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An Embedded System for a Bluetooth Controlled Mobile Robot Based on the ATmega8535 Microcontroller

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Abstract

Embedded systems have received significant attention during the last decade mainly because of their numerous applications. They can be found in robotics, smart buildings, fabrication equipments as well as medical, automation, industrial, commercial, military applications. Most of the modern embedded systems are based on microcontrollers. In this paper, we design and implement an embedded system based on the ATmega8535 microcontroller and use it for constructing a mobile robot. By interfacing a Bluetooth module into the proposed embedded system, it can provide a control system that uses Bluetooth as a standard technology for connecting (send/receive data to/from) remote devices. The control circuit of the proposed system is designed in a way such that a user can interface any kind of desirable peripheral. Furthermore, the mobile robot is provided with a sensor to measure the distance between the robot and any obstacle in its path and taking the proper action to avoid crashing. Using different programming languages, we prove the working of the system as a mobile robot. The proposed system can be reprogrammed easily to support a variety of applications.

Keywords: *Embedded system, Microcontrollers, Bluetooth technology, Mobile robot, Distance measurement.*

1. Introduction

Recent years have witnessed a remarkable growth in the features and applications of embedded processors and embedded systems.Specifically, advances in embedded processors have made available embedded systems with a computational capacity ready to support sophisticated intelligent mechanisms and the ability to host an overabundance of sensors, hence providing a new degree of freedom to sophisticated applications. Li et al. [1] report that extensive research about embedded system has been ongoing in both industry and academia. Embedded systems usually stand for the integration of a system (e.g., microelectronic) and its software into a larger system, which often monitors and controls equipment without the need for manual intervention. In other words, they are computing systems that have computer hardware and software embedded into them to perform computationally predefined tasks repeatedly based on using significant amounts of application-specific fixed-function logic. They can be found in a wide variety of consumer electronic devices such as cell phones, pagers, digital cameras, personal digital assistants, microwave ovens, answering machines, thermostat, home security, printers, and scanners as well as other applications (e.g., Agricultural, medical, military) [2, 3, 4, 5, 6].

Generally, the embedded systems use a combination of hardware and software to respond to events in the environment within defined constraints. In this context, a typical embedded system responds to the environment via sensors and controls the environment using actuators [7]. Building an embedded system is not an easy task because of the restrictions and constraints of those systems. One of such constraints is that an embedded system has to do single function repeatedly in contrast to a computer system which can do several functions at the same time. Another constraint is that the embedded system should react to the changes in its environment and to respond to events in real-time without delay [8, 9].

Today's embedded systems development ranges from microprocessor-based control systems to system-on-chip design and device software development; where several architectures have been proposed [10, 11, 12]. Many of these architectures are implemented as heterogeneous multi-core or system-on-chip designs [13,14]. In the same time, with the availability of recent highly efficient processors, some embedded system developers are implementing the majority of the system components in software rather than hardware [15]with different development models and techniques used in embedded systems software life cycle as discussed in[16].

On the other hand, with the increasing population in the mobile robotic applications, there are calls for the design and implementation of larger and more complicated robotic architectures. For instance, deploying ultrasonic sensors in a mobile robot for agricultural environments is proposed in [17], another mobile robot for security and inspection operations is developed by Flann et al. [18]. Ren et al. [19] proposed a mobile robot architecture for intelligent building security, whilein [20] a microcontroller-based robot arm is developed to help patients with paralyzed arm to do daily living activities. Also, as the Bluetooth technology has low power consumption and a secure way to connect and exchange information between devices, many researchers utilize it for connecting remote devices [21]. Hiroshi et al. [22] propose a home appliance control system over Bluetooth that enables remote-control for home appliances with a cellular phone, while an intelligent Bluetooth-enabled robot car are described in [23].

Indeed, the mobile robots will play an important role in our daily life in the near future, especially in agricultural and security applications. In this paper, the ATmega8535 microcontroller is used for designing and implementing an effective embedded system which we use to construct a general-purpose mobile robot. The developed system provides a control system that uses Bluetooth technology for connecting remote devices. For providing mechanical movements, we interface motor drivers to the microcontroller. In order to implement the whole system, software has to be written for the robot and the remote device (i.e., Mobile phone or Laptop). The code for the robot is implemented by Code Vision AVR (C compiler), while the code for the remote device is implemented by designing Graphical User Interface (GUI) using Java and C# programming languages. For the robot navigation, the user has to run the application and press the connect button, once the connection is established the user can control the motion of the mobile robot in any direction. The proposed mobile robot can be deployed in many applications such as military applications, intelligent transportation, seaport automation, airport automation, hospital services and agricultural applications.

This paper is organized as follows: Section 2 describes the hardware components used in building the proposed system. The block diagram and architecture of the whole system is demonstrated in Section 3. In Section 4, we explain the software implementation and robot snapshots. Finally, Section 5 presents the conclusions of the paper.

2. Hardware Components

This section describes the hardware components used in designing the embedded system. The following hardware components are used in designing the mobile robot:

2.1 The ATmega8535 microcontroller

A microcontroller is an integrated chip that has a processor, a memory, and several other hardware units built in its broad. The ATmega8535 microcontroller is basically from Atmels microcontroller family with 8K Bytes of in-system programmable flash memory. It is a low- power CMOS 8-bit microcontroller based on the AVRenhanced RISC architecture. ATmega8535 microcontroller provides various features including: 8K bytes of in-system programmable flash, 512 bytes SRAM, 512 bytes EEPROM,32 programmable I/O lines, 32 general purpose working registers, real-time clock (RTC), three flexible timer/counters: Two 8-bit timer/counters with separate prescalers and compare modes and one 16-bit timer/counter with separate presales, compare and capture modes, internal and external interrupts, a programmable serial USART, 10-bit analog to digital converter (ADC), on-chip analog comparator, programmable watchdog timer, an SPI serial port and three software selectable power-saving modes.

The pinout configurations of the ATmega8535 microcontroller is shown in Fig. 1. It is easy to configure as well as program; by executing instructions in a single clock cycle, the ATmega8535 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed. Further details and information about the ATmega8535 microcontroller can be found in [24].

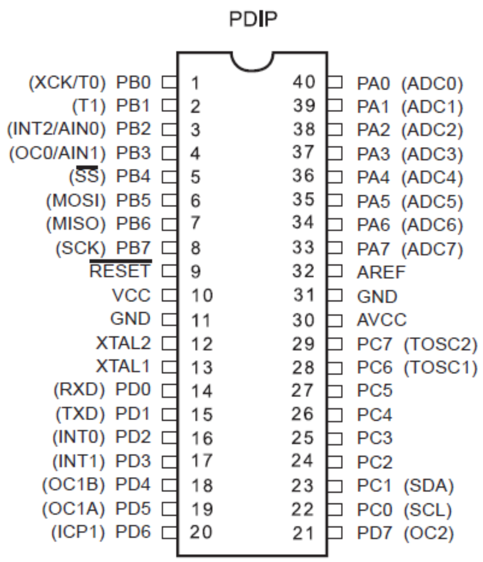

Figure 1. Pinout configurations of the ATmega8535 microcontroller

2.2 Bluetooth module

BlueLINK, a compact Bluetooth module (5V Serial TTL) from the RhydoLABZ Corporation [25], is a drop-in replacement for wired serial connections, transparent usage. It can be used for serial port replacement to establish connection between microcontroller and GPS, PC to embedded system/robot. The module has built-in voltage regulator and 3V3 to 5V level converter that can be utilized in interfacing with 5V microcontrollers. The Blue LINK module has only 5 pins (Standard 2.54 mm berg strip) GND, VCC, RX, TX, and RESET (see Fig. 2), as well as it is configured in transparent mode and hence there is no command required for normal operations. In the developed system, we use it to establish connection between the ATmega8535 microcontroller and the GUI application on a PC. Any serial stream from 9600 to 115200 bps can be passed seamlessly from PC/PDA/MOBILE to a target board.

Figure 2.The Bluetooth module (BlueLink)

2.3 L293D

L293D is a dual H-Bridge motor driver that is with and IC one can interface two DC motors which can be controlled in both clockwise and counter clockwise direction. The L293D has output current of 600 m A and peak output current of 1.2A per channel; the block diagram of the L293D is shown in Fig.3. Moreover, for protection of circuit from back EMF output diodes are included within the IC. The output supply (VCC2) has a wide range from 4.5V to 36V, which has made the L293D a reasonable choice for DC motor driver. In a single L293D chip, there two h-Bridge circuits inside the IC which can rotate two DC motors independently and simultaneously in any direction. It can drive small and quiet big motors. Due its size and features, we use it for controlling DC motor of the mobile robot.

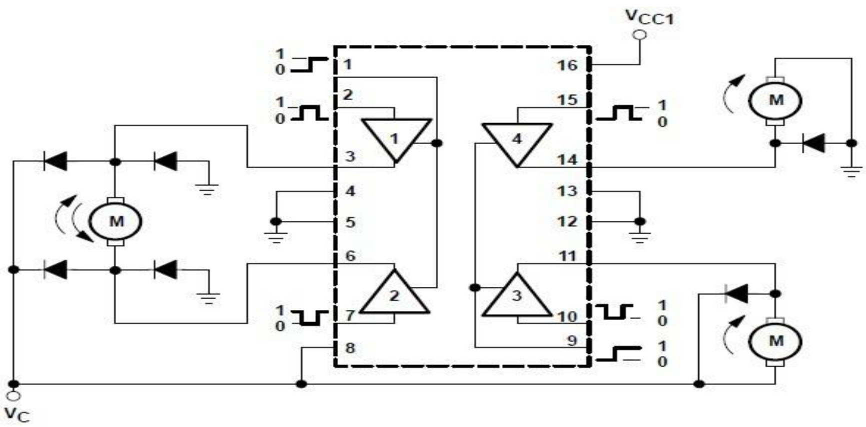

Figure 3. Block diagram of the L293D motor driver

2.4 DC motor

A DC motor is a device that works on direct current to convert electrical energy into mechanical energy for providing mechanical movements. The DC motors are used in robotics because of their small size and high energy output. DC motors are used for powering the drive wheels of a mobile robot forcing the robot to move.

2.5 Distance Measuring Sensor

GP2Y0A02YK0F, shown in Fig. 4, is a distance measuring sensor with an integrated combination of PSD (position sensitive detector), IRED (infrared emitting diode), and signal processing circuit. The sensor adopts the triangulation method so that the distance detection is not influenced by most of the reflectivity of the object, environmental temperature and the operating duration. The device outputs the voltage corresponding to the detected distance. So this sensor can also be used as a proximity sensor. The GP2Y0A02YK0F sensor reads the distance continuously and reports it as an analog voltage with a distance range of 20 cm to 150 cm. More details can be found in [26]. Other embedded system [27] can be used in the developed system to measure the distances between two target objects.

Figure 4.The GP2Y0A02YK0F distance measuring sensor

2.6 USART

USART (Universal Synchronous and Asynchronous Receiver and Transmitter) is the hardware to translate between parallel data and serial data. We use USART in the developed system to communicate from the microcontroller to other devices. Examples of such devices include the terminal tool in CodeVisionAVR, other microcontrollers that need to communicate for controlling the system, or a device that is communicating with the microcontroller to complete a task. Important features of USART in the ATmega8535 are full duplex operation and supporting both asynchronous and synchronous operations.

3. System Architecture

The architecture and block diagram of the proposed embedded system of the mobile robot is shown in Fig.5. The main controlling device in the system is the Atmega8535 microcontroller. We interface the bluetooth module mentioned above to provide wireless communication. For providing mechanical movements, we interface motor drivers to the microcontroller. In order to make the robot avoid crashing with any obstacle in its path, the GP2Y0A02YK0F sensor is used to measure the distance between the body of the robot and any object in its path. After establishing the required wireless connection between the remote device and the robot, data sent from the GUI is received by the bluetooth module which in turn is fed into the microcontroller as an input. According to the received data, the microcontroller acts on the DC motor of the mobile robot. The final design of the embedded system printed circuit board (PCB) is shown in Fig. 6, while a snapshot for front view of the proposed mobile robot is given in Fig. 7.

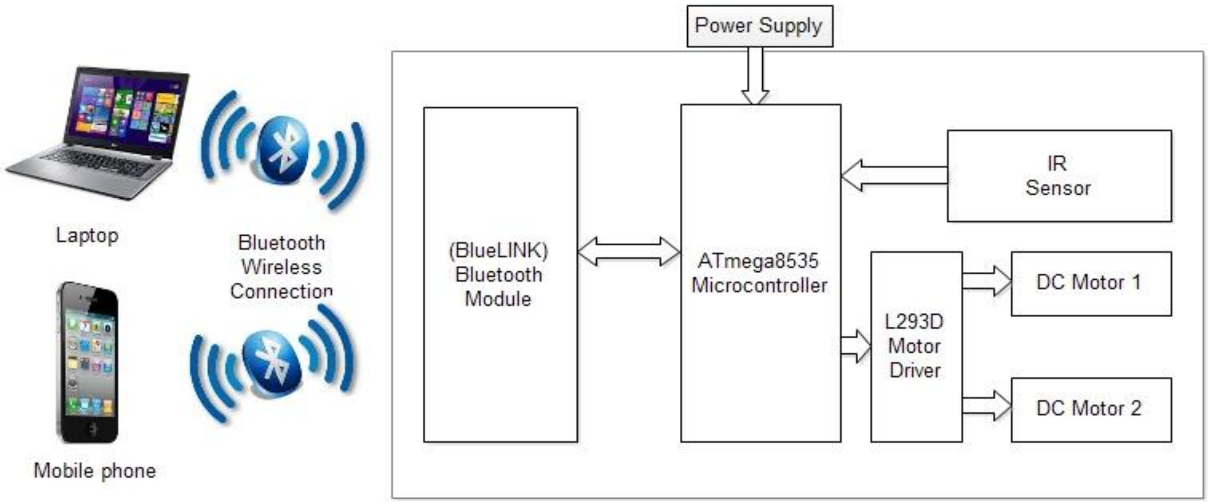

Figure 5. Architecture and block diagram of the proposed system

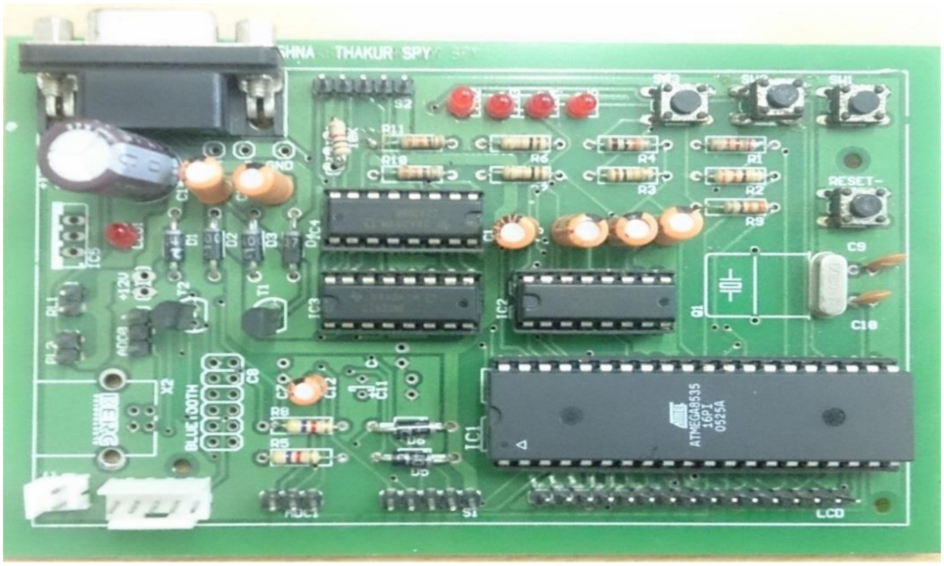

Figure 6. The embedded system printed circuit board (PCB)

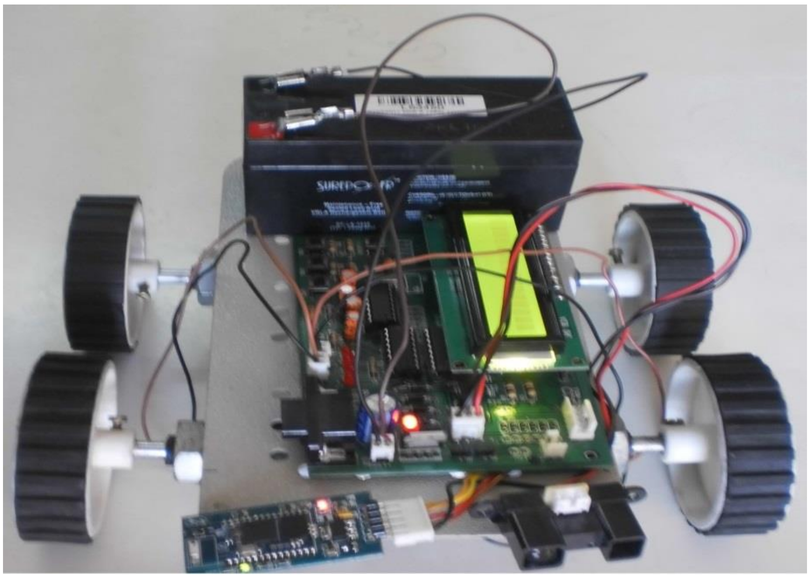

Figure 7.A **front view of the proposed mobile robot**

4. Software Implementation

In order to test the proposed system, software has to be written for the mobile robot components (e.g., ATmega8535 microcontroller) as well as the remote device (GUI). The code for the robot is implemented by Code Vision AVR (C compiler) to handle the DC motors, sensor readings, and any data coming from the remote device. While, the code for the remote device is implemented using other programming languages, namely Java and C# programing languages. The flowchart for the GUI program shown in Fig. 8 illustrates the various steps that have to be followed to perform successfully various motions of the robot. First, the user starts the software that starts immediately searching for the available COM ports and list them in a combo box. Second, the user has to press the connect button; if the connection is opened properly, it will display a message for a successful connection, otherwise an error message will be displayed. After opening a connection, a bidirectional stream between the mobile device and the robot is established to send and receive data. Finally, the user can easily control the motion of the robot in any direction. Figure 9 illustrates the GUI designed in Java programming language with several buttons for controlling the motion of the robot in a specific direction.

Figure 10 illustrates the various steps that have to be followed for setting proper connection to the remote device. The user has to set different USART parameters such as the baud rate, number of data bits, start bit, stop bit(s), and parity. Following setting up the USART parameters, the software enter a while loop that continuously checks for a received character as well as measuring the distance. Once a character is received and matched with the predefined characters, the robot moves exactly in the specific direction. Simultaneously, the sensor measures the distance between the robot and any obstacle comes in its path. The action of the robot is basedon the measured distance which is displayed on the LCD as shown in Fig. 11. If the distance is less than a predefined threshold value, the robot will take an action (in our case it will stop).

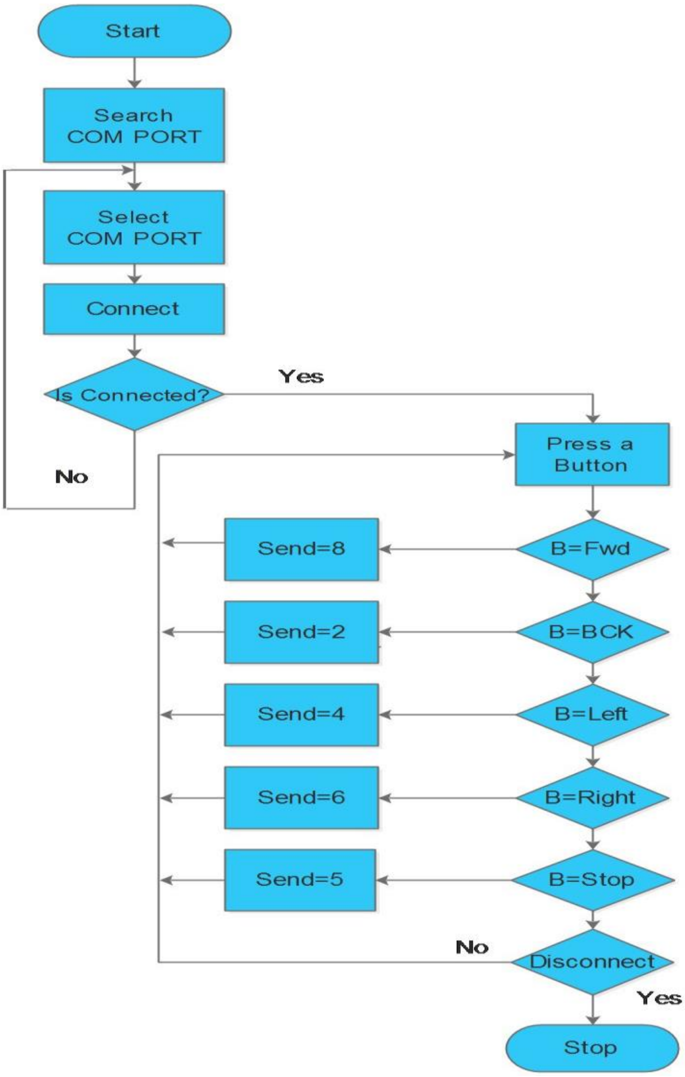

Figure 8. Flowchart for the Java GUI program

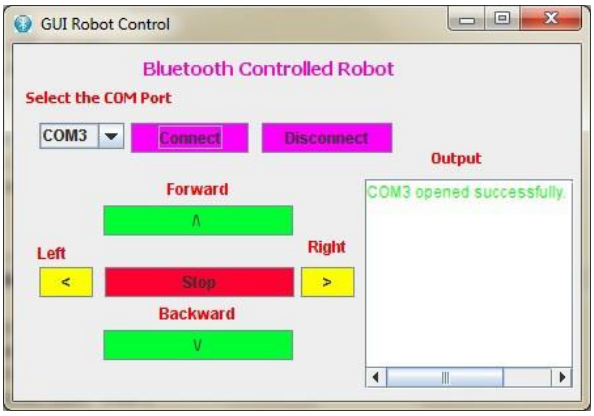

Figure 9.GUI for remotely controlling the motion of the mobile robot

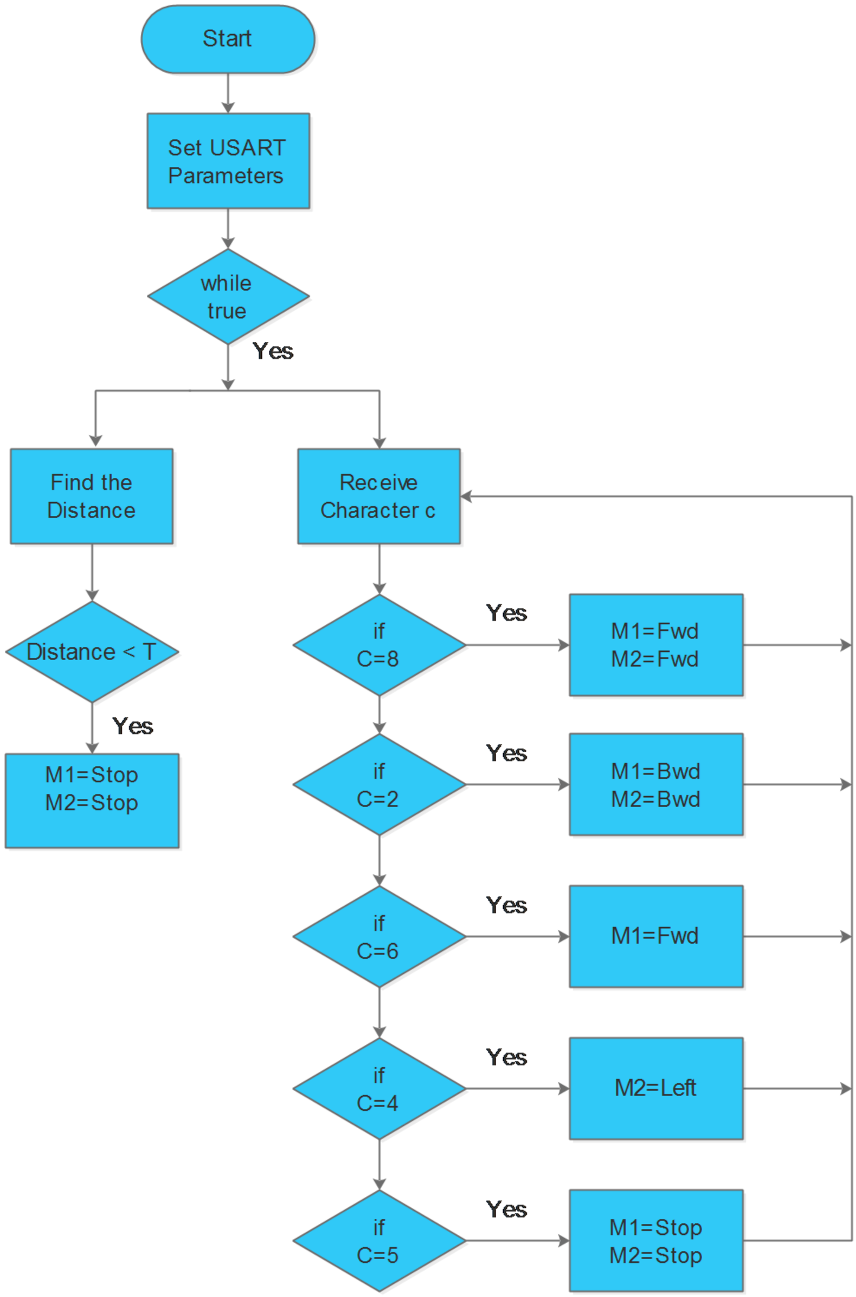

Figure 10.Flowchart of the embedded software controlling the robot

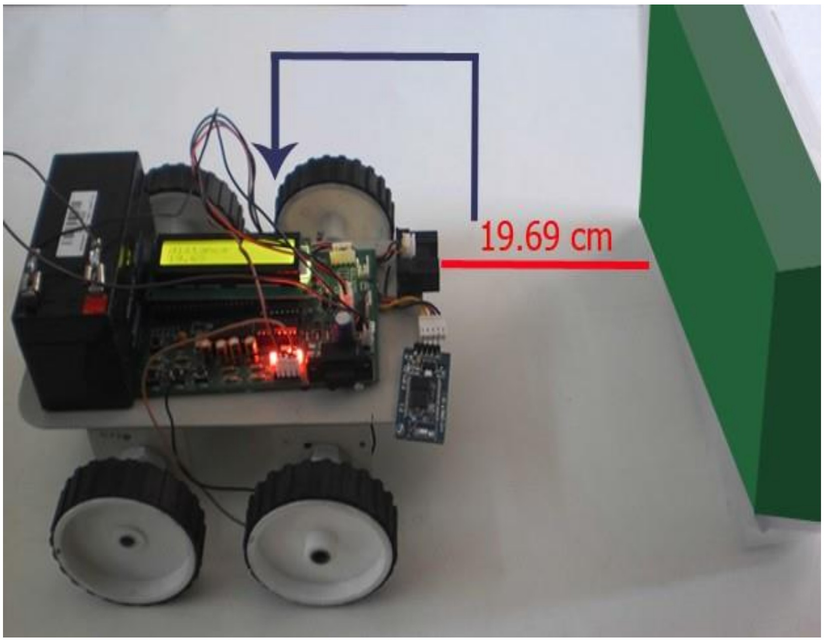

Figure 11. Distance measurement displayed on LCD

5. Conclusions

This paper has developed an embedded system for a Bluetooth controlled mobile robot based on the ATmega8535 Microcontroller, where the Bluetooth module (Blue LINK) is successfully interfaced onto the proposed system for providing a control system that uses features of Bluetooth technology for wireless communications. Tests carried out on the serial communication channel between the mobile robot and PC mobile phone show that the system and the remote controlling through the range of Bluetooth are working properly. In addition, the sensor is working properly for taking the proper action if the robot faces any obstacles in its path. The robot has been made visually interactive as there is 4 bit LEDs to monitor the outputs of the I/O ports. Furthermore, the control circuit is designed in a way such that a user can interface any kind of peripheral desirable as the control circuit supports digital, analog, and SPI based devices. The developed system is low cost and scalable that supports variety of applications with minimum changes to its core.

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