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Controlling Unmanned Ground Vehicle using Stationary Airborne System

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ABSTRACT: Communication is one of the important parameter which barricades itself during disasters. Along with this, the other problem is measurement of physical conditions of the calamity struck region. There must be simple ways to tackle them. The purpose of this paper is to unveil such a system which remains active at all times, and is fault-tolerant with respect to any unexpected events such as a natural disaster. Hence, it mainly involves transmission of distress signals, warning signals and other information related to disaster relief. These signals are acquired using an all terrain Unmanned Ground Vehicle. The signals and the physical properties of the region like gas leakage, damaged terrain etc. are sent to the ground station using a high altitude repeater called the airborne system, which is tethered to the ground.

KEYWORDS: Unmanned Ground Vehicle (UGV); Airborne system; pulse width modulation (PWM); payload; ground station; communication; ultrasonic transceiver; Zigbee transceiver; flight termination unit (FTU).

1 INTRODUCTION

A lot of damage is caused every year due to the impact of disasters and other emergency situations. Many lives are lost because they cannot get assistance from disaster relief services in time [1]. When such a situation strikes, each and every second is valuable and the sooner action can be taken, the more lives that can be saved. If it is possible to establish a system where a distress signal is sent out from the site of the disaster to multiple ground stations in all the surrounding directions, then the one nearest to its location can rush over there and begin relief operations. This may enable many lives to be saved in time and also improves the efficiency and effectiveness of the disaster relief operations [2]

A UGV [3] sends details of the disaster struck area to the high altitude repeater which in turn sends these data to the ground station for analysis. The control of UGVs is accomplished remotely, through a command system that allows the operator(s) to receive sensor data from the UGV and send motion commands to the vehicle [4]. The ground station, the airborne system and the UGV, each have Zigbees for the exchange of data and for control.

2 PRINCIPLE

The Unmanned Ground Vehicles are moving units that can readily face the harshest terrains maintaining sufficient speed, depending on the application for which it has been deployed. These vehicles can be wirelessly controlled so that they can traverse through the disaster struck area and send the data to the airborne system [5].

Apart from saving time, the above mentioned concept also provides another critical service in times of emergency: communication services. Once the disaster relief operations get underway, it is essential that all operations are carried out in a planned and co-ordinate manner. For this purpose, the communications established may improve the quality of disaster relief and ensure that all operations are carried smoothly.

The construction of the UGV is achieved by calibration and application of high accuracy sensors, analyzers and transduction technologies such as proximity sensing using Ultrasonic trans-receivers, GPS and Gas sensors. There have been

UGVs used for military [3] and industrial [6] purposes, but they are not very economical, and more importantly, the principles that we are prototyping has not been exploited in these fields. Also, most of the UGVs deployed are single purpose in nature. But the aim here is to showcase the importance of different principles demonstrated by the UGV, such as remote gas sensing with high accuracy, terrain analysis using GPS and high accuracy Ultrasonic transducers. The basic vehicle is implemented by syncing the motors and implementing the steering system. The UGV is interfaced with a remote control which communicates using signals in the radio frequency range. A Zigbee transceiver is mounted on it to communicate with the airborne system.

The airborne system contains a payload and parachute attached to a high altitude air balloon [7]. The balloon is filled with hydrogen gas to achieve better lift [8]. The payload consists of circuitry for communication with the UGV and the ground station(s). The circuit has a microcontroller which sends the signal to the Zigbee transceiver and the cut down mechanism. Depending upon the signal or data sent from the ground station, there can be cut down or communication [9].

3 Features And Working Of The UGV

ATmega328P – PU, the microcontroller controls the robot. The L298n H -Bridge is an electronics circuit that enables a voltage to be applied across a load in either direction. The circuit allows the dc motors to run clockwise and anti-clockwise. There are six motors and each motor has an individual driver. The dc motors have 100rpm and are used to give torque to the UGV to run on any possible terrain. The SkyNav SKG13 series is a complete global positioning system (GPS) engine module that features super sensitivity. It has n ultra-high sensitivity of -165dBm and consumes only 45mA at 3.3V. Fans are used as coolants to maintain the temperature. The UGV operates in two modes.

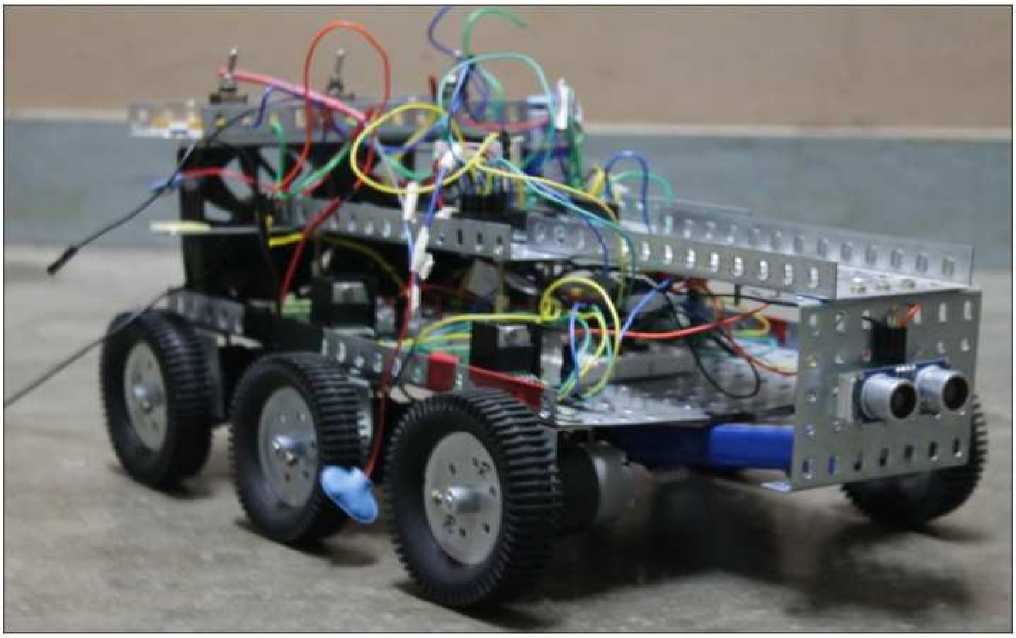

Fig. 1. The constructed Unmanned Ground Vehicle

3.1 Manual Mode

In this mode, the UGV is controlled using a Digital Proportional Radio Control System. The three wheels on the left are synchronised and are powered as a single unit. The control of the right side i s also similar. The UGV is made to turn either to the left side or right by controlling the current. When the current to the left side is reduced, the UGV takes a left turn. This is true for the right side also. Advantage of this logic is that when the current supply to either right or left is made zero, the UGV can take a complete 360 degree turn. The amount of current that is to be supplied to motor is controlled by pulse width modulation (PWM) through the microcontroller. The PWM signals are input to the motor drivers which draw the current from the battery depending on the signals and hence drive the motor. The PWM signals generated in manual mode depend on the Digital Proportional Radio Control System signals which are controlled manually.

3.2 AUTONOMOUS MODE

In this mode, the PWM generated depends on the output of the ultrasonic sensor. The output of the ultrasonic sensor is interfaced with the microcontroller. A threshold distance is fed to the micro controller and when the sensor senses the threshold distance the UGV is made to turn or deviate from the obstacle depending on its position.

Once the gas sensor detects gas leakage, the micro controller records it and sends it wirelessly to the airborne system. This data is sent to the ground station whose address is mentioned in it. The UGV is controlled such that it is always within the range of the airborne system.

4 FEATURES AND WORKING OF THE AIRBORNE SYSTEM

The airborne system was built using latex balloons [10] filled with hydrogen [8]. To get a better lift so that it can reach a greater height, multiple balloons were used. The deployment of the airborne system is carefully done so that there won't be any mishaps [7]. ATmega328P – PU is the microcontroller used in the airborne system's payload [11]. It controls the transceiver and a part of the flight termination unit. A boot loader from Arduino is burnt in the microcontroller for the easy usage of Arduino C. The parachute is used to make the payload return back to earth safely. When the tethering is detached and the airborne system reaches a certain height, then the balloon and payload are separated.

The FTU is linked to the ground station. The ground station controls when the cutting mechanism must work. Any of the floating ground stations can be used to cut the thread connecting the balloon and payload. Once the command is sent, the nichrome wire heats up for ten second and that is enough time to cut the thread between the payload and the balloon. The circuit has been designed such that the nichrome wire heats up at the cut-down altitude using a current surge from a Lithium-Polymer battery. Once the command to initiate the cut-down mechanism is given by the user, a nichrome wire is heated up by passing a current through it. This heated nichrome wire cuts the balloon from the payload and the payload descends down to ground, by the use of a parachute.

A 5V relay is used in order to switch on the heating circuit. Once the relay is driven, the switching occurs and the heating circuit loop is completed. This heats up the nichrome wire. The entire circuit is controlled by the microcontroller. The ATmega328P-PU required a 5V supply; there is a voltage regulator that steps down the input voltage to 5V and sends to it. Capacitors are used with the regulator to filter out any noise in the input signal. The required current to drive the relay in this circuit was 100 mA. However, the microcontroller is not capable of giving such a large driving current. A transistor acts like a switch and allows that current to flow from the Li-Po battery when a certain amount of current is sent from the microcontroller to the transistor. On giving the cut down command, a base current begins to flow through the transistor, and this causes the corresponding collector current to flow. This closes the loop on one side of the relay, causing the relay coils to get energized and switching occurs. Diodes prevent the reverse flow of current.

Fig. 2. Airborne System with three high altitude balloons for better lift

5 Features Of The Ground Station

There can be any number of ground stations depending upon the requirements. Each of the ground station consists of a Zigbee transceiver and a computer. The computer has the software required to acquire data from the transceiver. Data can be written into the transceiver to send it to the airborne system. The computers used for ground station are connected to the Zigbee and runs on a system built using the Arduino C just like the microcontroller. Whenever there is a requirement for urgent communication between the airborne system and other ground stations, a certain protocol is followed [12]. Each Zigbee has a specific address. Depending upon the address, the message is transmitted or received or a specific task is performed. There are three modes of signals which can be transmitted from the ground station(s).

5.1 Message Mode

Any ground station whose address is known priorly can be sent a text message from another ground station. It is obvious that the UGV is a mobile ground station due to the Zigbee present on it. The airborne system will act as a network tower in this case.

5.2 Broadcast Mode

In broadcast mode, a ground station can send message to all the other ground stations which are within the range of the airborne system. The address of the receiver is changed to BROADCAST.

5.3 Cut Down Mode

This mode is used to initiate the cut down mechanism. When the address of the Zigbee is changed to CUTDOWN it takes the address of the airborne system's Zigbee by default and initiates cut down.

The ground stations also receive the signals sent from the UGV. This works in the similar principle as the transmission. Since the UGV is in the range of the airborne system, it can easily send the data to its Zigbee. The data is sent back to all the nearest ground stations within the range of the airborne system for further analysis.

6 RESULTS

Various tests were performed using the UGV and the airborne systems. The UGV was tested for sensor and communication range along with manoeuvrability. The airborne system was tested for area covered.

Table 1. Testing of the UGV

Test [a]	Observations [b]	
	Ideal [c]	Practical [d]
Ultrasonic sensor range	0-400 m	20-350m
Gas sensor range	0-20m	0-5m
ASK transmitter range	0-500m	0-200m
Communication range [e]	-	Up to 300 m
Manoeuvrability on sand	Movable on up to 1 inch thick layer of heap of sand depending on the quality of sand	
Manoeuvrability on obstacles	Maneuverable above firm and rigid obstacles with 1-2 inches in height	

a. The type of test the UGV went through
b. Observed results for various tests
c. Results obtained when conditions are ideal
d. Results obtained during the test
e. Testing not done above 300 m due to security issues

Table 2. Range of communication

Sl. No.	Communication range covered using the airborne system [a]		
	Distance 1 [b] *(meter)*	*Distance 2* [c] *(meter)*	*Area* [d] *(meter squared)*
1	200	223.61	31415.92
2	400	412.31	125663.71
3	600	608.27	282.743.34

a. Vertical height of airborne system and the ground is constant at 100m
b. Distance between two ground stations where one is vertically below the airborne system
c. Distance between airborne system and ground the station which is slantly below it
d. Total area covered for the communication

7 CONCLUSION

Thus, a fully functional UGV was constructed. The airborne system fulfilled its purpose of being a high altitude repeater. The ground stations received signals from the UGV and the all three modes of transmission were tested. Many complexities were reduced in this system. The airborne system can be deployed within a period of twenty minutes. The entire setup can be done within thirty minutes. Such a system has wide applications in disaster management, defence, rural communication and industrial plants.

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