Application of Infrared Sensor for Shape Detection

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***Abstract*—This paper describes the use of multiple Infrared sensors to reconstruct a shape by detecting any changes in sensor displacement when there is an obstacle placed in front of the sensor. Meanwhile, the distance between IR sensors and the obstacle was set at 5 cm to minimize the noise contributed by the reflection of the sensor during data collection. A stepper motor was used in the experimental design to control the movement of an obstacle which rotates at 360° for one complete cycle. Additionally, *Arduino* Software was used as a microcontroller to control the switching mode of the sensor and *CoolTerm* Software was used to store the sensor output data in the text file format. For analysis, *Matlab* Software has been used to plot the graph of sensor value against the collected data. IR sensors are capable in measuring data up to 0.05 cm of resolution in displacement. Experimental results showed that by using IR sensors, it is possible to reconstruct a shape via plotting the graph for cylinder, hemisphere and ellipse shape obstacles.**

Keywords— Infrared; Distance Measuring Sensor; Arduino; CoolTerm; Matlab

I. Introduction

Infrared (IR) sensor has been widely used in industrial and medical fields for various applications. IR sensors play an important role in obtaining accurate data in order to reduce the noise level and errors as much as possible in every single test and process. There are two types of IR sensor which are modular and discrete sensor both can be used to measure distance at close and further distance [1]. Meanwhile the resolution of this sensor can be up to 0.1 mm [1]. Unfortunately, in robotic system IR sensor limited to it sensing accuracy, range and computing abilities [2]. The used of a stepper motor in controlling the movement of the obstacle can help engineers to produce two-dimensional (2D) images whenever there are changes in position [3].

Ultrasonic (US), IR sensor combine with camera, position sensing detector (PSD) and sensor with laser diode (LD) require a proper calibration for an accurate measurement [1]. Ultrasound with thermally excited silicon works at 100 kHz can measure distances up to 11 cm with an accuracy level of 2.5 mm [4]. Meanwhile, the outline of an object can be detected using PSD with the accuracy of 1% at a distance between 10 cm to 80 cm which produce optimum results at 35 cm to 63 cm [5, 6]. Other than that, LD which is based on self-mixing interferometry technique is able to give an accuracy of 0.3 mm in the range of 3 m in distance [7]. The combination of camera and IR LEDs sensor can help researchers to obtain high quality images with better resolution [1, 8]. Compare with ultrasonic range sensor, IR range sensor has the limit for maximum distance basically smaller than ultrasonic [9]. When the IR range sensor transmits its signal it will reflect back either from the offset of the reflected beam or from the intensity of the reflected light [9].

Even though US sensor, IR calibrated with a camera and other sensors that have been mentioned before can be used to measure distance, but using the IR sensor with a low-cost and easy to install is simpler and calibration of this sensor is not complicated. A laser scanner comes with high-resolution image and the price is expensive sometimes more than the mobile base itself [9, 10].

In this experiment, we are measuring the small changes in distance that can be detected by IR sensors. IR sensors with part number GP2D120XJ00F manufactured by SHARP have been used in this experiment are specifically for analog output distance measuring sensor. A major advantage using this GP2D120 is beam width this is because signal that transmit from IR sensor point directly to the require object [11]. There are capable in detecting any changes in displacement within the range of 4 cm to 30 cm. Results showed that small changes in displacement can be detected by sensor and a graph has been plotted for any changes in distance.

II. Methodology

A. Infrared Range Finder Sensor

An IR sensor specific for Analog Output Type Distance Measuring Sensor (GP2D120XJ00F) from SHARP consists of a light emitting diode (LED) and a detector (photo-transistor) mounted in a reflective configuration. This sensor is capable of detecting any changes in distance, and the resolution is up to 0.05 cm [12]. The distance measurement for this sensor is limited from 4 cm to 30 cm and to minimize the noise level during data collection, the distance need to be set at least 5 cm or above else the data received is considered as noise.

Since measurement with infrared light can be disturbed by any light source, there are a few options have been taken during data measurement these sensors are limited to a close room and in the dark place [2]. Reflect time for GP2D120 of the infrared range sensor is 38.3 ms ± 9.6 ms and the most useful output ranges are about 0.25-0.55 V [12]. The more

978-1-4673-6075-3/13/$31.00

quickly the sensor can give reflection to the receiver the faster it can give output value to the user [13]. There are five sets of IR sensor have been used, this idea gives an advantage in time for 360° scanning is shorter than using only one sensor [9].

B. Data Collecting and Storage

The output measurement for GP2D120 infrared range sensor which is in digital output does not require any conversion from analog to digital converter (ADC) so the distance in centimeter (cm) can be calculated [14]. Since this board has an analog-to-digital conversion function for the voltage range of 5 V. The calculation for conversion is then:

$$\text{Distance, cm} = 2076/(output_{analog} - 11) \tag{1}$$

CoolTerm is used to store the data from the output pin of IR sensor to Arduino in a text file format. This software needs to be connected to the Arduino serial port during data collection. This application cannot be concurrently opened with Arduino Serial Monitor it has to be either one to work.

C. Experimental Structure

To examine the performance of sensors working principle, a circuit system has been designed to control the switching IR sensor since this setup requires five IR sensors to operate at once in order to minimize the duration for each data collection. The entire sensor is being controlled by a control circuit which consists of ICs (LM234 comparator), relay 5 V and diode. This control circuit is responsible to turn ON and OFF the IR sensors one by one. While the first sensor is connected to the current other is not connected. By doing this it can be sure that only that IR received a reflected signal, and it is not a signal reflected by other IR sensors. As shown in Figure 1, the movement of the obstacle will be controlled by a stepper motor, which will rotate the obstacle at 360°. The stepper motor is set to rotate at a fixed angle which is a step angle of 2°, hence it requires 180 turns for one complete cycle.

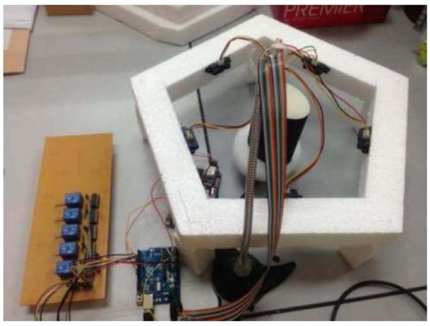
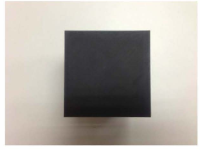


Fig. 1. Experiment setup using IR sensor and obstacle control using stepper motor

Every 2° of movement make by stepper motor Arduino will give an instruction to the IR sensor to take or measure distance between sensor and the obstacle. Each sensor requires 50 ms in order for the signal to transmit and receive by the receiver. The purpose to use more than one IR sensors is because to reduce time requires taking data for one complete cycle. Since each sensor requires five minutes for 360°, by using more sensors, this system is able to reduce four minutes and it only took one minute to collect data for 360° image. Unfortunately, if too many IR sensors are use the system will become bulky, which is not preferable for accurate and sensitive data. In the experiment there are four types of object have been used in this experiment cylinder, hemisphere, rectangle and oval shapes as shown in Figure 2.

a) Cylinder object



b) Rectangle object

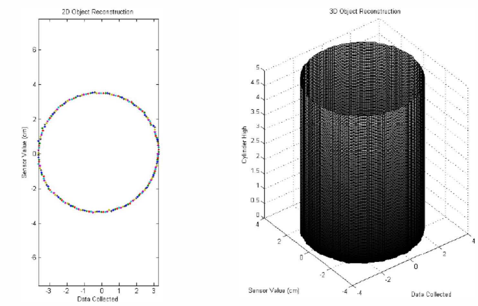
c) Hemisphere object

d) Oval object

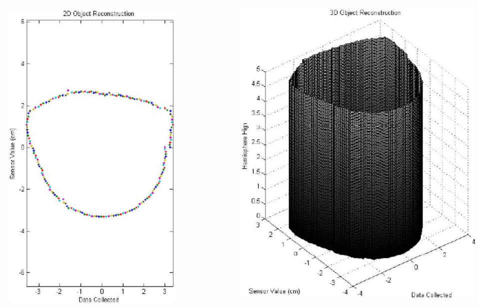
Fig. 2. The shape of the object used and it's position during data taken

III. RESULTS

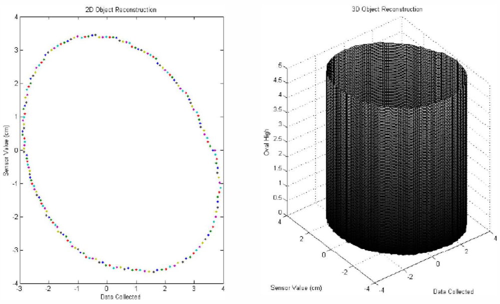
Matlab software has been used to plot every data captured by IR sensor to form a graph and a 3D image of the object. The measurement unit for the distance is in centimeter. An algorithm had been applied in order to produce different shape of the image captured.



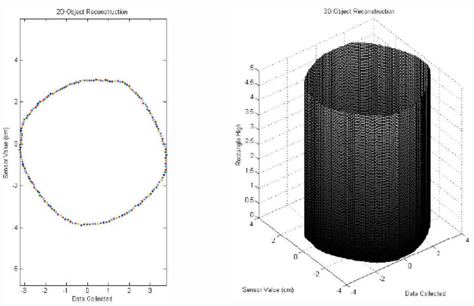
a) Sensor value data collection using cylinder object



b) Sensor value data collection using hemisphere object



c) Sensor value data collection using the oval object



d) Shape of rectangle object in 3D image

Fig. 3. The graph for the cylinder, hemisphere, oval and rectangle object in 3D form

Figure 3 shows the results obtained from IR sensors GP2D120, which gives analog data to the user. For the results, the object shape can be reconstructed in 2D and 3D form with a special algorithm. Cylinder and oval object give a better result compare to hemisphere and rectangle object. This is because GP2D120 sensors did not give a good reflectance signal when there is a straight line condition of the object. Data received by the microcontroller is not able to reconstruct a straight line image even though data taken in a dark place in order to avoid any light source from the surroundings.

IV. Discussion

This experiment has demonstrated that the pattern of the plotted graph produced will be different when a distinct shape of an obstacle is used. It is very important to make sure that the distance between IR sensor and the obstacle is more than 5 cm or above in order to reduce noise from sensor reading. Even though the application of lots of IR sensors used throughout the experiment is similar to the tomography working principle, there is a different with this experiment, more IR is used because of the time consuming since one IR able to take data five minutes for the whole 360° but by using five IRs it only took one minutes for the complete circle. Since the IR sensor image resolution does not depend on how many IR sensors is used during the experiment like tomography working principle, so if more sensors used the system will become bulky. From the results obtain it is also shown that, by using GP2D120XJ00F Infrared Sensor it is capable in collecting data and produce a 3D image of an object. The results will be useful for future various shape reconstruction by using multiples IR sensors.

Acknowledgement

The authors are indebted to Universiti Teknologi Malaysia (UTM) and the EScience Grant for supporting and funding this study (EScience Vote R.J130000.7923.4S027). We also would like to express our gratitude to Biomedical Electronic Laboratory Group members for their ideas and comments to the study.

References

[1] T. Chin-Fu, W. Yuan-Kai, et al. "Implementation and analysis of range-finding based on infrared techniques." *Control Conference (ASCC)*, 2011 8th Asian, 2011.

[2] K. Saman, "Twin Low-cost Infrared Range Finders for Detecting Obstacles Using in Mobile Platforms", *in International Conference on Robotics and Biomimetics,* Guangzhou, China, 2012, pp. 1996-1999.

[3] I. Matijevics, "Infrared Sensors Microcontroller Interface System for Mobile Robots." *Intelligent Systems and Informatics, 2007. SISY 2007. 5th International Symposium on Intelligent Systems and Informatics*, 2007.

[4] K. Christoph and H. Qiuting, "A CMOS Ultrasound Range-Finder Microsystem" *IEEE journal of soild-state circuits*, Vol. 35, No.12, Dec. 2000.

[5] C. Xiao and W. Chenliang, "Ultrasonic Distance Measurement Based on Infrared Communication Technology", 2009 *3rd International Symposium on Intelligent Information Technology Application*, Vol. 1,Nov. 2009.

[6] H.L. Chang, K.H. Woong, T.K. Kwang, "A Simultaneous map building system by using developed photo PSD sensors", *SICE-ICASE International Joint Conference 2006* Oct. 18-2 1, 2006 in Bexco, Busan, Korea .

[7] N. Michele, G. Guido, D. Silvano, "Absolute Distance Measurement With Improved Accuracy Using Laser Diode Self-Mixing Interferometry in a Closed Loop", *IEEE Transations on Instrumentation and Measurement*, Vol. 56, No. 5, October 2007.

[8] S. Hijikata, K. Terabayashi, K. Umeda, "A Simple Indoor Self-Localization System Using Infrared LEDs", *Networked Sensing Systems (INSS), 6th International Conf. P.* 1 – 7, 2009.

[9] P. Hyunwoong, S. Baek, S. Lee, "IR Sensor Array for a Mobile Robot", *Proceedings of the 2005 IEEE/ASME International Conference on Advance Intelligent Mechatronics, Monterey, Carlifonia, USA,* July 2005, pp. 928-933.

[10] D. Dedieu, V. Cadenat, P. Soueres, "Mixed camera-laser-based control for mobile robot navigation", *Proceeding of IEEE/RSJ International Conference on Intelligent Robots and Systems,* 2000, pp. 1081-1086

[11] Y. Khraisat, "Design Infrared Radar System", *Contemporary Engineering Sciences,* Vol. 5, 2012, no. 3, pp. 111-117.

[12] "SHARP GP2D120XJ00F Analog Output Type Distance Measuring Sensor", datasheet.

[13] A. Tar, G. Cserey, "Object Outline and Surface-Trace Detection Using Infrared Proximity Array", *IEEE Sensors Journal,* Vol. 11, No. 10, October 2011, pp. 2486-2493.

[14] A.N. Ibrahim, "Low Cost Obstacle Detection System for Wheeled Mobile Robot", *UKACC International Conference on Control 2012*, Cardiff, UK, Sept 2012, pp. 529-533.