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Designing a Smart Balloon and Android- Based Remote Control

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ABSTRACT

This article centers around how to design a smart balloon for scientific, recreational and military activities which is capable of operating at low altitudes without the need for a pilot license. In light of the smart balloon's advantages including long-duration flights as well as the lack of noise, it can substitute drones. Desirable internet coverages coupled with imaging from low altitudes serve as the other benefits of this system. This article has examined the use of flying robots for collecting information from environments such as mountains and glasshouse which are less accessible to human beings. Under this system, the sent and received data maintains high reliability because of the isolation of different parts from one another. The use of Android controls in the software system decreases the cost significantly. The Arduino board has been taken advantage of in the hardware system. It has found wide application in industrial products due to the simplicity and transparency of programming. The examination and analysis of the smart balloon reveals the fact that the system performs efficiently under various situations.

Keywords : Arduino Board, Balloon of Helium, Bluetooth Connection, Drone, Temperature and Humidity Sensor

I. INTRODUCTION

Unmanned Aerial Vehicles (UAVs), or drones, are aircraft that can be controlled remotely by a pilot or can fly autonomously based on preprogrammed plans or automation systems. A large number of industries and users are adopting this technology including the military, governments, as well as commercial and recreational users. Despite the prevalent image of a drone being a small airplane, equipped with a large array of sensors and weaponry, and controlled by a person sitting in an air-conditioned room far away, this represents only a very small and specialized application for drones. The term "drone" refers to all unmanned vehicles and encompasses a variety of categories including UAVs and Unmanned Ground Vehicles (UGVs), each classified into different types depending on their features. [1-2].

The development of UAVs has continued over the years. By the 1930s, they were capable of being controlled remotely. The Queen Bee, created in the UK, was the first reusable UAV. It was used by the Royal Air force and Navy as a target for shooting. Since then, the expansion has never abated [3]. As the UAVs could be designed in smaller versions than conventional aircrafts and the risk of detection could be avoided, their application for military purposes has been considered indispensable. With their reduced radar signature and the lack of risk to a pilot, UAVs quickly become popular for their reconnaissance capabilities in dangerous areas [4].

Recently, UAVs have taken on the additional role of remote strike tools. The United States first made use of Predator drones armed with a Hellre missile to remotely eliminate a target in late 2001. This marked a turning point for larger UAVs as they took on the dual role of reconnaissance and strike vehicle [3-4]. While larger UAVs worked on increasing airtime and armament size, smaller UAVs began to be employed as a close reconnaissance support for soldiers in the field. In the last few years, the creation of Micro Aerial Vehicles (MAVs) has become a huge industry in both the military and the public sector. MAVs are now used as research tools, for disaster and agricultural surveillance as well as recreational purposes [5-6].

As the technology advances, these aircraft are becoming more common and affordable, giving rise to debates that weigh their benefits against new ethical and legal concerns. Drones can take high-quality aerial photographs and video, and collect vast amounts of imaging data [6]. These high-resolution data can be used to create 3-D maps and interactive 3-D models which have multiple beneficial uses. For example, 3-D mapping of disaster areas can enable rescue teams to be better prepared before entering hazardous situations [7]. Since unmanned aerial vehicles are equipped with GPS, they can be programed and maneuvered accurately to precise locations. This is especially helpful in precision agriculture in which UAVs are used for a variety of farming needs such as spraying fertilizer and insecticide, identifying weed infestations, and monitoring crop health. The precision of UAVs saves famers both time and cost. Should the operators hold an appropriate license, they can use unmanned aerial vehicles to provide security and surveillance to private companies, sporting events, public gatherings and venues. Drones can also gather valuable data during and after natural disasters to aid in security and recovery efforts [8-9].

No doubt remains about the beneficial nature of these robots. Yet, they have their own drawbacks, one of them being the substantial costs of their accessories. The main components of flying robots (drones) include mainframe, brushless dc engine, flight controller, micro controller and joystick. The flight controller is responsible for adjusting engine power and maintaining the balance during the flight and take off. For a joystick to be considered satisfactory, it should have a broad range enabling it to control the drone from a far distance; generate commands without delay; and be durable and reparable, among others.

These features are associated with high costs and expenses. The drone's movement, high speed, and its propellers' shape produce noise which is more annoying than that of a vehicle, Nasa researchers allege. The other pitfall of drones lies in their high level of energy consumption which is triggered by their fight against the gravity. This, in turn, leads to the short duration of drones' flight. To mitigate this problem, high capacity batteries which are self-charging through solar panels have been chosen. However, the slow performance of drones (due to being self-charging through solar panels) as well as the method's inappropriateness for nights and cloudy days' counts as the major difficulties with this method. In view of the indisputable importance of drones, android-based balloons have been used in this article for the very first time to resolve this issue. These balloons capable of receiving data at low altitudes do not require flight permission, and can be relied on in various situations.

Another significant advantage of these balloons is that the need for taking off can be avoided as helium-filled balloons rise them into air. They, therefore, consume less energy than drones, resulting in longer flight duration. They produce less noise because of the way they move. Pricey drone controllers are no longer required to cause the balloons move. Smart phones are used to direct them instead which significantly reduce expenses associated with using accessories. After providing a brief introduction to smart balloons, their different components will be illuminated in section two. The third section is devoted to evaluating the general structure of these balloons, followed by presenting the results of testing these balloons in an indoor environment. The article concludes with illustrating the process of designing these balloons.

II. DESIGNING A SMART BALLOON

The design of each and every system requires taking its purposes into account. The aims of designing a smart balloon are as follows:

- Low energy consumption: The main problem with Quadrotors is linked to power and electrical energy supply which is required for a plane to take off and land. For instance, a 24-volt battery is needed for moving a Quadrotor in 10 minutes. However, connecting the robot to the floating balloons, the energy consumption decreases to a large extent.
- The use of components lighter than that of Quadrotors: As mentioned previously, Quadrotors have the controlling fight as their component which maintains the robot's balance during the flight through the adjustment of engine power. However, should the suggested method be applied through which the balloon is pulled up into the air, there would be no need for a flight controller and other accessories.
- Reduced costs: The cost of implementing the suggested system is lower than other flying robots due to its simple structure, the lack of need for other components, and the use of mobile phones as a controlling group for controlling robot engines instead of expensive joysticks. Figure 1 shows the block diagram of a smart balloon.

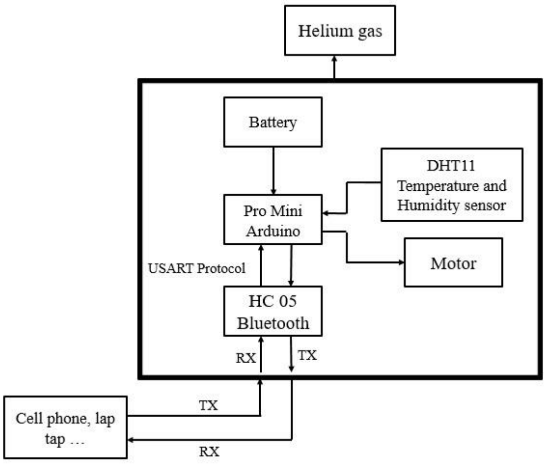

Figure 1. Block diagram of a smart balloon

Accordingly, the suggested system consists of three subsystems: electrical, software, and mechanical subsystems.

A. Electrical subsystem

This section introduces the electric components of a robot.

- Arduino Pro Mini

The Arduino Pro Mini is a microcontroller board based on the ATmega328p. It has 14 digital input/output pins (6 of which can be used as PWM outputs), 8 analog inputs, an on-board resonator, a reset button, and holes for mounting pin headers. A six pin header can be connected to an FTDI cable or Sparkfun breakout board to provide USB power and communication to the board. The pro mini board is shown in figure 2.

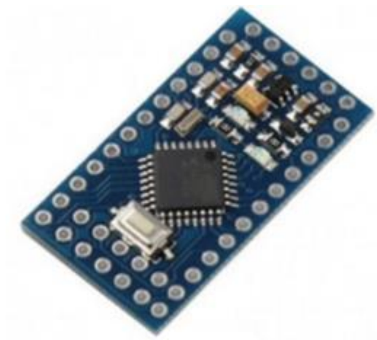

Figure 2. Pro Mini Board [12]

The Arduino Pro Mini is intended for semi-permanent installation in objects or exhibitions. The board does not come with pre-mounted headers, allowing the use of various types of connectors or direct soldering of wires. The pin layout is compatible with the Arduino Mini. There are two versions of the Pro Mini. One runs at 3.3V and 8 MHz, the other at 5V and 16 MHz. The Arduino Pro Mini was designed and manufactured by SparkFun Electronics. The features of the pro mini are shown in table 1 [12].

TABLE1. FEAUTHRES OF THE PRO MINI

Microcontroller	Atmega 328p
Operating Voltage	3.5- 5 v
Input Voltage	3.3- 12 v
Digital I/O Pins	14
Analog Input Pins	8
PWM Input Pins	6
Flash Memory	32 KB
SRAM Memory	2 KB
EEPROM Memory	1 KB
Operating Frequency	16 MHZ

Pin 0 is (RX) and pin 1 is (TX) used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the TX-0 and RX-1 pins of the six pin header.

- **HC- 05 Bluetooth Modules**

The Bluetooth module acts as an interface between Smartphone and microcontroller. We have opted for the HC-05 Bluetooth module for the system which can be used either as a receiver or a transmitter. Generally, our transmitter will be smartphone and the receiver will be the Bluetooth module. The Bluetooth module will give the commands (provided by smartphone) to the microcontroller [13].

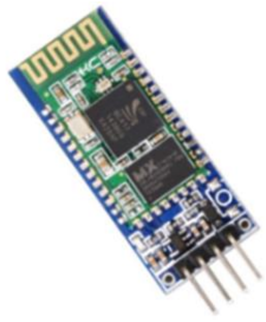

Figure 3. HC-05 Bluetooth Module [14]

The features of the HC-05 Bluetooth module are shown the table 2.

TABLE 2
FEAUTHRES OF THE HC-05 BLUETOOTH MODULE

Operating Voltage	3.3 v
Current	5 A
Operating Frequency	2.4 HZ
Range	10-23 m
Range of Operating Temperature	25-75 ^{o}C
Speed MAX	21 Mbps
Protocol Communication	USART Serial

- **DHT11 Sensor**

DHT11 is a temperature and humidity sensor. The DHT11 is shown in figure 4 [15].

Figure 4. Temperature and Humidity Sensor (DHT11)

The DHT11 sensor has the following performance range and accuracy, as shown in table 3.

TABLE 3. PROPERTIES THE DHT11 SENSOR

Operating Voltage	3.3- 5.5 v
Temperature Range	0-50 °C
Temperature Accuracy	+2% °C
Humidity Range	20-90% RH
Humidity Accuracy	+5% RH

Humidity is defined as the amount of water vapour in the air. It can be broken up into different classes including absolute humidity, dew point and relative humidity. The sensor used in this project, DHT1, is designed to measure relative humidity (RH). Relative humidity (RH) is the ratio of the amount of water vapour in the air to the saturated moisture level at the same pressure or temperature:

$$\frac{\rho_w}{\rho_{w_0}} \times 100 = RH \qquad (1)$$

Where RH is relative humidity (the beginning of the sentence is ambiguous as RH is the abbreviation of relative humidity), ρ_w is the density of water vapor, and ρ_{w_o} is the density of water vapor at saturation. The DHT11 sensor detects moisture in the air by measuring the electrical resistance between electrodes. It is fabricated with a moisture holding substrate. When substrate absorbs moisture, ionization takes place and results in the increase in conductivity between the electrodes. The relative humidity is proportional to the change in resistance between electrodes due to moisture absorbed.

- **DC Motor**

Coreless Dc Motors are a specialized form of DC motors, used when small motors and rapid acceleration are needed. The distinctive feature of coreless motors is that they are constructed without any iron core. They are available in cylindrical or disc forms. The coreless DC motor used in the robot is illustrated in figure 5 [16].

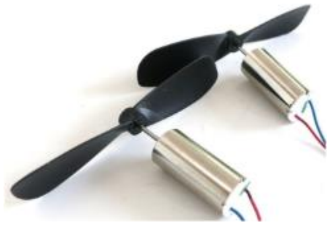

Figure 5. Coreless DC Motor

A motor will be able to run on 3.7 volts.

B. Software Subsystem

In order to monitor the DHT11 sensor and control balloon motors, the smartphone's icon should be clicked on and the Bluetooth should be turned ON, as shown in figure 6. For pairing devices, the HC-05 Bluetooth should be selected. Smartphone then sends its command to appliances via the Arduino pro mini board.

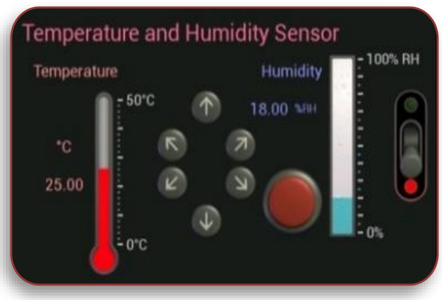

Figure 6. Android application

C. Mechanical subsystem

The balloon's size and quality are to be analyzed in this part. The balloon should be of such quality that does not lose air in high temperature, is capable of keeping gas for a long time, and is of little weight. The heavier the balloon would be; the more helium gas would be needed to keep the robot floating in the air. Balloons are normally made from latex or a combination of materials with high elasticity preventing them from bursting due to air pressure. In addition, in order to use the balloons in high temperature settings such as aircrafts, anti-fire materials are used in the construction of balloons. After determining the quality of the balloon, its size should be scrutinized as lifting the robot by balloons necessitates the careful examination of the required amount of helium gas. A liter of helium gas and air weigh 0.176 and 1.275 grams respectively with 1,099 grams' weight difference. The weight of the balloons without gas should be lowered to cause the balloon rise into the air. and if it is equal to this weight, the balloon will float. Therefore, using the following formula, you can figure out the amount of helium gas needed to lift the robot:

$$(1.099 \times \alpha_h) - W_b = W_R \qquad (2)$$

According to the equation described, α_h is equal to the amount of helium gas in liters, W_b is the weight of the balloon without gas, and W_R denotes the weight of the robot connected to the balloon.

III. THE GENERAL STRUCTURE OF SMART BALLOON

The proteus software of smart balloon can be seen in figure 7 .The data received by the Bluetooth module will be processed by the microcontroller in accordance with the given input in order to achieve the desired output. After pressing the buttons on the Android application, the microcontroller undertakes the role of processing the data received by the Bluetooth module to activate the motor and change the direction of rotation.

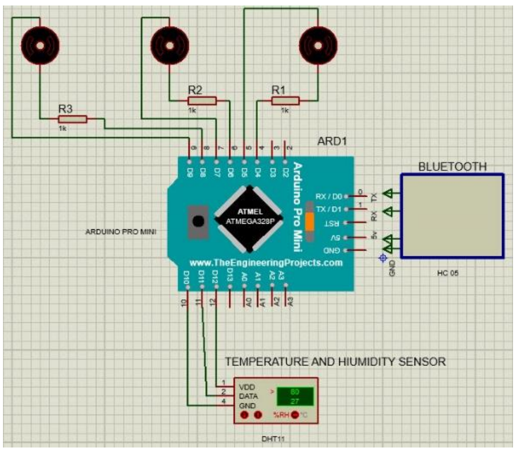

Figure 7. The proteus software of smart balloon

According to the figure above, a DC power supply is required to run the system. The DC power supply feeds the Microcontroller and the Bluetooth module. The Bluetooth module receives the signal sent from an android smart-phone in which the C programming language is installed and the microcontroller sends instructions. The movement and functioning of the motor can be controlled by the android-based software. The hardware of this project consists of the Arduino pro mini, the Bluetooth module, the DHT11 sensor, and the DC motor. The Bluetooth module is connected to the Arduino pro mini board in order to make connection with users feasible. Through the Bluetooth module for monitoring and controlling the particular motor reaches the board and process accordingly and the output of the Arduino goes to the DC motor and it controls the particular motor (I could not find the Farsi version of this sentence. It should be paraphrased). The DHT11 sensor measuring humidity and temperature is connected to the Arduino pro mini board and can be monitored through the Bluetooth module. The design of smartphone program is shown in figure 8.

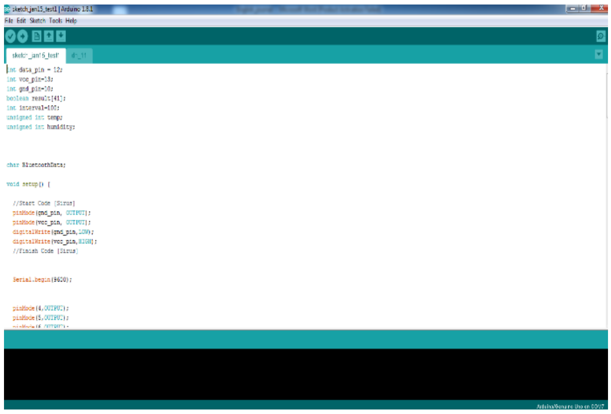

Figure 8. Smartphone program design

The general structure of a smart balloon is illustrated in figure 9.

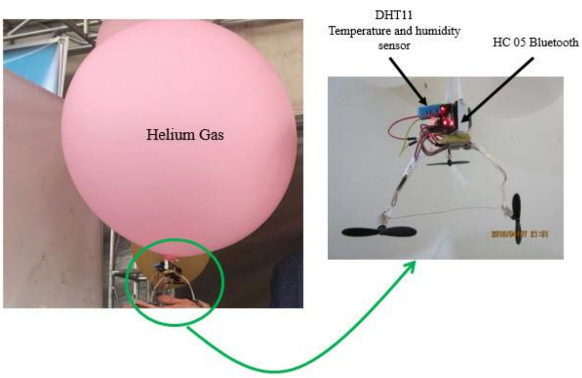

Figure 9. The general structure of a smart balloon

In order to keep the robot shown in figure 7 in air, we should take the points made above into account and calculate the required amount of helium based on the robot's weight. The designed robot weighs 456 grams. The weight of a balloon without gas is 10 grams. Thus, based on equation (2), the amount of helium gas is calculated as follows:

$$(1.099\times x)-10=456\ gr \rightarrow x=405.83 \quad (3)$$

X is equal to helium gas per liter in order to rise the balloon in the air and make the robot's control easier.

The robot being connected to the balloon and floating in the air, the control operation can then be started. This way, the balloon can be directed to any place for the purposes of obtaining information about the temperature and humidity. Keeping the robot steady, the exact information regarding the temperature and humidity which is viewable on a mobile phone is sent. The key point about these types of balloons is that they move slower than other flying robots in order to measure and send the information accurately. The slow movement of these balloons can be considered as one of their main advantages. The other major benefit of these balloons can be summarized in their programming which facilitates the isolation of various parts of the robot from one another. Indeed, the control and measurement of all parts of the robot including engines and sensors are performed independently. As a result, all data transmitted and received can be assumed highly reliable.

These balloons are able to obtain information about hazardous materials' pressure and leakage, all of which can be used in various researches, and scientific, military and other industries. The ability to provide internet coverage in the desired location is attributable to these balloons. Smart balloons can also be used as a low-altitude imaging device in a wide range of areas, such as event monitoring, tactical reaction and traffic disaster analysis. Environmental pollution which includes the pollution of water, air and soil has become a major issue occurring on a vast scale around the globe. Environmental pollution not only affects biodiversity negatively, but also endangers human health. Nanoparticles coated balloons as one the smart balloon's applications can curb pollution by absorbing even inaccessible environmental pollutants. The design of a flying robot to be used in meteorological research has been explored in this article. These robots can be of great help in environments such as mountains or greenhouses where human access is limited and acquiring online and moment by moment information about the temperature and humidity is a must.

IV. EXPREMENT ANALYSIS

This part aims at elucidating the results of the measurement of températures and humidity by the smart balloon. This experiment was performed at room temperature 38c within 10 minutes. Striving to acquire information about the temperature and humidity of various parts of the room, the balloon was moved to different parts. The results of the measurement of temperature and humidity by the smart balloon have been illustrated in the following table4.

Table 4. THE RESULTS OF THE MEASUREMENT OF TEMPRATURE AND HUMIDITY BY THE SMART BALLOON

Humidity	Temperature
28	31
26	32
28	31
25	35
24	35
24	35
26	33
32	30
32	30

As it can be seen, the temperatures of some places in the room were higher than the others. Please keep in mind that the temperature was higher near the window since the experiment was undertaken in the middle of the day. In contrast, the temperature of places with elevated airflow remains lower. It is noteworthy that as the temperature increases, the amount of humidity decreases as well.

V. CONCLUSION

Considering the flying robots' multiple application areas in today's world, efforts should be employed to mitigate the problems mentioned previously. Due to these robots' high speed and their locusts' specific location, they produce a lot of noise, the degree of energy required for taking off is high and therefore, the flight duration would be short. We can either use high capacity batteries or self-charging systems such as solar cells. In case the former alternative (high capacity batteries) is adopted, the robot would not be cost-efficient and light. The ability of flying robots to fly rests on being of little weight. The latter option (self-charging system) also suffers from some shortcomings. In fact, this alternative controls the robot with delay, may not be appropriate for nights and cloudy days, and the costs associated with advanced control categories and accessories such as flight controller (for maintaining the robot's balance during its take off) are unavoidable. Given the problems expressed above, this article suggested the design of a smart balloon for the very first time. Under this system, as the robot attached to the balloon floats in the air, the need for taking off would be eliminated which, in turn, reduces the degree of energy consumption. Importantly, the use of a mobile phone as a control handle instead of other accessories results in the reduction of the cost of designing a robot to a large extent. The noise produced by these robots is insignificant due to the way the motors and their locusts are located. Their speed is low as they are equipped with a balloon as compared to other flying robots. Simple structure, high reliability, and reparability explain why smart balloons have become increasingly common in photography (including photography of traffic accidents from a low altitude), Pharmacy, Meteorology, and Filming industries. They have also been successful in bringing internet coverage to everyone. Thanks to the economical nature of these balloons, they can easily substitute drones.

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