DTMF based Hybrid Robot for Air and Land

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ABSTRACT
This research and development focused on hybrid robot for air and land. Hybrid robot is combination of wheeled robot and unmanned aerial vehicle (UAV) system also called as Drone. Drone is controlled by using Telemetry module and wheeled robot is controlled by using Dual Tone Multi-Frequency (DTMF) module. Electronic Speed Controllers (ESC's) are used for balancing the speed of Drone and Flight Controllers are used for take-off and landing. Humidity, light and temperature sensors are implemented for measuring the weather in surrounding environment. Ultra sonic Sensors are used for proper landing and obstacle avoidance. Signals originating from sensors are sensed by microcontroller. This system results in hovering of drone with maintaining its proper balance and constant stability. Maximum time operated of drone is eight minutes using 2200 mAh Lipo battery. Battery performance can be increased by using large battery capacity.

General Terms
DTMF, ESC, IMU.

Keywords
Drone, DTMF, UAV, Multi rotors, Hybrid robot.

1. INTRODUCTION
Dual Tone Multi Frequency (DTMF) is used over the analog telephone lines in the frequency band of voice between the communication devices. DTMF technology is used in telecommunication system for signaling purpose. DTMF was developed by western Electric and it was first used in Bell system [12]. In this system, the DTMF is used to control the wheeled robot and Telemetry module is used to control the drone system. Electronic Speed Control (ESC) is used to control the thrust that has been produced by motors which is attached to body of drone system. Flight Controller is used for controlling the flight of Drone and landing [9].

Over the conventional helicopter, Drone system has several advantages such as overall design is simple and cost is low. Collective and cyclic pitch control is not required in this system [7]. GSM calling technique can be used, which in turn uses DTMF signals for communication. This is done by touch tone technique of GSM. UAV can be used in variety of applications such as military, survey, film making, agriculture aerial photography and others [8]. In recent researches, there is an active focuses on Quad rotor, which is one of the UAV. This system includes the human computer interaction as follows:

i. Human interaction: Controlling the robot by giving specific inputs.
ii. Computer interaction: Microcontroller placed on DTMF module to control the system.

Important component in this system are:

i. DTMF Module.
ii. AtMega Microcontroller.
iii. Electronics Speed Controllers.
iv. Flight Controller.
v. Motors & Sensors

2. RELATED WORK
Researches had proposed several methods for constructing a Drone system using different technology. Duckgee Park in 2001 studied on 3-DOF control free-flying vehicle. Non-linear control, optimal control for attitude control is used for flying in the drone system. The inputs and outputs are heavily coupled [1].

K. aruna and A. sri ramsagar proposed a land rover system which operates on DTMF. In this the robot is controlled by mobile phone which in turn sends the signal to the micro controller. Two mobile phones are used for communication. One is attached to robot and other one is with user. A call is made between mobiles. During the call, if any button is pressed then the corresponding tone is heard at the end of microcontroller. According to the received tone the microcontroller act up to it. Phoned stacked is used in robot to perceive the DTMF tone in this system [5].

Dirman Hanafi and Mongkhun Qetkeaw in 2012 proposed a remotely operated Quad-copter system. In this system, the graphical user interface is used for communication with Quad-copter. Communication between GUI and Drone is also done using wireless system. Balancing condition is done by FY90 controller and IMU 5DOF. Arduino Uno microcontroller is used. An ultra-sonic sensor sends an ultra-sonic signal which is used for detection of obstacles in path [3].

3. DRONE MODEL
In this system, the hybrid robot is constructed by making the combination of wheeled robot and multi rotor system. Using radio transmitter and receiver Drone is controlled. Components such as Cell phone, Microcontroller, ESC, Flight Controller, battery, motors and propellers are mounted on the frame [6]. The hover ability will be increased with the less weight as much as possible which in turn results in less power consumption [2].

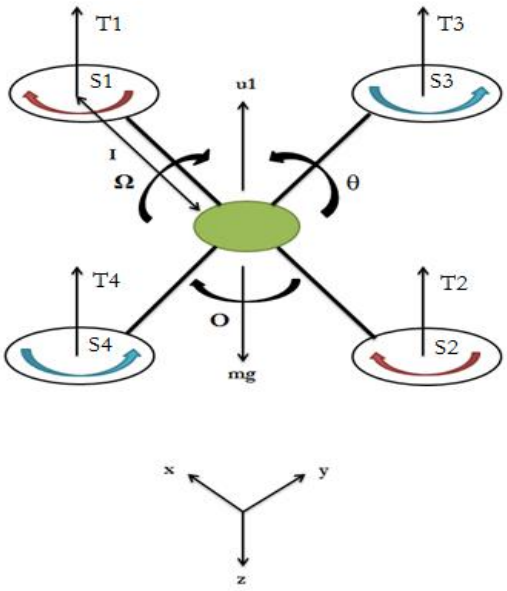

Figure 1: Drone model.

Figure 1 shows Drone model which uses Telemetry module for communication. Radio transmitter and receiver are used for transmission and reception of signals. Sensors are implemented for obstacles avoidance and camera is mounted for live streaming. All over thrust generated is shown in Figure 1 as well as the position, acceleration of gravity and pitch, roll and yaw are shown by using three Euler angles.

Table 1: Drone model description.

U1	Sum of the thrust of each motor
T1	Thrust generated by front motor
T2	Thrust generated by rear motor
T3	Thrust generated by right motor
T4	Thrust generated by left motor
M	Mass of Quad Drone
G	Acceleration of gravity
L	Half length of the Quad Drone
X, Y, Z	Three position
Θ, Ω, O	Three Euler angles representing pitch, roll and yaw

In Table 1, Drone model description is given which includes Thrust generated by all four motors, mass of Quad Drone, Three position and Three Euler angles representing pitch, roll and yaw.

4. WHEELED ROBOT MODEL

In this system, the wheeled robot is constructed by using a DTMF module. It includes the proximity sensors to detect the obstacles. ATMEGA micro-controller is used in this model. Data communication can be done in parallel as well as in serial. Operating voltage is between 5 V – 24 V [11].

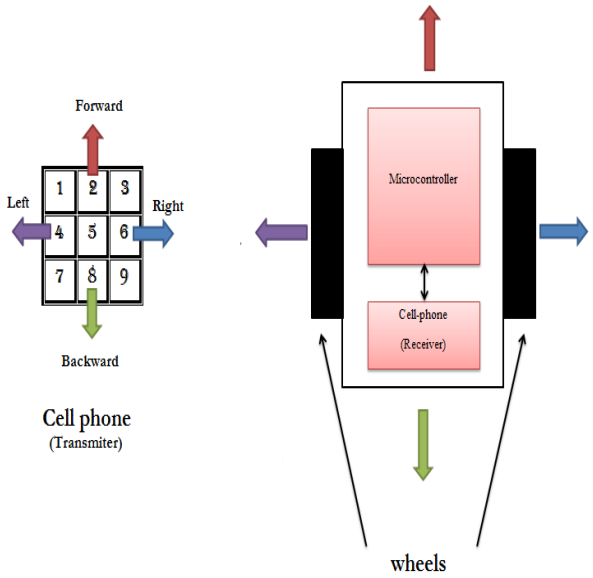

Figure 2: Wheeled robot model.

In Figure 2, wheeled robot model is shown. System is developed using DTMF Module. Touch tone method is used for communication which in turn uses GSM calling technique. Sensors are implemented for obstacle avoidance.

5. PROPOSED TECHNIQUE

Drone model and wheeled robot model is shown in figure 1 and figure 2. Drone system cannot be used as land rover is the major drawback. Similarly, limitations of wheeled robot are that it is used on land only. It cannot be used in air. Advantage of developing a hybrid robot is that both Drone and Wheeled robot system can be controlled using single device and can be used on land as well as in air. Using DTMF, the range of operating is increased.

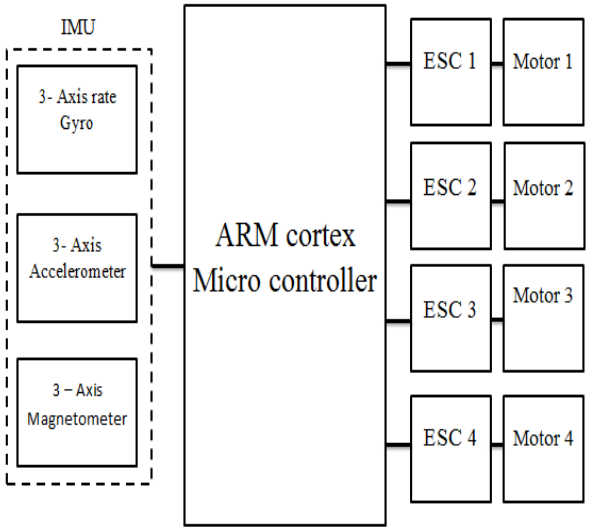

Figure 3: Drone system overview.

In figure 3, Drone system overview is shown. Inertial measurement unit (IMU) is measurement units consist of Gyro meter, Accelerometer and Magnetometer are connected

to ARM cortex Microcontroller. ESCs are connected to microcontroller to control the speed automatically through Pulse width modulation (PWM) Channels. Motors are connected to ESCs.

Programming and controlling the Drone can be done in many ways. In this system, RC transmitter is used in acrobatic and stable mode [8]. Gyroscope values are used to control the Drone in Acrobatic mode [10]. Joystick on the RC transmitter is used to control the 3 axes rotation speed. The orientation of Drone in the stable mode is determined by the sensors. To balance the Drone system, speed should be automatically controlled and this is done by implementing sensors. Using joystick, angle of rotation can be changed [12].

Controlling the wheeled robot is done by using several methods such as Bluetooth, zee bee, Wi-Fi, remote etc. This method has their own limitations such as designing issue and limited range. GSM calling technique for wheeled robot provides the wireless control ability to the robot.

5.1 GSM Calling:

The basic advantages of GSM calling technique is they can be controlled by any region of world by using camera [11]. Wheeled robot system overview is shown below.

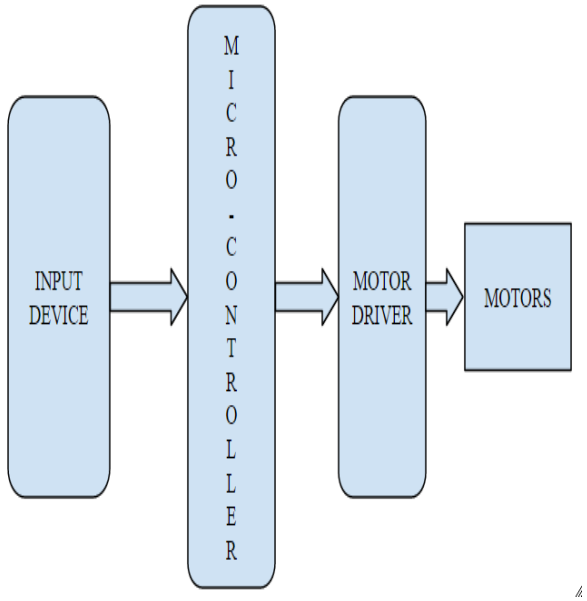

Figure 4: wheeled robot system overview.

Figure 4, shows wheeled robot system overview. Microcontroller is implemented on frame of robot. Microcontroller accepts the inputs from user and preforms the desired action. Motor drivers are the software which is connected to microcontroller. Motors drivers are used for clockwise and counter clockwise rotation of motors.

The keypad of DTMF is 4 x 4 matrixes which include low and high frequencies. Low frequencies are determined row wise whereas high frequencies are determined column wise [4]. DTMF keypad frequencies are shown below.

Table 2: DTMF keypad frequencies

Frequencies	1200-1210 Hz	1330-1340 Hz	1470-1480 Hz	1630-1640 Hz
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D

In table 2, DTMF keypad frequencies are shown. Keypad from 0 – 9 and A-D are listed according to their defined Touch Tone frequency.

6. RESULTS AND ANALYSIS

DTMF based hybrid robot for land and air is successfully developed. The system developed is used as a hybrid robot for land and air use. Hybrid system is developed by combining land rover and Drone system together. Camera and sensors are implemented for aerial photography, recording, military and surveillances purpose and for detecting obstacles in path.

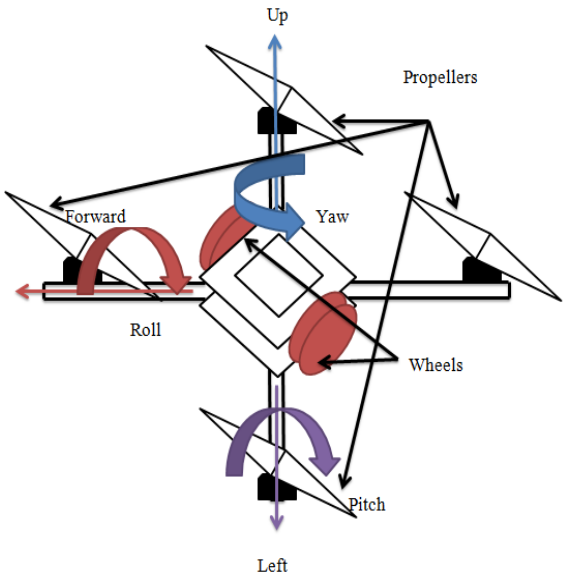

Figure 5: Hybrid robot model.

In figure 5, final product model that is hybrid robot is shown. This system is developed by attaching wheels to Drone and controlling it by using Touch Tone method of DTMF. The Yaw, Pitch and Roll angle is also shown. This system reduces the efforts of using two different systems for land and air use. Since the system is combination of land rover and drone, user can use a single system for both land and air uses. Wheeled robot model described above is used to control wheel part. Using GSM calling technique the wheeled robot is successfully controlled. Using Touch-Tone, keypad control of wheeled robot is done. Keypad 2 is press for forward movement whereas keypad 8 is press for backward movement. Similarly, key pad 4 and 6 is used for left and right movement.

The Drone system described previously is successfully controlled and implemented using Telemetry module which uses radio transmitter and receiver for communication. Wheeled robot moves in given direction along with Drone attached to it. While Drone take-off leaving behind the wheeled robot when it is not in use. The take-off and landing motion of drone is shown below.

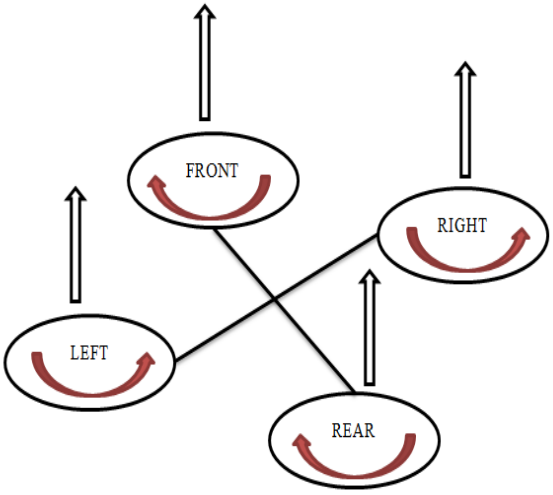

Figure 6: Take-off motion of Drone system.

In figure 6, Take-off motion is shown. By increasing the speed of four rotors, take-off motion is controlled. Vertical motion is changed. Front and rear rotor has clockwise motion whereas left and right rotor has counter clockwise motion.

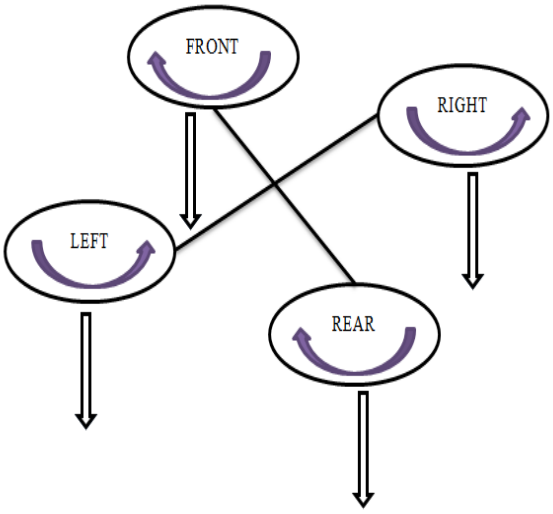

Figure 7: landing motion of Drone system.

In figure 7, landing motion is shown. By decreasing the speed of four rotors, landing motion is controlled. Front and rear rotor has clockwise motion whereas left and right rotor has counter clockwise motion.

7. CONCLUSION

The system develops a combination of wheeled robot and Drone system so that it can be used on land as well as in air. Using DTMF wheeled robot is controlled, this in turn helps in reducing the limitation of other systems. Using Telemetry module the drone is controlled. Sensors are used to measure humidity and temperature of nearby environment. The method in this system is able to perform the dual work of hovering and land rover. Considering all the disadvantages, problems and designing issues in the traditional system, the goal to construct hybrid robot for more efficient and better use was in the mind and it's been a really fruitful moment to finally conclude that hybrid robot is ready to fly. The system is developed with much more care with proper technicality and at the same time it is efficient.

8. REFERENCES

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