



Implementation of Unmanned Vehicle using GSM Network with Arduino

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Abstract— *A wide variety of applications in the present age need the use of robots as opposed to humans. Robots can perform tasks which are hazardous for humans or inaccessible to them. The basic idea of this system is based on the problems that are related to the above fact. Designing an unmanned vehicle that can be controlled via remote device and move in places where humans might not be able to reach shall solve many problems of applications such as spying, surveillance, search and rescue and also in the domain of science and research. By making use of rapid growing technology in robotics and automation, a robot which can be controlled by a cellular phone equipped with GSM network, which acts as a wireless communication link between the robot and the cellular phone, has been designed.*

Keywords— *Unmanned Vehicle, Robot, GSM, Arduino, DTMF Decoder*

I. INTRODUCTION

A robot is a software controlled mechanical device that uses sensors to guide one or more end-effectors through programmed motions in a work space in order to manipulate physical objects. Robotics is the study of robots defined as the combination of machine tool technology and computer science and is a form of Industrial Automation and is a technology with a future and for the future. It is a branch of technology that deals with the design, construction, operation and application of robots and computer systems for their control, sensory feedback and information processing. [1,2] It is a rapidly growing field, as we continue to research, design and build new robots that serve various practical purposes, whether domestically, commercially or militarily

Sir Issac Asimov, the father of robotics, coined three laws of robotics which are as follows:

1. A robot may not injure a human being or, through inactions, not allow a human being to come to harm.
2. A robot must obey the orders given by human beings, except when such orders would conflict with the first law.
3. A robot must protect its own existence, as long as such protection does not conflict with the first or the second law.

II. OBJECTIVE

Wi-Fi controlled devices make use of radio frequency as a medium to transmit data and control the device remotely. The Wi-Fi transmitter which is often a handheld device transmits signals to the device. The Wi-Fi receiver, an antenna, which is mounted on the device receives the signals sent by the Wi-Fi transmitter which instructs the devices for manoeuvres and other functions. However, Wi-Fi network has a limited range. A typical Wi-Fi 802.11 b/g/n/ac network has a range varying from 35 meters to several hundred meters with line of sight. The range further deteriorates when there are obstacles like walls, trees etc. in the way. Bluetooth controlled devices work on Bluetooth technology for sending and receiving of data which uses short wavelengths (UHF Radio Waves). Bluetooth was designed to send data over short range and thus, its range spans up to 60 meters even with the new 4.0 version.

The IR systems which employ the infrared technology work only on the principle of line of sight. An IR transmitter device, generally a remote control, is directed to the device being controlled. Furthermore, the communication is fettered if there are obstacles and other hindrances.

In this paper, cellular phones using GSM network is used to control an unmanned vehicle (a robotic vehicle). This technique overcomes all the shortcomings of aforementioned technologies like network coverage issue, communication problems over obstacles and interferences and required line of sight. This technique is solely dependent on worldwide GSM network, which is up and running 24x7 and has very minimal interference. The unmanned vehicle is interfaced with a GSM network consisting of a GSM enabled cellular phone, DTMF decoder, Arduino Uno microcontroller board and two motors. Any GSM enabled cellular phone can be used, including low end black and white feature phones with basic function to high end Android OS / iOS operated smartphones. No special requirements are needed for two cellular phones. One is used as a transmitter (handheld remote controlled device) and other is used as a receiver interfaced with the unmanned vehicle.

Figure 1 and Figure 2 depicts the overall functionality of the system. A call is placed either from a fixed phone or a cellular phone to the cellular phone interfaced with the unmanned vehicle. The call takes place through GSM network. As soon as the call is received by a cellular phone, it is auto answered and the connection between the sender and receiver is established. During the call, if any button is pressed on the keypad of a fixed line or a cellular phone, a tone corresponding to the key pressed is generated. This tone is called as DTMF (Dual Tone Multiple Frequency). The

generated code is received by the DTMF decoder through the cellular phone's headphone output (3.5 mm audio jack). The DTMF microcontroller decodes the tones to resultant binary digits which are in turn sent to the Arduino Uno microcontroller board. The Arduino Uno controller board is programmed to make decision based on the input from the DTMF decoder and accordingly outputs the signals to the motors attached. The two motors help the unmanned vehicle to manoeuvre forwards, backwards, left and right. Since only two cellular phones are needed in order to place a call and establish connection, intricate transmitter and receiver are not needed, thus reducing overall complexity and complications of the circuit design.

III. SYSTEM OVERVIEW

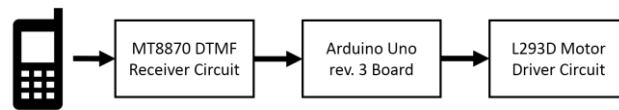


Figure 1: DTMF Communication Architecture

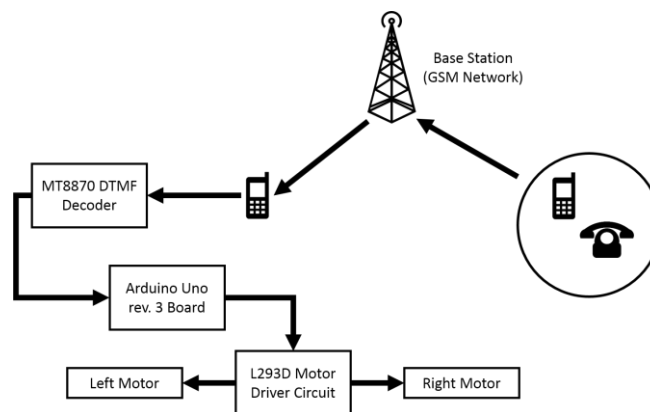


Figure 2: Functional block Diagram of the System

IV. SYSTEM COMPONENTS

The components used in this system are fairly simple and easily available on online stores, or electronic shops. They are:

- Robot chassis along with two wheels
- Two DC motors (60 – 500 RPM)
- Arduino Uno microcontroller board
- IC MT8870 (DTMF decoder)
- IC L293D (Motor driver)
- Miscellaneous components (Breadboard, Jumper wires, Batteries, Registers etc.)

V. HARDWARE COMPONENTS

In this section the hardware components illustrated in figure 2 are explained in detail.

A. DTMF Decoder

A basic Integrated Circuit of number MT8870 is used as the DTMF decoder. The function of the decoder is three stage:

1. Receive the DTMF tone generated by the cellular phone via 3.5 mm audio jack
2. Process the tone received and convert it into corresponding binary digit
3. Forward those digits to the Arduino for decision making

		Tone B [Hz]			
		1209	1336	1477	1633
Tone A [Hz]	697	1	2	3	A
	770	4	5	6	B
	852	7	8	9	C
	941	*	0	#	D

Figure 3: DTMF Frequencies

Figure 3 shows a table of frequencies that are used for a typical 4 X 4 keypad consisting of keys 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, *, #, A, B, C, D. Low frequency is represented by a row and high frequency is represented by a column. When a key is pressed, superimposition of the two frequency is produced, thus generating a tone.

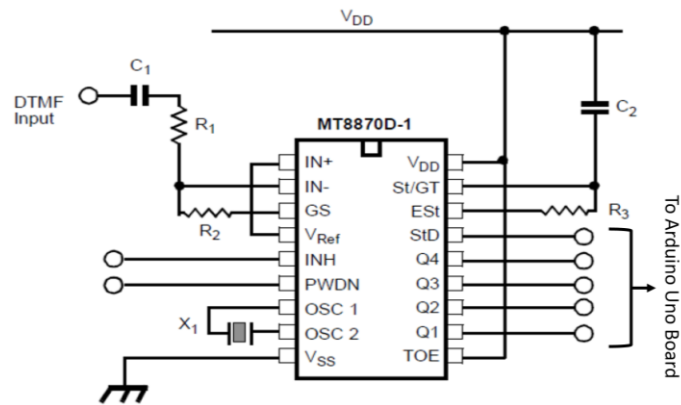


Figure 4: Circuit Diagram of IC MT8870

Figure 4 depicts a circuit diagram of the IC MT8870 DTMF decoder which takes the DTMF input from the cellular phone's 3.5 mm audio jack gives outputs on the pin number 11, 12, 13, 14 and 15 to Arduino Uno board. Pin 11 to 14 are the data output (Q1-Q4) while Pin 15 is the delayed steering output (StD).

B. Motor Driver

Integrated Circuit of number L293D is used in this system as the motor driver. This IC is very common across majority of robotics projects which deal with unmanned mobile vehicle. L293D is a dual H-Bridge motor driver and is capable of driving two DC motors simultaneously. With the help of this IC, the motors can be moved bidirectional. The L293D have two enable pins, i.e. Pin 1 and Pin 9, which need to be high in order to activate both the H-Bridges.

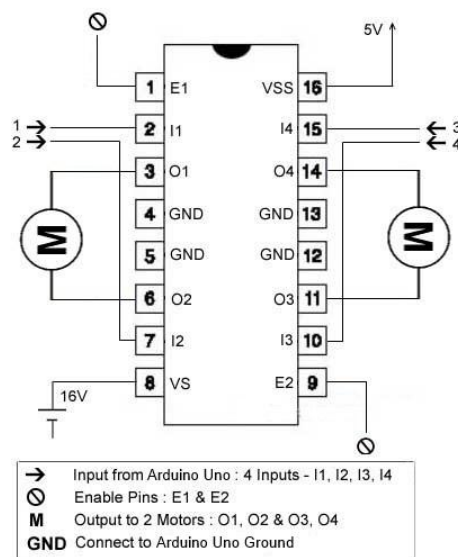


Figure 5: Circuit Diagram of IC L293D

A circuit diagram for L293D motor driver is shown in Figure [5]. The left motor is connected to Pin 3 and Pin 6. The right motor is connected to Pin 11 and Pin 14. Altogether these pins act as an output based on the input received through Pin 2 and Pin 7 for left motor and Pin 10 and Pin 15 for right motor from the Arduino Uno board.

Based on the voltages received from the input pins the motors

- spin forwards if the first pin is high and other is low
- spin backwards if the first pin is low and other is high
- halts if both the pins are low

Manipulating these motor movements, the unmanned vehicle can be manoeuvred in different directions. This is explained in Section VI.

C. Arduino Uno Board

The Arduino board is specially designed and developed for students for learning, experiment and research purpose. It is a single board system which is equipped with 8-bit Atmel AVR microcontroller. The board can be powered by a USB port as well as a DC adapter or a battery source. The Arduino Uno features 6 analogue input pins and 14 digital input/output pins for added functionality. Various shields like prototype shield, Wi-Fi shield, Bluetooth shield etc. can be added to the already feature rich Arduino. Figure 6 represents a typical Arduino Uno rev. 3 board.

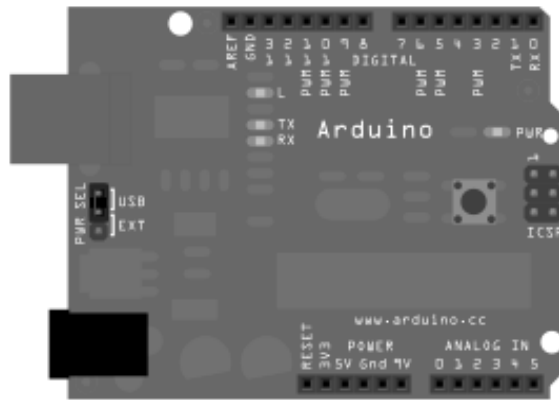


Figure 6: Arduino Uno Board Design

VI. STEERING ANALYSIS

Depending upon the movement of two motors, the unmanned vehicle can be manoeuvred in several directions. For the vehicle to steer

- Forwards – move both the motors forwards
- Backwards – move both the motors backwards
- Left – move the right motor forwards
- Right – move the left motor forwards

Mentioned above are the four basic manoeuvres of the unmanned vehicle. A detailed table containing the movements of right and left motors and the final movement of the vehicle is given in Figure 7.

Movement of Left Motor	Movement of Right Motor	Movement of the Vehicle
Forward	Forward	Forward
Forward	None	Right
None	Forward	Left
Backward	Backward	Backward
Backward	None	Left
None	Backward	Right
Forward	Backward	Sharp Right
Backward	Forward	Sharp Left
None	None	At Halt

Figure 7: Steer Analysis of two Motors and the Vehicle

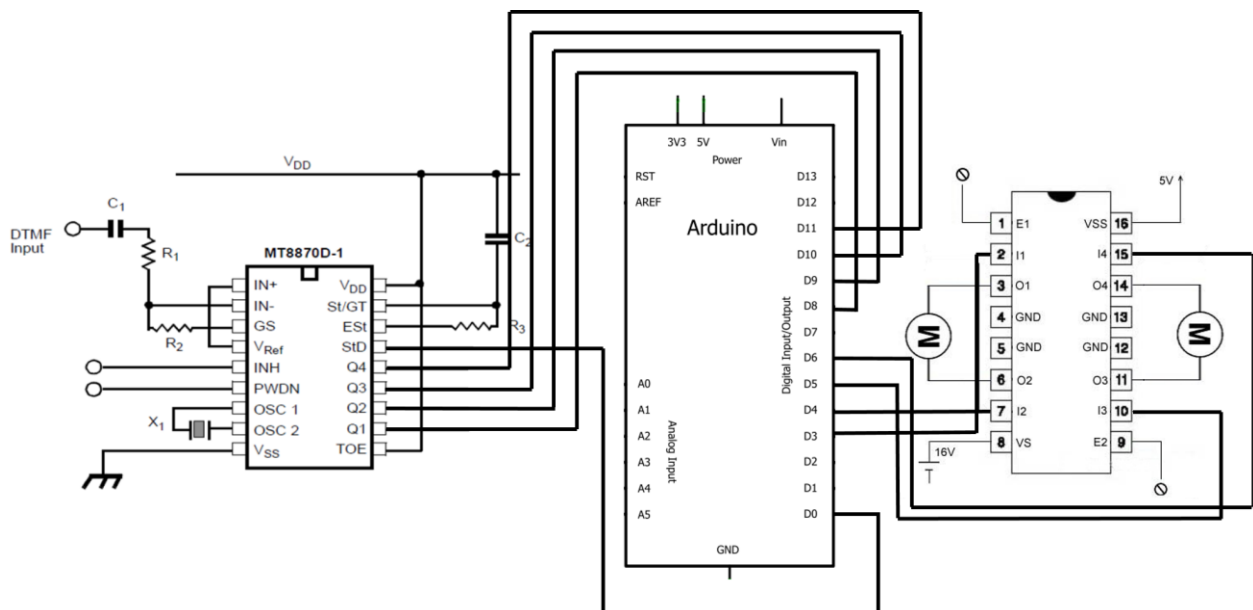


Figure 8: Circuit Design

VII. CIRCUIT DESIGN

Figure 8 depicts the circuit diagram of the system as a whole. In order to understand the circuit diagram, we first need to understand how the three components viz. the Arduino board, the MT8870 DTMF Decoder IC and the L293D Motor Driver IC are connected. DTMF decoder receives the input from DTMF tone acquired from the 3.5 mm audio jack (headphone output) of the cellular phone. The tones are parsed and decoded by the MT8870 DTMF Decoder and are passed to the Arduino Uno board as an input. The DTMF Decoder gives the output on Pin number 11, 12, 13, 14 and 15.

The output received from Pin 15 is connected to Digital Pin 0 of the Arduino Uno board. Other outputs from Pins 11, 12, 13 and 14 are connected to Digital Pins 8, 9, 10 and 11 respectively. Based on the equivalent binary digit of the DTMF tone received by the Arduino, a decision is made for Pins 3, 4, 5 and 6 regarding which pins should be high or low. These ultimately control the motors of the unmanned vehicle.

On the L293D IC, the outputs received from the Arduino Digital Pins 3, 4, 5 and 6 are fed to the L293D IC as input. Based on the Arduino's decision, the Pins are either high or low which activates the motors and moves the vehicle.

It is not a hard and fast rule to connect the Pins as per Figure 8. The user may connect it in any fashion comfortable to him, provided that he makes changes to the algorithm and program code accordingly.

VIII. SOFTWARE COMPONENTS

The Arduino Uno boards come equipped with an IDE (Integrated Development Environment) software. Writing programs in this IDE is fairly simple because the programs are written in C and C++, which is same as that of traditional microcontrollers, but with added functionality. For example, flashing of programs to the board i.e. uploading is just one mouse click job. Serial outputs can be viewed on a Serial Monitor which helps in debugging of code. A piece of code in Arduino IDE is called as a sketch.

IX. ALGORITHM

The algorithm for this system is very straight forward. Pressing a key on the keypad results into movement of vehicle in the corresponding direction. These are the actions performed based on the following key pressed:

- 2 – The vehicle moves forwards
- 8 – The vehicle moves backwards
- 4 – The vehicle takes a left
- 6 – The vehicle takes a right
- 1 – The vehicle takes a sharp left
- 3 – The vehicle takes a sharp right
- 5 – The vehicle halts in its position

X. PROGRAM CODE

The following is the program code developed in Arduino IDE

```
// Variables used
int dtmf;
String dial;

int Motor1Pin1 = 3;
int Motor1Pin2 = 4;
int Motor2Pin1 = 5;
int Motor2Pin2 = 6;

void setup() {
  Serial.begin(9600);
  dial = "";

  // Arduino Outputs

  pinMode(Motor1Pin1,OUTPUT); //set pin 3 as output
  pinMode(Motor1Pin2,OUTPUT); //set pin 4 as output
  pinMode(Motor2Pin1,OUTPUT); //set pin 5 as output
  pinMode(Motor2Pin2,OUTPUT); //set pin 6 as output

  // LED Output on pin 13
  pinMode(13, OUTPUT);

  // MT8870DE Outputs to Arduino Inputs
  pinMode(8, INPUT);
  // Significant bit 1, pin 11 on MT8870
  pinMode(9, INPUT);
  // Significant bit 2, pin 12 on MT8870
  pinMode(10, INPUT);
```

```
// Significant bit 4, pin 13 on MT8870
pinMode(11, INPUT);
// Significant bit 8, pin 14 on MT8870
pinMode(7, INPUT);
// Significant StD
}

void loop() {
dtmf = 0;
if (digitalRead(8) == HIGH) dtmf = dtmf + 1;
if (digitalRead(9) == HIGH) dtmf = dtmf + 2;
if (digitalRead(10) == HIGH) dtmf = dtmf + 4;
if (digitalRead(11) == HIGH) dtmf = dtmf + 8;

if (dtmf == 1) dial = "1";
if (dtmf == 2) dial = "2";
if (dtmf == 3) dial = "3";
if (dtmf == 4) dial = "4";
if (dtmf == 5) dial = "5";
if (dtmf == 6) dial = "6";
if (dtmf == 7) dial = "7";
if (dtmf == 8) dial = "8";
if (dtmf == 9) dial = "9";
if (dtmf == 10) dial = "0";
if (dtmf == 11) dial = "*";
if (dtmf == 12) dial = "#";

Serial.println(dial); // The digit contained in DTMF data

// Decisions based on the key pressed on the keypad

if(dial == "2")
{
digitalWrite(13, HIGH);
forward();
}
else if (dial == "8")
{
digitalWrite(13, LOW);
backwards();
}
else if (dial == "4")
{
digitalWrite(13, LOW);
left();
}
else if (dial == "6")
{
digitalWrite(13, LOW);
right();
}
else if (dial == "1")
{
digitalWrite(13, LOW);
sharpLeft();
}
else if (dial == "3")
{
digitalWrite(13, LOW);
sharpRight();
}
else if (dial == "0")
```

```
{
digitalWrite(13, LOW);
stopMotor();
}
}

// Maneuver functions

void forwards()
{
digitalWrite(Motor1Pin1,LOW);
digitalWrite(Motor1Pin2,HIGH);
digitalWrite(Motor2Pin1,LOW);
digitalWrite(Motor2Pin2,HIGH);

}
void backwards()
{
digitalWrite(Motor1Pin1,HIGH);
digitalWrite(Motor1Pin2,LOW);
digitalWrite(Motor2Pin1,HIGH);
digitalWrite(Motor2Pin2,LOW);
}
void right()
{
digitalWrite(Motor1Pin1,LOW);
digitalWrite(Motor1Pin2,HIGH);
digitalWrite(Motor2Pin1,LOW);
digitalWrite(Motor2Pin2,LOW);

}
void left()
{
digitalWrite(Motor1Pin1,LOW);
digitalWrite(Motor1Pin2,LOW);
digitalWrite(Motor2Pin1,LOW);
digitalWrite(Motor2Pin2,HIGH);
}
void sharpLeft()
{
digitalWrite(Motor1Pin1,LOW);
digitalWrite(Motor1Pin2,HIGH);
digitalWrite(Motor2Pin1,HIGH);
digitalWrite(Motor2Pin2,LOW);
}
void sharpRight()
{
digitalWrite(Motor1Pin1,HIGH);
digitalWrite(Motor1Pin2,LOW);
digitalWrite(Motor2Pin1,LOW);
digitalWrite(Motor2Pin2,HIGH);
}
void stopMotor()
{
digitalWrite(Motor1Pin1,LOW);
digitalWrite(Motor1Pin2,LOW);
digitalWrite(Motor2Pin1,LOW);
digitalWrite(Motor2Pin2,LOW);
}
}
```

XI. APPLICATION

There are many projects in real world where unmanned vehicles are used. There are also certain fields where unmanned vehicle can be introduced. The following few real world applications follow the key concept of using unmanned vehicle. This system is just a prototype built on these similar conceptual lines.

A. Military Operations

The use of unmanned vehicle in military is not a new concepts. For decades unmanned vehicles are used as a human substitute. These vehicles have paramount importance in military because no human life is in danger while the operation is being performed.

B. Aviation

The use of unmanned vehicle in case of commercial aviation is not popular, but certainly taken into consideration. However, its application in aviation other than commercial sector is widespread. An example would be Unmanned Aerial Vehicle (UAV) which does not facilitates a human pilot and is controlled remotely in order to perform military service, civil operations like firefighting and policing, surveillance etc.

C. Space Exploration

Unmanned probes are sent in outer space in order to carry out research and aid in exploring our limited knowledge of space and universe. The land rover sent on Mars called Curiosity is a perfect example of automated unmanned vehicle.

D. Rescue and Search Operations

There are some deleterious situations wherein the environment is new, hazardous or not suitable for human intervention. These conditions are mostly reflected in rescue and search operations where sending an unmanned vehicle is a perfect option.

E. Surveillance

Unmanned vehicles can also be used in civil operations like monitoring and surveillance. By doing so, the cost involved for the human workforce is drastically reduced.

XII. FUTURE SCOPE

The designed used for unmanned vehicle in this paper can further be improved and enhanced to meet suitable needs according to its application. A camera can be mounted on top of it which can send videos and images to the remote phone connected via 3G or 4G network. Sonar and infrared (IR) sensors can be added which will fully automate the unmanned vehicle, sending surrounding information via sonar sensors and detecting and avoiding objects using infrared sensors. This added functionality will help the vehicle to maneuverer on its own after it loses the GSM network coverage.

XIII. CONCLUSION

In this paper, the design and implementation of the unmanned vehicle is explained. Introduction of robotics followed by the conventional approach of unmanned vehicle with Wi-Fi, Bluetooth and Infrared along with its shortcomings is illustrated. These drawbacks are overcome using the described hardware and software components. The algorithm along with program code is demonstrated. In summary, an unmanned vehicle is developed, with help of Arduino board using GSM network and DTMF tone, which manoeuvres in different direction by pressing a key on the keypad of a cellular phone which acts as a remote and is connected to the cellular phone attached to the vehicle via voice call.

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