The Integration of Smart Anti-Collision Robotic System

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Abstract— The robot is the unit that can sense sensitively, think wisely and interact properly. The robot can work effectively in any environment with or without supervision. The cognitive robots can perform numerous tasks such as decision, processing, route selection, planning, and taking decisions with respect to the environmental modifications. Mental robots incorporate the desired specification of the smart systems in the naturalistic environments. This project displays a typical design of a smart robotic system to avoid the obstacles that might be encountered while moving freely in an ambiguous path by using ultrasonic sensor. In addition, the robotic system can be changed over to follow another behavior to operate the robot manually based on android phone application via (HC – 05) Bluetooth module.

Index Terms— Obstacle Avoiding, Anti-collision Robotic Systems, Robotic Control Design, Ultrasonic Sensor Module.

1. INTRODUCTION

The computer world deserves to be classified as the most intelligent fields all around the universe when the human thinks that the world might completely work under the robotic systems. The mobile robots are not wide spread due to their leisurely expanding and complexity of the applications. Most of technologies such as architectures, mechatronics were developed considerably nowadays in order to offer the entire requirements for keeping the outside world up to date. The importance of the motion is proposed and discussed by different technologies due to the endless obligation to control the motion of objects competently [1, 2]. The motion is the characteristic of all robot kinds' particularly mobile robots, anti-collision robots and the route follower robot. However, the most wise thinking that can be thought is that how could the robotic system reach to a convincing movement or behavior. The assumption that states the human being moves in the whole directions even in the crowd due to their sense for the existence of the objects and even the other persons. It is proposed that either the robot should know and sense its way out by detecting the objects around. It is worth mentioning that if the object detection and robot motion through the objects are solved, there would be another challenge should be satisfied that is the robot is proposed to reach the desired location successfully. The robot direction towards the desired location cannot only be thought to satisfy the least cost path. There might be another idea is that by following the environment that has the most dynamics or the most visited which seems that this idea is better than following the motion of the people [3]. There exist a lot of challenges presented all around the world to discuss the motion of the robot and the object detection in different environments.

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With respect to those presentations, Sony corporations presented an entertainment robot that kicks a ball by an interactive program in Delhi, 2004. It is obvious that the robot needs massive appreciations to discover ball location and to move towards it accordingly. The presentation even pointed that the robot can follow the new location of the ball in order to start new tracking operation. In this work, the robotic system can be used in various applications especially in the risky places that the human cannot reach. The creativity of the designed system shows that the robot can be controlled automatically or manually by a decision form the supervisor based on the android application.

2. ROBOTIC SYSTEM COMPONENTS

The proposed robotic system is constructed from several components identified as follows:

1. Arduino UNO microcontroller.
2. L293D motor Driver.
3. HC – 05 Bluetooth module.
4. Ultrasonic Sensor.
5. DC motor.

2.1. ARDUINO UNO MICROCONTROLLER

Arduino MCU is an open source electronic board compatible with the hardware and software. Arduino Microcontroller are made in several forms such as mini, UNO, Nano, Mega, etc. [4] The whole module is considered the most appropriate microcontroller with both the sensors that read information of an environment, and either with hard portions such as the motors, actuators, and the other sophisticated components. The ATMEGA [5] unit is considered as the

central part that holds the programming code to apply the control action on desired environments. Lastly, the implemented MCU in this work and seen in Fig.1 is Arduino UNO board.

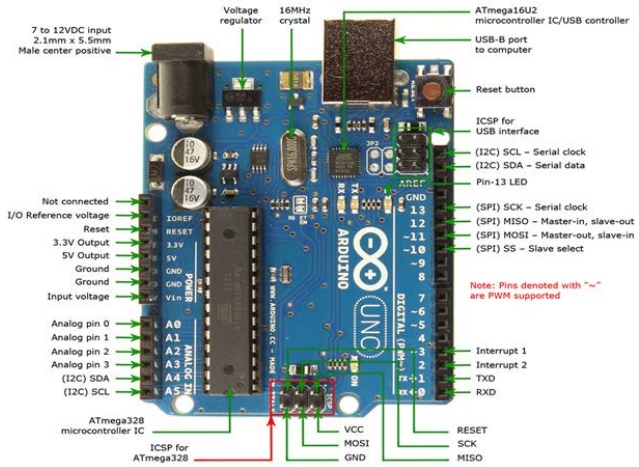

Fig.1. Arduino UNO Microcontroller

2.2. L293 D Motor Driver

The module is an integrated circuit with high voltage and current and four channels created to satisfy TTL logic standardization in addition to drive the loads like the motors, relays, etc. and even to flip the power of the transistor. For simplicity, the module can be used as two bridges such that every two channels are connected to an enable port [6]. The module needs to be provided by external power in order to guaranty the operation even at a low voltage. In accordance with the specification of the module, the drive shown in Fig.2 provides 600 mA output current per channel, 1.2 peak output current per channel, protects the module form high temperature degrees, provides 1.5 V immune against noise, and it uses clamper diode operation principle.

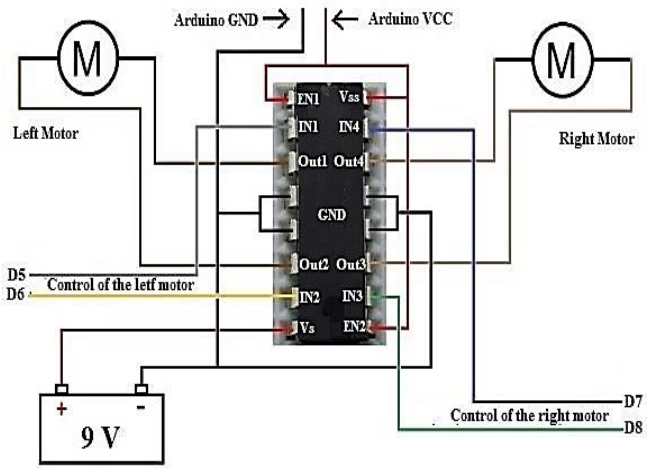

Fig.2. L293D Motor Driver Module

2.3. Bluetooth HC – 05 Module

The module can be described as a simple unit employs Bluetooth serial port to communicate between the source and the destination wirelessly. The proposed Bluetooth module is specified by an enhanced data rate of 2.0, radio frequency baseband of 2.4 GHZ, and modulation technique around 3Mbps. The Bluetooth module shown in Fig.3 is designed to be supported by blue core external distinct chip that work under the domination of the adaptive frequency [7]. The important terminal of the module can be identified by VCC connected to VCC of Arduino, GND to the GND, RX is connected to TX and TX is connected to the RX pin in the Arduino MCU respectively.

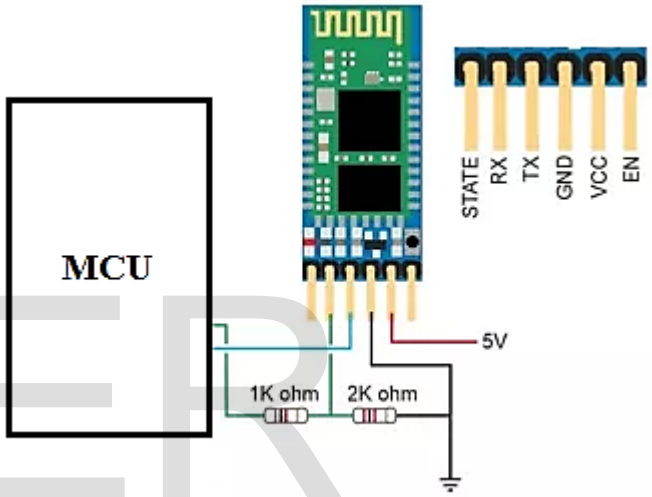

Fig.3. HC – 05 Bluetooth Module

2.4. Ultrasonic Sensor

The ultrasonic module is known as HC – SR04 used to discover the obstacles that might be encounter. The module sends and receives ultrasonic waves simultaneously such that the broadcasted waves are reflected back again from the nearest objects. Most of the applications nowadays use ultrasonic sensors to perform different jobs such as automatic door openers, alarm systems, robotic systems, reconfigurable manufacturing systems, etc. It is worth mentioning that the ultrasonic module is compatible with several kit and microcontrollers. The sensor shown in Fig.4 is constructed from four terminals identified by VCC, GND, Trigger terminal that generates the wave as pulses, and Eco terminal receives the common output between sensor and the GND.

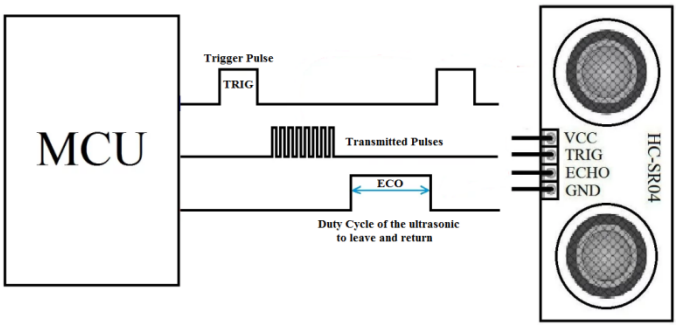

Fig.4. HC – SR04 Ultrasonic Sensor Module

The trigger pulse of duration of 10 C is sent from Arduino microcontroller to trigger terminal in the ultrasonic sensor. The sensor receives the pulse and sends a set of 8 ultrasonic pulses at 40 KHz searching for an object to be detected, if the object is detected the pulses are reflected back and the sensor sends a pulse of 5V carrying the weight of the detected distance via echo pin. If not, the echo reset after 38 µs. Furthermore, the Arduino computes the distance of the reflection with respect to the Time, which represents the width of echo pulse in µs as follows [8]:

$$\text{Distance in cm} = \frac{\text{Time}}{58} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

2.5. DC MOTOR

The DC motor module is the unit that can be controlled by DC voltage such that it can move forward, backward, left, and right with respect to polarity of the voltage. The mechanical motions generated by these motors can produce electricity in the other side which creates what is called electric motor. The electric motors convert the power into mechanical energy such as the small motors, the motors in the automobiles, robots, blinders, etc [9]. For more illustration, a simple DC motor is shown in Fig.5.

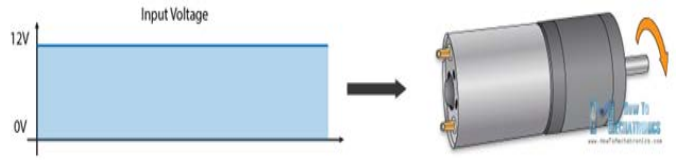

Fig.5. DC Motor Module

3. THE PROPOSED WORK

The proposed system is designed to be working separately by changing over between two behaviors. Let's call the first behavior as manual behavior and the second as automatic behavior. Control language of the proposed overall system should satisfy the both behaviors that contains overall system activities in a single Planet. Whereas, the controller can choose a specification suitable to be adaptable with environment that is proposed to be under control. As shown in the control system design diagram in Fig.6, the proposed system (the Plant) is constructed from two different subsystems G1 and G2 and the specification can change over between the behaviors with respect to main supervisor of the system. It is worth mentioning that the system needs to be under the domination of the main supervisor (Human) in order to apply the change on the system. Each subsystem works by following a specification modeled by the supervisor such that the desired behavior of the module is not violated. According to the systems appreciations and the symbol given to control system components, it can be stated that our proposed robotic system is subdivide into two modules controlled by the main supervisor. The first module G_1 represents the android phone based control robot that can depend completely on the instruction given by the supervisor such that moving the robot throughout Bluetooth coverage area. Whereas, the second module G_2 represents the automatic robotic system satisfies anti-collision control specification such that the robot can avoid the obstacles encountered.

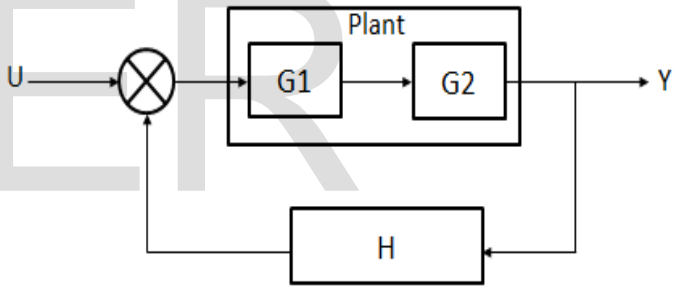

Fig.6. Control unit Design Approach

The specifications of both subsystems are followed depending on the feedback control system supervised partially by the system H. For more simplicity, the combination of the system is shown as a block diagram in Fig.7.

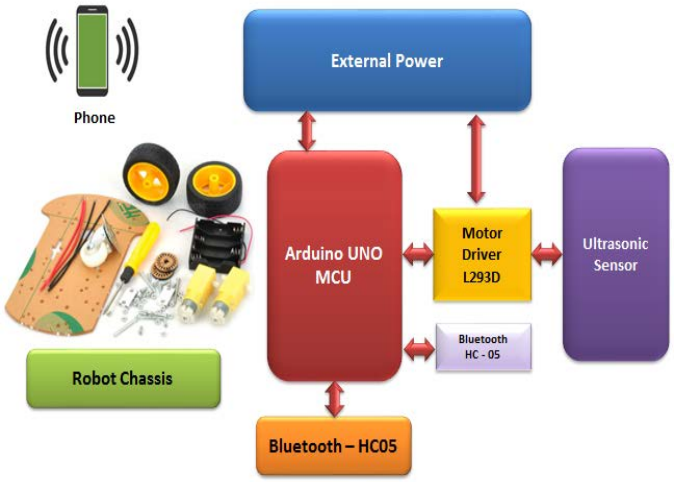

Fig.7. System Combination Block Diagram

The working principle of the overall system is fulfilled via the feedback control system that moves the robotic system into different directions with respect to coverage area of the Bluetooth module. It can be stated from the schematic Fritizing software connection of the whole system in Fig.8 that the overall system can be changed over to follow the second behavior of the system by a command from the supervisor. The second system behavior or the automatic behavior will be satisfied by avoiding the obstacles from a distance of 5 centimeters with respect to Eq.1 as long as the robot is moving to any direction by using ultrasonic module to read the reflection of the waves.

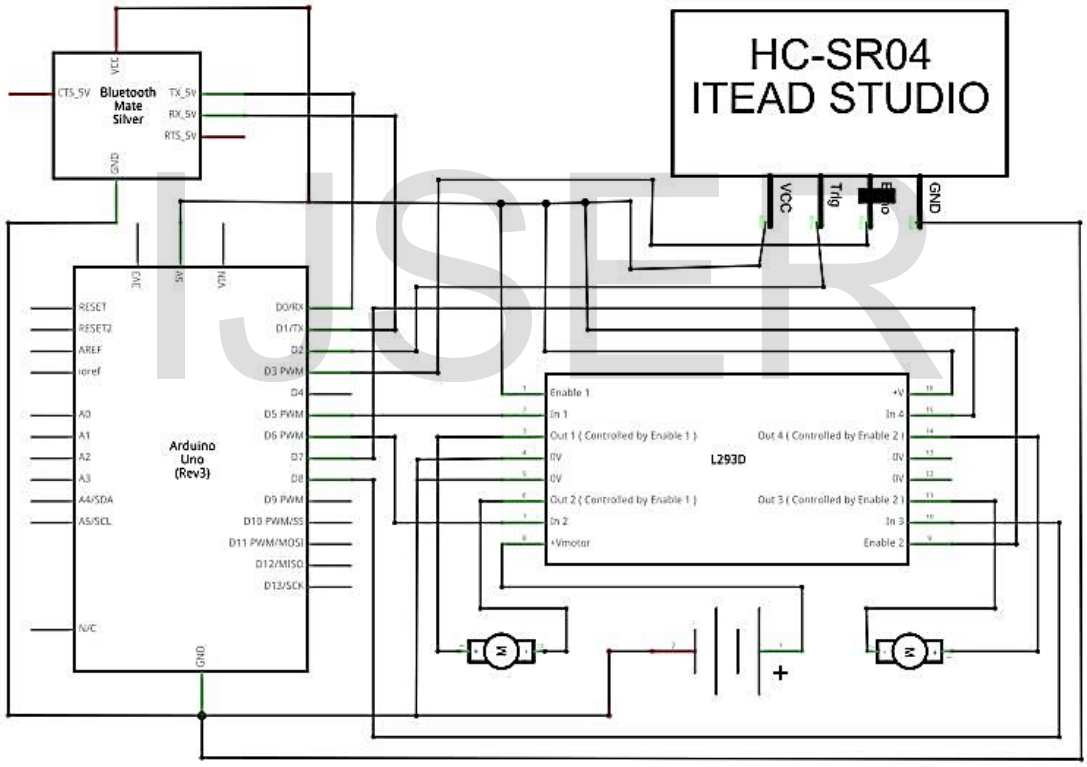

Fig.8. The Schematic Connection of the Overall System

For more direct visibility, it is intended to demonstrate the entire system module as real combination in Fritizing software as shown in Fig.9.

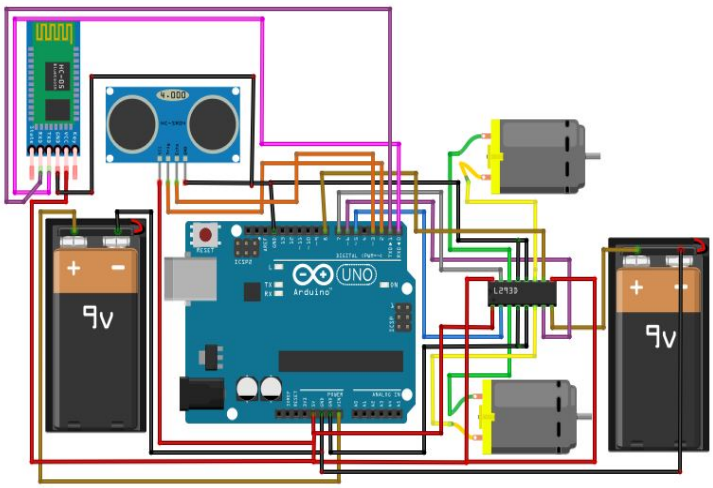

Fig.9. Robotic System Combination in Reality

For simplicity, the movement methodology of the DC motor drive can be illustrated as shown in Table 1.

TABLE 1
L293D MOTOR MOVEMENT DESCRIPTION

Direction	Motor1	Motor2
Forward	ON - counter clockwise (CCW)	ON - clockwise (CCW)
Backward	ON - clockwise (CCW)	ON - counter clockwise (CCW)
Right	ON - counter clockwise (CCW)	OFF
Left	OFF	ON - clockwise (CCW)

Last but not least, the changeover process between the two behaviors is performed by Android APK program shown in Fig.10 that is created in an online APK creation program; however the creation procedure is omitted for clarity.

Fig.10. Mobile Phone Application APK

Finally, the behavior of the overall system can be illustrated in the flowchart shown in Fig.11.

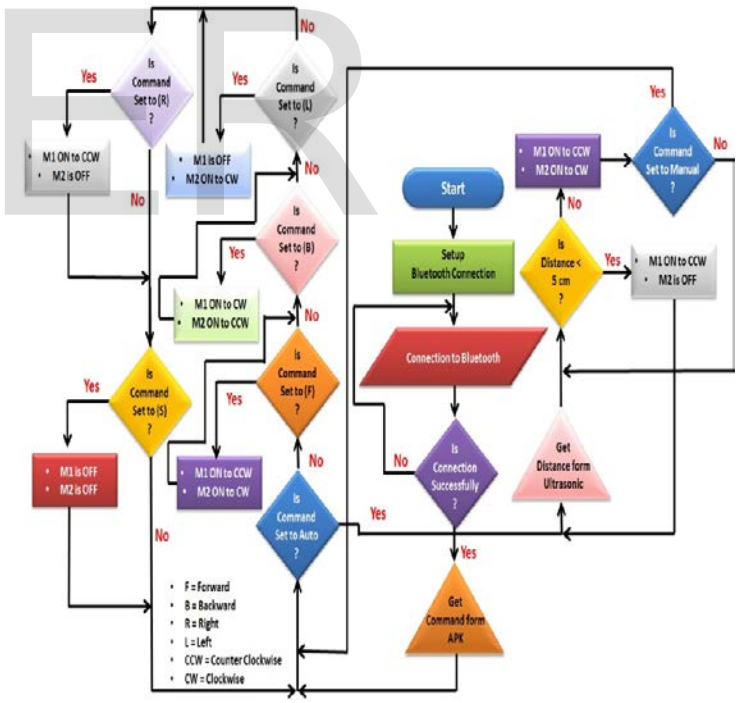

Fig.11. Programming Code as Flowchart

4. CONCLUSIONS

The necessity to use navigation has increased recently while such a technique needs to avoid the obstacles that might be faced. Hereby, the importance of the obstacle avoidance strategy is emerged clearly. The applications of the obstacle avoidance robots are wide spread in

various fields. Theses robots can be implemented in major applications such as inside the house as a service robot, obstacle avoidance robot, reconfigurable manufacturing systems, and so many serious scientific applications such as sending the robot to some risky places that human being cannot reach. The proposed obstacle avoiding robot entered those applications majorly due to the endless effort performed to collect the required information about the environment to get rid of the obstacles. As an example, the most appropriate field that such a robotic system can be applied is the reconfigurable manufacturing systems specially the part that manufactures car bodies by using an autonomous system to detect the touched part by the ultrasonic and apply the tasks on the section. In this proposed work, a unique integrated system is designed in a low cost to control robotic systems automatically and manually based on android application APK. Finally, most of the researchers are convinced that the other face of the proposed robotic system which is named as anti-collision or obstacle avoidance is going to be included in major applications in the future.

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