

## AN IMPLEMENTATION OF A USER FOLLOWING ALGORITHM ON A HUMAN ASSISTANT OBSTACLE AVOIDING ROBOT

M. M. Punchihewa<sup>1</sup>, A. Seeni<sup>2</sup> and Y. M. T. Y. Bandara<sup>3</sup>

<sup>1</sup> Pioneer Institute of Business & Technology (PIBT), Sri Lanka. Email: malzpunhiewa@gmail.com

<sup>2</sup> Pioneer Institute of Business & Technology (PIBT), Sri Lanka. Email: markaraze@gmail.com

<sup>3</sup> Pioneer Institute of Business & Technology (PIBT), Sri Lanka. Email: tybandara@gmail.com

### ABSTRACT

User following robots with human assistant have traditionally been an important research topic. Various approaches have been investigated towards incorporating functions of sensing, actuation, and control in order to identify and locate the target person in a crowd in real time. This paper proposes a method and an implementation to automate the act of hauling load which is commonly faced while moving through the tiresome and often exhaustive routines engaged with travelling. The device/system is verily a personal porter, human assistant, which is further embodied with obstacle avoiding sub systems. That keeps a safe following distance behind the user; thus maintaining a total liberty of movement. The use of ultrasonic sensors and infrared sensors are proposed in combination of the algorithm provides the system with the ability to perform positioning and user following. The implementation of the research paper can be easily involved in many applications, such as for airport travel, transporting sports equipment, usage in hospitals, nursing homes or assisted living amenities, and many other miscellaneous personal uses.

**Key words:** obstacle detection, user positioning, ultrasonic, infrared

### 1. INTRODUCTION

A smart robotic follower of a person would be an immense important in a situation where an assistant is required. This paper discuss how autonomous system can act in contact with human behavior In order to follow, the robot must know the exact position of the operator and must be able to determine its own path in order to follow the intended target. The robot is equipped with two ultrasonic sensors and one infrared sensor. Based on this configuration the system was developed. The system algorithm is comprised with two sections, (2.1.) a User following function and (2.2.) obstacle avoiding function.

The content of this paper is organized as follows, section 1 narrate the related work and literature review of the study. The methodology and the algorithm are described in Section 2. In evaluating the proposed system and the algorithm, Section 3 annotate several testing and their results. Eventually, areas of future work and the references used are includes in section 4 and 5, respectively.

#### 1.1. Literature Review

Human collaboration robots have been widely discussed and researched in the domain[1,2,3] yet authors found that most available research

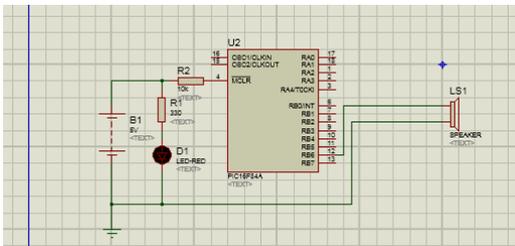
knowledge proposes application of image processing and complex computer vision techniques to track a human operator. Some research has still utilized methods such as following a light-emitting device pattern [2]. A human-robot interactive system had been designed to assist novice to control a humanoid robot, along with an RGB-D sensor such as Kinect or Xtion for detection. [3] An intelligent behavior is used to conquer the goals of identifying the target person and the surroundings of the robot, along with the advancement of a control strategy for stable human-following capability. [4] However, there are shortcomings for such a room, which requires considerably high cost equipment and the limited locations where it can be placed. In [5] the author proposes an environment, fixed room tracking area similar to a home with cameras placed in the four corners and laser range sensors to identify and track the coordination of the targeted human. Human following function is presented by using a Smart card which is continuously sends signal to the tower, which is placed on the pocket of the user and Ultra Sonic Sensor on the rigid robot body. [6]

This research is influenced by the idea of implementing a human tracking robot with less complexity and coming up with a minimum viable product. Current proposal uses a simple

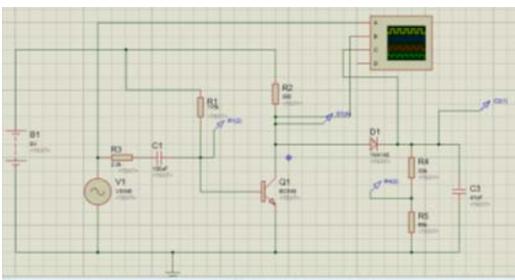
ultrasonic signal to track the position of the operator which immensely simplifies the tracking process. Having multiple receiver sensors adds the advantage of the capability to track even in a crowded scenario. Obstacle detection is added as an added feature to the tracking robot using infrared sensors which enable the robot to track and follow the user in a practical disturbing environment.

**2. METHODOLOGY**

A transmitter, is designed for the human operator to carry with him, which comprises of an ultrasonic transmitting device. The robot is fixed with multiple ultrasonic receiver sensors which would track the signal transmitted by the transmitter. The main purpose of the transmitter is to transmit the 40 kHz ultrasonic signal to the system with a considerable voltage that can be detected at the far end of the receive system without having any distortion. Current tracking system is scoped with two receivers where it can be further increased to fine tune the tracking operation [4, 5]. One circuit is produce the ultrasonic transmitter with power and the operating signal required the other circuit is adopted to grab the signal from the transmitter so that it can be used and process by the PIC18F452 microcontroller to measure the distance to the user and direct towards the user.

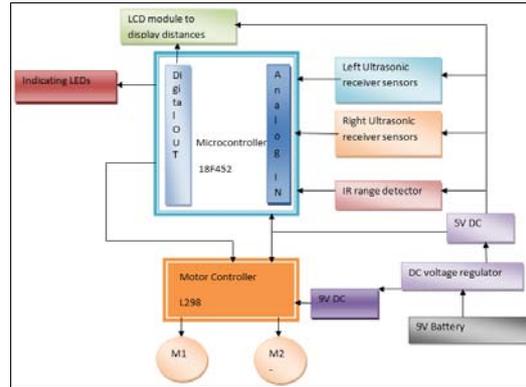


**Figure 3: Transmitter circuit diagram**



**Figure 1: Receiver circuit diagram**

Main modules used in the system is designed and completed to achieve the system overall functions.

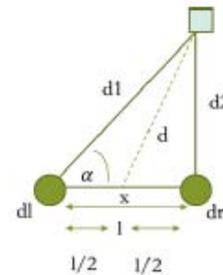


**Figure 2: Block diagram of the system**

PIC18F452 is used to handle the receiver operation and execute the tracking algorithm. The system can continually detect the position of the user, which is holding the ultrasonic transmitter. The correctness of target detecting is much better if the distance between the two receivers is higher, as long as the receivers are in the active range.

**2.1. User detection**

Following calculations (eq. 01, eq. 02, and eq. 03) are performed to calculate the distance to the operator.



**Figure 4-The location of the operator with respect to the two receiving sensor**

$$d = \frac{\sqrt{2d_1^2 + 2d_2^2 - l^2}}{2} \tag{01}$$

$$d_1^2 = \frac{WA}{4\pi \left(1 + \frac{R_s}{R_l}\right) V_0^2} \tag{02}$$

$$V_0 \propto \frac{1}{d_1} \tag{03}$$

Applying the equation (03) to the real world test results where, Direct current voltage

proportional to the distance from the user. Therefore,

$$d \propto \frac{1}{Vdc}$$

$$d = \frac{k}{|Vdc|} \quad (04)$$

2.2. Obstacle detection

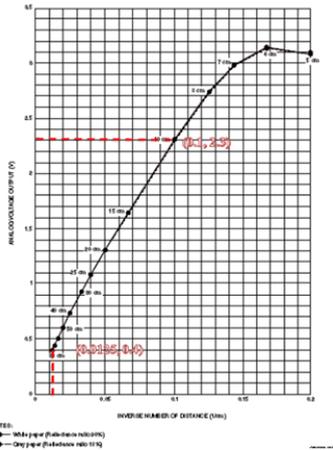


Figure 5: GP2Y0A021YK Example of Output Characteristics with Inverse Number of Distance

$$\frac{y - 2.3}{x - 0.1} = \frac{2.3 - 0.4}{0.1 - 0.0125}$$

$$d = \frac{1.9}{0.0875v - 0.01125}$$

$$d = \frac{21.7143}{0.1 - 0.12857} \quad (05)$$

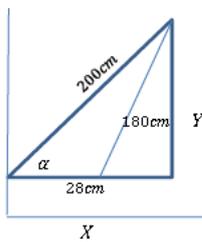


Figure 6-The location of the operator with respect to the infrared sensor

$$180^2 = 200^2 + 28^2 - 2 * 200 * 28 \cos \alpha$$

$$\cos \alpha = \frac{200^2 + 28^2 - 180^2}{2 * 200 * 28}$$

$$\alpha = \cos^{-1} \left( \frac{200^2 + 28^2 - 180^2}{2 * 200 * 28} \right)$$

$$\alpha = 41^\circ$$

$$y = 200 \sin \alpha$$

$$x = 200 \cos \alpha, x=150cm \quad (06)$$

The algorithm is a formation of the programming of the overall system. The program proceed in such a way that a pin is first initialized. Pin 9 and 10 is configured as inputs from the ultrasonic receivers to the microcontroller interface. Once the signal has been grabbed, the PIC18F452 microcontroller converts such analog inputs to a digital value. When the pin is set to input, a while loop is initialized to wait at input until the signal is received.

The PIC18F452 assign inputs and outputs ports to obtain the ultrasonic and infrared signal then it will measure those voltage values through analog to digital conversion. Then it is configured and calculate the distances "dl", "dr" and range of obstacles around from the results obtained through analog to digital conversion in such the program was written to direct and calculate the distances difference "dl-dr". If both "dl" and "dr" values are lower than 200, If obstacle distance is lower than 15 centimeters, the luggage carrier would stop in such cases.

In turn where the system fulfil those conditions other way then the program would continue to check whether the values for "dlr". If "dlr" is less than 0 then the motors will rotate clockwise for about 10 milliseconds. Similarly if "dlr" is higher than 0 then the motors would rotate anticlockwise for about 10 milliseconds and in both situations the program may direct to check for ultrasonic and infrared voltages again. But when "dlr" value flows to be equal to 0 then the program is written to direct the vehicle move facing forward for about 10 milliseconds and check for ultrasonic and infrared voltages to track the user's positions and the directions.

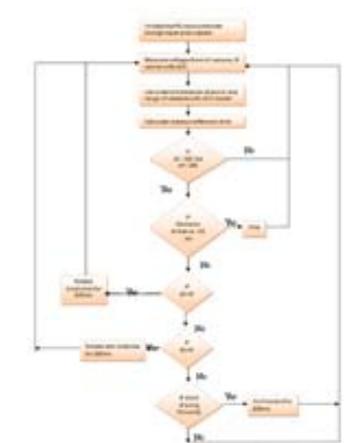


Figure 7: System flowchart

### 3. RESULTS

The user detectable range is shown in dashed lines. (Fig 08 and Fig 09) distance range is specified as  $d_l < 200$  &  $d_r < 200$  in software. Therefore the upper and lower boundaries are determined if one ultrasonic sensor detects its distance over 200 cm. The upper boundary occurs due to the highest measurable distance of left and right sensors. In the upper boundary when the user is at point A, the right sensor (SR) will reach to its maximum defined distance level 200cm. Similarly when the user is at point B, the left sensor will reach to its maximum defined distance level 200cm. On those points the distance AS1 and BSR are 181cm each. This is basically due to the range of the ultrasonic sensors. Their operating working range is normally defined at low distances as 45 degrees. The lower boundary is determined when the user is at a point somewhere in the semi-circle. (Fig 08) For an example if operator is at point P (14 cm above the midpoint of the sensor line) this will make an Isosceles triangle as below. When the user is trying to reach below the point P any sensor will detect its distance as above the 200cm since it is out of its range of measure. This is also due to the limitation of the range of the ultrasonic receiver sensors.

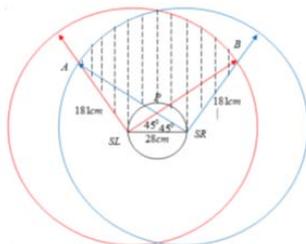


Figure 8- Working range

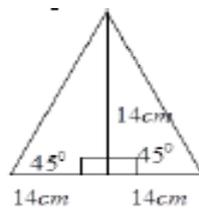


Figure 9-Isosceles triangle determining working range

### 4. CONCLUSION

This paper tries to add to the existing body of knowledge the possibility of designing and implementing a smart follower robot which will facilitate the human, robot collaboration. Authors believe that the accuracy and the

effectiveness of the proposed architecture can be immensely improved by increasing the number of receiver sensors. The successful implementation of the proposed architecture will facilitate various fields such as airport luggage carrying process, sports, medical and differently abled human support.

The limitations of this prototype are the limited operating range, limited weight carrying capacity, locating the user only with two ultrasonic sensors, indication of front obstacles (not avoiding them) and working for limited time duration ( depending on the size and charge of the battery). Those limitations can be avoided and more features can be added when designing the final product.

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