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EXTERNAL FACTORS INFLUENCING ON ACCURACY OF DISTANCE MEASUREMENT BY USE OF ULTRASONIC SENSORS

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Abstract: **Ultrasonic sensors (US) are widely used sensors for Measuring objects distance in different applications such as parking sensors in automobiles, Robotic navigation, measuring distance between two objects etc. In our paper, we have tested and reported how the external factors Effects on the accuracy of distance measurement system using ultrasonic sensors. The aim of the paper is to define a starting point for designing the technical set up of the obstacle detection for developing the navigation assistance system for the visually impaired persons. The distance measured using this sensor is compared to the actual distance of the object from the sensor to the measured Distance Error (DE) under different experimental conditions.**

Keywords: *Ultrasonic sensor, distance measurement, Distance error, microcontroller, Arduino, Jitter.*

I INTRODUCTION

In human beings vision is acts as a biological sensor for sensing and detecting objects in the path of the user. Visually impaired individuals need an assisting device to detect objects in their path. In today's Smart digital world, a combination of different sensors is used. There use combination with a processor could be used as a substitute for biological sensors and therefore enhancing human capabilities.

Different kinds of sensors namely radar laser sensors, ultrasonic sensors, Cameras etc. are used for detecting objects in applications such as adaptive cruise control, park pilot in automobiles, unmanned aerial vehicles etc. In our case we are developing a local navigation system for the visually impaired persons. We intend to use the Ultrasonic sensors to detect the objects in the path of the user.

This system estimates and informs the user about the distance of the obstacle from the user. Thus, the accuracy of the distance of obstacle detect and the estimated very important to ensure the safety of the user. In this paper, at first, the optimum distance and angle (in case of using multiple sensors) at which the sensors could be placed is calibrated. Further, we have tested the accuracy of the distance estimated by the ultrasonic sensors. In here sensors using a distance measurement system (DMS) tested at different levels of environmental conditions like changing temperature, pressure and movement of the object as well as the sensors.

In this paper we intend to detect obstacles from the paths of visually impaired people by which use of ultrasonic sensors. And also detect the distance and angle to that obstacle.

II RELATED WORK

Now a days different sensor are used to detection of obstacles in different areas of application. Related work in this area is for Personal Navigation Device which is a Voice controlled navigator designed for visually impaired and blind people. Some of them are a car driven by visually impaired drivers by Dennis Hong which integrates by several computer systems, sensors and cameras to detects the environment around the vehicle and provide useful information of alternate forms of sensory input, including sound and vibration.

A robotic arm called the Luke Arm for the amputee's senses movement in various muscle groups through the attached electrodes, which further convert the muscle movements into motor control. This device by Dean Kamen allows the user controlling the arm rather than relying on a cross-body pulley system.

Uses of sensors for observe obstacles have performed very well for vehicles to enable collision

avoidance and assisted driving. In our navigational assistance system for the visually impaired persons, here we use a combination of multiple sensors namely ultrasonic sensors and camera to observe obstacles and alarm the user about object around him. The accuracy of the detection of objects using these two sensors.

Ultrasonic sensors are used for many applications like automatic door openers intrusion alarm systems, detecting distance of obstacle etc. In our case, we are interested of using the ultrasonic sensor to the purpose of detecting the presence of obstacle and the distance of the object from the user. The ultrasonic sensor being light weight and compact, its accuracy and robustness compared to other sensors like infrared IR sensors which are sensitive to light changes. It is advantageous to use them in place of or in combination with sensors.

Ultrasonic sensors have been used in automobiles for detecting objects and collision avoidance mechanism. The accuracy of distance of obstacle detection and collision avoidance is better by use of ultrasonic sensors than other technologies. A wearable obstacle detection system which comprises of two sonar sensors, a micro-controller which computes the distance to the nearest obstacle based on the emitted ultrasonic wave and also echo, and two vibrators that provides signals to the user about the existing obstacle. And also uses a system that comprises of an embedded computer, an orientation tracker a sensor array, and a set of pager motors. It detects obstacles in the user's path ways and guides the user through an obstacle-free path using range values at consecutive times.

Using a combination of multiple sensors improves the quality of the obstacle detection system and ultrasonic sensors.

III ULTRASONIC SENSORS AND FACTORS INFLUENCING DISTANCE MEASUREMENT

The objects detection or obstacles in the path or around the user is important for many applications in the devices and gadgets of our everyday usage. The devices, whether big like vehicles or small like mobile phones requires sensors which must be compact and accurate. Ultrasonic sensors are most commonly used due to both their simplicity and low cost.

By the way a US sensor transmits 40 kHz ultrasonic waves from its trigger end much outside the range of human hearing and receives 40 kHz ultrasonic waves back by the echo end. This pulse travels away in the form of conical shape at the speed of sound (340 m/s). The waves are reflected in the presence of an object. The time of travel of the sent and received wave

Are used to calculating distance between the sensor and the object.

By the use of multiple sensors in our obstacle detection and distance measurement system (DMS). Hence, in this paper we tested the optimum distance at which the ultrasonic sensors could be placed to avoid cross talk between sensors as well as ensure that there is no objects present in front of the sensors go undetected due to sensors placed on too far away from each other by missing some regions.

We tested the accuracy of the distance measured using ultrasonic sensor1 (US1) in presence of ultrasonic sensor2 (US2). This is for to test the interference between multiple sensors are placed close to each other, and if any cross-talk exists between the multiple ultrasonic transmitters placed close to each other leads to distance measurements errors. The accuracy of the measured distance from detected objects, and the object is moving or stationary, is dependent on several factors influencing. Since the visually impaired users travels with his or her local navigating system in different and changing environmental situation.

The factors influencing the accuracy of distance measurements by use of ultrasonic sensors are studied in this paper. The ultrasonic sensors in our experiment are connected to on Arduino Mega 2560 micro-controller. The accuracy of ultrasonic sensor depends on the accurately propagated and returned sound waves in the medium.

IV EXPERIMENTS

Here we use the HC-SR04 US sensor for our object detection and navigating system. To test that covers the range by ultrasonic sensors we tested the accuracy of the distance measured using the US sensor placed at different angles that ranging from -30 to 30 degree and then compared with the distance estimated by the sensor that is estimated distance (ED) to the actual distance (AD) of the object from the sensor. And we also tested that the accuracy of the sensor under different external conditions influencing like temperature, pressure changes, vibrating surface and moving objects by again comparing with ED and AD.

To estimation of the accuracy of distance measured under pressure changes we placed the US sensor at a maximum distance of one meter and we considering the distance covered by a white cane and applied external pressure into the way of the sound wave that triggered from the sensor using a ventilator of 1500 watts. The distance measurement taken by placing the object at different distances ranging from 10 cm to 200 cm under different experiments. Temperature of the medium in which the triggered sonic wave is changed by the way of blowing hot air into the triggered sonic wave again use of the ventilator. We then tested the accuracy of the distance measured. Then we take another experiment by placing the sensor on a surface that vibrating continuously and compare the ED and AD. Then, we estimate the accuracy of distance

measurements of when the sensors is placed still on the platform and the objects is at motion. That is we take accuracy of distance of moving object. The object is placed at a known distance and moved manually and the ED and AD are recorded and to estimate the accuracy under these mentioned physical conditions. The accuracy of distance estimation is quantified using the metric Estimated Distance Error (EDE). EDE is calculated by the method of subtracting the ED from AD

.V RESULTS AND DISCUSSION

Accurate detection of obstacles by use of sensors influence on several factors. That is the sensitivity of the sensor at its different external conditions is of utmost consideration for building an object detection model. Distance at which the sensors were placed from the objects, accuracy of the objects detected at different external conditions are very important to build an accurate object detection model.

A. Angular Range

The ultrasonic sensors detects that obstacle that take place only up to a certain angular ranges only. If objects falling out of this boundary this range are not detected by sensors. In this cases if we are use multiple sensors, the sensors are arranged such that no region is left blind where an existing objects are not detected. Like that, we need to calculate the maximum range at which the obstacle is detected.

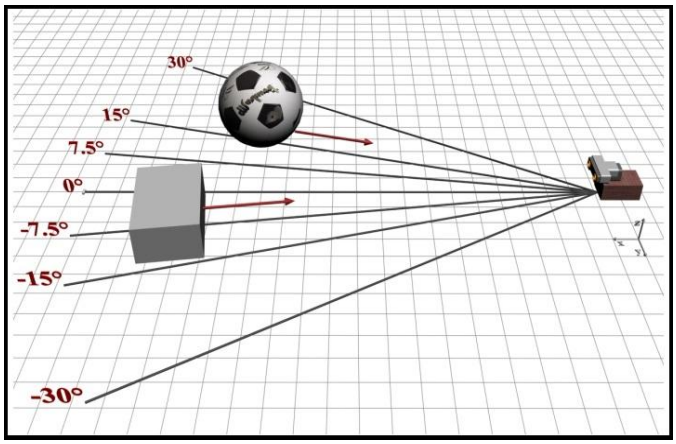

Figure 1 Experimental Setup for maximum Angular Range Estimation

Figure 1 shows that the possible ranges of the ultrasonic sensor we used. The objects placed at 10 and 20 cm from the object were placed at different angular positions as shown in Figure.

There is any error found in the measured distance of object from the user or failure of detection of the present object is very difficult to the visually impaired persons and it may leads to result in accidents. Thus, it is very essential to have the sensors must be positioned within the mentioned object detection range.

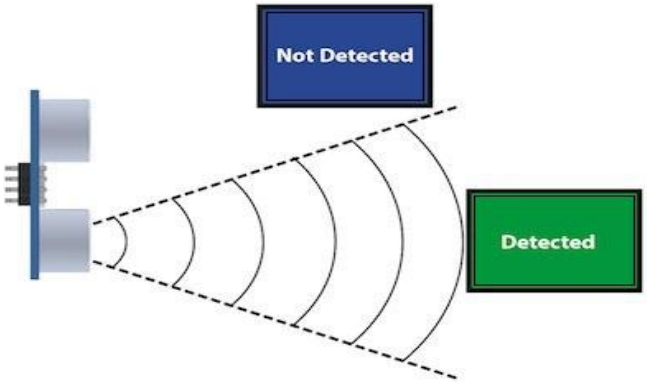

Figure 2 Boundary region of ultrasonic wave cone.

In figure 2 shows that's any objects placed within the region of its wave cone only detected by the sensor. If any obstacle are placed outside of that boundary cannot detected by the sensor.

B. Influence of Pressure Change

Ultrasonic sensors are use air as the medium to send or receive sound waves, then it also determine the presence of an object in front of the sensor. If any change in the movement or properties of this medium such bulk movements might change in the acoustic waves, causing errors in calculation of distance between object and ultrasonic sensors. In open condition, changes in air pressure or air currents direction might cause the beam to get deflected and incorrect distance due to incorrect path length estimated.

Here we have estimated that the distance error at the distance of the object from the sensor ranging from 10cm to 100 cm considering the distance covered by a white cane used by visually impaired to sense objects. The results in Figure 3 show that an increase in distance error at change in air pressure compared to the distance error at normal air pressure condition. However, the error is not comparatively high thus stating that the change in air pressure does not have impactful influence on the accuracy of the DMS.

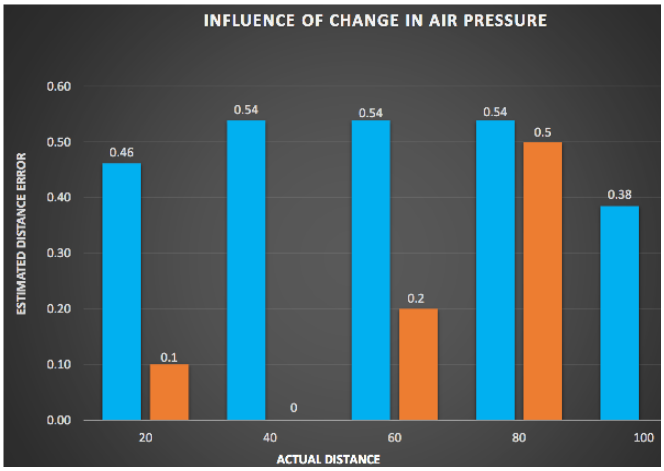

Figure 3 Distance error Estimation under the influence of Pressure Change

C. Influence of Temperature Change

It is important to determine the impact of temperature of the transmission medium which is air in case of ultrasonic sensors to build an accurate distance measurement system. Ultrasound waves are travel with the speed of 340m/s and the velocity of sound in air is dependent on temperature if we analyses an increase in temperature causes the slowing of the speed of sound thus increasing the sensing distance. The change in air temperature causes the speed of sound to change by 0.17 degree per degree. And hence all Pepperl+Fuchs ultrasonic sensors use a temperature probe to compensate this error. In our distance measuring system, the increased time between the sending of the ultrasonic pulse and its return to the receiver is measured. The accuracy of the target distance measurement depends on the accuracy of the speed of the transmitted waves. Hence, we have analyses the distance measurement error at normal temperature (NTE) and at high temperature (HTE). The results as shown in Figure 4a and 4b**.**At normal temperature which also increases with increase in the distance of the object from the sensors.

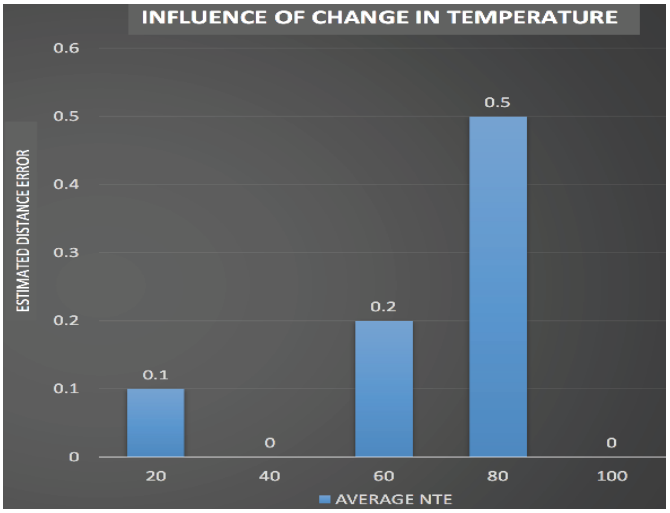

Figure 4a Distance error Estimation at High Temperature

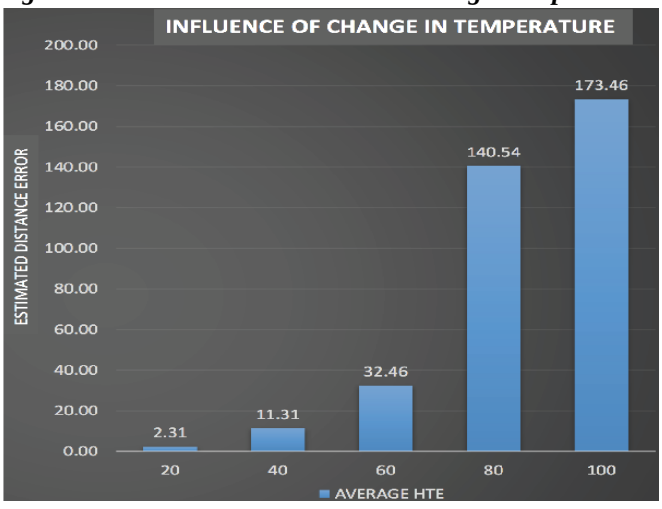

Figure 4b Distance error Estimation at High Temperature

D. Influence of Moving Sensor

In general case most of the sensors are used for distance measurements in the navigating systems are generally mounted on moving surfaces or on the body of the users. These sensors are tends to vibrating which might affect the accuracy of the distance measurement system (DMS). Thus, estimating the influence of the movement of the sensors on the accuracy of DMS is essential for the estimations. In order to test the influence of moving sensor on the accuracy of the DMS, we have mounted the sensor on a continuously moving objects. Further we placed the objects at distances ranging from 10 to 100 cm from the sensor again estimates the distance covered by a white cane. The measured distance error with the moving sensor (VSE) is very higher compared to the distance measured using a still ultrasonic sensor (ADE). Figure 5 shows that the ED with a moving sensor is not much higher than the ADE. The percentage of error with a moving sensor is not more than 6% which is comparatively low.

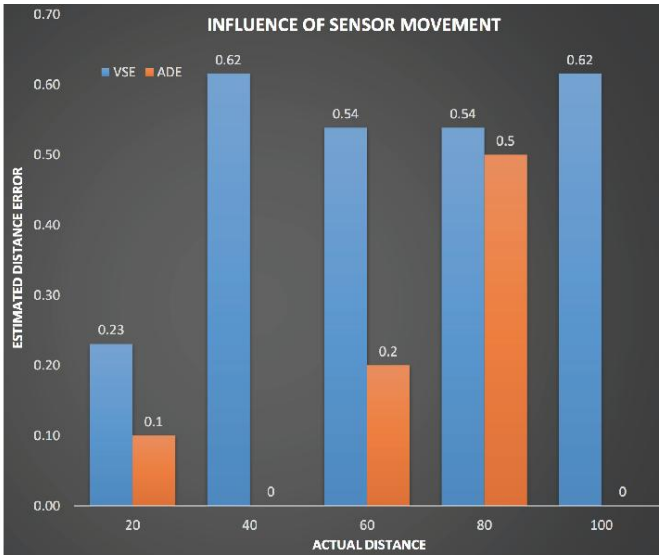

Figure 5 Distance error Estimation with Moving Sensor

E. Influence of Moving Object

Here the case is the movements is for object, the distance estimated from the moving objects is also important. The DMS used while navigating, not only estimates distance from the stationery objects in the path but also the moving objects also. Thus, the accuracy of the distance measured is determined by estimating the distance between the moving object and from a non-moving object placed a distance ranging from 10 to 100 cm from the sensor. The results of this experiment as seen in Figure 6 state that the movement of obstacle has a great influence on the accuracy of distance measurement. To avoid this bias we used median values instead of average value to calculate the distance error and the results show that the movement of objects have not affecting on the accuracy of the distance measurements. And hence we need to avoid the accidental high distance error

also, determining multiple distance values is necessary to avoid any bias.

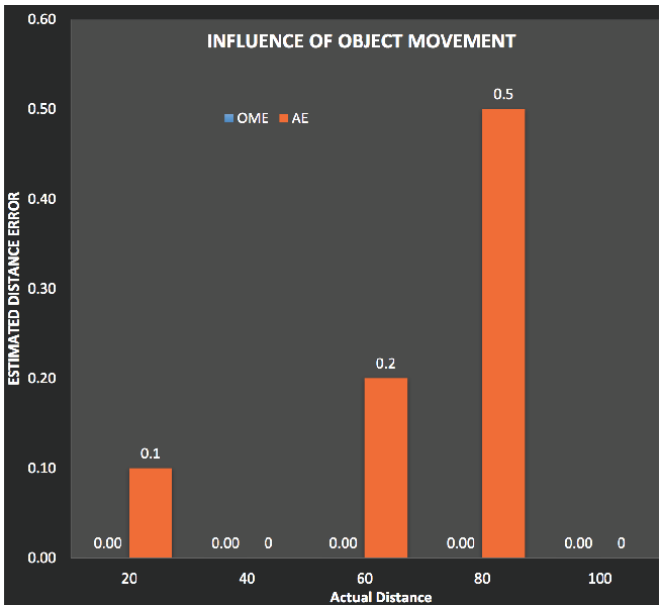

Figure 6 Distance error Estimation from Moving Object

VI SUMMARY

This paper explains the factors that influencing on the accuracy of detection measurements of distance of objects using Ultrasonic Sensors in navigation system for the visually impaired persons. The findings of this paper put forward as the basis for design and technical set up of the obstacle detection system. The distance between the object and the sensor, movement of the object or the sensor, change in pressure or temperature have a very high influence on the accuracy of the detection of objects as well as the calculation of distance between the objects and the user. Thus, placing and detecting the objects at an optimized lengths becomes the crucial to ensure safety of the visually impaired or blind user. Thus the results of these experiments show that inaccuracy in distance estimation between user and the objects is considerably low thus indicating ultrasonic sensors as a good choice for detecting objects for our navigation system. However, further improvement in the distance estimation and objects detection can be achieved by using a combination of other sensors along with the ultrasonic sensors.

VII FUTURE WORKS

The experimental findings of our current work would be used to design the technical set up of our navigational assistance system for the visually impaired or blind users which detects the

Objects and obstacles in the path of the user, and also this navigating system measures the distance of the user from the obstacle or objects and finally alarms the user about the information regards with the objects. Using multiple ultrasonic sensors in combination with some other sensors leads to improve the accuracy of the objects detection system. The results show that the measurable distance between the sensor and estimations that affect and influence of external environmental factors on the quality of distance measurement is very important to design a good quality navigational system and also it ensuring the safety of the user.

REFERENCES

[1] CECITECH 2012, "Kapten plus: Voice-controlled mobility assistant," http://www.cecitech.com/kapten-mobility-- -gps navigator--voice controlled.

[2] D. Hong, "Making a car for blind drivers," TED. LLC, 2011.

[3] Guizzo, "Dean Kamen's luke arm."

[4] N. Amin and M. Borschbach, "Quality of obstacle distance measurement using, ultrasonic sensor and precision of two computer vision-based. Obstacle detection approaches," in IC-SSS. IEEE, 2015

[5] D. Jain, "Path-guided indoor navigation for the visually impaired using minimal building retrofitting."

[6] P. Kausalya and S. Poonkuntran, "A comparative performance. survey of obstacle detection of mobile robot using various sensor technologies," in VIVECHAN. International Journal of Research, vol. 5. IMSEC, 2014

[7] S. Cardin, D. Thalmann, and F. Vexo, "Wearable obstacle detection system for visually impaired people." Proceedings of Haptex. 05 - Workshop on Haptic and Tactile Perception of Deformable Objects. 2005, pp. 50–55.

[8] B.-S. Shin and C.-S. Lim, "Obstacle detection and avoidance system to visually impaired people," in In Proc. 2nd Int. Workshop on Haptic and Audio Interaction Design, vol. 4813. Springer LNCS, 2007, pp. 78–85.

[9] Nain. And M.Borschbach. "Classification criteria for local navigation digital assistance techniques for visually impaired," in 13th International Conference. on Control, Automation, Robotics and Vision. IEEE, 2014, pp. 1724–1728.

[10] M. I. Ecemis and P. Gaudiano, "Object recognition with ultrasonic sensors," in Proceedings on International Symposium on Computational Intelligence for Robotics and Automation. IEEE, 1999, pp. 250–255.

[11] D. P. Massa, "Acoustic/ultrasound-choosing an ultrasonic sensor for proximity or distance measurement part. Sensor- proximity- or- distance- measurement- 825, 1999.

[12] P. P. N. 2015, "Ultrasonic sensors knowledge. (part 4): Influences on measurement accuracy," http://www.pepperl-fuchs.com/global.