OBSTACLE AVOIDANCE
PERSON TRACKING ROBOT
USING BUBBLE REBOUND ALGORITHM

SHWE YI PAING

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By

SHWE YI PAING
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ABSTRACT

The current ultrasonic impediment evasion robot just purposes an ultrasonic sensor during the time spent obstruction aversion, which must be tried not to accord to the decent snag evasion course. Hindrance evasion cannot follow extra data. An individual following portable robot is a creative versatile robot, which can perform individual following and impediment evasion undertakings all the time. Ultrasonic Position based approach is used in this framework for recognizing and finding the objective individual. This system also used the Bubble Rebound Algorithm (Using Ultrasonic Sensor) which can avoid the obstacles on the way of tracked person. The focus of this system is to investigate the feasibility of developing a person-tracking robot system using ultrasonic positioning for person tracking and ultrasonic sensor for obstacle avoidance. This system is implemented with C Language on Arduino IDE by using ultrasonic position sensors and Arduino Mega board.

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CHAPTER 1

INTRODUCTION

With the development of artificial intelligence technology, mobile robots are broadly utilized in canny processing plants, present day planned operations, security, accuracy horticulture and different angles. The wheeled portable robots have been generally utilized away and transportation fields. The focal point of this framework is to keep away from deterrents between the following individual the robot and follow an individual. The main thing to understand the independent movement control of a versatile robot is to get the data of the general climate and move it to the principal regulator to change over it into control order, to guarantee that the robot can securely and steadily keep away from all snags while moving to the objective, which can be accomplished when the portable robot has major areas of strength for a framework. Various sorts of sensors are expected for various data. The detecting advances of portable robots incorporate aloof detecting in light of different cameras, sound system vision and infrared cameras and dynamic detecting utilizing different sensors to identify dynamic or fixed snags continuously. Laser running is utilized to investigate the wheel slip of the four-wheel sliding guiding portable robot. A few different investigations have proposed target following of wheeled portable robots in light of visual strategies [1]. For an obscure climate, sensors are normally utilized for insightful snag aversion and way arranging. The early strategy for deterrent evasion and way arranging is to identify the stickers on the ground by infrared beam for route. This strategy must be utilized in a known climate. As of now, the exploration on a snag aversion robot is generally about the engine driving rule, engine speed guideline conspires and going standard, and the examination on hindrance evasion is likewise about impediment evasion. An individual following versatile robot is a robot that follows an individual while at the same time carrying out impediment evasion. Individual following is a procedure utilized by robot and independent vehicles to follow a human inside a particular reach. The robot follows the objective individual and evasion the obstruction between the objective and robot. Not many individuals concentrate on versatile robots when they experience pits during programmed travel. In reference 1, this research making to track moving object in line tracking process using control the motor’s velocity.

In reference 2, these research focus to discover obstacle and then avoidance these obstacles by using PIC.

1.1 Objectives of the Thesis

The main objectives of this thesis are:

- To implement a person-tracking mobile robot by using ultrasonic position system.
- To apply a person-tracking when the target person makes a turn at a corner
- To execute an obstacle avoidance mobile robot by using bubble rebound algorithm.

1.2 Motivation of the Thesis

The robot is wanted in numerous applications that the versatile mobile-robot have the option to follow and track an individual. There have been various endeavors in writing to make individual following robots. In any case, current individual following portable robots are not fit for working in unstructured conditions. Since a few principal draws near, like vision and infrared sensors, are not completely solid in all circumstances, investigating different methods is fundamental. The fundamental target of this examination is to research the possibility of fostering an individual following robot framework utilizing an ultrasonic situating frame work.

1.3 Organization of the Thesis

This thesis consists of five chapters, abstract, acknowledgment and references. The mobile robot based on ultrasonic position system for the person tracking and obstacle avoidance is introduced in chapter one. This chapter also describes motivation, objectives of the research work and motivation. Backgrounds theory is presented in chapter two. In chapter three, Methodology of the person tracking and obstacle Avoidance mobile robot is presented in this chapter. In chapter four, Design and Implementation of person tracking and mobile robot is explained. The conclusion of the research work is drawn in chapter five. In this chapter, future extension and limitations of the system are also described in this chapter.

CHAPTER 2

BACKGROUND THEORY

Mechanized Guided Vehicles have numerous possible applications in assembling, medication, space and protection. Hindrance Avoidance Robot is utilized essentially in implanted frameworks. The primary extent of the framework is to naturally redirecting automated vehicle as required at whatever point any boundary comes on its methodologies. It evades any static boundaries before the robot and afterwards will follow the committed individual. There are a few ways to deal with the individual following robot and they are momentarily made sense of as follow.

2.1 Vision -Based Approach

It is a system using a camera to get the picture of the objective person. The picture should be invigorated ceaselessly. This technique expects that the objective individual acknowledgment is productive, but this may consistently be a test. Resulting to recognizing the objective person in an image, the control information, including headings and distances, will be handled from the assortments of the goal position and size in the image. The robot should then have the choice to push towards the objective person considering this information. Different investigates have taken on and changed this method for managing foster the singular following compact robots. Regardless, a couple of weaknesses can regardless be adequately basic to influence the efficiency of target ID. One component that impacts the ID is light condition. Concluding the objective person in the image can be to some degree more problematic when the assortment or splendor of the goal is not adequately surprising to make it not exactly equivalent to that of the establishment or various hindrances. Another component that impacts acknowledgment is the simultaneous development of individual and robot. The vision sensor can lose objective person when the objective individual moves unreasonably quick. A couple of researchers used powerful cameras. This reduced the issue of losing the objective individual, but extended the difficulty in the computation plan. This method is not fitting for the robot to perform obstruction revulsion. It is difficult for the robot to separate between the objective individual and various obstacles. The situation might be more lamentable when there are a couple of individuals moving around in a comparative environment. It is possible and sensible for the robot to lose the objective individual expecting that the environment is unstructured, strategies [9]. As illustrated in figure 2.1.

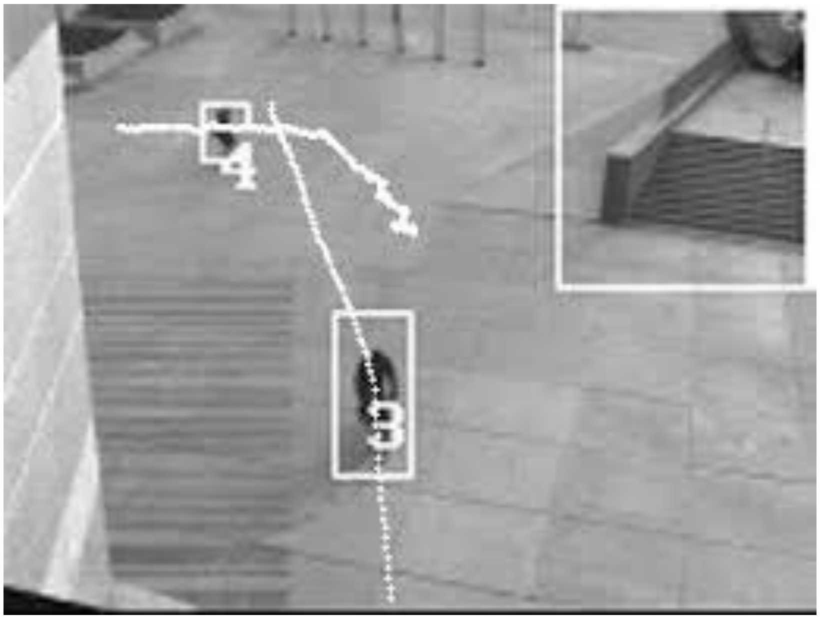

Figure 2.1 Camera Based Tracking

2.1.1 Appearance-based methods

Appearance put together strategies that recognize areas with respect to the premise of tangible similitudes are a promising conceivable answer for versatile robot route. The primary thought behind the procedure is to head the robot towards the snag free position utilizing similitudes between the layout and the dynamic pictures (F. Vassallo et al., 2000). The likeness between the picture examples can be got by utilizing highlight finders, including corner based locators, locale based indicators and dispersion based descriptors (Alper et al., 2006). In any case, the vast majority of these strategies consume a great deal of cycle on time which is not fitting for continuous frameworks. To deal with this issue in portable robot applications, calculations are planned in light of the presence of individual pixels. The order of the hindrances is done by utilizing the pixel distinction between the layout and dynamic picture designs. In basically, any pixel that contrasts in appearance starting from the earliest stage named an impediment. Notwithstanding, the strategy requires three presumptions that are sensible for different indoor and open air conditions which are (Saitoh et al., 2009):

- Obstacles must be different in appearance from the background.
- The background must be flat.
- There must be no overhanging obstacles.

The principal supposition is to recognize snags from the beginning, the second and third suspicions are expected to gauge the distances between identified impediments and the robot. There are a few models for addressing variety.

The principal model is the RGB (Red, Green, Blue) model which is utilized in screen screens and most picture document designs in any case, variety data for RGB model is extremely uproarious at low Intensity. The RGB design is generally changed over completely to a HSV (Hue, Saturation, and Value). In HSV, Hue is what people see as variety, S is immersion and Value is connected with brilliance, (or HIS (Hue, Intensity, Saturation) model) and in HIS, H and S addresses equivalent to boundaries in HSV variety models yet I am a force esteem with a reach between [0,1] where 0 is high contrast is 1. These variety spaces are thought to be less delicate to commotion and lighting conditions. The information picture is first convolved with a smoothing channel to lessen the commotion impacts, and afterward smoothed picture is changed over completely to HIS, HSV or any connected variety space regarding the created calculation (Fazl-Ersi and Tsotsos, 2009). A reference region is gotten from this picture which may be any state of math, for example, trapezoidal, triangle or square, and histogram upsides of this reference region are produced (Saitoh et al., 2009). At long last, an examination between the describe picture and the ongoing picture is made utilizing some predefined limit values. For example, accept that the receptacle esteem, Hist (H (x, y)), of the produced histogram and the edge value,TH, are thought about, where H(x, y) is the H esteem at pixel (x, y). On the off chance that Hist (H (x, y)) > TH the pixel (x, y) is arranged into the protected area, or, in all likelihood it is characterized into the snag district.The outcomes are addressed to the issue in a paired pictures in which the protected way.It is addressed with white yet the deterrents are addressed with dark. Notwithstanding, distinguishing puts simply based on tangible similitude is excessively shortsighted; better places might look basically the same, even with a rich detecting technique because of lighting conditions, shadows on brightening Furthermore, for dynamic conditions there may be surprising stains on the ground which might be the identified as a hindrance and leads the robot to a perilous path.

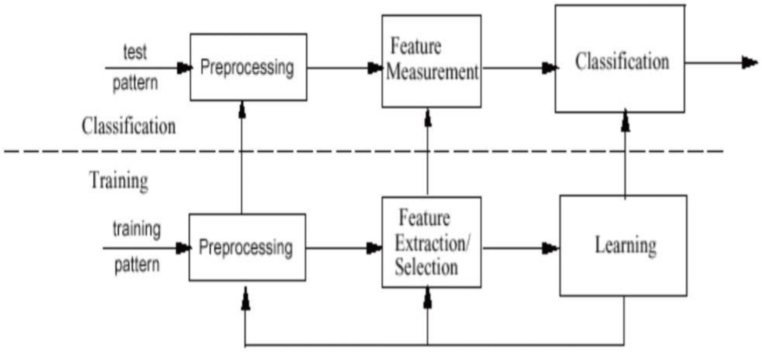

Figure 2.2 Appearance Based Methods

2.1.2 Self-Localization

Firstly, the mobile-robot delivers an assumption picture utilizing its ongoing best gauge of where its current area is. Then, the model edges removed from the assumption picture are contrasted and coordinated and the edges separated from the camera picture through a drawn out Kalman channel. The Kalman channel naturally then yields refreshed values for the area and the direction of the mobile-robot. The represent the course of self-restriction in Figure 2.3. In Figure 2.3 (a) shows a common camera picture.

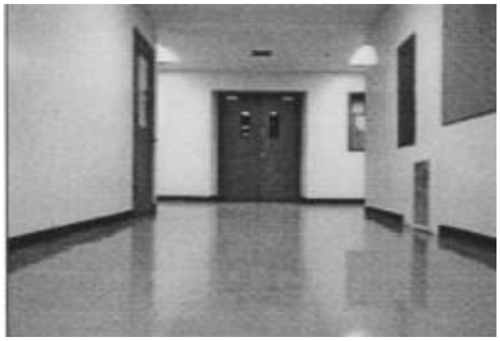

Figure 2.3 (a) Camera Picture

Displayed in Figure 2.3 (b) is an assumption picture delivered from the wire-outline model of the climate; this assumption map is overlaid on the camera picture. As may be obvious, the disparity between the different edges in the fundamental camera picture and the featured edges in the assumption map is brought about by the blunder between where the robot really is and where the robot thinks it is.

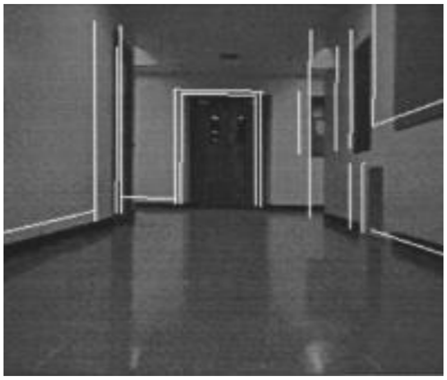

Figure 2.3 (b) Expectation Map Overlaid On The Camera Picture

Displayed in Figure 2.3(c) are the edges removed from the camera picture. Note specifically that not all dark level varieties in the camera picture convert into edges. As made sense of in [6], this is because of the way that the framework just searches for those edges in the camera picture that are in vicinity — both spatially and in the Hough space — to the edges in the assumption map.

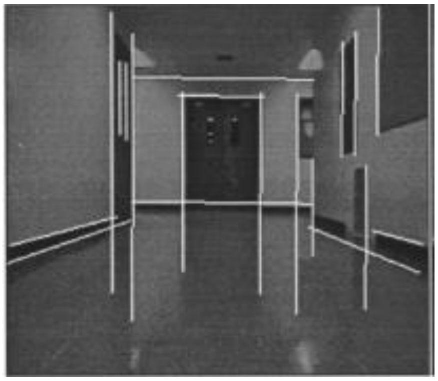

Figure 2.3 (c) Edges Extracted From The Camera Picture

Displayed in Figure 2.3 (d) is a re-projection into the camera casing of those model edges that were effectively utilized for self-confinement. The way that these re-projected edges fall precisely where they ought to be a declaration to the exactness of the outcome created by the Kalman channel.

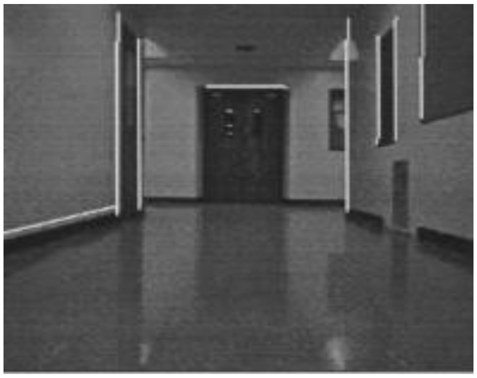

Figure 2.3 (d) Matched Model Edges Reprojected into The Camera Frame

Displayed in Figure 2.3 (e) are two little symbols, in nearness to one another, the splendid one relating to the refreshed position and direction of the robot and the fairly obscured comparing to the old position and direction.

Figure 2.3 (e) Two small icons showing the robot's old and the updated positions in the hall

In Figure 2.3 (f) is an augmented adaptation of the picture in Figure 2.3 (e). By rehashing the self-restriction, the robot can address its position blunder and explore independently toward its destination.

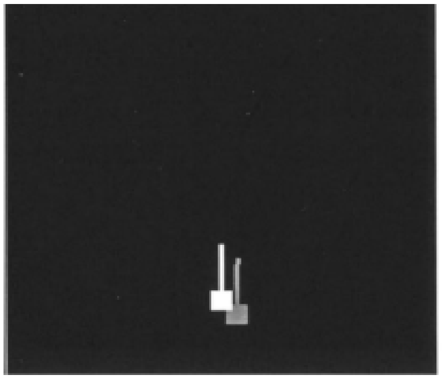

Figure 2.3 (f) Enlarged Version Of (e). The Gray Icon Is for The Old Position and The White Icon Is for The Updated Position

2.2 Non Vision-Based Approach

Non vision-based approach uses a couple of various rangefinders, similar to sonar sensors, infrared sensors, and others sensor. These rangefinder on the robot can know the distance between the nearest article and the real rangefinder. Since the robot cannot perceive thing and target individual, this approach should be taken on to do either obstruction repugnance while reviewing all of the articles as obstacles or individual following when the objective individual is for the most part the nearest thing to the robot with no in the center between. Using a Nomad 200 flexible robot outfitted with 16 sonar rangefinders, the distance of the thing can be handled by the nearest sonar unit, and the harsh heading moreover not completely settled from the overall area of the sonar unit, which distinguishes the nearest distance. The robot can be gainfully modified to perfect obstacle avoidance. Nevertheless, the robot which executes individual following endeavor, even in an environment with a fair condition, is at this point problematic and not feasible.

2.3. Transmitter and Receiver Based Approach

Using a transmitter and beneficiary methodology, the transmitters arranged on the objective individual convey messages, as ultrasonic sound-waves or squinting LED. The authorities arranged on the robot get those signs. Resulting to calculating the distance and the place of the objective person from those signals, the robot knows where to push to go itself towards the objective individual and reduction the in the center between. In [8], As follow two transmitter-and-recipient based approaches have been discussed.

- Person Tracking Using Blinking LED Devices: These are requires furnishing the objective person with two infrared LED device contraptions with fixed distance among them and using a camera on the robot to distinguish the two contraptions. This resembles the vision-based approach. The chief differentiation is that the signs from infrared LED contraptions should be firmer and not affected by the exacerbation there of brain, for whatever length of time they are not obstructed by any deterrent. The camera turns and to keeps the objective person in the image. By enlisting the distance between two LED lights and the deviation of the two lights from the central vertical center point in the image, the compass and the heading of the objective individual can be obtained independently by the robot.
- Person Tracking Using an Ultrasonic Positioning System: This system is to set up the ultrasonic transmitters on the objective individual and the recipients on the robot. By handling the time stretch among sending and getting the ultrasonic sign, the distance between the objective individual and the robot which are not altogether permanently established. The point can moreover be figured from the time defer between a couple of beneficiaries. These systems are straight-through for individual understanding, but they are not sensible when there are checks between the objective individual and the robot. The disclosure of blocks will be an issue using these approaches. With basically have no other additional instrument, the robot cannot execute obstacle aversion.

2.4 Intelligent Space Approach

The wise space approach utilizes a couple of sensors, for instance, visual or non-visual sensors that are arranged in the environment to perceive both the robot and the objective person. Along these lines, the location information of the robot and target individual will be in the overall not altogether permanently established by the sensors in the shrewd space. From the general spots of the robot and the objective individual, the robot development will be organized by this savvy space and controlled through the association [8]. In any case, the ideal procedure in this investigation is to design an autonomous robot that completes tasks in unstructured circumstances. This approach then, becomes an unacceptable notwithstanding the way that it may be worked all over.

2.5 Various Types of Sensors for Detection

A sensor is a machine that hunts and responds to particular sorts of contribution from the environmental elements It may be converted into data that can be deciphered by people or machines. The particular information could be movement pressure, temperature, gas or something of other natural cycles.

A result is by and large a sign this is changed to intelligible demonstrate communicated electronically over an organization or at the sensor area for additional handling or perusing. A sensor changes over inspiration like light and interaction of move into electrical signs. These signs are succeeded by a connection point that change language them into a parallel code and it is shipped off a PC for handling. Coming up next is a rundown of normal sensor types utilized in different applications. Various kinds of many sensors are:

- Proximity
- Accelerometer
- IR Sensor (Infrared Sensor)
- Pressure
- Light
- Touch
- Flow and Level
- Position
- Magnetic (Hall Effect Sensor)
- Microphone (Sound Sensor)
- PIR
- Strain and Weight
- Ultrasonic

There are numerous classifications of various sensors such as Active and Passive. Dynamic Sensors are those which request a power signal or an outer sign. Latent Sensors direct the result reaction without requesting an outside power signal. One more kind of arrangement depends on the method for creation utilized in the sensor. The last characterization of the identification sensors is Digital and Analog Sensors. Simple sensors identify the simple result, a persistent result signal related with a deliberate number.

Information on computerized sensors utilized for variance and transmission is advanced in nature.

2.5.1 Proximity Sensor

The proximity sensor is a sensor that can be radiated to local items without actual contact as displayed in Figure 2.4[15]. The closeness sensor sets a light emission free from an electromagnetic field or light field, and frequently distinguishes changes in the return signal or in the field. Not a similar vicinity sensor targets guarantee not similar sensors. Closeness sensors might have a high unwavering quality and long useful life due to the need of mechanical parts and without actual contact between the detected item and the sensor. Closeness sensors are utilized to screen the vibration between the shaft and its help bearing.

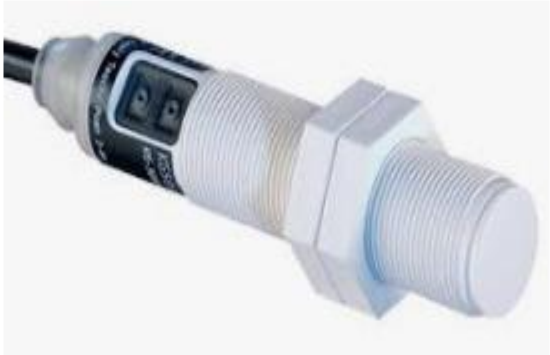

Figure 2.4 Proximity sensor

2.5.2 Accelerometer Sensor

The accelerometer sensor might be utilized to gauge the advanced upon the sensor as displayed in Figure 3.3[16]. An accelerometer is an electronic sensor that actions the speed of an article in space to decide the condition of the item in space and to 11 screen its movement. Speed increase is the pace of progress of an item's speed, which is a vector amount. There are two kinds of speed increase powers: dynamic and static. Static power is the power applied on an article. Dynamic powers are the powers that continue on an article at various speeds.

Figure 2.5 Accelerometer Sensor

2.5.3 IR Sensor (Infrared Sensor)

Infrared (IR) Sensor Module is a distance nearness sensor "switch". At the point when an article or obstruction nearly hinders the screen before two LEDs. It starts an infrared transmitter-recipient module as displayed in Figure 3.4. The reasonable LED is the IR transmitter while the dark LED is the IR beneficiary.IR sensor show in figure 2.6[17].

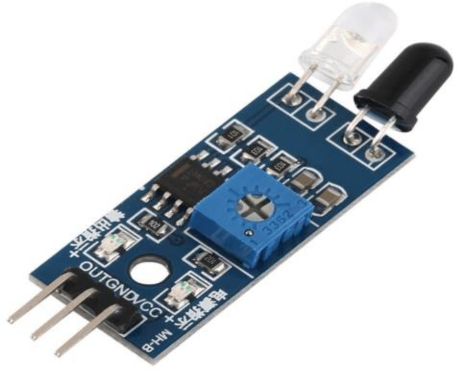

Figure 2.6 IR sensor

It uses the electromagnetism reflex guideline where when the reflection surface (object) is nearer, the beneficiary will acknowledge more grounded signal from transmitter because of more limited travel distance of reflected of wave. The IR Sensor Module incorporates a digit yield fundamental sign framework. Computerized Output is high or low, so this module might be utilized as a beginning button, however not as a distance meter. It distinguishes article or boundary inside twenty centimeters before the transmitter-beneficiary IR LEDs.

2.5.4 Ultrasonic Sensor

Ultrasonic Sensor is done by transmit signal wave at mighty frequency that can touch human. And then, that point works out the distance at the necessary time and trust that sound will return. Sensor measure distance are not difficult to know and dependable and without harm. Ultrasonic sensor given two centimeters - four hundred centimeter or one feet to thirty feet distance activity of estimation take it, and then layered exact could reached three millimeters. Ultrasonic position sensor has high level of signal transmit to human and receive those signals by sensor receiver. In figure 2.7[14], Describe the ultrasonic sensor and the ultrasonic sensor work is as follow in figure 2.8[14].

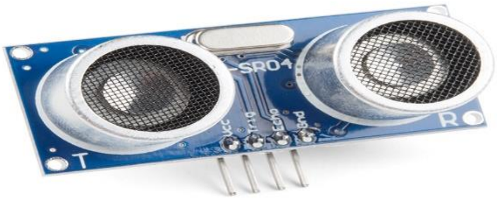

Figure 2.7 Ultrasonic Sensor

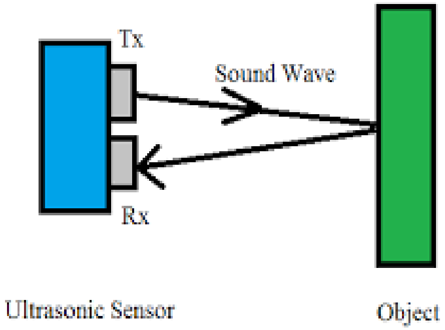

Figure 2.8 Ultrasonic Position Sensor

2.6 Description the Person Tracking and Obstacle Avoidance Algorithms

All of the algorithms are background algorithms for person tracking and obstacle avoidance mobile robot.

2.6.1 The Bug Algorithms

These simplest obstacle avoidance algorithms described is called “the bug algorithm”. According to this when an obstacle is encountered, the robot fully circles the object in order to find the point with the shortest distance to the target, and then go the boundary of the obstacle from this point in figure 2.9[8].

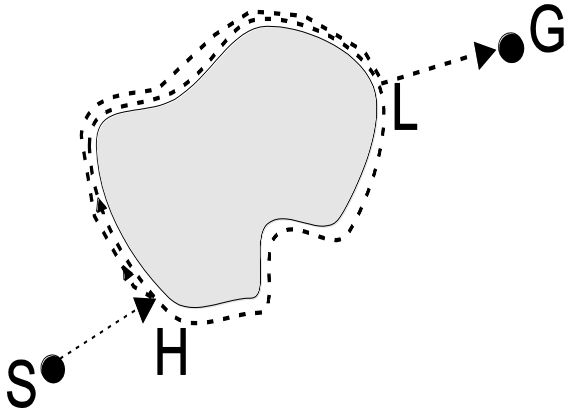

Figure 2.9 The Bug Algorithm

2.6.2 Potential Field Algorithm

While the bug algorithms are based on a purely reactive approach, the following algorithms tend to view the obstacle avoidance as a sub-task of the path planning, in a deliberative approach.

The potential field algorithm assumes that the robot is driven by virtual forces which attract it towards the goal, or reject it away from the obstacles. The actual path is determined by the resultant of these virtual forces in figure 2.7 and Figure 2.10[8].

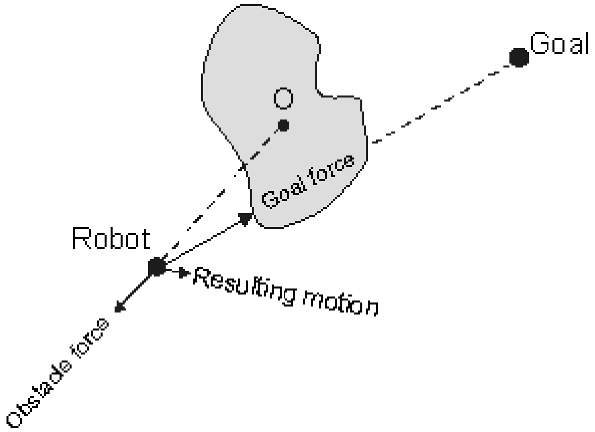

Figure 2.10 Potential Field Algorithm

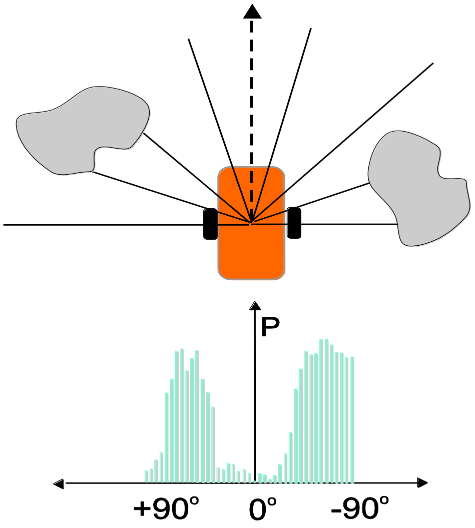

Figure 2.11 Polar Histogram used in VFH method

2.6.3 The Bubble Band Technique

These method defines a "bubble" containing the maximum available free space around the robot, which can be travelled in any direction without collision. The shape and size of the bubble are determined by a simplified model of the robot's geometry and by the range information provided by the sensors.

2.6.4 Vector Field Histogram Method

Vector Field Histogram, or VFH algorithm overcomes the problem of the sensors noise by creating a polar histogram of several recent sensor space around the robot. Show in figure 2.12[8].

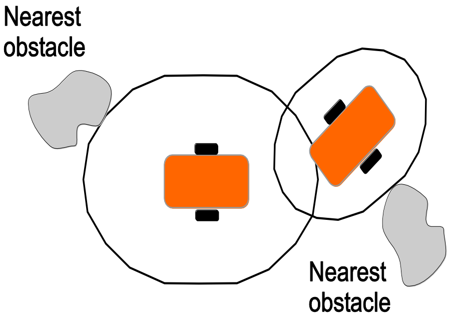

Figure 2.12 Bubble Band Concept

2.7 Summary

This chapter presents the detail of theory background about person tracking and obstacle avoidance mobile robot and then various types of avoidance algorithms are reviewed and various sensor are described in details.

CHAPTER 3

Methodologies

In this system, Bubble Rebound Algorithm is used for person tracking and obstacle avoidance mobile robot implementation.

3.1 Bubble Rebound Algorithm

This system aims to cover the robot from collision when tracking and which could damage the robot system. When the bumper sensor sets an input signal as 1, the process should go directly to "stop." If the bumper sensor signal value is not set, the person tracking can be continued. When the sensor ranges are smaller than the 20 cm threshold, the action for obstacle avoidance should be made. In the event that the former situation no longer exists, the robot is taking out in tracking the person. The detail processing steps are explained as following sections.

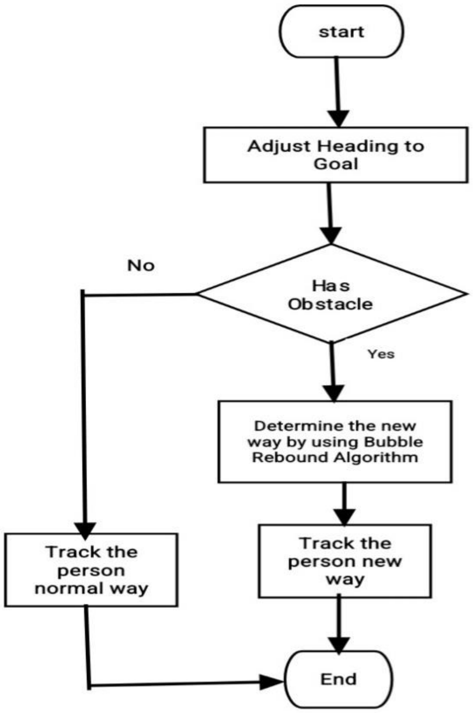
start
Adjust Heading to Goal
No
Has Obstacle
Yes
Determine the new way by using Bubble Rebound Algorithm
Track the person normal way
Track the person new way
End

Figure 3.1 The System Flow

3.2 Implementation of Bubble Rebound Algorithm

Show in Figure 3.2, flow of the Bubble Rebound Algorithm. Firstly, robot move to person. In way track obstacle is detected, the robots “rebounds” in a new direction using Bubble Rebound Algorithm.

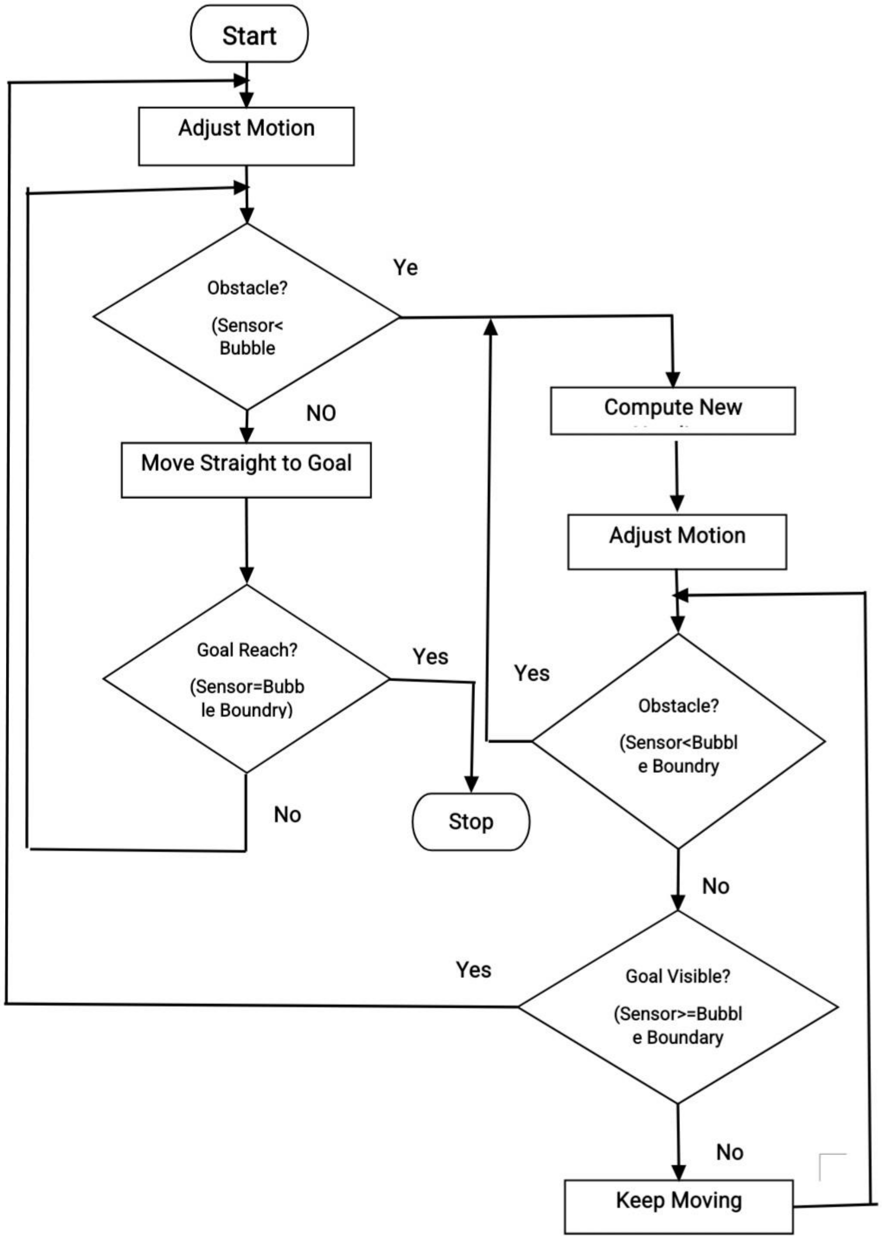

Figure 3.2 Flow of the Bubble Rebound Algorithm

3.2.1 Specific range of Bubble Rebound Algorithm

In Figure 3.3, range A is Ultrasonic Sensors range and range B is Sensitivity Bubble Boundary range of the Ultrasonic sensors. ∝ is the bubble boundary angle of ultrasonic sensors.

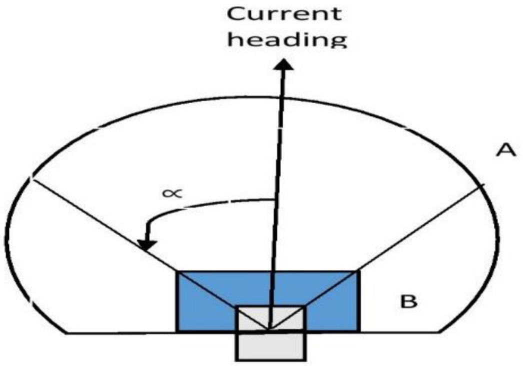

Figure 3.3 Bubble Rebound Range and Angle Of Ultrasonic Sensors

3.2.2 Process of Bubble Rebound Algorithm

In figure 3.4[8], description of the rebound working. In this figure, "S" is the robot start point. "H" is the hit-point a position of the robot at the time of the detection of an obstacle. "V" is the point where the robot again visibility of the target and "G" is the target.

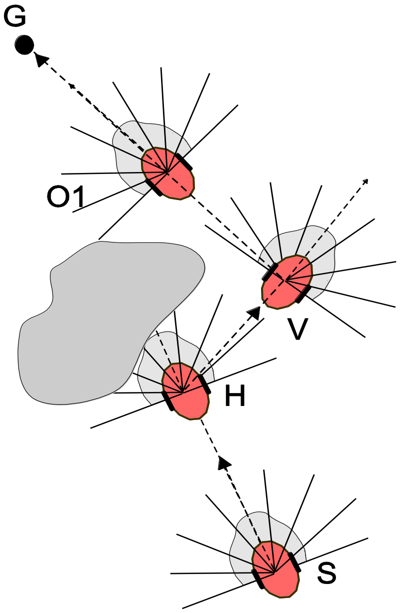

Figure 3.4 Process Of Bubble Rebound Algorithm

3.3. Using Bubble Rebound Algorithm for Obstacle Avoidance

Firstly, the mobile-robot moves straight towards the goal. If an obstacle is detected within the sensitivity bubble, the robots “rebounds” in a direction found as having the no obstacles, and continues its motion in new direction until the target becomes visible. Depending on the condition of the mobile robot is able to choose the true path. A determination makes process of barrier avoiding the outside limit of an object area detection occurs as a result of a sudden impulse and without premeditation.

If N is the number of ultrasonic sensors, the following code defines the sensitivity bubble range:

```
unsigned int ultrasonic sensor_range [N];
unsigned int Sensitivity Bubble Boundary[N];
Sensitivity Bubble Boundary[i]=K_i*V*delta_t;
int check_for_obstacles(void)
  {
  for (i=0; i<N; i++)
  {
  If (ultrasonic sensor_readings [i]<=Bubble_Boundary[i]
  return (1);
  }
  else return (0);
  }
```

Show in figure 3.5[1], robot is turn the right when obstacle has been left. Because left sensor range is smaller than the sensitivity bubble boundary range.

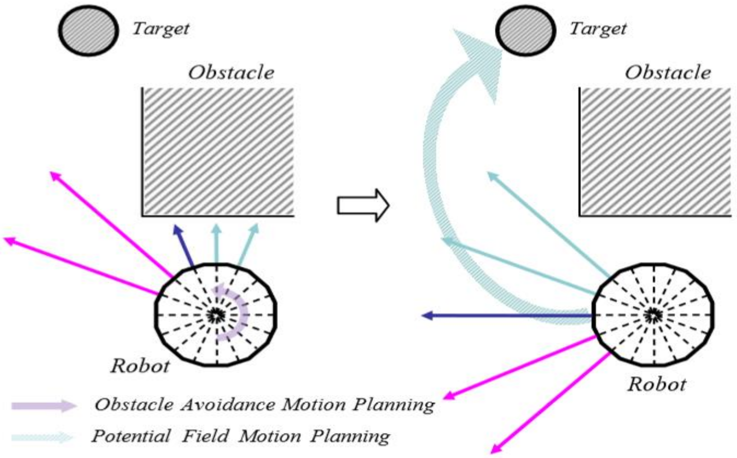
Target
Obstacle
Robot
Target
Obstacle
Robot
Obstacle Avoidance Motion Planning
Potential Field Motion Planning

Figure 3.5 Right Turn The Robot For Obstacle Avoidance

In figure 3.6[1], robot is turn left when obstacle is right. Because sensor range is smaller than the bubble boundary range.

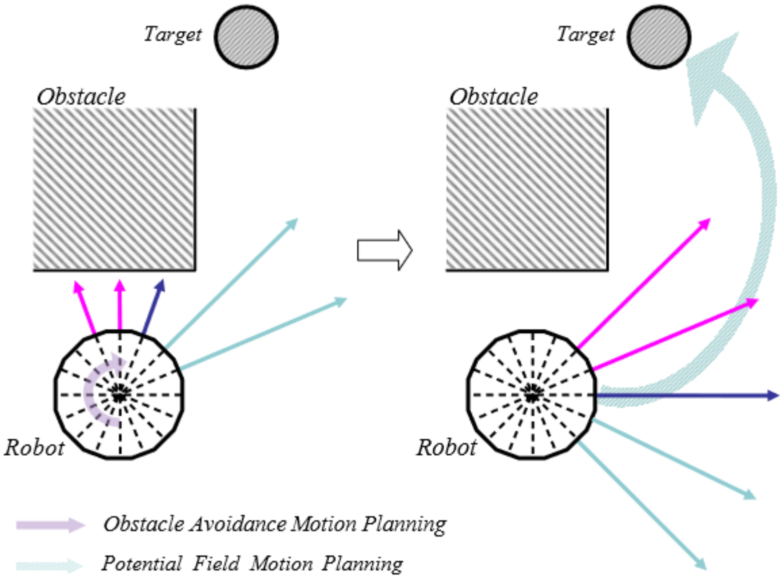
Target
Obstacle
Robot
Target
Obstacle
Robot
Obstacle Avoidance Motion Planning
Potential Field Motion Planning

Figure 3.6 Left Turn The Robot For Obstacle Avoidance

Show in figure 3.7[1], robot is turn right when obstacle is front of the robot. Because front sensor and left sensor range is smaller than the bubble boundary ranges of the sensor.

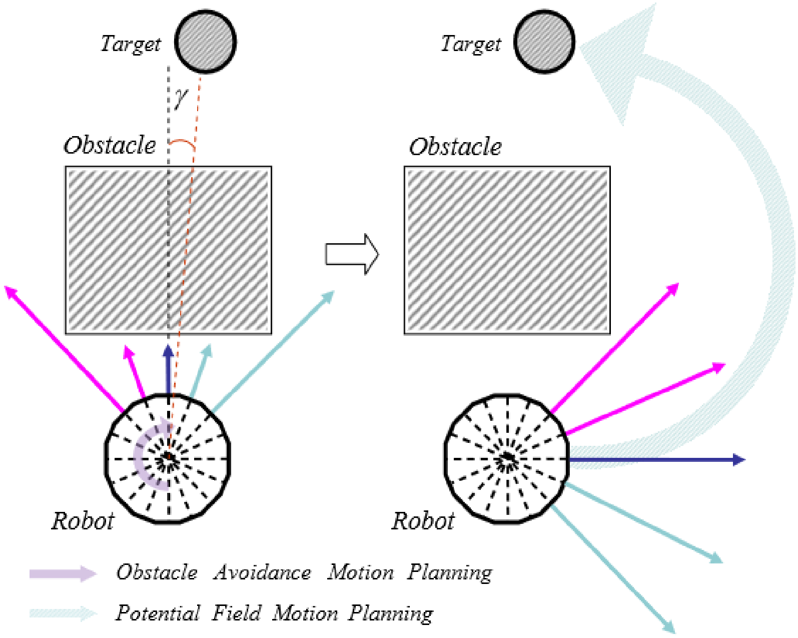
Target
γ
Obstacle
Robot
Target
Obstacle
Robot
Obstacle Avoidance Motion Planning
Potential Field Motion Planning

Figure 3.7 Obstacle Avoidance for left (obstacle in front of the robot r>0)

Show in figure 3.8[1], robot is turn left when obstacle is front of the robot. Because front sensor and right sensor range is smaller than the bubble boundary ranges of the sensor.

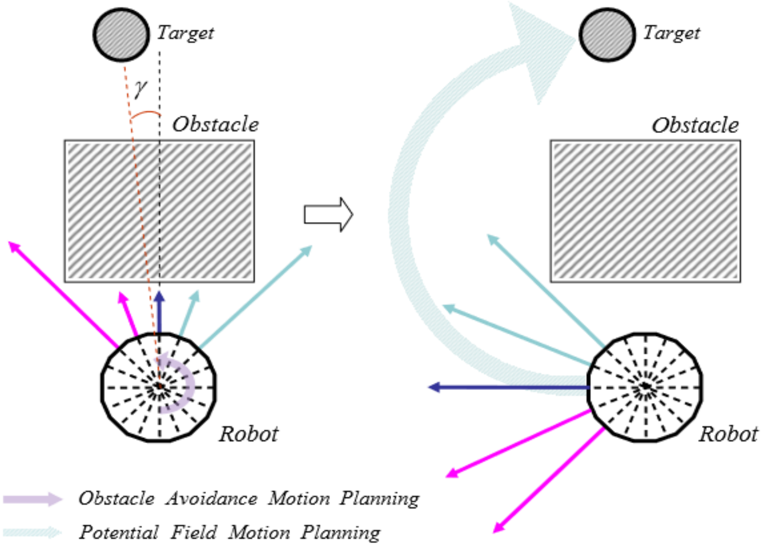
Target
γ
Obstacle
Robot
Target
Obstacle
Robot
Obstacle Avoidance Motion Planning
Potential Field Motion Planning

Figure 3.8 Obstacle Avoidance for right (obstacle in front of the robot r<0)

3.4. Using Bubble Rebound Algorithm for Person Tracking

Firstly, the robot moves straight towards the tracked person. If an obstacle is detected within the sensitivity bubble, the robots “rebounds” in a direction found as having the no obstacles, and continues its motion in new direction until the goal becomes visible. If the person is a moving condition, the tracking system maintains the distance between the Person and Robot at 60cm. If the person is detected the front view of the robot and the distance of the robot and the person is greater than 40cm, it keeps going on. Although the person is detected the front view of the robot, but the person is not moving; the robot goes straight to track person until the distance is greater than 30 cm.

If N is the number of ultrasonic sensors, the following code defines the sensitivity bubble range:

```
  unsigned int ultrasonic sensor_range [N];
  unsigned int Sensitivity Bubble Boundary[N];
  Sensitivity Bubble Boundary[i]=K_i*V*delta_t;
  int check_for_trackig(void)
        {
        for (i=0; i<N; i++)
        {
        If (ultrasonic sensor_readings [i]<=Bubble_Boundary[i]
        return (1);
        }
        else return (0);
        }
```

3.5 Detection for the Person Tracking and Obstacle Avoidance

The rebound angle is calculating by weighted arithmetic mean. Weighted arithmetic mean is computed by using following equation:

$$\bar{x} \;= \frac{\sum_{i=1}^{N} \propto_i w}{\sum_{i=1}^{N} w_i} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \;\mathbf{3.1}$$

- $\bar{x}$ is the weighted arithmetic mean
- w is the weight
- x is the data

In weighted arithmetic mean is the rebound angle $\propto_R$, the data are the ultrasonic sensor angles $\propto$ and the weights are the distance values d , reported by the sensors. So

$$\propto_R = \frac{\sum_{i=1}^{N} \propto_i d_i}{\sum_{i=1}^{N} d_i} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \;\mathbf{3.2}$$

3.5.1 Distance Detection for the Person Tracking and Obstacle Avoidance

The Speed of Sound for ultrasonic sensor is v=343 m/s. So, Velocity of the Ultrasonic Sensor is v=0.0343 cm/μs.

V=1/29.1 cm/μs……………………………………………………………… 3.3

The time delay for ultrasonic sensor is in Equation 3.4.

Travel Time = distance / Speed of sound ……………………………………… 3.4

By calculation in equation 3.4, We know distance between transmitting and receiving signal.

Distance = (travel time / 2) * Speed of sound 3.5

3.6 Components List of the Proposed Robot and Explanation

By using of this components, developing the person tracking and obstacle avoidance mobile robot.

- **GM25-370-24140 DC Gear Motor**

  DC Gear motor show in figure 3.9[18]. It consists of an electric DC motor and a gearbox or gearhead. This gearhead is used to reduce the DC motor speed, while increasing the DC motor torque. So, user can get lower speed and higher torque from gear motor.

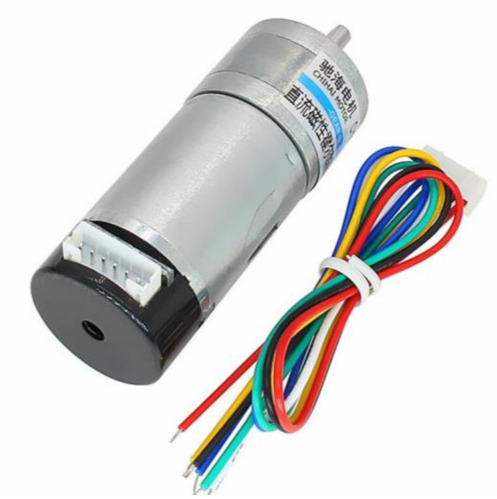

Figure 3.9 GM25-370-24140 DC Gear Motor

- **25mm Motor Bracket**

By adding the motor bracket in robot [19], this is the support of our motor or as alternatives mounting options. Motor Bracket dimensions is 1.2x1.2x1inches (31x31x26 mm)

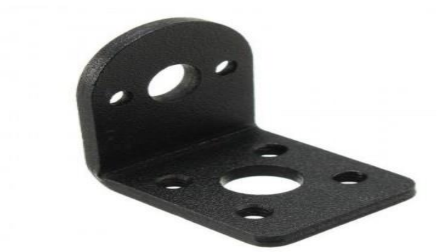

Figure 3.10 25mm Motor Bracket

- **DC Motor Wheel**

  In system, used the four wheels at robot. Four wheeled robots are the most balanced robots among another wheeled robot style. DC motor wheel is shown in figure 3.11[11].

Figure 3.11 DC Motor Wheel

- **Motor Driver HW-095**

  Motor drivers acts as an interface between the motors and the control circuits. It can control both speed and spinning direction of DC motors. The function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor. Show in figure 3.12[12]and Specification of the HW-095 are as follow in Table 3.1.

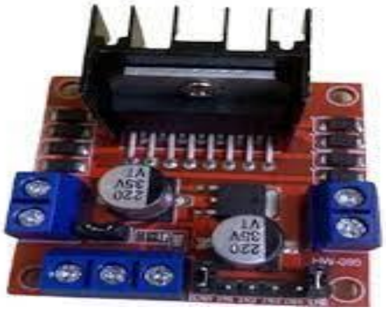

Figure 3.12 Motor Driver HW-095

Table 3.1 Specification of Motor Driver

Type	Working Tempters
Operation Voltage	7 to 35 Voltage
Current	2 A
Max power consumption	200W
Size	55mm*49mm*33mm
Weight	33 g

- **LM2596 Adjustable Power Supply**

  The DC-DC Step-down Adjustable Power Supply Module with 3digit LED Display is based on monolithic integrated circuit LM2596, basils suited for easy and convenient design of a step–down switching regulator. LM2596 Power supply is in figure 3.13[20].

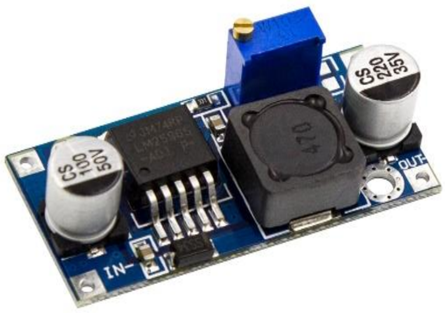

Figure 3.13 LM2596 Adjustable Power Supply

- **UNO Prototype Shield**

  Arduino UNO Prototype Shield (Robot DYN) [21] is specifically developed for easy connection between Arduino Mega and other devices.

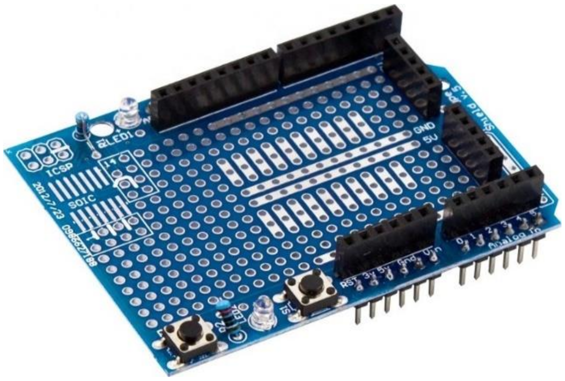

Figure 3.14 UNO Prototype Shield

- **Arduino Mega Board**

  Arduino Mega depends on the Atmega 2560 microcontroller. It includes digital input and output pins-54, where 16 pins are analog inputs, 14 are used PWM outputs hardware serial ports, an ICSP header, a power jack, a USB connection and reset button. The power supply of this board can be done by connecting it to a PC using a USB cable, or battery or an AC-DC adapter. The operating voltage of this microcontroller is 5volts, but the input Voltage will range from 7volts to 12volts.Figure of Arduino Mega Board show in figure 3.15[10] and Specification of the Mega Board are as follow Table 3.1[10].

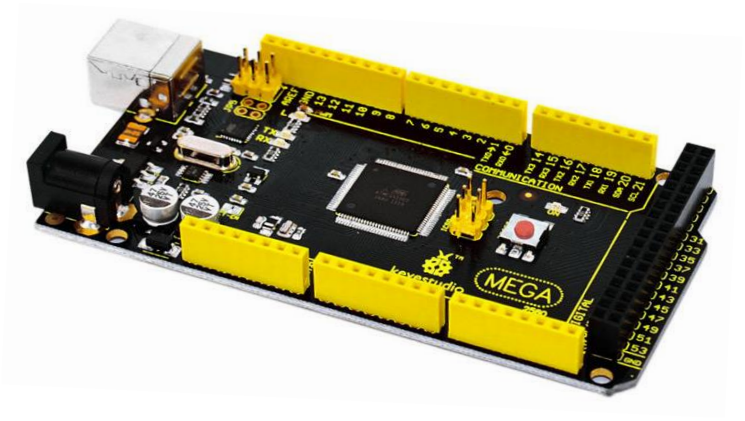

Figure 3.15 Arduino Mega Board

Table 3.2 Specification of Mega Board

TYPE	Working Tempters
INPUT VOLTAGE (LIMIT)	6-20V
DIGITAL I/O PINS	54 (of which 15 provide PWM output)
ANALOG INPUT PINS	16
DC CURRENT PER I/O PIN	20 mA
DC CURRENT FOR 3.3V PIN	50 mA
FLASH MEMORY	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
CLOCK SPEED	16 MHz
LED_BUILTIN	13
LENGTH	101.52 mm
WIDTH	53.3 mm
WEIGHT	37

- **Cells Lithium Battery 1500mAh**

  Lithium 103450 3.7V, 1500mAh rechargeable Li-Po battery is high quality and durable with large capacity of 1500 mAh , less worry when battery’s going dead with a short time. Show in figure 3.16 [13] and features of Li-Po battery are as follow in Table 3.3[13].

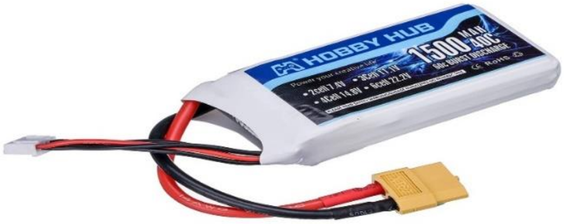

Figure 3.16 Cells Lithium Battery 1500mAh

Table 3.3 3-Cells Lithium Battery 1500mAh

Type	Working Temperature
Capacity	1500mAh
Rechargeable	Yes
Charging Voltage	4.2V
Rated	3.7V
Working Temperature	10de-50de

- **DIY Robot Chassis**

DIY robot kit is a special built kit for construction for mobile robot, especially automatic mobile robot is shown in figure 3.17 and figure 3.18.

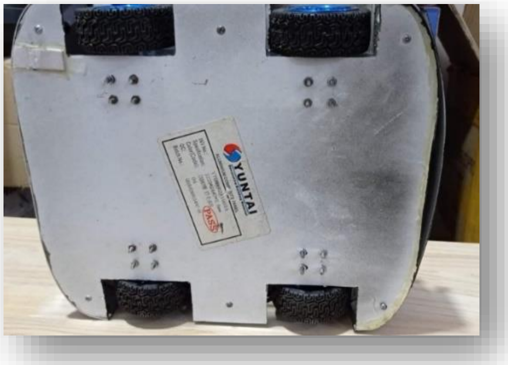

Figure 3.17 DIY Robot Chassis(Back)

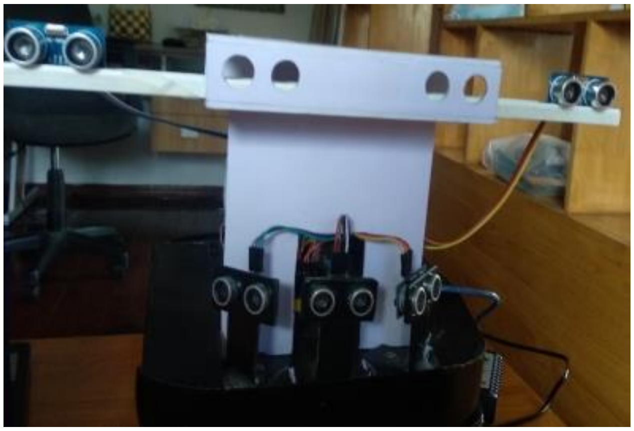

Figure 3.18 DIY Robot Chassis (Front)

Table 3.4 DIY Robot Chassis

Use Of Components	Quantity(pcs)
GM25-370-24140 DC Gear Motor	4
25mm Motor Bracket	4
DC Motor Wheel	4
Motor Driver HW-095	1
LM2596 Adjustable Power Supply	1
UNO Prototype Shield	1
Arduino Mega Board	1
3-Cells Lithium Battery 1500mAh	1
DIY Robot Chassis	1
Ultrasonic HC-SR04 Distance Measuring Sensor	3
Ultrasonic HC-SR04 Position sensor	2

- **Ultrasonic HC-SR04 Distance Measuring Sensor**

  The HC-SR04 ultrasonic sensor uses sonar to determine distance to an object like bats do. There are only four pins that are VCC (Power), Trig (Trigger), Echo (Receive), and GND (Ground). Ultrasonic sensor function is send sound waves from the transmitter, which then bounce off of an object and then return to the receiver. By calculating the travel time and the speed of sound, the distance can be calculated. Describe the figure 3.19[14].

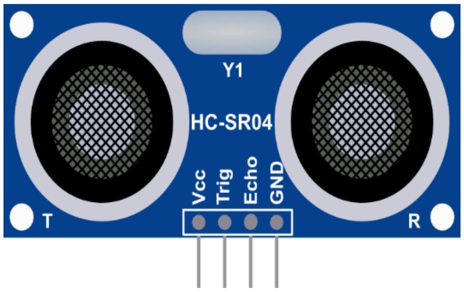

Figure 3.19 Ultrasonic sensor

- **Ultrasonic Position Sensor**

  Ultrasonic Sensor are done by transmitting signal wave at mighty frequency that can touch human. Ultrasonic position transmitter section send signal and then back those signal to sensor's receiver. So, the sensor knows a distance between sensor and person. Ultrasonic position sensor work is as follow figure 3.20[22].

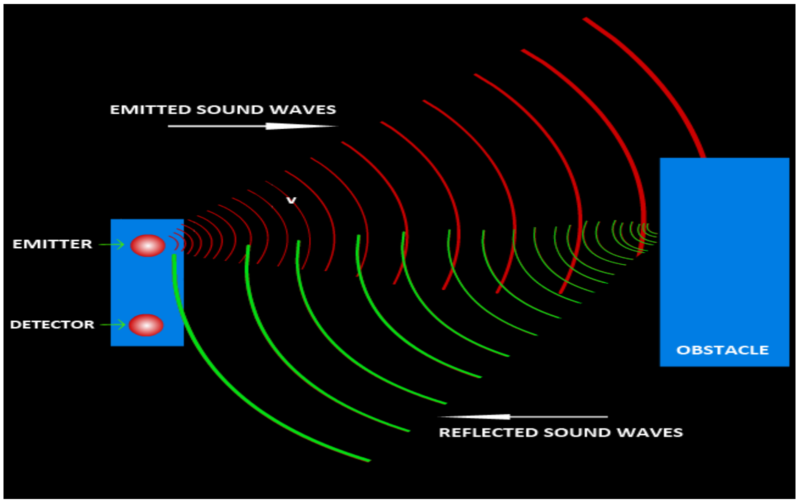

Figure 3.20 Ultrasonic position sensor

3.7 Summary

The ultrasonic position system based on bubble rebound algorithm is implemented as the mobile robot. And then explain the use of components detail. The architecture of the proposed system consists of ultrasonic distance sensor and ultrasonic position sensor.

CHAPTER 4

System Design and Implementation

In this section, description of the real time experiment result for obstacle avoidance person tracking mobile robot.

4.1. Implementation of the System

The robot uses an ultrasonic sensor to detect the nearest level is 30cm for the consideration of obstacle, and the nearest level of the person tracking is 40cm, 60 is considered as the farthest distance and the distance between 40 and 60 is the intermediate distance. The robot uses an ultrasonic sensor to detect if there is a barrier in the path, and it combines the bubble rebound control algorithm and microcontroller to determine which direction to go and changes direction from the DC motor. When the robot detects a barrier in its path of person tracking, it stops, looks left and right, and then turns to the direction indicated by the extra space in front of it and goes until the person is tracked.

There are two parts in system implementation. These are software implementation and hardware platform.

Software Implementation: In this proposed system, the software is developed by using C++ language on Arduino IDE. There are three ultrasonic sensors for obstacle avoidance and two ultrasonic sensors for person tracking, and starting from a possible situation under the control of bubble rebound algorithm. This robotic system is developed on the Arduino MEGA board and the testing conditions are shown in followings.

Motor Pin Definition

```
int ledPIN_1=14; // Motor IN 1

int ledPIN_2=15; // Motor IN 2

int ledPIN_3=16; // Motor IN 3

int ledPIN_4=17; // Motor IN 4
```

Control Rule 1: Person Stop and Following Robot Also Stop

```
if (FrontSensor<30)
{
digitalWrite (ledPIN_1, LOW); digitalWrite (ledPIN_2, LOW);
digitalWrite (ledPIN_3, LOW); digitalWrite (ledPIN_4, LOW); delay (500);
Serial.println(" Stop ");
}
```

In this condition, the following robot is stopped because of the tracked person also stop. Really, Front Ultrasonic sensor for obstacle avoidance distance range is 50 cm. But, this range is problem for my actual testing. Because of motion of the robot. So, the front obstacle detection reading distance is reached to the lower bound of the nearest limit of 30 cm. And the program stops all of the motor in the system (so the robot will stop and wait until the tracked person is starting to move) as shown in above block of code.

Bubble Rebound Algorithm Control Rule 2 (Person Tracking)

```
else if (RightSensor2<60&&LeftSensor2>60)
{
digitalWrite (ledPIN_1, HIGH); digitalWrite (ledPIN_2, LOW);
digitalWrite (ledPIN_3, LOW); digitalWrite (ledPIN_4, HIGH);
Serial.println(" Right "); delay (300);
digitalWrite (ledPIN_1, LOW); digitalWrite (ledPIN_2, LOW);
digitalWrite (ledPIN_3, LOW); digitalWrite (ledPIN_4, LOW);
}
```

In the control rule 2 condition, there are two sensors for person tracking: “RightSensor2” and “LeftSensor2”. This rule2, ultrasonic left sensor and ultrasonic right sensor range is 100 cm. But, this range is problem for my actual testing. Because of motion of the robot. So, I defined the specific range of these sensors. If the “RightSensor2” data reading is less than 60 and the “LeftSensor2” data reading is greater than 60. So, the distance between the person and the robot is a considerable distance and the reading of RightSensor2 is nearer than the LeftSensor2: the person is detected in right side of orientation and then the robot turns to the right to follow the person to be same orientation.

Bubble Rebound Algorithm Control Rule 3 (Person Tracking)

```
else if (LeftSensor2<60 && RightSensor2>60)

{

digitalWrite (ledPIN_1, LOW); digitalWrite (ledPIN_2, HIGH);

digitalWrite (ledPIN_3, HIGH); digitalWrite (ledPIN_4, LOW);

Serial.println(" Left "); delay (300);

digitalWrite (ledPIN_1, LOW); digitalWrite (ledPIN_2, LOW);

digitalWrite (ledPIN_3, LOW); digitalWrite (ledPIN_4, LOW);

}
```

In the control rule 3 condition, there are two sensors for person tracking: “RightSensor2” and “LeftSensor2”. This rule2, ultrasonic left sensor and ultrasonic right sensor range is 100 cm. But, this range is problem for my actual testing. Because of motion of the robot. So, I defined the specific range of these sensors. If the “LeftSensor2” data reading is less than 60 and the “RightSensor2” data reading is greater than 60. So, the distance between the person and the robot is a considerable distance and the reading of LeftSensor2 is nearer than the RightSensor2: the person is detected in left side of orientation and then the robot turns to the left side to follow the person to be same orientation.

Bubble Rebound Algorithm Control Rule 4 (Obstacle Avoiding)

```
else if (LeftSensor<20 && RightSensor>30)

{

digitalWrite (ledPIN_1, HIGH); digitalWrite (ledPIN_2, LOW);

digitalWrite (ledPIN_3, LOW); digitalWrite (ledPIN_4, HIGH);

Serial.println(" Right "); delay (500);

digitalWrite (ledPIN_1, LOW); digitalWrite (ledPIN_2, LOW);

digitalWrite (ledPIN_3, LOW); digitalWrite (ledPIN_4, LOW);

}
```

In the control rule 4 condition, there are three obstacles avoiding ultrasonic sensors: “LeftSensor”, “Front Sensor” and “RightSensor”. This rule 4 ultrasonic left sensor, ultrasonic front and ultrasonic right sensor range is 50 cm. But, this range is problem for my actual testing. Because of motion of the robot. So, I defined the specific range of these sensors. If the “LeftSensor” data reading is less than 20 and the “RightSensor” data reading is greater than 30. So, the distance between the person and the robot is a considerable distance for obstacle avoiding and the reading of LeftSensor is nearer than the RightSensor: the obstacle is detected in left side of orientation and then the robot turns to the right side to avoid the obstacle to be opposite orientation.

Bubble Rebound Algorithm Control Rule 5 (Obstacle Avoiding)

```
else if (RightSensor<20 && LeftSensor > 30) {

digitalWrite (ledPIN_1, LOW); digitalWrite (ledPIN_2, HIGH);

digitalWrite (ledPIN_3, HIGH); digitalWrite (ledPIN_4, LOW);

Serial.println(" Left "); delay (500);

digitalWrite (ledPIN_1, LOW); digitalWrite (ledPIN_2, LOW);

digitalWrite (ledPIN_3, LOW); digitalWrite (ledPIN_4, LOW);}
```

In the control rule 5 condition, there are three obstacle avoiding ultrasonic sensors: “LeftSensor”, “Front Sensor” and “RightSensor”. This rule 4 ultrasonic left sensor, ultrasonic front and ultrasonic right sensor range is 50 cm. But, this range is problem for my actual testing. Because of motion of the robot. So, I defined the specific range of these sensors. If the “RightSensor” data reading is less than 20 and the “LeftSensor” data reading is greater than 30. So, the distance between the person and the robot is a considerable distance for obstacle avoiding and the reading of RightSensor is nearer than the LeftSensor: the obstacle is detected in right side of orientation and then the robot turns to the left side to avoid the obstacle to be opposite orientation.

Bubble Rebound Algorithm Control Rule 6 (Person is in front way)

```
else if (LeftSensor2>60 && RightSensor2>60) {

digitalWrite (ledPIN_1, HIGH); digitalWrite (ledPIN_2, LOW);

digitalWrite (ledPIN_3, HIGH); digitalWrite (ledPIN_4, LOW);

Serial.println(" Forward ");}
```

In the control rule 6 condition, there are two sensors for person tracking: “RightSensor2” and “LeftSensor2”. Really, these two Ultrasonic sensors for person tracking range is 100 cm. But, this range is problem for my actual testing. Because of motion of the robot. So, I define the specific range. If the “RightSensor2” data reading is greater than 60 and the “LeftSensor2” data reading is greater than 60. So, the distance between the person and the robot is a considerable distance and the reading of two tracing sensors are greater than the lower bound limit: the person is detected in the straight orientation and then the robot no need to consider the new orientation and need to follow the person to be same orientation.

Bubble Rebound Algorithm Control Rule 7 (Free obstacle in the person tracking way)

```
else if (LeftSensor2>40 && RightSensor2>40)

{

digitalWrite (ledPIN_1, HIGH); digitalWrite (ledPIN_2, LOW);

digitalWrite (ledPIN_3, HIGH); digitalWrite (ledPIN_4, LOW);

Serial.println(" Forward ");

}
```

In the control rule7 condition, If the “LeftSensor” data reading is greater than 40 (Upper bound distance limit for obstacle avoiding) and the “RightSensor” data reading is greater than 40 (Upper bound distance limit for obstacle avoiding). Really, these two Ultrasonic sensors for person tracking range is 100 cm. But, this range is problem for my actual testing. Because of motion of the robot. So, I define the specific range.So, the distance between the person and the robot is reasonable distance for obstacle avoiding and the reading of the two sensors are no need to consider for the avoiding status; so the robot no need to avoid the obstacle and to be continue forward orientation.

4.2. Design of Person Tracking and Obstacle Avoidance Mobile Robot

This system focus to cover the robot from collision when tracking and which could ruin the robot process. The bumper sensor detects the obstacle and stops. But the bumper sensor does not detect the obstacle in specific range, person tracking can be executed. When the sensor ranges are smaller than the 20 cm threshold, the process for obstacle avoidance should be made. In the event that the former situation no longer exists, the mobile robot is made in tracking the person. Overview design of the system show in figure 4.1.

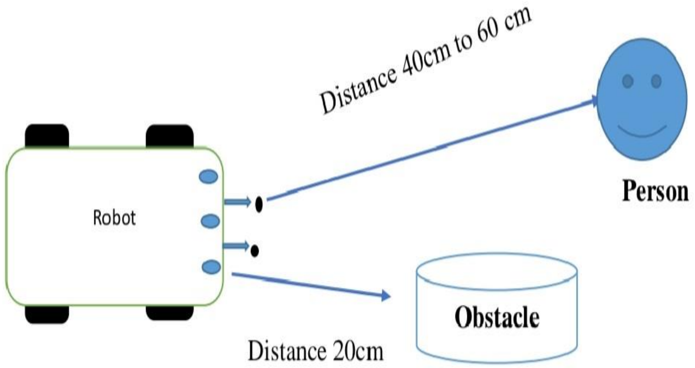

Figure 4.1 Overview Design of the System

Design of the robot person tracking and obstacle avoidance robot can be implement in figure 4.2.

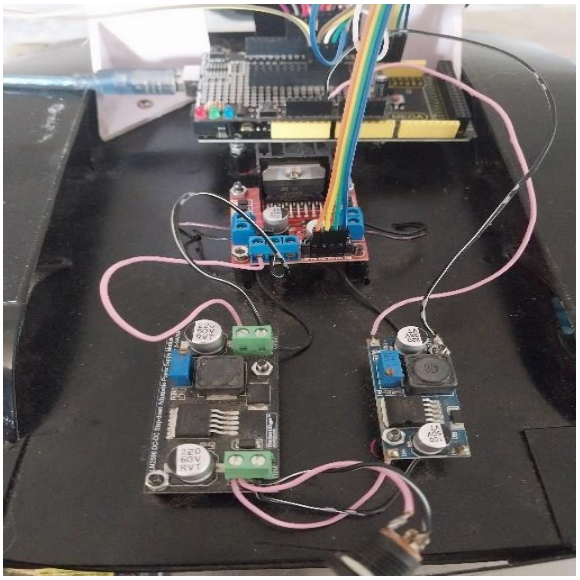

Figure 4. 2 Design of the Mobile Robot

4.3 Circuit Diagram of the System

A circuit diagram shows the components of the circuit as simplified and show the connections between the devices.

4.3.1 Circuit Diagram of Obstacle Avoidance

In this system, phase I implementation is Obstacle Avoidance implementation. This implementation show in figure 4.3. These implementations used the Arduino Board, three ultrasonic distance sensors and motor driver. The three ultrasonic distance sensors 's transmit pin is connecting the Arduino board input pin. Next step, three ultrasonic distance sensors 's receive pin connected with Arduino board's input pin. Arduino Board' s output pin is connecting motor driver. And motor driver controls the DC motor wheels. These control circuit are run in 5Voltage operation.

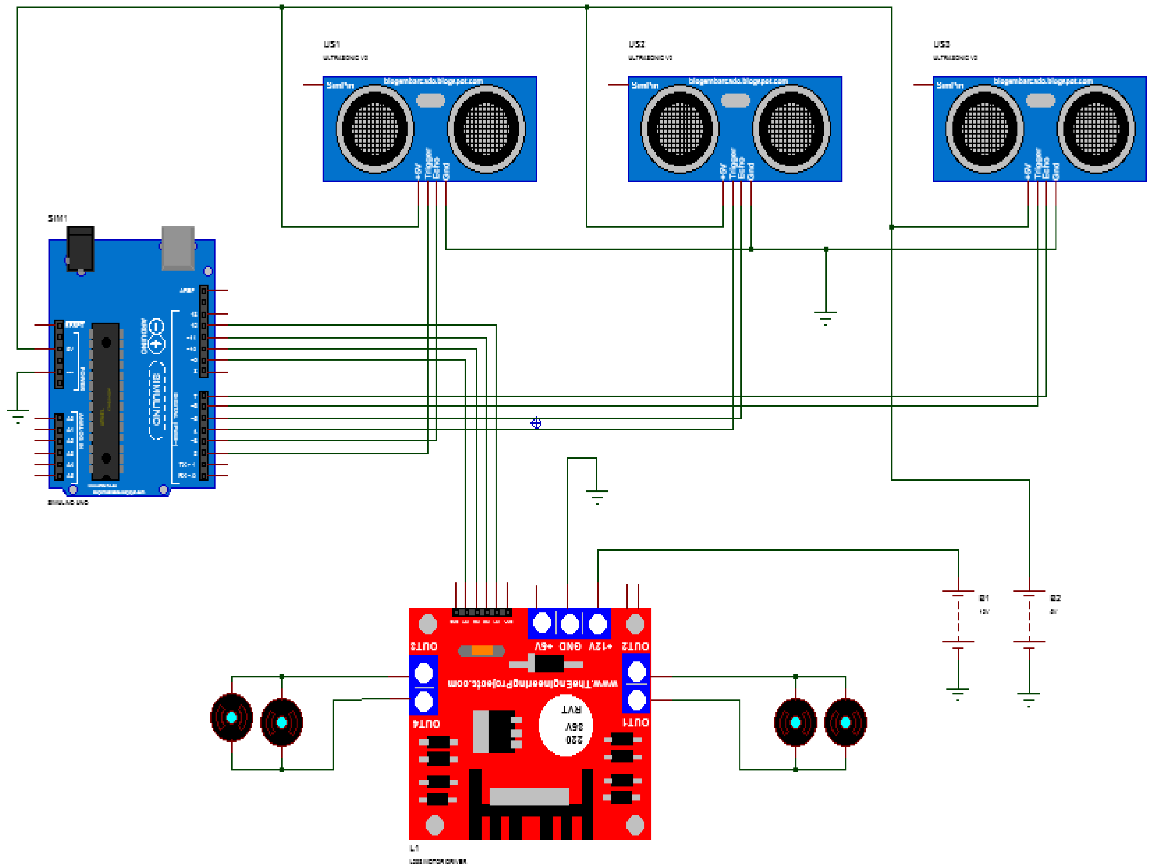

Figure 4. 3 Circuit Diagram of the Obstacle Avoidance

4.3.2 Circuit Diagram of Person Tracking

In this system, phase II implementation is Person Tracking implementation. This implementation show in figure 4.4. These implementations used the Arduino Mega Board, two ultrasonic position sensors and motor driver. The two ultrasonic position sensors ‘s transmit pin is connecting the Arduino Mega board input pin. Next step, two ultrasonic position sensors ‘s receive pin connected with Arduino Mega board’s input pin. Arduino Mega Board’ s output pin is connecting motor driver. And motor driver controls the DC motor wheels. These control circuit are run in 5Voltage operation

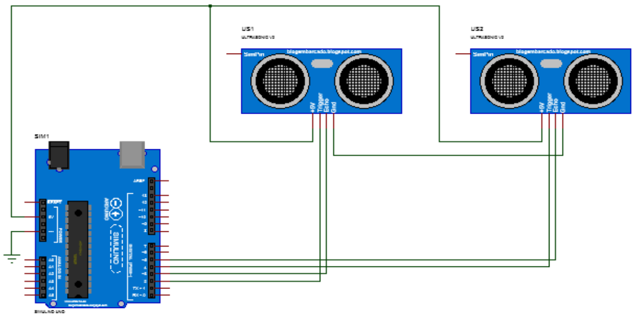

Figure 4.4 Circuit Diagram of the Person Tracking

4.4 Real Time Experimental Result

By using the Arduino IDE, this system shows the result with the serial monitoring. In Figure 4.5, serial monitoring result for obstacle avoidance and Figure 4.6 is serial monitoring result for person tracking.

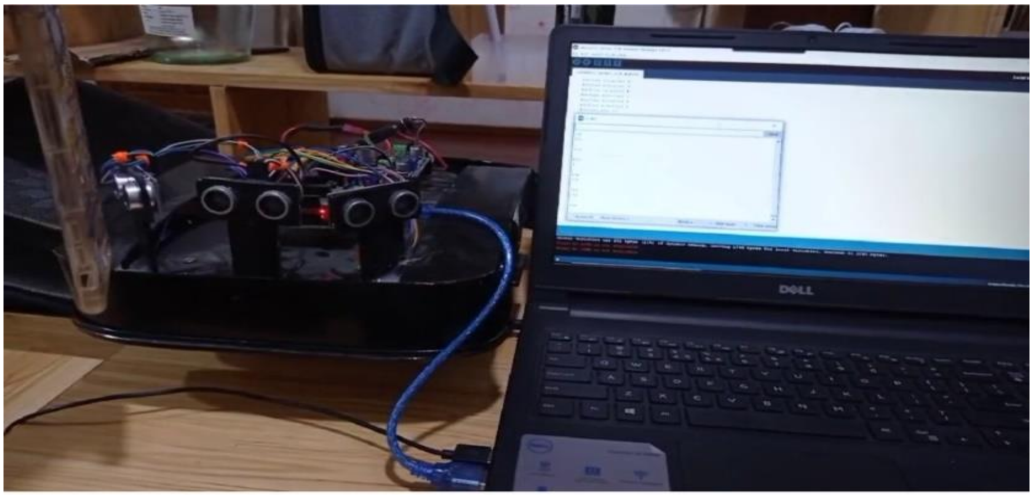

Figure 4.5 Serial Monitoring Experiment Of Obstacle Avoidance

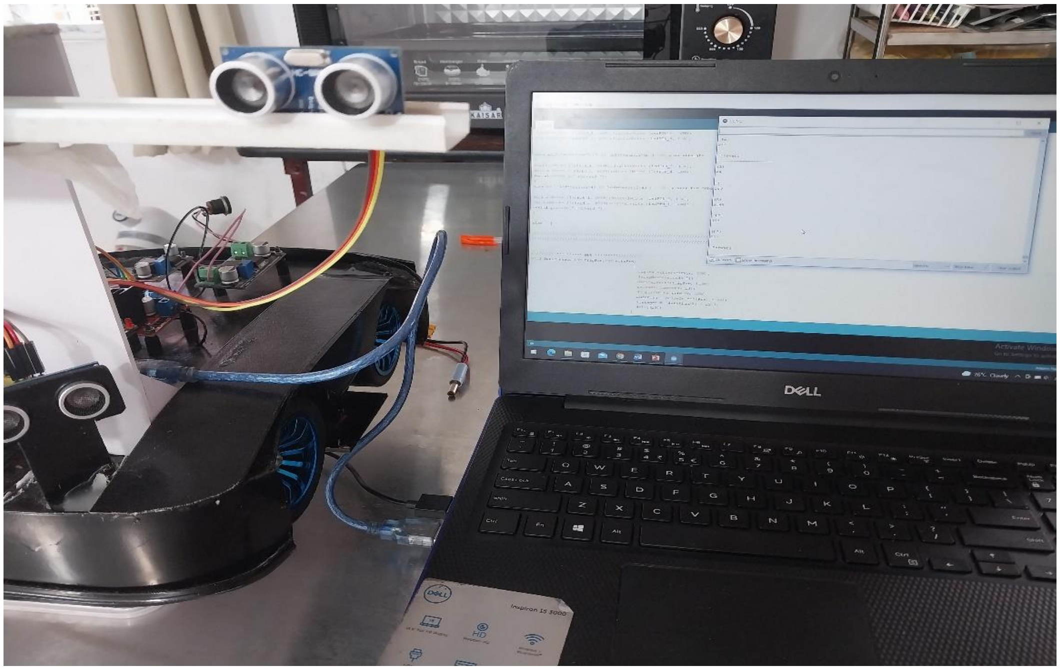

Figure 4.6 Serial Monitoring Experiment Of Person Tracking

4.4.1 Mobile Robot turn at left when obstacle right Experiment

First implementation, mobile robot is turned at left when the obstacle is right. Because Ultrasonic sensor is less than bubble boundary sensor. (Ultrasonic Sensor <20 centimeter).

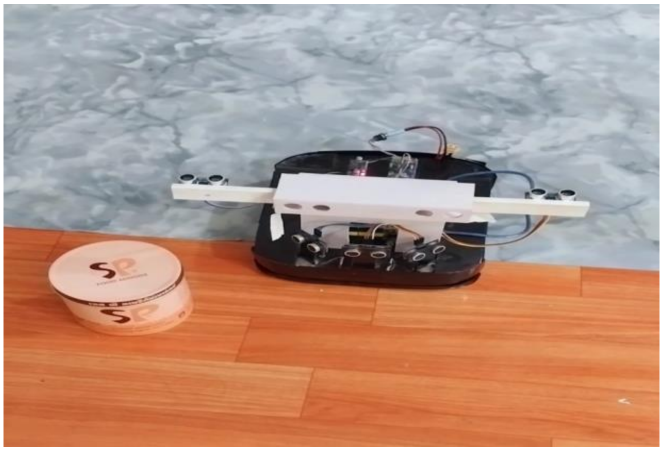

Figure 4.7 Mobile Robot Turn At Left

4.4.2 Mobile Robot turn at right when obstacle left Experiment

Next implementation, mobile robot is turned at right when the obstacle is left. Because Ultrasonic sensor is less than bubble boundary sensor. (Ultrasonic Sensor <20 centimeter).

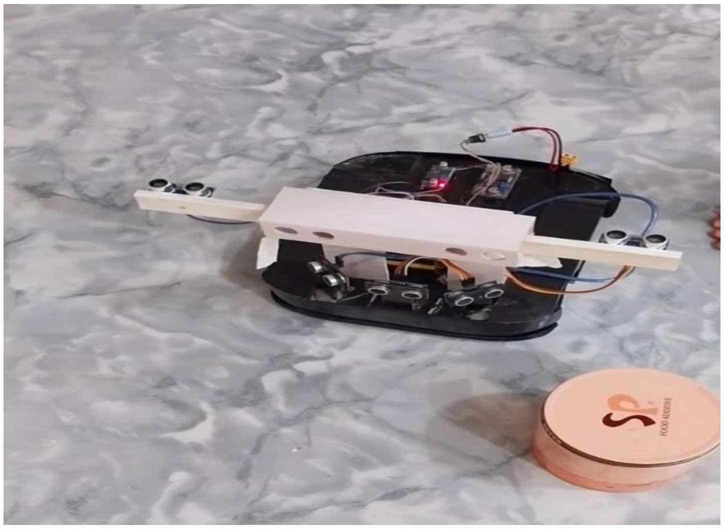

Figure 4.8 Mobile Robot Turn At Right

4.4.3 Mobile Robot stop when obstacle in front of the robot Experiment

In implementation, mobile robot is stop when the obstacle is in front of the robot. Because Ultrasonic sensor is less than and equal to bubble boundary sensor. (Ultrasonic Sensor <=20 centimeter).

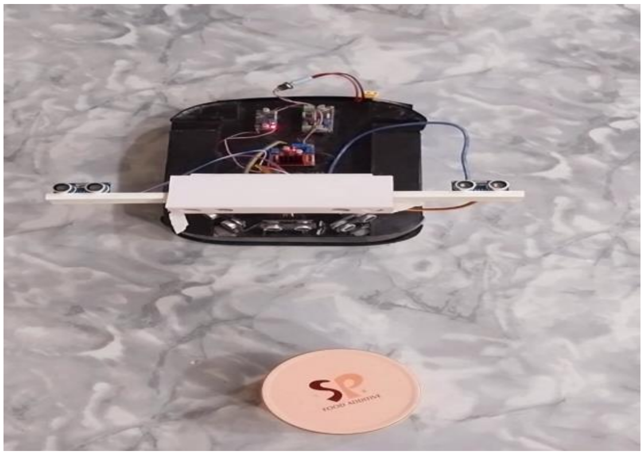

Figure 4.9 Mobile Robot Moving Stop

4.4.4 Experiment result for Person Tracking

In implementation, mobile robot is followed the person. When the person turns at right, robot turns right. And then person turns left, robot turns left too.

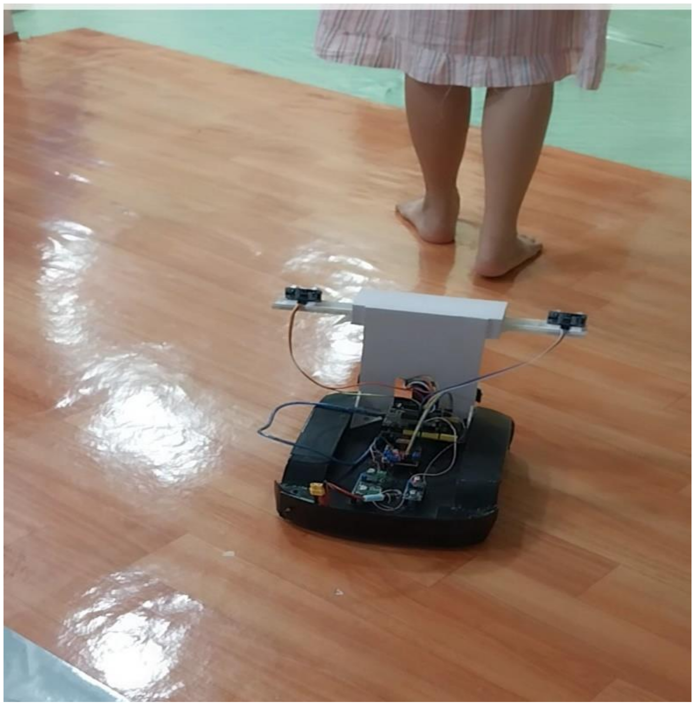

Figure 4.10 Person Tracking Mobile Robot

4.5 Description of the Experimental Result for Person Tracking

The Table 4.1 is describing the test of Person Tracking portion of my system. Detect Range 1, the left, front and right obstacle avoidance ultrasonic sensors range are greater than the 30 cm. Tracking for left sensor and right sensor is greater than the 60 cm. In this condition, the robot is tracking process. For Detect Range 2, In Detect Range 3, the left, front and right obstacle avoidance ultrasonic sensors range are greater than the 30 cm. Tracking for left sensor is greater than 60 cm and right sensor is less than the 50 cm. the left, front and right obstacle avoidance ultrasonic sensors range are greater than the 30 cm. Tracking for left sensor is less than 50 cm and right sensor is greater than the 60 cm. In this condition, the robot direction is turn to left and person tracking process. In this condition, the robot direction is turn to right and person tracking process. Next range 4, the left, front and right obstacle avoidance ultrasonic sensors range are greater than the 30 cm. Tracking for left sensor and right sensor is less than the 30 cm. In this condition, the robot motion is stop.

Table 4.1 Experimental Result for Tracking

Criteria	Obstacle Avoidance Sensor (Left) Unit-cm	Obstacle Avoidance Sensor (Front) Unit-cm	Obstacle Avoidance Sensor (Right) Unit-cm	Tracking Sensor (Left) Unit-cm	Tracking Sensor (Ring) Unit-cm	Route	Velocity
Detect Range 1	>30	>30	>30	>60	>60	Continue Current route	10cm/s
Detect Range 2	>30	>30	>30	<50	>60	Change Orientate to left and continue	0cm/s
Detect Range 3	>30	>30	>30	>60	<50	Change Orientate to right and continue	0cm/s
Detect Range 4	>30	>30	>30	<30	<30	stop	0cm/s

4.6 Description of the Experimental Result for obstacle avoidance

The Table 4.2 is describing the test of Obstacle Avoidance section. In detect range 1, obstacle avoidance left sensor, obstacle avoidance front senor and obstacle avoidance right sensor range are greater than the 30cm.This condition, the robot is continuing current route. For detect range 2, left sensor is less than 30 cm, front sensor and right sensor is greater than 30cm.In this implementation, robot direction is change to right and continue motion. For detect range 3, left sensor and front sensor is greater than 30 cm and right sensor is less than 30 cm. In this implementation, robot direction is change to left and continue motion. Next implementation 4, left and right sensor is greater than 30 cm and front sensor is less than 30 cm. This condition, robot motion is stop.

Table 4.2 Experimental result for obstacle avoidance

Criteria	Obstacle Avoidance Sensor (Left) Unit-cm	Obstacle Avoidance Sensor (Front) Unit-cm	Obstacle Avoidance Sensor (Right) Unit-cm	Route	Velocity
Detect Range 1	>30	>30	>30	Continue Current route	10cm/s
Detect Range 2	<30	>30	>30	Change Orientate to right and continue	0cm/s
Detect Range 3	>30	>30	<30	Change Orientate to left and continue	0cm/s
Detect Range 4	>30	<30	>30	stop	0cm/s

4.7 Experimental Result (Time Consuming Point of View)

The Table 4.3 is describing the testing of delay time for person tracking and obstacle avoidance implement.

Table 4.3 Experimental Result (Time consuming Point of View)

Criteria	Setting Delay Time	Result for Respond	Result on Serial Monitor
Time To Complete one whole circuit	10 ms	Enough to detect and respond in time	Can’t catch by human vision
	100ms	Not enough to detect and respond the rules of the proposed system	Enough time to catch and trace by human vision

4.8 Summary

In this chapter, the experimental results for performance analysis of person tracking and obstacle avoidance mobile robot are described as serial monitoring and real time experiment.

CHAPTER 5

CONCLUSION AND FURTHER EXTENSIONS

A primary target of this framework is to explore the possibility of fostering an individual following robot framework which utilizes ultrasonic situation framework. In this framework utilized C Programming to foster individual following portable robot. The information created by the ultrasonic situation framework can be used by the robot. Utilizing the ultrasonic situating framework has been settled by sequencing the execution request of those two controls.

This framework was to examine the practicality of fostering an individual following robot framework utilizing an ultrasonic situation framework. To achieve this goal, the accompanying objectives have been accomplished in this framework.

1. Make the connection point between the ultrasonic situation framework and the robot framework in the working system.

2. Foster the plan of the calculation that can keep away at the same time from hindrances and track the assigned individual in an unstructured climate.

3. Finish the individual following analysis when there is no impediment between the robot and the objective individual and the individual following examination when there is an impediment between the robot and the objective individual.

4.Show the individual following when the objective individual makes a turn at a corner and the individual following in an unstructured climate.

5.1 Discussion

This system aimed to detect the person to track and to avoid the obstacle on the running route. Firstly, this system is implemented for obstacle avoiding process by using Arduino Uno-board with motor drivers on four forward / reverse motors and combination of three ultrasonic sensors. It was a good robot in avoiding obstacle.

Second, this system adds the remaining process for the tracking, the Arduino uno-board is not compact for tracking and obstacle avoiding process. So, this system development changes the Arduino Mega board and add the new compactable shield. In the implementation phase for person tracking and obstacle avoiding, this system used five ultrasonic sensors (same sensors) are used. But it is not worked correctly, because it is detected wrongly the person as an obstacle and avoided instead of tracking. (Mix and conflict tracking and obstacle avoiding)

So, this system added two new ultrasonic sensors (Ultrasonic Position Sensors) for tracking. After changing the sensors, it can work as perfectly. The newly changed sensors can detect more variable range and distance avoidance sensors (three ultrasonic sensors).

5. 2 Benefits and Applicable Area

Each time the robot detects a barrier, it automatically shifts its position to the left or right and follows the path in the absence of human guidance then follow the target. The programming of the microcontroller is easy to use. It can avoid accidents. It is a low-cost circuit. Barrier avoiding robots can be used in almost all mobile robot navigation systems. It can be used as a part of a robot. It can be used for household chores such as automatic vacuuming. This system is used to avoid collisions. The design is developed for using in risky area. Barrier avoidance is one of the best applications to prevent many accidents and deaths.

5.3 Limitations and Future Extensions

This robot is able to produce the basic moving activities using four gear DC motors. They have created a robot with an excellent intelligence that can easily sense barriers and activate the signal from the sensor so that it can completely avoid barriers in its path and following the target person. But this system only used ultrasonic position and lack of dedicated or specific target can be mixed and wrong tracking may occur. The future work of the system includes improving robot design so that a sensor / device will also be added such as GPS, or other positioning specialized device to be perfectly tracking in this system.

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Appendix

Algorithm for Obstacle Avoidance

```
Input   RightSensor  ← distance;
        FrontSensor  ← distance;
        LeftSensor   ← distance;
BEGIN
        Adjust heading to goal;
        Detect the obstacle ();
        if (obstacle found == 1)
        {
                Step 1: Compute new heading;
                        Check Orientation ();
        Step 2: Adjust motion;
        }
        else
        {
        Moving straight to goal;
        }
        end if
END
Check Orientation ();
```

```
    {
    if (LeftSensor <bubble_boundary && FrontSensor <bubble_boundary && RightSensor <bubble_boundary)
    {
    Stop moving;
    }
    end if

    if (LeftSensor > bubble_boundary&& FrontSensor >bubble_boundary && RightSensor >bubble_boundary )
    {
    Moving straight to goal;
    }
    end if
if (LeftSensor <bubble_boundary && FrontSensor >bubble_boundary && RightSensor >bubble_boundary)
    {
    Change orientation to right;
     }
    end if
    if (LeftSensor >bubble_boundary && FrontSensor >bubble_boundary && RightSensor <bubble_boundary)
    {
    Change orientation to left;
     }
    end if
if (LeftSensor <bubble_boundary && FrontSensor <bubble_boundary && RightSensor>bubble_boundary)
    {
    Stop moving;
    Change orientation to right;
    }
    end if
    if (LeftSensor >bubble_boundary && FrontSensor <bubble_boundary && RightSensor <bubble_boundary)
    {
    Stop moving;
    Change orientation to Left;
    }
    end if
```

Algorithm for Person Tracking

```
Input   RightSensor2  🡐 distance;
        LeftSensor2   🡐 distance;
BEGIN
        Adjust heading to goal;
        Detect the person ();
        if (person found == 1)
        {
                Step 1: Adjust motion;
        Step 2:         Tracking;
        }
END
Detect the person ();
        if (LeftSensor2 <bubble_boundary && RightSensor >bubble_boundary)
        {
        Change orientation to left for track;
         }
        end if

        if ( LeftSensor >bubble_boundary && RightSensor <bubble_boundary)
        {
```

```
Change orientation to right for track;
 }
end if
```