Proposal of Observation Balloon For Testing Centers

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2023.3.8

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1 Introduction

1.1 Problem

Our group need to design a floating balloon drone that monitors students who are taking tests. The balloon or the drone needs to be non-noisy and provide aerial observation of the students to make sure that they are not cheating. Normally, if we want to use the drone to monitor the students, the sound will heavily affect the students and it may cause danger. Therefore, we want to create a safer machine that can achieve the goal. We can remotely control the direction and the height of the balloon. So the equipment of power is the most important thing to design. Meanwhile, how to control the balloon flying in the horizontal plane and vertical plane is also another problem. We need to make two different power to let the balloon fly in the space freely.

And also the shape of the balloon cannot be too big that we need to use the machine indoor. But we need to connect the camera and the circuit board in the balloon. So how to balance the weight of all the equipment and the buoyancy force that the balloon can provide is a significant thing.

1.2 Solution

Our design is a none-noisy balloon drone that can be controlled by human remotely to monitor the students that taking the exam. The most important part is that we need to make it not noisy as the normal drone. We want to use some special way to avoid using noisy motor. For example, we use the buoyancy of the balloon instead of the power of propellers to balance the weight of the vehicle. And we also use the rope to control the balloon up and down to vanish the noise. To make it more useful, we make the drone equipped with several cameras which can send the pictures to our cellphone with Bluetooth. And if possible, we want to use the computer version to automatically detect if there are any students suspected cheating.

As for the balance between buoyancy and weight, we need to try many times after all the equipment are connected than we need to adjust carefully.

1.3 Visual Aid

Figure 1: ideal balloon system

1.4 High-level Requirements List

- The balloon can move freely in horizontal direction and the speed should be less than 0.3m/s and larger than 0.1m/s while moving
- The noise cannot reach to 70dB since it is the maximum amount of noise that the EPA has determined humans can tolerate (without hearing loss, sleep disturbances, anxiety, learning disabilities, etc.).
- It can capture the image of students and the resolution reaches the 720P. Also, it should transmit to user's phone within 1 seconds delay to provide evidence if students are cheating.

2 Design

2.1 Block diagram

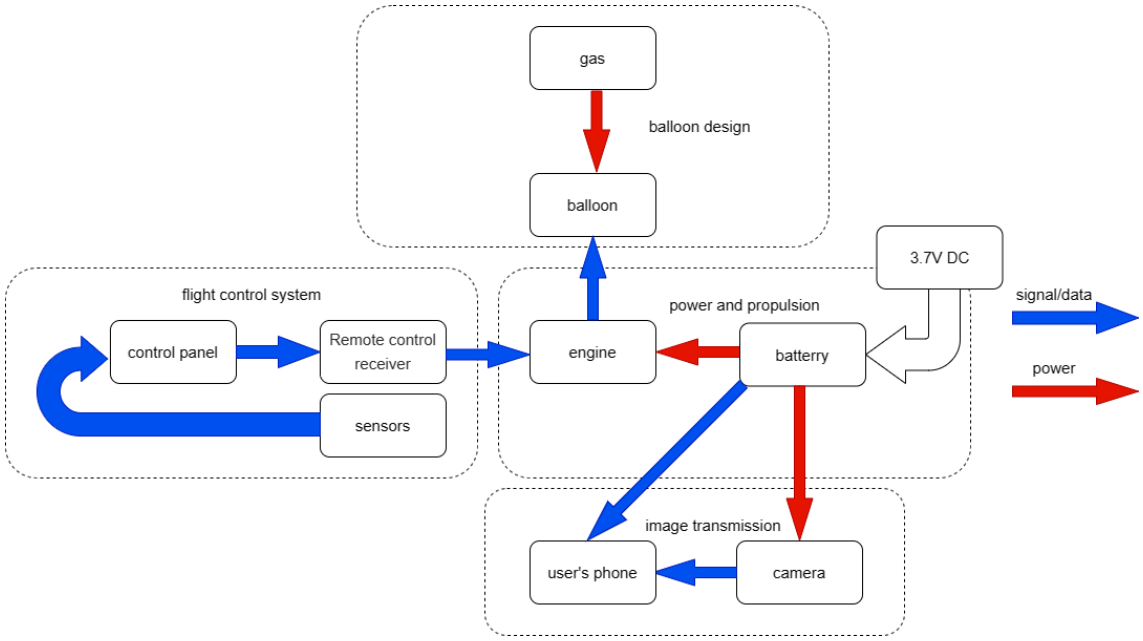

Figure 2: Block diagram

2.2 Interaction between subsystems

The flight control subsystem needs to interact with the power and propulsion subsystem to ensure that the drone can maintain the desired altitude, speed, and direction. The power and propulsion subsystem, in turn, provides the necessary power for the motor to drive the propellers and control the speed and direction of the drone.

The image transmission subsystem needs to interact with the flight control subsystem to ensure that the drone is in the correct position and orientation to capture high-quality images and videos. The camera needs to be mounted on the drone in a stable manner to reduce the impact of environmental factors such as wind and air resistance.

The balloon design subsystem needs to take into account the requirements of all the other subsystems to ensure that the drone can achieve its desired performance and functionality. For example, the balloon needs to be designed with good stability to reduce the impact of wind on the drone, and it needs to be lightweight to improve flight efficiency and stability.

2.3 Physical Design

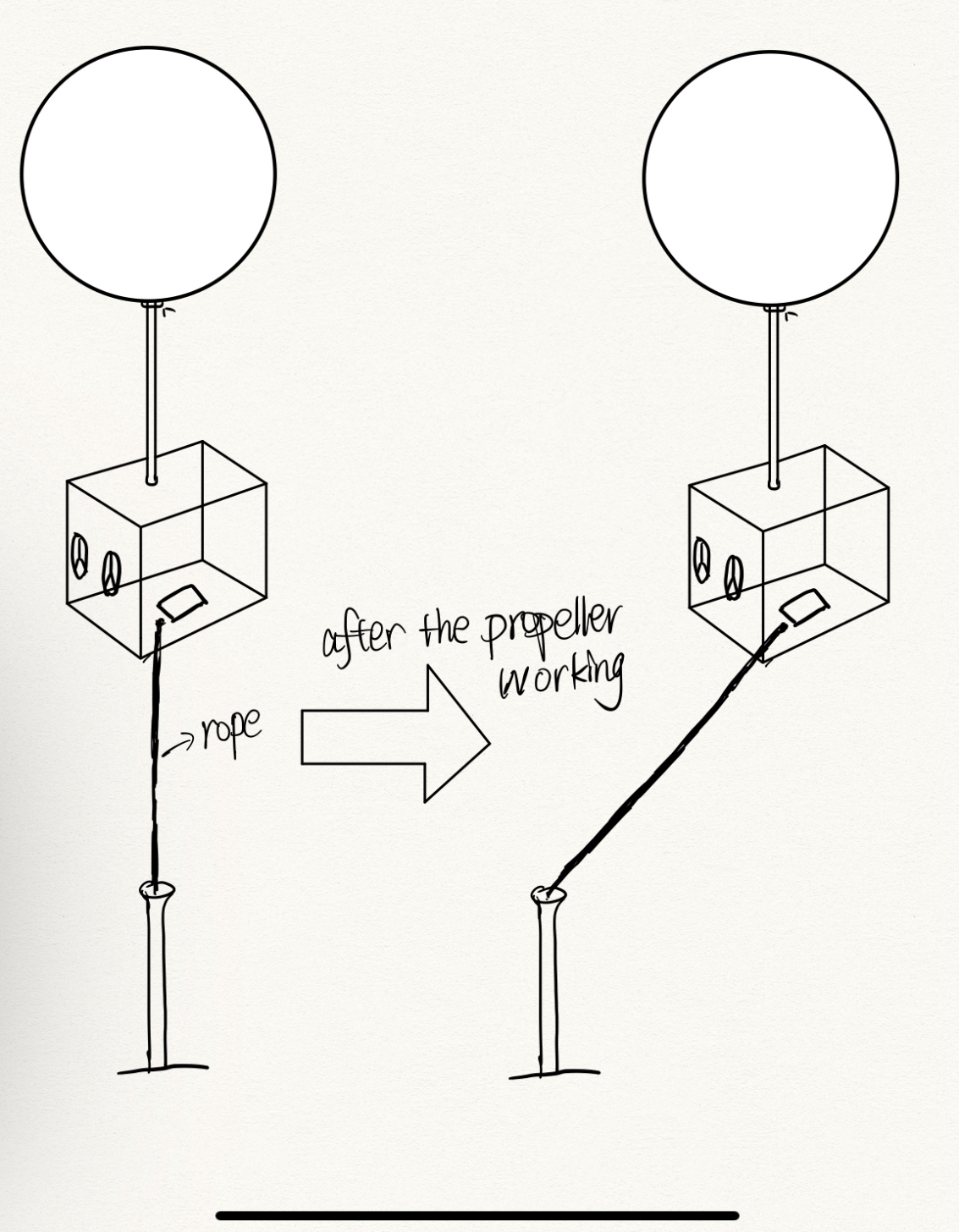

Figure 3: Physical Design

2.3.1 FLIGHT CONTROL SUBSYSTEM

Overview:

What we need to achieve in this subsystem is that the balloon needs to move freely in the indoor environment, and we can control the flight of the balloon through the remote control panel. So we decided to design a control panel, including the joystick and other controls necessary to control the speed, height and direction of the balloon's movement.

Requirement:

In this subsystem, we select the appropriate sensors to detect the altitude, speed and direction of the aircraft. Throughout the balloon flight, we use algorithms to stabilize the aircraft during flight and adjust the control surfaces for direction control. Sensors collect information about the balloon's height, speed and displacement direction and send it to the control panel. The information is processed by the control panel, and the operator can control the control panel based on the information collected and send instructions to the engine to adjust and correct the flight of the balloon in time.

2.3.2 POWER AND PROPULSION SUBSYSTEM

Overview:

In order to achieve the effect of not interfering with the exam, we will choose a suitable motor, which does not have the noise and propeller, but provides the necessary power for the balloon. In addition, we will design and integrate a battery system that can provide sufficient time for the motor and control system. Power management is implemented in this system to monitor battery voltage and ensure the safe flight of the balloon.

There are two motors need to be used in our balloon drone. Each of them is the rope-control motor, and the propeller-control motor. And there should be two batteries to supply the power of them.

Requirement:

There are three requirements we want to consider, the noise level, the weight. After testing, we think the noise cannot be larger than 70dB since it is the maximum amount of noise that the EPA has determined humans can tolerate (without hearing loss, sleep disturbances, anxiety, learning disabilities, etc.). Also the weight should be smaller than 10 gram.

2.3.3 IMAGE TRANSMISSION SUBSYSTEM

Overview:

We'll buy a camera that can capture footage. After the camera takes a picture, we can transfer the picture to the user's phone. We also control the batteries used in the camera system. To be specific, we hope it has high resolution since the purpose of balloon is to capture high-quality images and videos and see if there are students cheating.

Requirement:

The camera needs to have a sufficiently high resolution to capture details. And the payload capacity of balloon is limited, so the camera needs to be lightweight and compact to reduce the burden on the balloon.

Furthermore, it needs a stabilization system. Since the flight of a balloon can be affected by environmental factors such as wind and air resistance, the camera needs to have a stabilization system to ensure the stability of the images and videos. For the image, we hope the low latency. Balloons need to transmit images and videos in real-time, so the camera needs to have low latency to ensure transmission quality and flight stability.

2.3.4 BALLOON DESIGN SUBSYSTEM

Overview:

We design the overall structure of the balloon, including shape, color and size, and choose which gas to use based on its weight, durability and strength. And select the materials used for the balloon and its connecting parts. Finally we use 3D printing or laser cutting to create a physical model of the balloon. The design needs to fully consider the stability, control, weight, power, safety, camera, and materials of the drone to ensure that it can achieve the expected flight and mission goals. A balloon-powered drone is easily affected by wind, so it needs to be designed with good stability to reduce the impact of wind on the drone. The balloon needs to be remotely controlled for precise positioning and navigation in the air. The design needs to include wireless control and communication equipment. The weight and size of the balloon can affect the drone's flight performance, so it is important to ensure a lightweight design to improve flight efficiency and stability.The balloon needs to have safety measures to prevent loss of control or crashes. The design needs to include safety switches, loss of control protection, and return functions. And the design is shown in next figure.

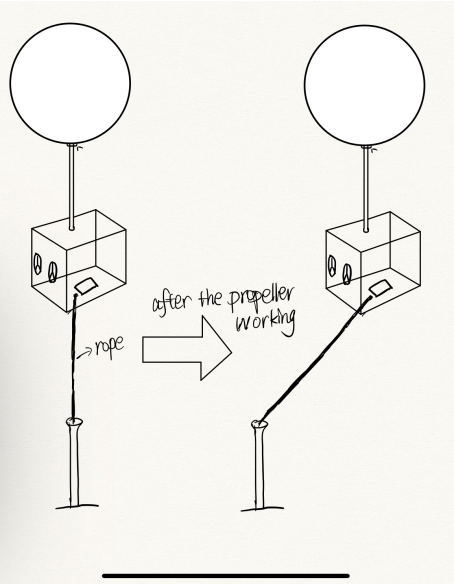

Figure 4: Physical Design

Requirement:

The drone needs to be stable at a certain wind speed. We must ensure the drone will not suddenly drop and hurt student. We require the dropping velocity less than 8 km/h, and the acceleration be zero. The rope we use in the design needs to be strong enough. It can bear at least 1kg of weight.

2.4 Tolerance Analysis

First of all, we should consider the power of the motor and the overall quality of the balloon. Too heavy a balloon, or too little power from the motor, will cause the flight to fail. So we have to determine the mass of the balloon and the type of gas inside.

The design and integration of the circuit is also important, as balloon acceleration may require relatively high power. We need to find and ensure that each component in the circuit is in good condition for its operation. And in order not to affect the exam conditions, we must choose a motor with minimal noise, to achieve a silent effect.

The design of the shape and structure of the balloon is very important, in order to stabilize the flight, we need to design a stable structure.

In order for the balloon to float, we need a buoyancy force greater than or equal to the gravity of the whole device.

$$F_{float} = \rho_{air} g V_{balloon}$$

$$G = m_{He} g + m_{equipment} g$$

$$m_{He} = \rho_{He} V_{balloon}$$

$$m_{equipment} \approx 0.15kg$$

$$\rho_{He} = 0.1786 \frac{kg}{m^3} \, , \rho_{air} = 1.29 \frac{kg}{m^3}$$

$$then\ we\ can\ get\ the\ V_{balloon} \approx 0.2m^3$$

$$which\ can\ let\ the\ F_{float} > G$$

Figure 5: Tolerance Analysis

In our calculations, buoyancy is greater than gravity, which keeps the whole thing afloat. And the volume for the balloon is reasonable which proves that our design is feasible.

Also, for the function of moving, we use two propellers as power supply. Although the power is not such large, we do not expect the balloon to move very fast. We just need the propulsion be larger than the air friction.

Next, for the function of detecting. We do a survey about it and find that in houses less than 10 meters high, the 720P camera is strong enough to capture some fine details including if someone are cheating.

3 Ethics and Safety

3.1 Ethics

According to the IEEE Code of Ethics, as professionals, we hold paramount the safety, health, and welfare of the public and are responsible for promptly disclosing factors that may endanger the public or the environment. Therefore, when testing our balloon flying and doing the Helium filling, we will take precautions to ensure public safety. Warning signs will be placed around the test sites to prevent unauthorized entry to potentially dangerous areas.

As for the IEEE Code of Ethics, we will avoid any unlawful conduct in our professional activities, specifically relating to laws and regulations regarding balloon flying. Compliance with all regulations and laws is essential to ensure the safety of the public and the environment. Lastly, we will seek, accept, and offer honest criticism of technical work, acknowledging and correcting errors, in line with the IEEE Code of Ethics. We will actively seek guidance and constructive criticism from peers and experts to optimize our project and ensure the highest level of technical excellence.

3.2 Safety

When we control the flight of a balloon indoors, there is a risk of losing control, so we need to prepare for balloon loss of control and clear the area to avoid injury to people and damage to property. At the same time, since the balloon is filled with helium, if it leaks or bursts indoors, it can have a certain impact on the indoor air quality, so we must prepare ventilation equipment, such as exhaust fans, and promptly do ventilation work.

When installing a motor and camera below the balloon, it is easy to scratch the balloon, so the surface of the balloon should be checked for any risk of air leakage after assembly. During the balloon's flight test, collisions with ceilings, floors, or objects such as tables and chairs are likely to occur, so we should choose a suitable location to minimize the losses caused by collisions.

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