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Monitoring Moving Objects in Real Time on the basis of Ultrasonic Sensors

Harsha Bhalla[1], Aayurshi[2], Ravi Antil[3]
[1, 2]*Student,* [3]*Project Guide, Department of Electronics and Communication Engineering, MVSIT, Sonipat*

Abstract: ***In modern world of automation systems, movement of objects whether inside factory or outside factory for loading on ship, always has to be safety. Objects can be large and require a system that controls states around them. Monitoring can be done by people around the objects, but in this way, there are restrictions. The most significant restriction is related to range of operability. Also, there are delays in receiving commands, and everything can be confusing by using communication of several people. In order to overcome these restrictions, the system should provide a user-friendly interface which can show immediately and in real time the states from any side of the object to one person. Therefore, ultrasonic sensors based automation system to control conditions remotely from anywhere around the object, anytime is needed. The proposed Ultrasonic Control System consists of a microcontroller hardware side and an application which forms the software side of the project. The system will work wirelessly via Bluetooth connection. The microcontroller will communicate with ultrasonic sensors to achieve the objective.***
Keywords: Real Time Controlling, Automation Systems, Arduino Mega, Ultrasonic Sensors

I. INTRODUCTION

Analysis of the relationship between collisions and the reaction time of the driver or the operator [1] of the moved objects in the factory shows that many accidents could have been avoided if there had been time to maneuver. A useful role plays warning signals to the operator by data from sensors indicating a possible dangerous situation. Sensor devices that convert electric current to ultrasound waves are called ultrasonic sensors. Their principle of operation is analogous to the work of the RADAR, they catch the target by the reflected signal.

The speed of sound is constant. Based on this, such a sensor calculates the distance to an object corresponding to the time interval between the output of the signal and its return. [2] The action of the Ultrasonic Control System is based on this principle of ultrasonic radiation.

This allows to determine the approaching of the moving object to other objects, fence, etc. [3] In the proposed system, ultrasonic sensors are ultrasound generators, and at the same time receivers of reflected pulses. In the central controller, the signal is processed and the distance to the object or fence is calculated.

But ultrasonic sensors operate in a restricted area, so they are used by groups, in order to cover all needed region. Signals from sensors are remotely. The program sends the queries to the Knowledge Base (KB) and receives the answers about current state of each ultrasonic sensor separately in real time 5-10 times per second. This frequency of scanning space around allows the operator to understand the situation around the moving object and make decisions faster to avoid possible collision or dangerous situation. The answer from knowledge base is represented in form of "warning" or "alarm" state and based on this information operator can correct the further direction of moved object. Also, the received information can be a part of system for moving objects automatically without operator.

II. METHODOLOGY

The system consists of four parts

A. First part is the microcontroller unit Arduino Mega board that is responsible for receiving data from the sensors, sending data to Serial Port and getting processed data back from Serial Port.
B. Second part is the sensors – ultrasonic sensors to measure the distance to any object which is closer than three meters.
C. Third part is the C# Windows Form application which receives data from Serial Port and process them.
D. Fourth part is the KB which consist of important information about each sensor and gives the C# Windows Form application the answer about the statement according to the current data. KB gives the information separately for each of five sensors. Data in the KB is represented in Symbolic form.

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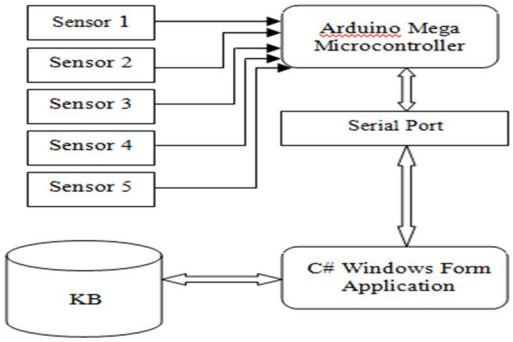


Fig.1 Block Diagram of the System

These units are responsible for the giving information to the user about the closest object in five different directions. Based on this data, user can decide what to do to keep the system safe from the collision.

III. STRUCTURE OF THE SYSTEM

As we can see, the ultrasonic sensors send the information about current distance to the microcontroller. Then data processed and sends further through serial sort to the C# Windows Form application. From the side of the program, it sends the queries to the KB asking about the states for each sensor. The friendly user interface in C# Windows Form application graphically shows to the operator all result in real time. So, operator can easily understand what is going on around the object he is responsible for.

IV. TOOLS AND TECHNOLOGY

A. Arduino Mega Microcontroller

The Arduino Mega board is a microcontroller running on the ATmega2560. [4] The board has 54 digital input/output, 16 analog inputs, a quartz resonator 16 MHz, a USB connector (virtual COM port through which the board is programmed and can be controlled from the console), power supply, and a reset button. The board has all that is necessary to support normal operation of the microcontroller.

B. Ultrasonic Sensors

There are five US-015 ultrasonic sensor which are used in the project. The ultrasonic sensor is used to calculate the distance to the object in front of it. Its range is up to 4 meters at an angle of 15 degrees.

C. Bluetooth Adapter

Module HC-06 is a Bluetooth adapter which are used for signal transmission, for example data from sensors. By default, the module has the transmission speed of 9600 baud.

D. Arduino IDE

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and another open-source software [5].

E. Microsoft Visual Studio

Integrated development environment Visual Studio is a full-featured integrated development environment for Android, iOS, Windows, cloud and the Internet. Visual Studio helps when writing code, regardless of language, from C#, VB and C++ to JavaScript and Python using real-time. Microsoft provides a free version of Visual Studio called the Community edition that supports plugins and is available at no cost [6].

V. IMPLEMENTATING RESULTS AND DISCUSSION

The system has been performed on the Arduino Mega board. Bluetooth module is used to transmit data between microcontroller and laptop. Data, obtained from sensors, is sent to C# Windows Form application for further processing.

A. Testing the Hardware

After it was obtained that all hardware devices were working perfectly, the testing of them began.

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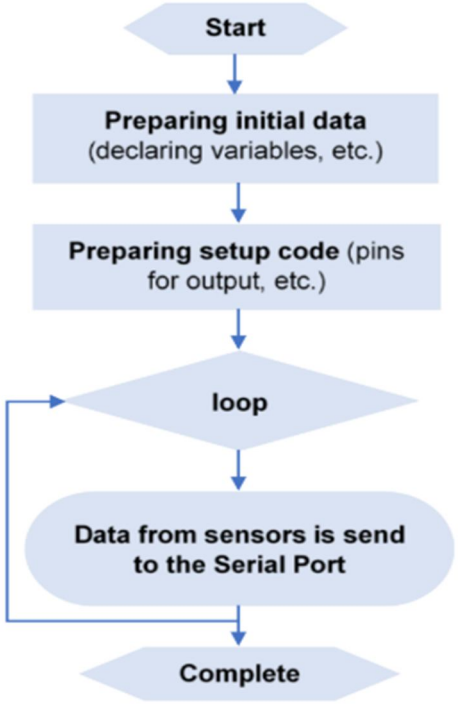


Fig.1 Flow Chart of the Hardware Communication

In the hardware side of the system the variables for the ultrasonic sensors are used. For each variable pin number is assigned. In the Arduino two functions are included in each code: void setup() and void loop(). The first function is run only once and the second one is run continuously. When the system starts to work, the code in the microcontroller forms the string which is going to be send to the serial port. Each value in the string is a calculated distance obtained from each sensor. The values are separated by "-" sign. Figure 3 shows the results of testing in the Arduino IDE.

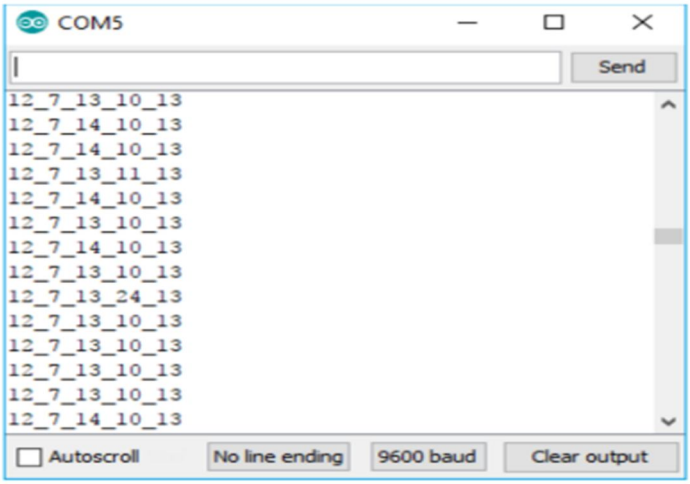


Fig.3 Results of Testing Hardware

B. Testing the Software

The application which is run on laptop are used with the hardware system to carry out monitoring the system via Bluetooth connection.

This application was created in the Visual Studio environment and was written in C# programming language. By using the C# Windows Form application, with a friendly interface, the operator is able to monitor the actual sensors values, and control the "Warning" and "Alarm" situations according to the results of communication between application and KB.

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Reading the data from the KB is made by SPARQL Querying. [7] The KB itself has representation in Notation-3 form. For providing Querying process in the program, "dotNetRDF" library [8] was included into the project. It gives plenty of options to work with Notation-3 files. For asking the KB a method was created which helps to decrease coding and optimize the processing time. To get the information from the Serial Port we need to open it and create the thread for exchanging data in both ways in Real Time. The main specific characteristic of interaction is that from Arduino Mega microcontroller we get the string which consist of information about all five sensors together. In program we decrypt the string and process obtained data.

Figure 4 shows the results for each sensor in Real Time. We can see that for the three sensors it's "Warning" state, for the one it's "Alarm" state and for the last one it's green zone (safety distance).

The position of the system can be changed or some objects can be approached to the sensors. The information in these cases will be changed automatically for each sensor separately in Real Time and represented in this window in C# Windows Form application. The information updates 5 times a second which is quite fast and is sufficient for the project.

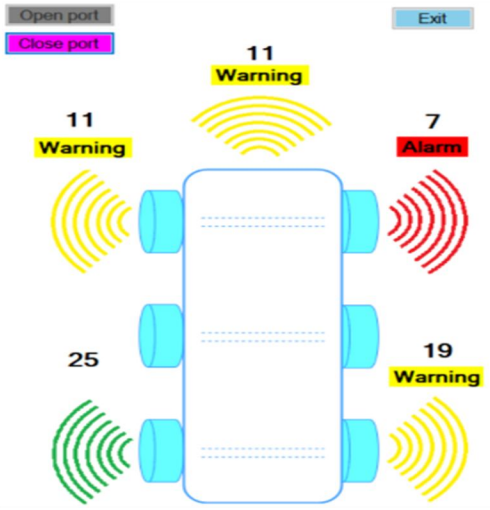


Fig.4 Results of Testing Software

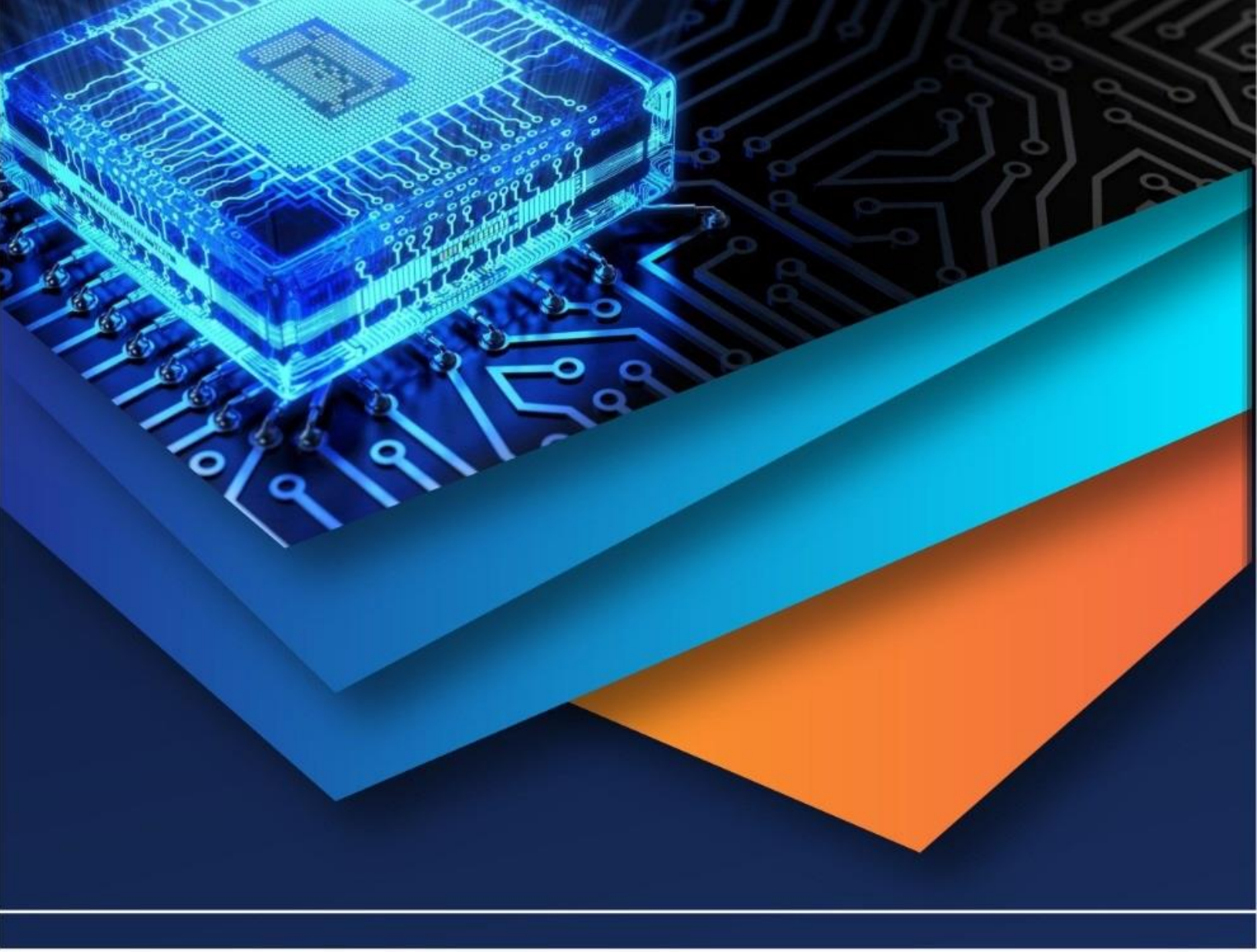
VI. CONCLUSIONS

The aim of this research was to design and perform a communication system between ultrasonic sensors, microcontroller and application. All these had to be done in Real Time to control current situation around the moving object by measuring the distances to the approaching other objects or fences and given the two results "Warning" or "Alarm" according to the answer from KB for each sensor separately. The target has been carried out successfully. The significant characteristic of the system is the idea to exchange the information between microcontroller and application by encrypted string, which consists of all necessary information. The hardware part of this approach is cost effective and low maintenance. The application is user friendly and fast. Represented information is updated 5 times a second. Finally, the developed system can be used in real factory to avoid collisions.

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