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Fabrication of a DTMF Based Guided Vehicle

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ABSTRACT

Today's world mainly focuses on reducing human effort and maximizing efficiency. Machines are replacing humans in many hazardous working environments. Automation is playing an important role in saving human efforts in most of their day-to-day works. A robotic vehicle has been developed in this project which can be particularly used in a small scale industry. The robotic vehicle is controlled by a mobile phone that is connected to the robot through a GSM network which acts as a remote controller. DTMF technology is used, which enables the robot to be controlled over the GSM network. The keypad of the mobile phone acts as a remote to control the vehicle's movement. The robotic vehicle developed is not an Automated Guided Vehicle (AGV) as an operator has to manually operate the vehicle. A sensor is attached to the front of the vehicle which senses obstruction in its path and enables the vehicle to avoid collisions with moving or fixed objects. The vehicle features battery powered motors and computer technology that has been programmed to drive to and from specific points. This research work involves the fabrication of a working model vehicle controlled over a GSM network using DTMF technology. The guided vehicle can work in environments such as transporting materials from a warehouse to production lines to reduce human effort and increase efficiency.

Keywords: DTMF, Robot, Vehicle, AGV, Sensor, Prototype

1. INTRODUCTION

A machine which is programmable by a PC and is equipped for doing a perplexing arrangement of activities without human interference is known as a robot. It is an electro-

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mechanical machine which is guided by a computer, mobile phone or programming and is thus able to do tasks on its own. The Robot Institute of America defines “A robot is a reprogrammable multifunctional manipulator designed to move material parts, tools or specialized device through variable programmed motions for the performance of a variety of tasks” [1]. There are various benefits of using a robot in an industry. They are capable of performing various varieties of tasks and applications while being precise and consistent at the same time. Being able to complete tasks faster they allow for increased production and profit margin. Other benefits are that they can work in environments which can be harmful and dangerous for a human worker. Generally established industries use AVG's to transport many different types of materials which include heavy containers, racks, rolls etc. It includes transporting materials from a warehouse to production lines. They excel in applications like regular delivery of stable loads, medium throughput/volume when on-time delivery is critical and late deliveries are causing inefficiency etc. The AVG does also have their share of disadvantages like a potentially high initial investment, not suitable for non-repetitive tasks, decreased flexibility of operations. The purpose of this project is to overcome the limitations of the AGV's and to give a considerable option for small scale industries so that they can also obtain an equal amount of profits as of large scale industries by implementing our designed vehicle in industries.

1. 2. Need for DTMF Guided Vehicle

- Low Initial Investment as compared to an AGV system.
- Suitable for Non- Repetitive tasks.
- Low Maintenance Costs.
- Not restricted to a pre-defined path.

2. RELATED WORKS

A). A. Jadhav *et al.* (2012) investigated the use of cell phone technology in ground combat vehicles. They outlined the usefulness of DTMF technology in comparison to (RF) Radio Frequency for robotic communication. They concluded from their investigation that an alternative method to radio frequency can be produced to decrease the RF noise from the environment [2].

B). P. Pradeep *et al.* (2010) developed an advanced design for a robot that can be used in mars exploration using DTMF technology. Here they have chosen the cell phone technology due to its merits [3].

C). G.K. Dey *et al.* (2013) designed a robot that can be controlled from distance by the help of DTMF technology and can be used for rescue and security applications. They have assembled the robot with various sensors and pick and place module so that it could be of real help in any situation where humans cannot reach like tunnels, hidden places etc [4].

D). K.V.V.S.R. Bhaskar *et al.* (2013) constructed a land rover with the help of a DTMF decoder which is used to communicate and instruct the robot. They have stated the primary purpose of the robot in the conclusion which is to abstract information from places where human activities are restricted [5].

E). H. Rashid *et al.* (2016) designed and developed a room cleaning robot using DTMF technology. Here they have used Arduino Uno as the microcontroller of the robot. The robot is developed to implement an automatic cleaning system [6].

F). A. Srivastava *et al.* (2014) created a robot for intelligent farming using DTMF technology. Here they have used various sensors for various automatic agricultural activities. The robot can be used in places where manual farming by farmers is difficult [7].

3. METHODOLOGY

Autonomous robots in industries has been a trend for several years and the years coming. A low cost AVG system ranges from 40-50 lakhs (Indian Rupees) which practically becomes impossible to afford by MSME industries. This guided vehicle will fulfill all the merits of an AVG while providing employment at the same time. The methodology followed throughout the research is illustrated in Figure 1. DTMF technology has been implemented in the project which is a simple, and cost effective communication method. The vehicle operates between two working mobile phones while being connected to GSM network. The project exhibits a lab prepared working model whose functions would be similar to a real life fully functional vehicle. A combination of hardware & software which are easily available or accessible were used in the assembly of the vehicle. The design is simple and hence enables us to interpret the optimal utilization of the vehicle. The design was initially prepared in solid works to test its real world compatibility. The vehicle was tested out in the field after it was assembled. This project helps us to investigate the feasibility and efficiency of implementing DTMF as a method of communication in modern robotics. It also helps to explore advance capability of robotics technology in Industrial Technology and to decrease the level of complexity of robots for an average user.

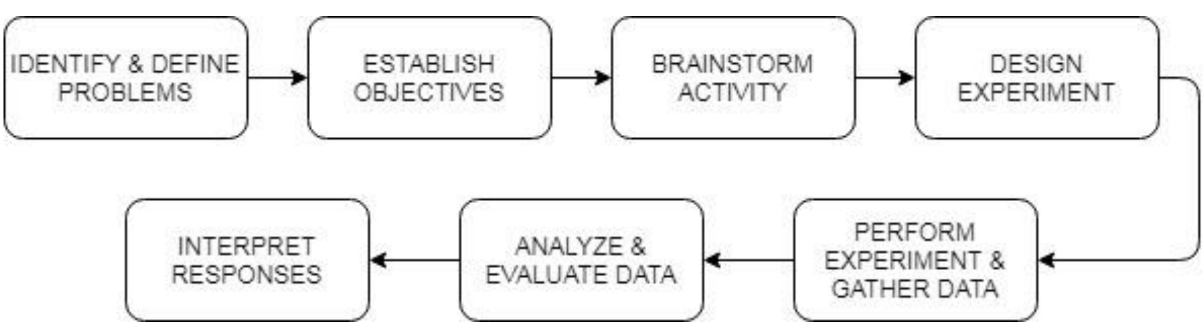

Figure 1. Systematic Representation of the followed methodology

4. WORKING METHOD

The robot consists of Solar Panel, Batteries, HC-SR501 PIR Sensor, DTMF decoder IC MT-8870D, AT89S51 Microcontroller IC, Driver L293D IC, DC geared motors and 2 mobile phones. The primary mobile phone is with the operator that will drive the vehicle. It will act as the DTMF decoder and will transmit the signal to the secondary mobile phone that is attached with the vehicle. The control signal is transmitted through the GSM network. The robot is controlled by the primary mobile phone that makes a call to the secondary mobile phone attached to the robot.

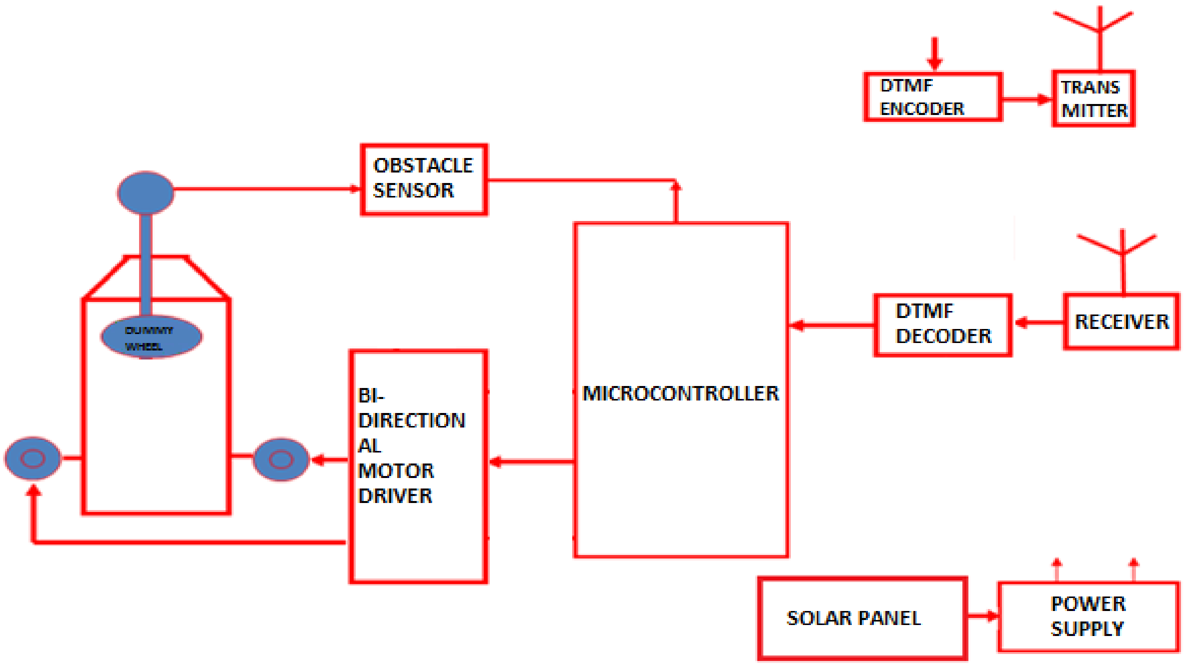

Figure 2. Block Diagram Representation.

The primary mobile phone's keypad is used to control the robot movement toward the desired location. In the course of a call, if any button is pressed a tone corresponding to the button pressed is heard at the other end called 'Dual Tone-Multi frequency' (DTMF) tone. The secondary mobile phone will act as the DTMF receiver and will transmit the signal to the DTMF decoder. The received tone is decoded by the DTMF Decoder IC MT-8870D. The decoder IC internally consists of an operational amplifier whose output is given to pre-filters to separate low and high frequencies. Then it is passed to code detector circuit and it decodes the incoming tone into 4bits of binary data.

The signal is then processed by the microcontroller IC AT89S51. It processes the signal according to which it has been programmed. The Microcontroller IC sends signals to the motor driver IC L293D which drives the motor forward, reverse, left or right. The vehicle can be controlled from anywhere in the world (of course where GSM/CDMA network is available). The PIR sensor attached at the front of the vehicle acts as an obstacle detector. The robot is programmed in such a way that the data output from the sensor is prioritized first. The data output from the sensor is binary i.e. (0 or 1).

If the output is '0' then it means that there is no obstacle in the path of the vehicle so it can easily proceed ahead but if the output is '1' then there must be some obstacle in the path of the vehicle and the whole system shuts down. After the obstacle gets removed, the system gets activated and functions like before. The vehicle is equipped with a cargo bed to carry and unload materials or transport from one place to another.

The robot is powered by three 4-Volt rechargeable batteries which are charged by a solar panel attached at the top of the vehicle. It helps in reducing the carbon footprint and make use of renewable energy simultaneously. A functional block diagram of the robot is illustrated in Figure 2. Through Figure 3 & Table 1, we can get an idea of the vehicle control system.

Table 1. Functionalities of the mobile Keypad.

Key pressed	Movement of the vehicle
1	the cargo bed moves up
2	the vehicle moves forward
3	the cargo bed moves down
4	the vehicle turns left
5	the vehicle stops
6	the vehicle turns right
8	the vehicle moves backward

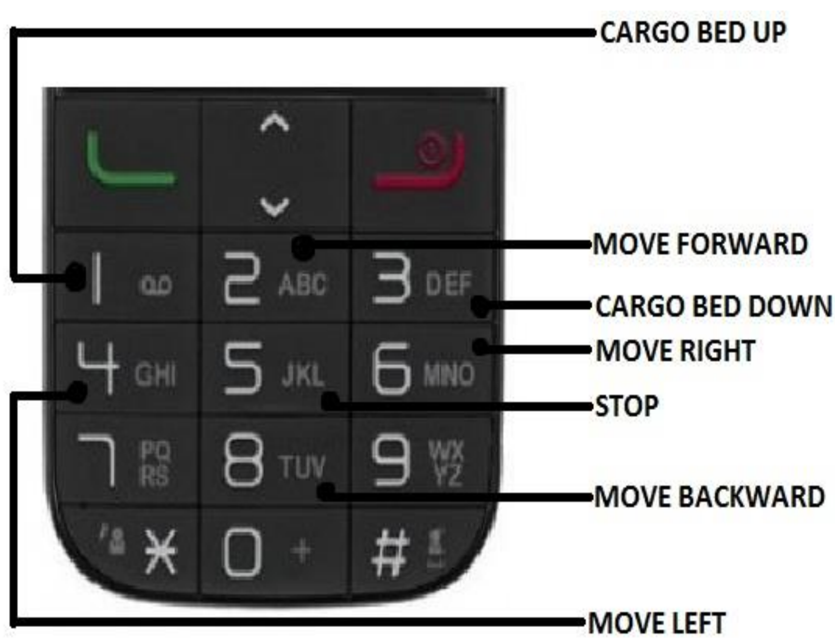

Figure 3. Functionality of the primary mobile phone.

5. DESIGN AND IMPLEMENTATION

5. 1. Mechanical design

The body of the robot has been made of mild steel and cuboids' shape of 0.65 m X 0.15 m. There have been two strong grip rubber tires installed with two different DC motors at the rear along with another caster wheel installed in the front of the robot vehicle to ensure proper balancing and rotation. Figure 5 shows the mechanical design of the robot vehicle prepared in solid works, while figure 6 shows the final fabricated model. A cargo bed is attached at the rear end of the robot to ensure successful loading and unloading of cargo, to and from the desired points. The proposed design of the vehicle is merely a prototype and hence, cannot be directly used in industries.

This design is only prepared for studying the role of the vehicle in the industry and can be modified on further necessary requirements. A number of other accessories can be used in the vehicle depending upon the work it is assigned to. An experimental design carries various advantages which is illustrated in Figure 4.

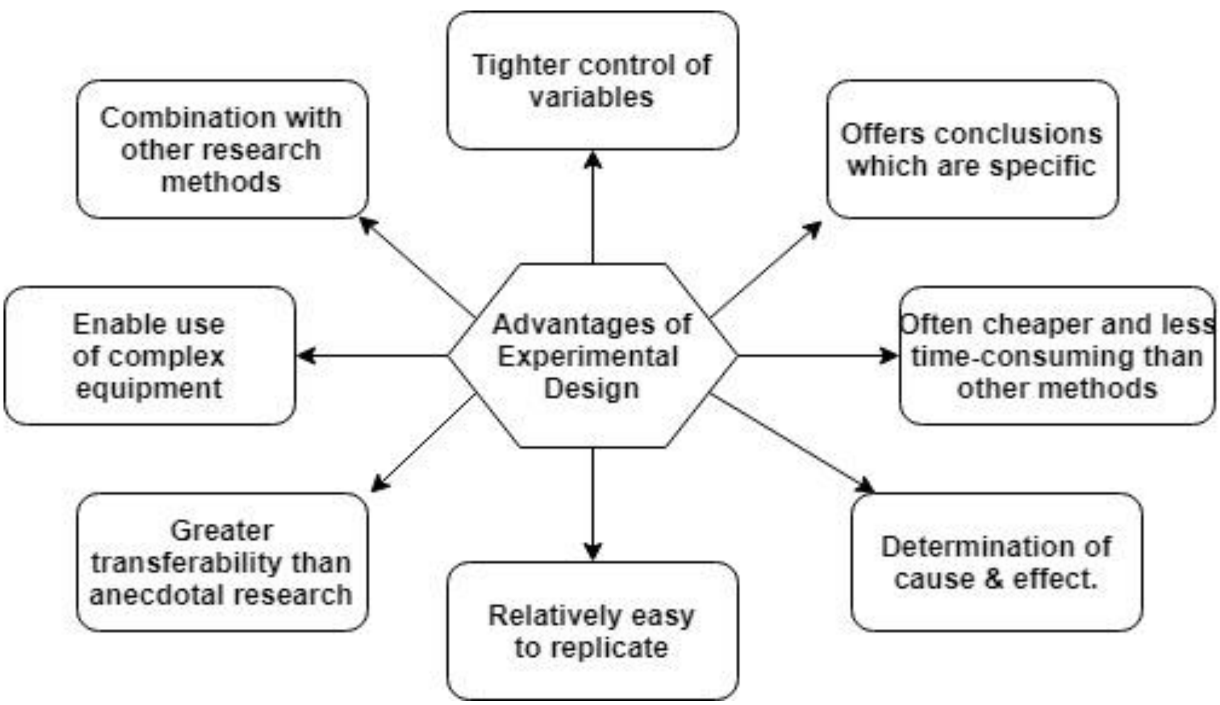

Figure 4. Schematic representation of advantages of experimental design.

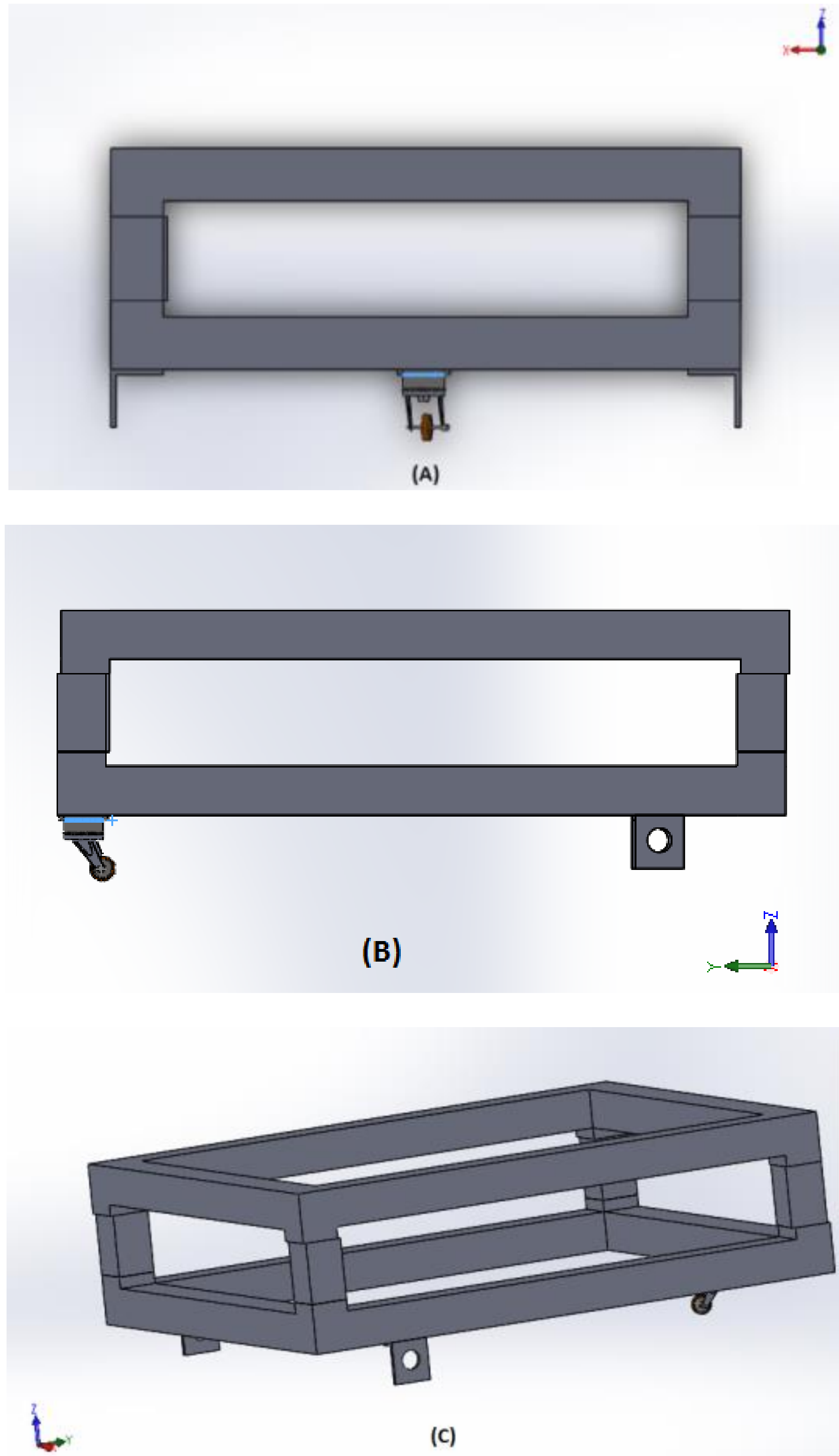

Figure 5. (A) Front View of the Solid Works Model, **(B)** Left Side View of the Model, **(C)** Isometric View of the Model.

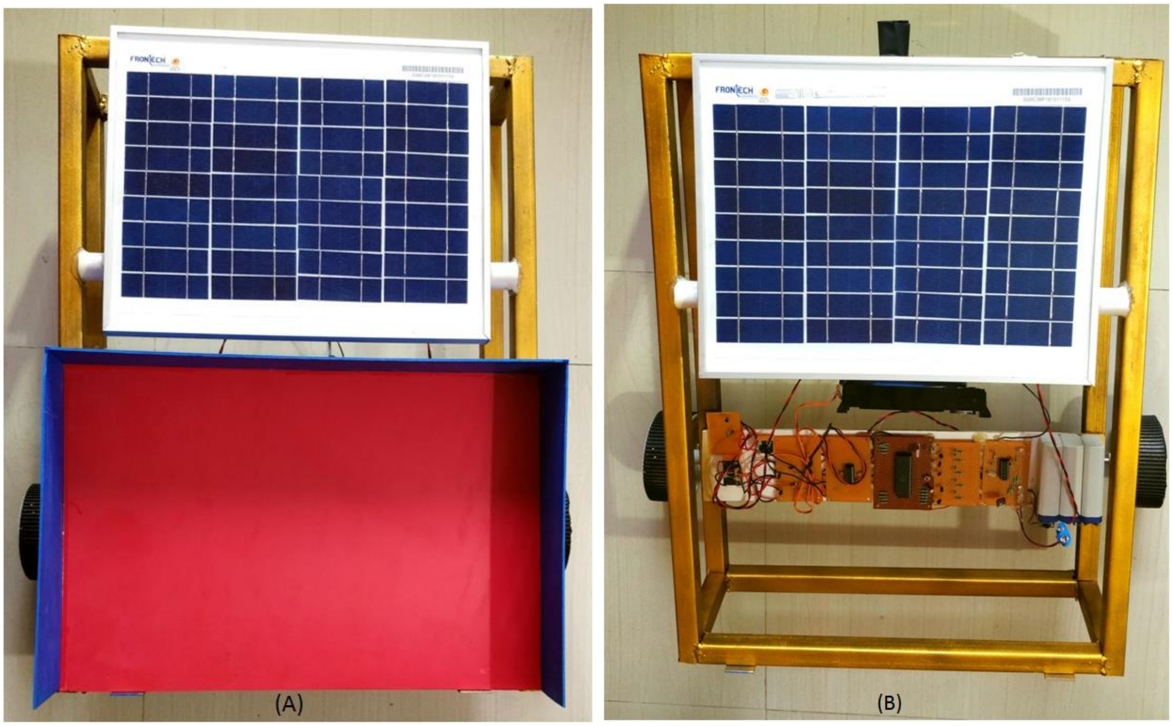

Figure 6. (A) & **(B)** Fabricated Model Representation

5. 2. Hardware

The vehicle consists of certain open source hardware and accessories for its functioning. The primary hardware used in constructing the vehicle can be seen in Table no. 2. The particular hardware used are easy to find and replace, which suited best for the experimental lab designed robotic vehicle. These hardware increases the accessibility to the system and can be easily and inexpensively fabricated.

Table 2. Primary Hardware Components.

Sl No.	Component Description	Quantity
1)	Microcontroller(AT89S51)	1 Nos
2)	DTMF Decoder(MT-8870D)	1 Nos
3)	PIR Sensor(HC-SR501)	1 Nos
4)	Motor Driver(L293D)	1 Nos
5)	DC Motor	2 Nos
6)	Solar Panel	1 Nos
7)	Batteries 12V (4 Volt each)	3 Nos

Table 3. DTMF data output and signal frequency encoding [8].

Low group(Hz)	High group(Hz)	Digit	OE	D3	D2	D1	D0
697	1209	1	H	L	L	L	H
697	1336	2	H	L	L	H	L
697	1477	3	H	L	L	H	H
770	1209	4	H	L	H	L	L
770	1336	5	H	L	H	L	H
770	1477	6	H	L	H	H	L
852	1209	7	H	L	H	H	H
852	1336	8	H	H	L	L	L
852	1477	9	H	H	L	L	H
941	1336	0	H	H	L	H	L
941	1209	*	H	H	H	H	H
941	1477	#	H	H	H	L	L
697	1633	A	H	H	H	L	H
770	1633	B	H	H	H	H	L
852	1633	C	H	H	H	H	H
941	1633	D	H	L	L	L	L
ANY	ANY	ANY	L	Z	Z	Z	Z

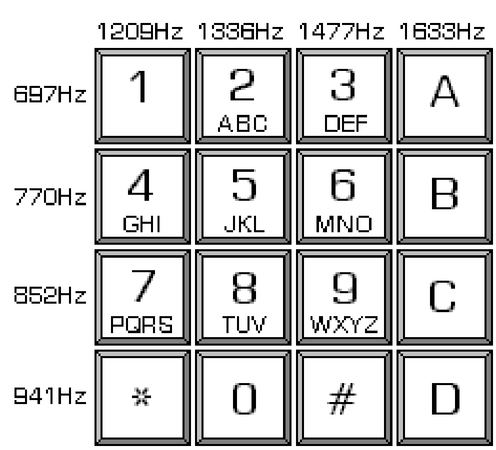

Figure 7. Dual Tone-Multi Frequency (DTMF) Map [9].

AT89S51 Microcontroller

It is an 8-bit microcontroller with 4K bytes of In-system programmable flash memory. It is more suitable for new designs and projects rather than its old model AT89C51. Its distinctive features make it a perfect first choice for projects. It is a low power and high-performance CMOS microcontroller. It has 40 pins for its operation. It can easily be programmed and acts as the heart of the robot [10].

MT-8870D DTMF Receiver/Decoder

DTMF stands for Dual Tone-Multi Frequency. It detects the dial tone from a telephone line and decodes the keypad pressed on the remote telephone. Whenever a key is pressed in the matrix keypad it generates a unique tone consisting of two audible tone frequencies. The communication from the remote controller to the signal receiver consists of tone generator to tone receiver. It uses digital counting techniques to detect and decode all 16 DTMF tone-pairs into a 4-bit code. After decoding the commands are sent to the microcontroller for further processing [8].

HC-SR501 PIR Motion Sensor

PIR stands for (Passive Infrared). It is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. It is highly sensitive, has high reliability, has ultra-low voltage operating mode and is best for battery powdered automatic controlled products. It has a sensing range of 3 to 7 meters which can be adjusted by the potentiometer available on the device. It has 3 pins for its operation [11].

L293d Motor Driver

This motor driver is used to operate the DC motors, so that the robot may be able to move. It acts as a mediator between the microcontroller and the motors. The microcontroller alone cannot run the motors due to lack of sufficient energy, where the motor driver comes into play. It is designed to provide bidirectional drive currents of up to 600 mA at voltages from 4.5 V to 36 V. It is a 16-bit chip and is used to run two motors [10].

DC Motor

This project uses two dc motors to run the robot and a caster wheel at the front. This configuration was chosen by keeping in mind, that it's simply a prototype. The motors are driven by the motor driver. These are 12 volt geared motors which provide high torque and low RPM. These motors are ideal to carry loads and are used in all terrain robots and various other robotic applications. These motors have an RPM of 200. They have a 6mm shaft diameter with an internal hole. They have a torque of 2 kg/cm with a maximum no-load current of 60 mA and maximum load current of 300 mA [12].

Solar Panel

A solar panel of 12 V & 20 W is used to power the Guided Vehicle. The panel provides a renewable source of energy and keeps the battery charged for utilization.

6. OPERATIONAL FLOWCHART

The operation procedure of the Guided vehicle is shown in the following flowchart i.e. Figure 8. The flowchart illustrates the functioning hierarchy of the used hardware.

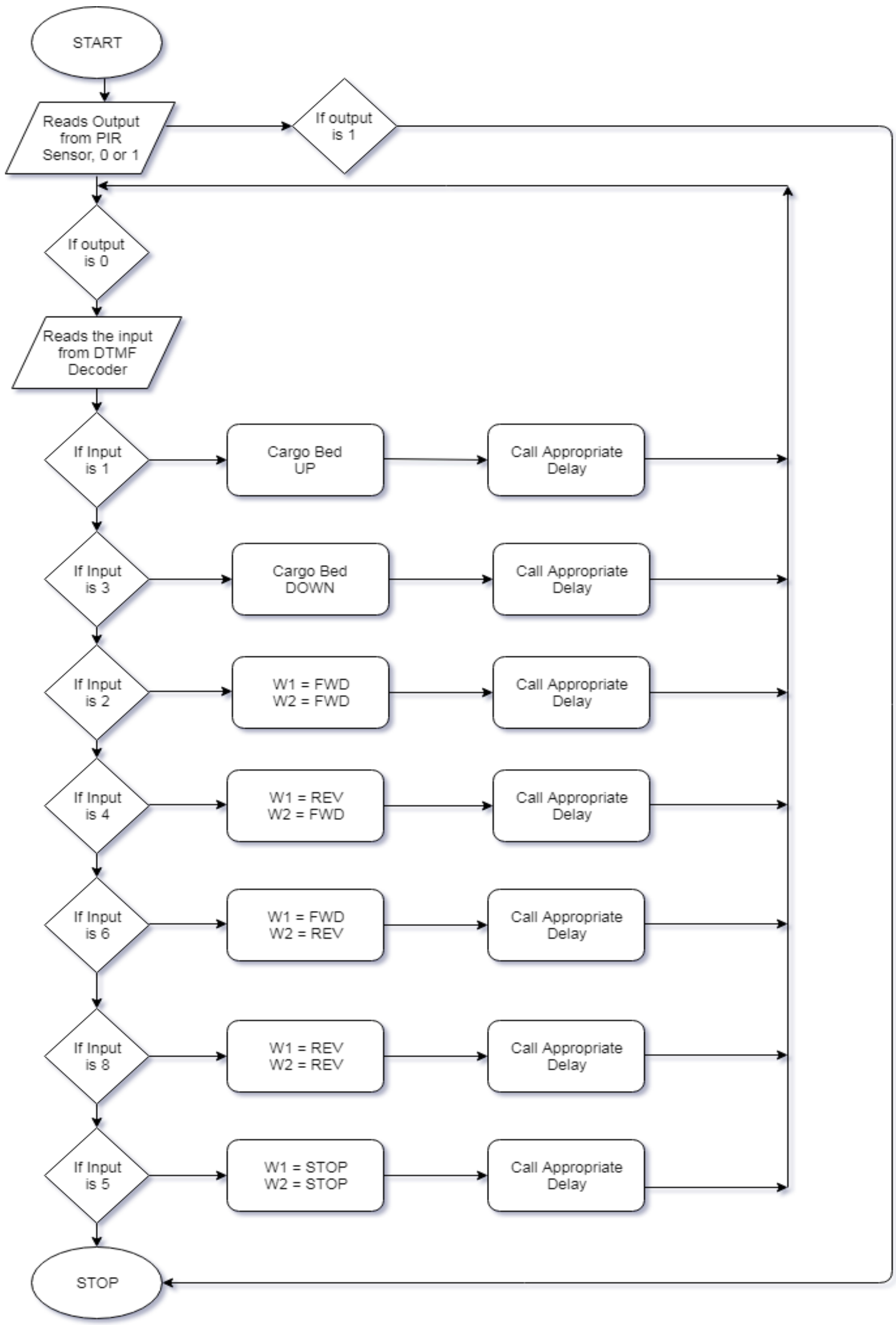

Figure 8. Operational Flowchart of the Guided Vehicle.

7. EXPERIMENTAL RESULTS

The experimental results for the robot vehicle on different terrains are tabulated in Table 3 to Table 5.

Table 3.

KEY PRESSED	VEHICLE MOVEMENT	TIME TAKEN TO START MOVEMENT(Sec)
2	VEHICLE MOVES FORWARD	1.3
4	VEHICLE TURNS LEFT	0.9
6	VEHICLE TURNS RIGHT	1.5
8	VEHICLE MOVES BACKWARD	2.3
5	VEHICLE STOPS	0.6
1	CARGO BED MOVES UP	1.1
3	CARGO BED MOVES DOWN	1.6

Table 4.

KEY PRESSED	VEHICLE MOVEMENT	TIME TAKEN TO START MOVEMENT(Sec)
2	VEHICLE MOVES FORWARD	1.9
4	VEHICLE TURNS LEFT	1.6
6	VEHICLE TURNS RIGHT	0.5
8	VEHICLE MOVES BACKWARD	1.7
5	VEHICLE STOPS	2.6
1	CARGO BED MOVES UP	2.1
3	CARGO BED MOVES DOWN	1.2

Table 5.

KEY PRESSED	VEHICLE MOVEMENT	TIME TAKEN TO START MOVEMENT(Sec)
2	VEHICLE MOVES FORWARD	2.1
4	VEHICLE TURNS LEFT	2.7
6	VEHICLE TURNS RIGHT	0.8
8	VEHICLE MOVES BACKWARD	1.8
5	VEHICLE STOPS	1.2
1	CARGO BED MOVES UP	0.8
3	CARGO BED MOVES DOWN	1.6

The robot vehicle shared an average delay of 1 to 2 seconds to start due to network congestion, which can further be enhanced for better accuracy. With the given specification of different motors and power sources, the vehicle is able to carry a load of maximum 2 Kg.

8. SUMMARY AND CONCLUSIONS

The paper exhibits detailed fabrication and working of the lab prepared DTMF based guided vehicle. DTMF technology plays a crucial role in the project as it fills up the gap between the controller and the vehicle. This control method uses commercial mobile communication networks as the path of data transmission which in turn enables the user to control the mobile robot continuously by sending the mobile phone DTMF tone. Importance of the DTMF technology can easily be derived through projects carried out by various researchers. The robotic vehicle successfully demonstrates its superiority in overcoming the drawbacks of an AVG system, which would in turn help the MSME industries to benefit from it. The design of the vehicle is not limited to this project, as it can be altered by targeting its functions and the work environment it is subjected to. As days passes on, the use and the acceptability of robotics are getting more and more popular because of its friendly features. Robotics technology is also adopting numerous new methods and development. Commercial production of DTMF based guided vehicle with more advancement may be able to bring another new revolutionary change in the industrial robotics sector. The robot which has been developed is a step in the research and development of an industrial robotics to help transportation works for increasing comfort. Future research and updates can be done for more improvement of the robot to turn it into a complete model for commercial use.

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