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An Advanced Ultra Sonic Traffic Monitoring System using Loops and Cross-Over Bridges

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ABSTRACT
This paper presents a research work on an embedded system called Traffic Control Device (TCD) which is implemented as a prototype on a four way road with loops for controlling vehicle and traffic system. In the practical state, this device able to count various types of vehicle such as car, bus, cargo etc by using ultrasonic ranging detector (sonar) covered by wireless sensor networks (WSNs) and check the permitted vehicles based on Vehicle Detection Algorithm (VDA). The system is also capable to demonstrate the number of the vehicles along with their types on a display at the entry point of the road. By notifying this information it can be easily understand whether the road is busy or free. In this paper, the presented solution is given for 3 different types of vehicle; the model of the hardware configuration is flexible enough to get a better performance.

General Terms
IoT, Wireless Sensor Networking, Artificial Intelligence, Traffic Management System.

Keywords
Arduino Mega Board, Sonar, Ethernet Module, Workstation Computer, Traffic Control Device, Vehicle Detection Algorithm.

1. INTRODUCTION
The traffic control system is required in every developed country for controlling traffic and minimizing the jam. Traffic is the part of the road which cannot be avoided but it can be minimized by developing appropriate management system. Most importantly, when someone realizes which road is free then he can easily change his route to reach his destination by saving time. Thus this will also help the traffic management system to be minimized. This paper discussed our research on a loop & cross-over Bridge based on 4 way road systems which are capable to detect the number of vehicles on the road, the types of the vehicles and check the permitted vehicles. All these tasks are going to be maintained automatically by a workstation. The proposed algorithm, Vehicle Detection Algorithm (VDA) which capable to do the following tasks:

1. Count the number of vehicles
2. Detect the permitted vehicles
3. Detect the types of the vehicle
4. Measure the speed individually

The sensing module is placed on the road at a certain height thus all the vehicles can pass under it. The main sensor of the system is a set of Sonar [1] modules, which are capable to measure the height individually under itself. This entire project needs to calculate some heights. When a vehicle passes under this system, a set of Sonar nodes pick the different height of that vehicle in the lane individually. After detecting the different heights of the vehicle, the maximum measured height is assumed as the estimated height of that vehicle particularly and the summation of length of the engaged nodes presents the width of that vehicle. This height-width can be matched to detect the type of that vehicle with the trained height-width of it as previous. Suppose, H_c & W_c is the accurate height & width of private cars, H_b & W_b is the accurate height & width of the passenger bus and H_t & W_t is the accurate height & width of the cargo trucks. Now if the measured lengths are approximately equal to H_c & W_c then the system can detect the vehicle passed away under this system is a car. Using this same algorithm, the system can easily identify the vehicle which is passed away under the system is a passenger bus, cargo trucks or any other types of vehicle. As all the information is kept in the database of the workstation [2] thus the condition of the road can be easily demonstrated in display system which is kept on the entry point of the road. Before entering the next road the propeller might see the display and can identify easily which road is free to go for him to reach. Another characteristic of this system is that it can monitor the permitted vehicles. For instance, a city road doesn't allow for passing any heavyweight cargo trucks, after identifying such kind of vehicle a warning message will be sent to the control manager that an illegal transport passed away on that road particularly. Then the control unit can take the necessary action against the propeller of this vehicle. As this project is replacing the motion pictures with just a few numeric figures so the data size which is passed to the database might be in the form of bytes per sensing unit which will save a huge memory spaces along with minimizing management hassle. So in TCD, the data size is tiny in comparison with existing traffic management system. . The technical part has been implemented using Arduino IDE software [3].

2. RELATED LITERATURE AND SYSTEM
Vehicular traffic is continuously extending around the world day by day, especially in large urban areas. So many researchers are working on this field and invented new methods to reducing the road traffic. Most of the research activities are based on the management of traffic lights in an efficient way [4]. As the road traffic are increasing day by day around the world so the existing methods for traffic management are being incapable in terms of performance, cost, and maintenance.

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The traffic control units are using artificial intelligence [5] on the developed countries like USA, UK, France, Germany, Japan etc. Also they have introduced the wireless sensor to maintain traffic signals and vehicle detection for reducing traffic gathering. The core issue to manage the traffic is managing the quantity of vehicles passing at a time. So it is not just to signal them in an intelligent way but also to design the roads in an efficient manner. Some vehicle detection devices are also available in marketplaces such as Monnit Industrial Vehicle Detection Sensors [6], M100 Wireless Vehicle Detection Sensor [7], Civic Smart's Vehicle Detection Sensor [8] etc. But the prices and their uses are too expensive and complex accordingly. So the proposed system is cost effective and user friendly which is capable to detect the vehicle just by measuring its height and width. Also this system will minimize the vehicular information into tiny format just a set of bytes in the central database.

3. VEHICLE DETECTION ALGORITHM (VDA)

In this paper, Vehicle detection has been controlled by VDA. This algorithm detects the distance between vehicle and system. After detecting this, The VDA calculate the height and width of the vehicle then check the type of the vehicle.

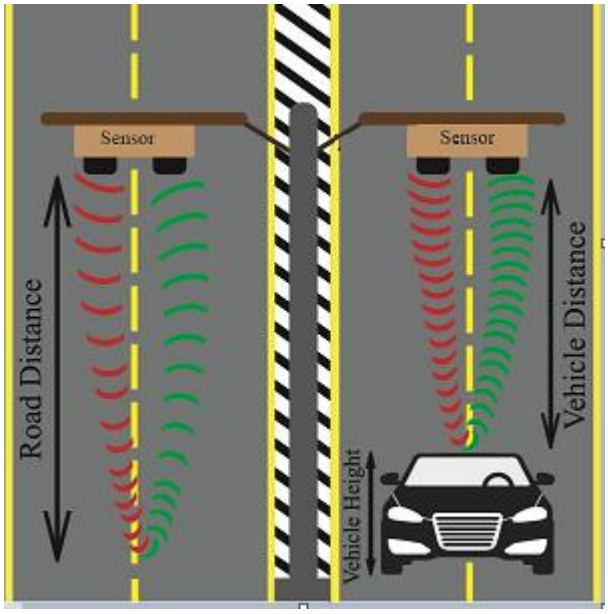

Fig 1: Working model of the system.

The pseudo code of the VDA was written below:

```
1)  Define carMaxHeight, carMinHeight,
2)  Define busMaxHeight, busMinHeight
3)  Define truckMaxHeight, truckMaxHeight
4)  Define maxLegalHeight
5)  Var  array[size], vehicleCount = 0, roadDistance
6)  Var  vehicleHeight, distance, size = 0, test = 0
7)  Void loop()
8)  distance = getDistance()
9)  IF  distance < roadDistance Then
10)      array[size] = distance
11)      size++ & test++
12) ELSE IF distance == roadDistance Then
13)          IF test != 0 Then
14)              min = getMin( array[size] )
15)          END
16) END
17) vehicleHeight = roadDistance – min
18) IF vehicleHeight <=  maxLegalHeight  Then
19)              Calculate Width
20) IF( ( vehicleHeight <= carMaxHeight ) && ( vehicleHeight >= carMinHeight ) ) Then
21)          Print("Car")
22) ELSE IF ( ( vehicleHeight <= busMaxHeight ) && ( vehicleHeight >= busMinHeight ) ) Then
23)          Print("Bus")
24) ELSE IF ( ( vehicleHeight <= truckMaxHeight ) && ( vehicleHeight >= truckMinHeight ) ) Then
25)          Print("Truck")
26) END
27) END
```

The following variables are assumed as constant:- carMaxHeight, carMinHeight, busMaxHeight, busMinHeight, truckMaxHeight, truckMinHeight and roadDistance. The Sonar gives more than one distance after some microsecond. The distance calculating procedure has been shown in Fig 1. Those distances have been stored in an array and check the minimum value. This minimum value is the minimum distance between vehicle and system. The Vehicle Height is calculated by subtracting between Road Distance and Minimum value. The width is being calculated by width measurement procedure that is explained on section 3.4. After calculating Vehicle Height, the type of the will be checked as follows:

3.1 Car Detection

A car has the lowest height among the experimental three different vehicles. After calculating the vehicular height, the detection process of the car is written below.

```
IF ( ( vehicleHeight <= carMaxHeight ) && ( vehicleHeight >= carMinHeight ) ) Then
        Decision "Car"
```

The Vehicle Height is checked with Car Max Height and Car Min Height [12]. If the condition is true then the decision is a car. The VDA algorithm showed that the vehicle passed under this system is a car and. The height and type also through to the database.

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3.2 Bus Detection

The City Bus detection procedure in VDA is also same as Car detection. The condition is written below.

IF((vehicleHeight <= busMaxHeight) && (vehicleHeight >= busMinHeight)) Then

Decision "Bus"

The Vehicle Height is checked as like the procedure of Car detection written in section 3.1. The Bus Max Height and Min Height is constant value. If the condition is true then the decision is Bus that is passed under the system. The VDA check the height of vehicle that is used to know the type.

3.3 Truck Detection

Truck Detection is also the same procedure to detect the car and Bus. The Algorithm of pseudo code that is written in section 3 declares some constant value about the truck. The condition is written below.

IF((vehicleHeight <= truckMaxHeight) && (vehicleHeight >= truckMinHeight)) Then

Decision "Truck"

The constant value is truck Max Height and Min Height. This used in VDA because the vehicle height is checked by this constant value. If the condition is satisfied by VDA then the decision is Truck that is passed under the system.

3.4 Width Measurement

Width of the vehicle can be measured by suing multiple sensors at a time. In the following figure 6 sensors has been shown by considering the width of the road named as S1, S2, S3, S4, S5, S6.

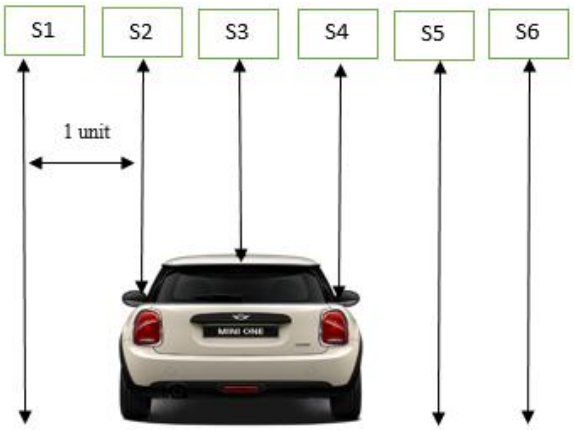

Fig 2: Width Measurement of the Vehicle

The distance between each sensor is 1unit. Thus the width of the road is 5 units. When a vehicle passes under the system, the sensor measures the distance from road as well as the vehicle. In fig 2, S1, S5 and S6 are free means they are getting max height. At that time S2, S3 and S4 are engaged to measure the surface distance of the vehicle. Now the width of the vehicle can be measured by using one formula written below, where C_w presents the car width:

1) C_w = totalSensorUnit – freeSensorUnit
2) Or, $C_w = (S_{12} + S_{23} + S_{34} + S_{45} + S_{56}) – (S_{12} + S_{45} + S_{56})$
3) Or, $C_w = 5 – 3$
4) Or, $C_w = 2$ (Unit)

4. VDA BASED TRAFFIC SYSTEM

The main achievement of VDA is to detect the type of the vehicle that is passed under this system. The technical part has been implemented using Arduino IDE software. The core of the system is an Arduino Mega 2560 Board, Ethernet Module [9] and Sonar. All the system needs to collect distance from the vehicle and measure the height-width and detect the type using VDA. The Arduino Mega board is used for controlling Ethernet module and Sonar. The Sonar detects the distance in some microseconds. After getting the distances the vehicle type detection and count process begins. The counted vehicular information goes to the local display panel. At the same time the core systems sends these information to the workstation for further analysis.

4.1 Core Functionalities

The core of the system detects the distance from the vehicle. When the road is free the distance is same as the road distance. The road distance is constant that is not changing because the system is set up on the road using a tower like as lamp tower. When a vehicle is passing under it, various distances are captured from different nodes of the module. After getting the distances the detection process begins. The hardware structure has been shown in the Fig 3. This figure presents the working activities of a single Sonar unit.

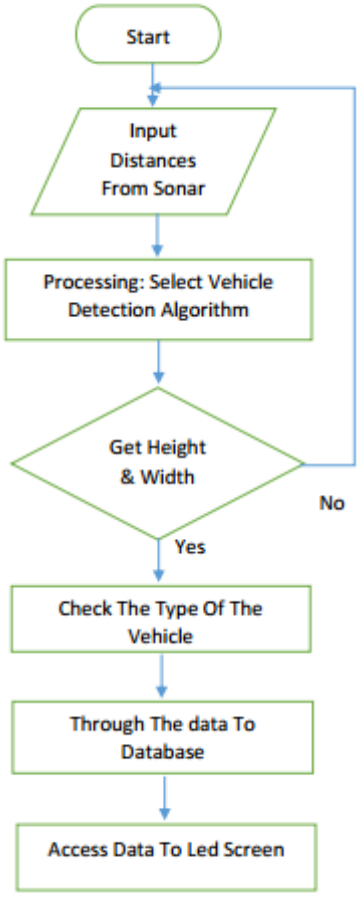

Fig 3: System Model of Traffic Control System

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Different distances have been stored an array because the sonar measures the distances in some microseconds. The minimum value of this array is the near distance between the system and the vehicle that is used to calculate maximum height of the vehicle. The maximum height is also checked with some constant value for detecting the type. After detecting the height from the program the vehicle height and type is passed to the database with the help of Ethernet module. The workstation stores the data in a sequential format. This procedure has been known Internet of Things (IOT). The IOT [11] is introduced here as a number of modules are engaged to handle the entire task.

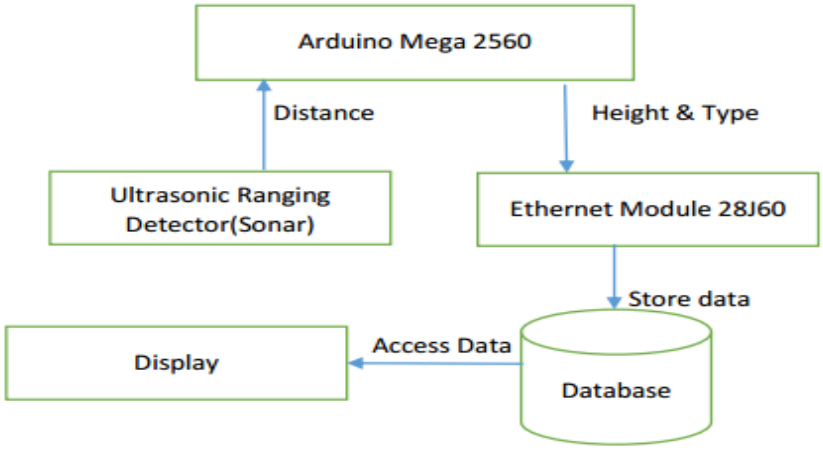

Fig 4: Block diagram of a Single Vehicle detection Unit

4.2 Machine Interfacing and Operation

The core of the system is Arduino Mega 2560 having microcontroller ATMEGA2560 [10]. The microcontroller receives the distance measured from the sonar and helps to calculate the height using VDA. The microcontroller calculates the actual height and checks the type of the vehicle. After completing all operation of VDA, the actual height and the type of the vehicle have been transferred to the database with the help of Ethernet module which is set up with the IP address that helps to detect the database server through the internet. The Ethernet module 28J60 has been set up with system IP address and server IP address which helps to detect the system server also. After storing the data in the database, the data has been accessed to the LED screen that helps to know how many vehicles passed under this system on the road. The LED has been connected to the database through the internet. The total system has been controlled by microcontroller ATMEGA2560 before storing the data in the database.

4.3 Average speed measurement

By using the stored data in the database, the measurement of the average speed of the vehicle can be calculated.

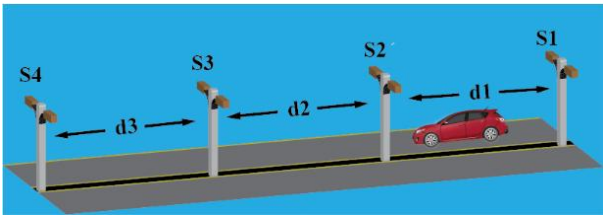

Fig 5: Average Speed Measurement

Suppose, System Id = S, Vehicle Type = VT, Vehicle Height = VH, Vehicle Passing Time = VPT, Distance from Previous System = D, then the table is,

Table 1: Database table of a specific Vehicle

S	VT	VH	VPT	D
S1	Car	H	T1	0
S2	Car	H	T2	D1
S3	Car	H	T3	D2
S4	Car	H	T4	D3

This is the database table of a car that is passed under the system S1, S2, S3, and S4. When the car is passed away under the system S1, S2, S3, and S4 then all of the information will be passed to the database. The distance between system S1 and S2 is D1 as like as the distance between system S2 and S3 is D2. Now the average speed of this car by using this data from the database can measured. When vehicle passed from system S1 to S2 then Speed,

$$Speed_1 = \frac{\mathrm{D1}}{\mathrm{T2} - \mathrm{T1}}\ \mathrm{m/s}$$

As like as the vehicle speed from the system S2 to S3,

$$Speed_2 = \frac{\mathrm{D2}}{\mathrm{T3} - \mathrm{T2}}\ \mathrm{m/s}$$

And the last speed is measured from the system S3 to S4,

$$Speed_3 = \frac{\mathrm{D3}}{\mathrm{T4} - \mathrm{T3}}\ \mathrm{m/s}$$

From the above mentioned formulas, the average speed of the vehicle can be measured. In this paper, a car is considered as

an example in the data table, table 1. The average speed of the vehicle is,

$$average\ speed = \frac{Speed_1 + Speed_2 + Speed_3}{\text{number of system} - 1}\ \text{m/s}$$

4.4 Graphical View

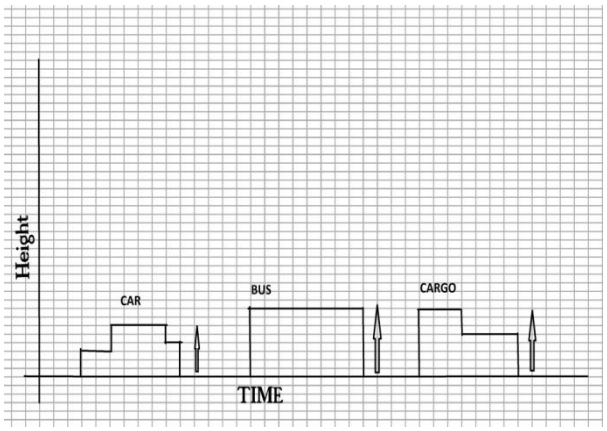

Figure 6: Graphical View of Vehicle

In this graph, The Time is measured in X axis and the Height is measured in the Y-axis. By considering the shapes, the objects shapes are as like as car, bus and cargo trucks etc. Those three objects are considered as major vehicles in our prototype. Suppose the 1st object that is small and looks like a private car. By considering the same theory, the 2nd object is larger than the previous object and that looks like a passenger bus. The last shape looks like as a cargo truck. When any types of vehicle passed under the system then the data measured from the sonar will be passed to the graph and the graph generates a shape as like as the vehicle that is passed. Suppose R1 = Read1, R2 = Read2, R3 = Read3, R4 = Read 4 and R5 = Read5.

Table 2: Data read from Sonar

R1	R2	R3	R4	R5	Decision
1	2	3	2	1	Car
4	4	4	4	4	Bus
4	4	2	2	2	Cargo

In the meantime, the Time that is situated on the X-axis measured the speed of the vehicles. At this moment, The Height that is being situated on the Y-axis measured the actual height of the vehicle which is used to detect the types of the vehicle. In Table 2, it has been showed the data of the generated graph. This graph has been generated directly from Arduino Processing software. The Arduino Processing IDE is software which is capable to generate the graphs and shapes comes from Arduino serial monitor.

5. ROAD DESIGN

The proposed road design is suitable for using this system. After completing the road, the vehicles are not required to stay for a traffic jam. The design of this road is:

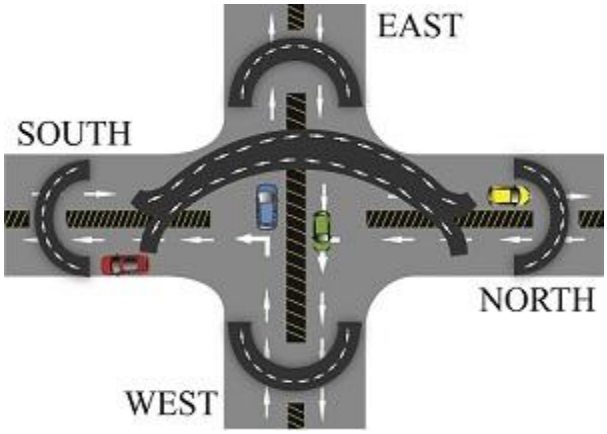

Fig 7: Suitable Road Design

In this figure, if any vehicle wants to go to South from North then the propeller has 2 options. One takes left turn and goes to the east side for taking U-Loop to go south road, another is being used to bridge for going to south road. At the same type, if any vehicle wants to go east from the West then the propeller has 2 options. One takes left turn and goes to North side for taking U-Loop to go East side. Another is being gone to the straight road under the bridge. The way for going east to West and South to North is the same procedure as North to South and West to East. The selection of the free road is being identified after seeing the display that is connected with the workstation and show the information of road condition measured by the traffic control system.

6. LIMITATIONS & FUTURE PLAN

This paper presents how to maintain a traffic management by using wireless sensor networking on a loop & cross-over Bridge based on 4 ways road systems. The wireless sensor networks are used to maintain traffic signal, vehicle detection and capabilities of the road in a particular situation. The proposed system that is capable to calculate the number of vehicles is passed away on the selected road. If someone wants to know whether a specific road is free or not then he can easily reach to his destination by avoiding the traffic jam.

This project is totally based on specific lanes, and it will work properly if and only the vehicle maintains the lane. The VDA measures only the heights of the lane having or without having vehicles. So for a number of passing vehicles in the same lane at the same time will make the system totally confused. For this motivation, only one vehicle's information such as type, height, weight and speed have been measured at a time. The next one limitation is being measured the same heights at a moments when a vehicle is stay under the system. For this purpose, the VDA algorithm measure same heights at a time that is confused for detecting the type and the speed of the vehicle.

As the proposed system is capable to count the number of vehicles passing through a particular road, so by data mining it is possible to produce a report indicating the percentage of road damage. The ultra sound sensing modules are capable

only to measure the height. So if a traffic jam occurred due to road accident or any other reason, the sensors will get a static height. So here an automated quadcopter with video camera based observation system would be helpful to identify the situation appropriately. So the system will broadcast a live stream to the central monitoring unit or the workstation. Thus the authority could take necessary steps whether by human intervene or machine guidance as applicable.

7. ACKNOWLEDGEMENT

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8. REFERENCES

[1] Sonar Module: https://www.sparkfun.com/products/13959.

[2] Database Systems: https://www.mysql.com/.

[3] Arduino IDE: https://www.arduino.cc/

[4] Juhi R Srivastava, T. S. B. Sudarshan, Intelligent traffic management with wireless sensor networks. IEEE Digital Libray, **DOI:** 10.1109/AICCSA.2013.6616429, 03 October 2013.

[5] Shreyta Kulkarni, Vikesh Dass & Aseem Sharma, International Journal of Innovative Research in Computer Science & Technology (IJIRCST) ISSN: 2347-5552, Volume-2, Issue-2, March-2014.

[6] Monnit Industrial Vehicle Detection Sensor:

http://www.quizee.club/url/H.

[7] M100 Vehicle Sensor: http://www.quizee.club/url/O.

[8] Civic Sensor: http://www.civicsmart.com/.

[9] Ethernet Shield: http://www.quizee.club/url/K.

[10] ATMEGA2560: http://www.quizee.club/url/L.

[11] IoT: http://www.quizee.club/url/P.

[12] Car Height Calculation: http://www.quizee.club/url/M.