alarm generator and a lithium ion battery is attached to the temple. There is very small amount of wires which have no external appearance.

Fig. 4. The prototype of the proposed system

The total weight including the glass is 165 gm. The user feels that it is very light and easily wearable. The current consumption of the system is 40 and it can be used for 25 hours 1000mA rechargeable battery. This system has a very high tolerance about temperature. Its operating temperature is -20^o to + 90^{o}C. Table II. shows that the specification of the proposed prototype system and the system proposed by Kim et al. [10].

TABLE II. THE SPECIFICATION OF THE PROPOSED SYSTEM AND THE SYSTEM PROPOSED BY KIM ET AL. [10]

System	Proposed System		Kim et. al.'s [10] system	
Detecting range	Distance(cm)	300 cm	Distance(cm)	300
	Angle(^{o})	60	Angle(^{o})	125
Total weight	160 gm (including battery)		1.57kg (including a 800g vest)	
Current consumption	40 mA		65	
Battery	1000 mAh, 4.7 V (standard mobile lithium ion battery)		7.9Ah, 12V (Enin Universal Lithium Battery, LG)	
Continuous using time	25 hour		147 Hour	
Total Cost	$10		$150(including vest and PDA)	

B. *Experimental Results and Discussion.*

Using the proposed prototype system, several experiments are carried out for detecting the obstacle. In this system, new pulses are transmitted as soon as the echo from the previous pulse is detected. After transmitted, previous pulses are processed before interrupted by the new pulses. The, interval between two scan for this prototype system is 1 second To determine the accuracy of this prototype, the detecting range is divided into five areas and each area covers 60cm distance. Three obstacles were placed in each area and average accuracy was measured. The comparison of the accuracy between the prototype system and Kim et al.'s [10] system and Kim et al.'s system is shown in Fig. 5.

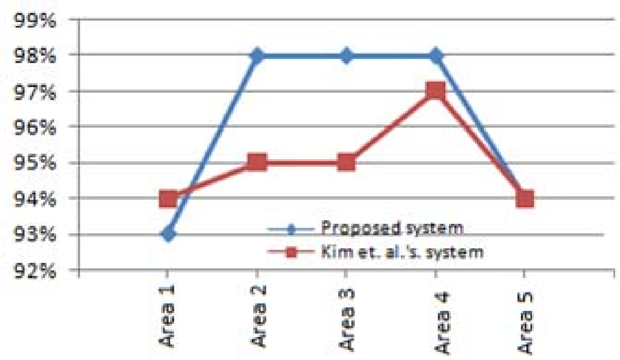

Fig. 5.The Comparison of Accuracy between the proposed system and Kim et al.'s [10] System

The Fig. 5. shows that at Area 1, the average accuracy of the proposed system was only 93% but that of Kim et al.'s [10] system is 94 %. At Area 2, Area 3 and Area 4 the accuracy of the proposedis98% but within this region the accuracy of Kim et al.'s [10] system is 95%-96%. At the last area, (Area5) both systems show the same accuracy and it is 94%. The average accuracy of Kim et al.'s [10] is 95%. In the proposed system the accuracy decreases when the obstacle is very near (<60cm) and the accuracy is excellent when the obstacle is between Area2-Area4 (<60-240cm). But the average accuracy of the proposed system is more than 96% which is very laudable.

V. CONCLUSIONS

This paper proposes the design and implementation issue of an efficient automated walk-in assistant for the blinds. The proposed system consumes lower cost, lesser weight and simpler design and implementation issues. Though the accuracy is little bit lower at very near position, the average accuracy of the system is better than existing dominant work. Hence, it can be concluded that this paper is able to play a great contribution to the state of the art and will play a great role to assist the blinds to walk easily.

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