Drone

Requirements Definition Document

RDD Version 3.0

Team #02
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1. Introduction

The large and steadily growing drone market creates numerous opportunities for creative drone design. These days, drones are utilized for many purposes such as for recreation or professional missions. Drones are needed to conduct many missions that may be dangerous if conducted by humans such as surveillance on war, search and rescue, and weather monitoring. Therefore, developing a drone could be very helpful for many crucial activities.

The main objective of this project is to create well-structured software implementation for a drone system. Our proposed design aims to create a functional and reliable drone which will serve as a template for the ease of software implementation. This document details the important functionalities and features of the drone. The end goal of this report is to create a well-structured design to be integrated with software to provide a fully functional and reliable drone.

The remainder of the report will discuss the detailed design of the drone. Section 2 lists the objectives of our drone. Section 3 illustrates the design concept of the drone as well as the system organization. Section 4 discusses the capabilities to be included within the drone. Finally, Section 5 details the design constraints of the drone.

2. Objectives

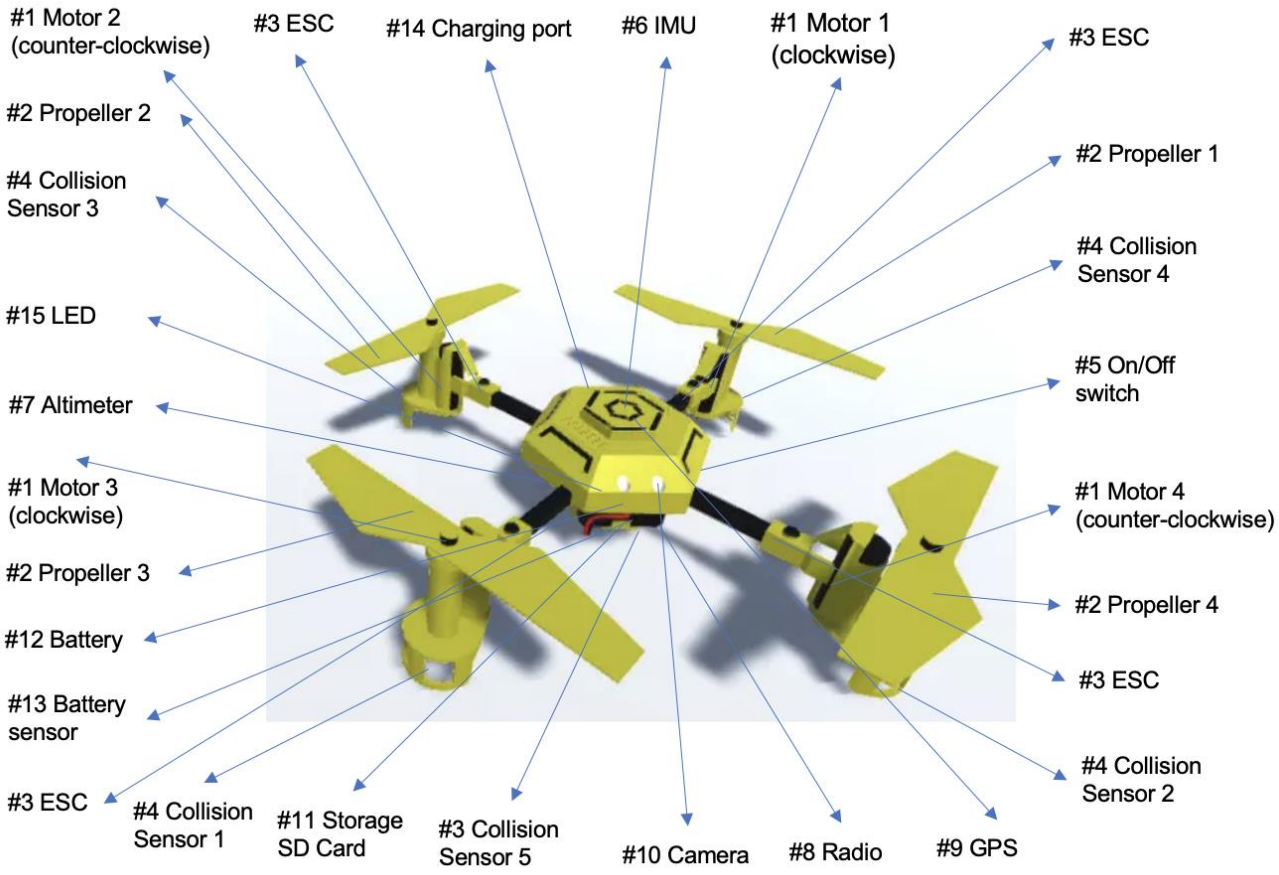
Building a reliable drone system involves many technical and organizational complexities. It requires thorough analysis and careful consideration on the features that should be given to the drone, the design of the whole system, and how the system can be implemented within software. Through this challenging project, we will learn the techniques to design reliable software, which is essential when we enter the software industry. In order to demonstrate these techniques sufficiently through this project, clear goals must first be established. Therefore, we set our objectives as follows:

- Determine the best drone features and design to be implemented
- Develop a drone system that is reliable and user-friendly
- Simulate a drone using computer software
- Allow for seamless integration from the design to software implementation

3. System Organization

In order to accomplish our goals, it is important to design a robust system for the drone. The drone will be 3.9” x 3.6”x 1.6” in dimension. The main features include:

four motors, four propellers, four electronic speed controllers(ESC), five collision sensors, inertial measurement unit(IMU), an altimeter, a radio, a GPS module, a camera, onboard storage, a battery, a battery sensor, a LED, and a controller. The controller allows the user to control the drone. These control features include flight and camera functionality. Below are the design figures of the proposed drone and controller. Further down each component within the drone and the remote controller is discussed.



1.

Figure 1
A design representation of the drone

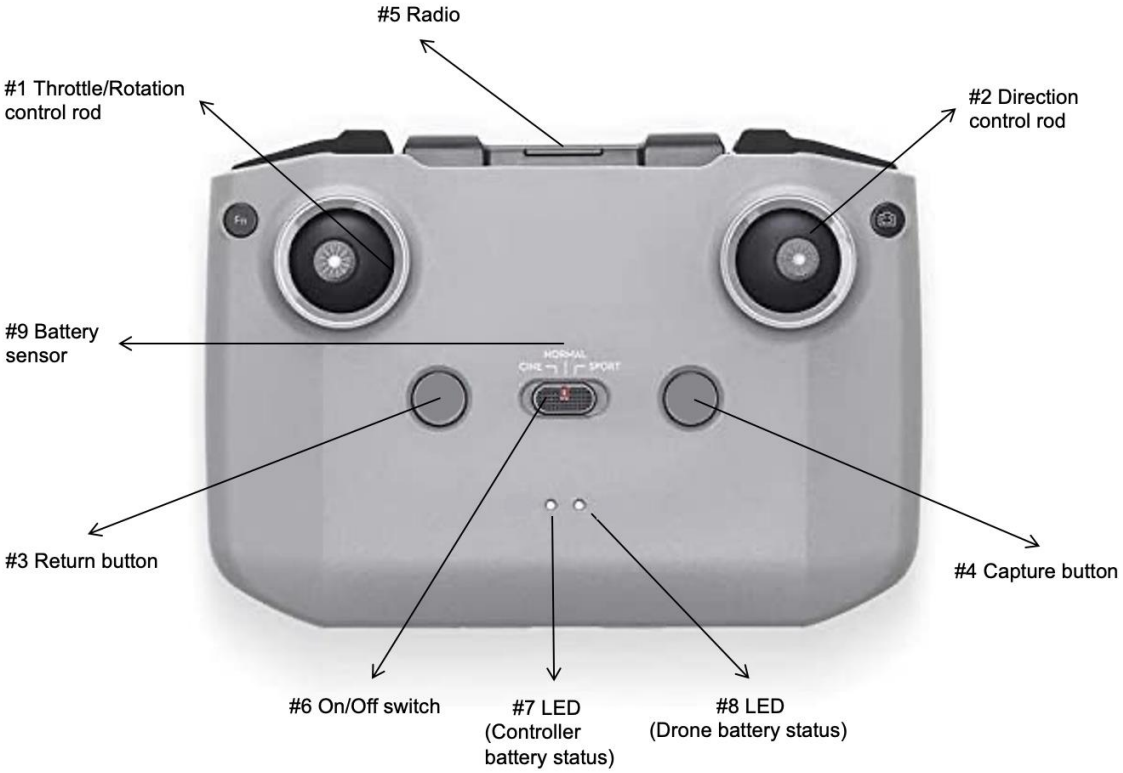


Figure 2
A design representation of the remote controller

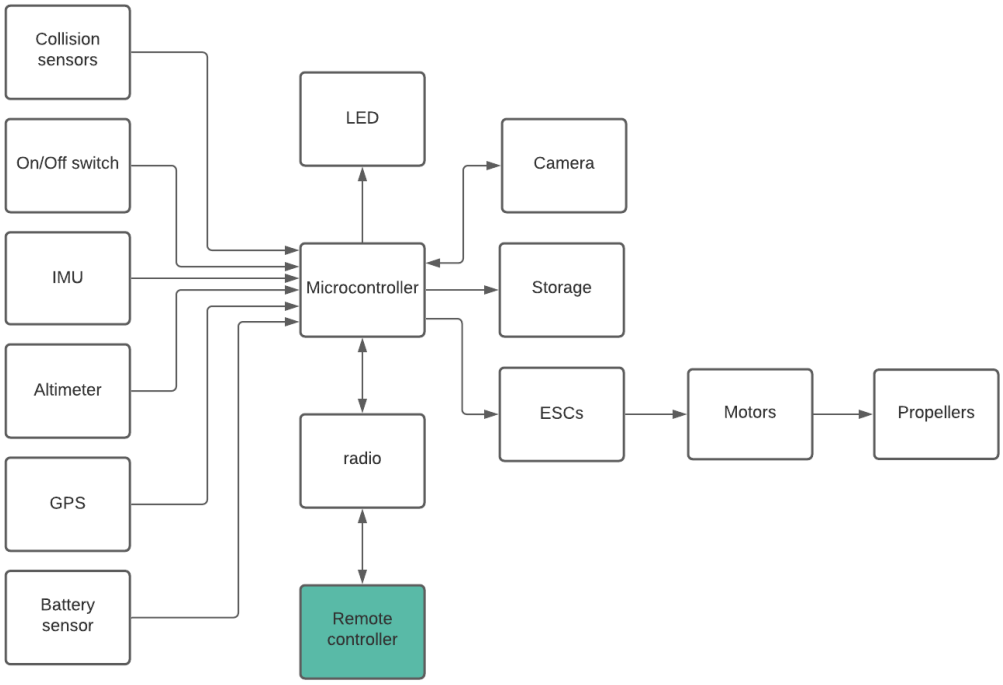


Figure 3
Block diagram showing all physical interfaces of the microcontroller in the drone

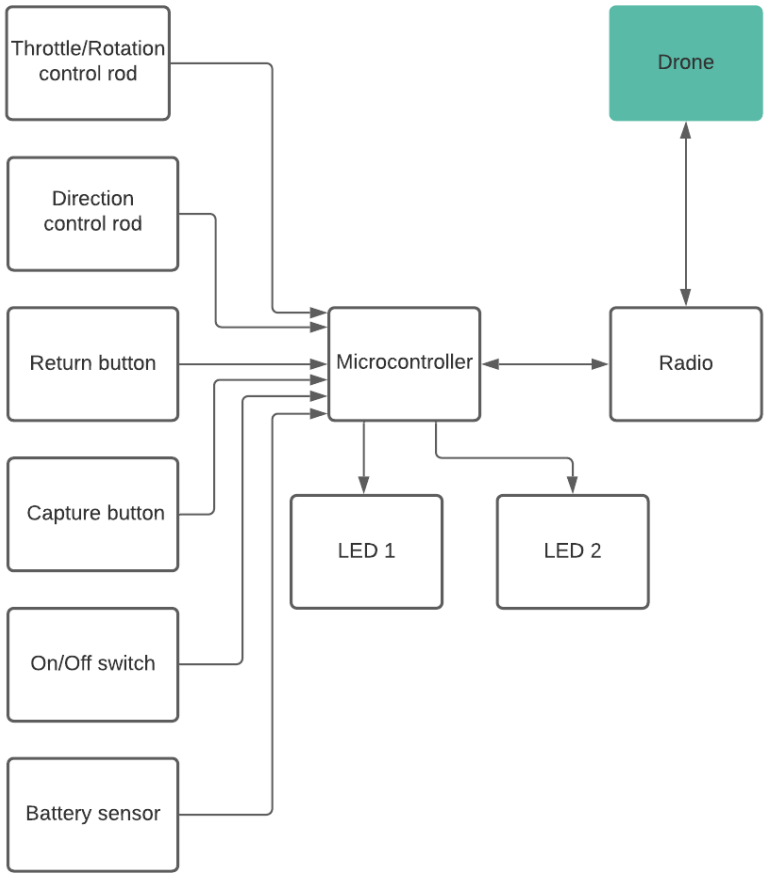


Figure 4
Block diagram showing all physical interfaces of the microcontroller in the controller

2. 3.1 Drone Components

- #1 Motors: The drone will be equipped with 4 motors in order to provide thrust to the drone for the purposes of take-off and speed adjustments.
- #2 Propellers: 4 carbon propellers will be included and attached to the motors. The propellers will work with the motors to provide flight capability.
- #3 ESCs (Electronic speed controllers): ESCs are the devices that control the rotation rates of motors based on the microcontroller's signals. Each motor requires one ESC.
- #4 Collision sensors: The drone will be equipped with 5 collision sensors to prevent the drone from colliding with the surrounding environment. Collision sensors 1, 2, 3, and 4 would cover an area 360 degrees around the drone to detect if there is any terrain nearby in the horizontal direction to the drone. Collision sensor 5 will detect the terrain in the vertical direction underneath the drone. If the horizontal sensors detect nearby terrain, it will prevent the drone from moving toward the terrain, in order to prevent a collision from occurring. If the vertical sensor detects terrain underneath and close to the

drone, it will send a signal to let the drone adjust the thrust to prevent a hard landing.

- #5 On/Off switch: The switch will allow the user to turn the drone either ON or OFF.
- #6 IMU (Inertial Measurement Unit)
  - Gyroscope: This will provide the measurement of the angular rate of the 3 axes (x, y, and z) of the drone to prevent the drone from flipping.
  - Accelerometer: This will provide the measurement of the acceleration rate of the 3 axes (x, y, and z) of the drone to prevent the drone from accelerating too fast.
  - Magnetometer: This will establish cardinal direction. This is used to provide directional information to the drone when using 'return back' feature
- #7 Altimeter: The altimeter will be used to determine the altitude of the drone. This sensor will be utilized for hover mode feature, in which the drone will maintain its current altitude when there is no throttle input from the user.
- #8 Radio: The radio will act as a transmitter and receiver from and to the remote controller.
- #9 GPS: the GPS module will locate and save the take-off coordinates of the drone when the drone switch is turned on. This component is used for the 'return back' feature. This feature, when activated, will send a signal from the controller to the drone, which causes the drone to return to the take-off point.
- #10 Camera: The drone is equipped with a camera that is capable of taking 1080p quality pictures when the user presses the 'capture' button from the controller.
- #11 Storage SD Card: An 8 GB SD card is needed in order to store the images taken by the drone. Once the storage is full, additional pictures taken will not be able to be stored.
- #12 Battery: A battery located inside the drone is the power source of the drone.
- #13 Battery sensor: A sensor to indicate the status of the battery, either Normal or LowBat when the battery is under 20%.
- #14 Charging port: A charging port to recharge the drone's battery.
- #15 LED: 1 LED to indicate the status of the drone; Green light when the drone is ON, No light when the drone is OFF, and Red light when the drone's battery status is low. The low battery status has a higher priority, therefore in the event of low battery when the drone is on, Red light will be shown.

3. 3.2 Controller Components

- #1 Throttle/Rotation control rod: The rod is able to move only in 4 directions: up, down, left, and right. This will be used both to control the thrust of the drone and to rotate the drone horizontally. By moving the rod forward/backward, the speed of the motor increases/decreases. As a result, the drone will go up/down vertically. When the user moves the control rod

right/left, the drone will rotate its facing direction clockwise/counterclockwise horizontally.

- #2 Direction control rod: This will be used to control the pitch (y-axis) and the roll (x-axis) movements of the drone. The rod is able to move 360 degrees around to determine the direction movement of the drone.
- #3 Return button: This button will send a signal to the drone to notify the drone to return to its take-off position.
- #4 Capture button: This button will send a signal to the drone to capture an image.
- #5 Radio: The radio will act as a transmitter and receiver from and to the drone.
- #6 On/Off switch: The switch will allow the user to turn the remote controller either ON or OFF.
- #7 LED (Controller battery status): The first LED is used to indicate the battery level of the remote controller. When the controller is ON and the battery level is not low, a green LED will be shown. If the controller is ON and the battery level is low, a red LED will be shown.
- #8 LED (Drone battery status): The second LED is used to indicate the battery level on the drone. When the drone is ON and the battery level is not low, a green LED will be shown. If the drone is ON and the battery level is low, a red LED will be shown.
- #9 Battery sensor: A sensor obtains the battery level status of the controller and signals to the remote controller's microcontroller if the battery level is low.

4. Capabilities

In order to build a reliable and fully functioning drone, numerous useful capabilities are included within our drone design. The flexibility and inclusion of numerous capabilities will contribute to the reliability and overall functionality of the drone. Below is the list of proposed drone capabilities:

4. 4.1 Control and Mobility

- The drone is able to move around all 3 axes (X-axis, Y-axis, and Z-axis) based on the specified direction from the remote controller. X-axis is to roll left and right, Y-axis is to pitch forward and backward, Z-axis is the higher/lower altitude.
- The drone is able to rotate its facing direction 360 degrees around.

5. 4.2 Functionalities

- Capture Images: the drone is equipped with a 1080p camera to capture images when the user presses the 'Capture' button from the controller.
- Image Storage: The included 8 GB SD card allows users to take and save multiple images.
- Rechargeable drone battery: A rechargeable battery is attached to the drone. It is rechargeable when the drone's battery level is low.
- LED indication: The LEDs on the drone and the controller can inform the user of their status, whether they are ON, OFF, or Low battery.

6. 4.3 Sensing

- Avoid Collision: The five collision sensors will prevent the drone from colliding with the surrounding terrain nearby. This prevents the drone from moving towards terrain that would cause a collision.
- Prevent Flipping: The gyroscope attached to the IMU (Inertial Measurement Unit) will prevent the drone from flipping. This prevents the uncontrollable state of the drone during flight.
- When the battery level of the drone or the controller is low, battery sensors detect this information and transmit this information to the remote controller.

7. 4.4 Autonomous

- Altitude hold: There is an altimeter sensor to allow the drone to hover at its current altitude. This will automatically occur whenever there is no throttle input from the user (the throttle control rod is at the neutral position).
- Return to take-off position: Utilizing GPS, in the event of low-battery, lost connection, or when the user presses the 'Return' button, the drone will be able to return to its take-off position based on the coordinate stored when the drone took off.
- When a collision sensor detects an obstacle while the drone is auto-returning, the microcontroller of the drone recalculates and finds another path to the original take-off position.

5. Design Constraints

Every product has constraints in its design in order to control the features in the final product. The recognition of constraints is important for the implementation of the drone features. The design constraints for the drone are as follows:

- All system and software features will be developed using C# on the Unity AirSim platform for compatibility reasons.