

Florida International University
Knight Foundation School of Computing and Information
Sciences
Software Engineering Focus

Final Deliverable

Project Title: Sahara UI Drone Link

Process Team Members: Javier Cueto , Natalie Almonte , Angel Chavez

Product Owner : Javier Cueto

Instructor: Masoud Sadjadi

Abstract

This document presents a comprehensive overview of the Sahara Industrial Drone User Interface Application, developed to address the challenges of controlling and managing industrial drones. The application emerges from the need for an intuitive and efficient interface for piloting drones in various industrial scenarios. Traditionally, drone operations have been managed through less interactive and often cumbersome methods, which can limit the user's ability to effectively control and monitor drone activities.

Overall, the Sahara Industrial Drone User Interface Application represents a significant step forward in drone control technology, offering a user-friendly, adaptable, and efficient solution for managing industrial drones in a variety of settings.

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Introduction

In Fall 2023, a team of Capstone 2 students embarked on a project to modernize industrial drone operations, resulting in the development of the Sahara Industrial Drone User Interface. This application, crafted using Python and the Kivy framework, stands as a testament to their technical acumen and understanding of the real-world challenges in drone management. Addressing the complexities and limitations of traditional drone control systems, the Sahara UI attempts to provide an intuitive, responsive, and feature-rich platform, empowering operators to navigate and control industrial drones with unprecedented ease and efficiency. This project not only showcases the students' capability to integrate advanced programming and user experience design but also reflects their commitment to enhancing operational standards in the field of industrial drone technology.

Current System

Current systems in the realm of industrial drone control often rely on outdated user interfaces or, in more rudimentary setups, operate directly through command prompt instructions. These antiquated approaches present significant usability challenges, especially in high-stakes industrial environments where precision and ease of control are paramount. Outdated interfaces typically lack intuitive design, making it difficult for operators to access critical functions quickly and accurately. This can lead to increased training times and a higher likelihood of operator errors. Moreover, systems that operate through command prompt instructions require a deep technical understanding and familiarity with command-line syntax, which is not always feasible in fast-paced industrial settings. Such limitations not only hinder operational efficiency but also impede the adoption of drone technology in industries that could greatly benefit from its application. The shift towards more modern, user-friendly interfaces like the Sahara UI is a necessary step to unlock the full potential of industrial drone technology.

Purpose of System

The Sahara application is built using Python and Kivy, a popular framework for creating natural user interfaces. It features a multi-threaded architecture that integrates controller inputs, network management, and server communication, ensuring responsive and real-time interaction with the drone. The interface includes distinct sections for flight initiation, controller settings, drone configurations, application preferences, and network connections, each accessible through clearly defined and easily navigable buttons.

A significant part of the application is dedicated to handling controller inputs, making it compatible with various types of gamepads and controllers, thus broadening its usability. Additionally, the network settings allow users to connect to drones over a network, offering real-time status updates and controls. The design of the application emphasizes simplicity and user-friendliness, ensuring that even users with limited technical expertise can operate the drone effectively.

User Stories

This section delves into the specific user stories that have been actualized in the current iteration of the Capstone Selection Process project. These stories formed the foundational guidelines for developing the project's features. Additionally, it outlines potential user stories that are earmarked for consideration in the project's future developmental phases.

Implemented User Stories

These user stories reflect a focus on ease of use, flexibility, and robustness in the drone control interface, catering to the needs of different users in a variety of operational scenarios.

1. **As a drone operator, I want to be able to start and stop the drone flight easily, so I can control the drone's operation effectively.**
 - *Implemented through a "Begin Flight" button in the UI.*
2. **As a user, I need to configure controller settings, so that I can use various types of game controllers with the drone.**
 - *Implemented through a "Controller Settings" section in the UI.*
3. **As a drone operator, I want to adjust drone settings, to ensure the drone operates according to the requirements of different tasks.**
 - *Implemented through a "Drone Settings" option.*
4. **As a user, I need to be able to access and modify application settings, so I can customize the UI according to my preferences.**
 - *Implemented through an "App Settings" feature.*
5. **As an operator, I need to configure network settings, to connect the drone to different networks and manage its online functionality.**
 - *Implemented through a "Network Settings" section.*
6. **As a user, I want to receive real-time feedback from the controller, so I can monitor the input I am providing.**
 - *Implemented through continuous controller input monitoring.*
7. **As an operator, I need to see the current Wi-Fi SSID and IP address, so I can ensure the drone is connected to the correct network.**
 - *Implemented in the "Network Settings", showing the Wi-Fi SSID and IP address.*
8. **As a user, I want to easily connect to the drone's server, to ensure a stable connection for controlling the drone.**
 - *Implemented through a connection tab within the network settings.*

9. **As a drone operator, I want an intuitive interface for controlling the drone, to reduce the learning curve and potential operational errors.**
 - *Implemented through a user-friendly UI with clear labels and buttons.*
10. **As a user, I need the application to be responsive to different screen sizes, so I can use it on various devices.**
 - *Implemented through dynamic font and layout adjustments based on screen size.*

Pending User Stories

1. **As a drone operator, I want a dashboard that displays real-time telemetry data (like altitude, speed, battery life), so I can monitor the drone's status during flight.**
2. **As a user, I need the ability to customize the control layout, so I can arrange the interface according to my personal preferences and ease of use.**
3. **As an operator, I want the UI to have a night mode, to reduce eye strain and enhance visibility in low-light conditions.**
4. **As a safety officer, I need clear visual and auditory alerts for critical warnings (like low battery, signal loss, proximity alerts), so I can promptly respond to potential hazards.**
5. **As a novice user, I would like an interactive tutorial or guided mode when I first use the application, to help me understand how to operate the drone effectively.**
6. **As an experienced operator, I want the ability to create and save custom flight profiles (like patrol routes, survey patterns), so I can quickly execute routine missions.**
7. **As a user, I need multi-language support in the UI, to ensure that operators of different linguistic backgrounds can use the application.**
8. **As a fleet manager, I want to be able to manage multiple drones from the same interface, to streamline the control process for a fleet of drones.**
9. **As a technician, I need easy access to diagnostic tools and logs within the UI, to troubleshoot and maintain the drone efficiently.**
10. **As a user, I want a responsive touch interface for tablet and smartphone control, to operate the drone remotely without needing a traditional PC setup.**

Project Plan

This section outlines the strategic planning and methodologies employed in bringing this project to fruition. Embracing agile development practices, this project was structured around carefully organized sprints, the specifics of which are elaborated in this section. Additionally, it provides an in-depth look at the selection of both software and hardware components integral to the project's success. Due to the very limited development time the team was only able to undertake 2 sprints of development

Hardware and Software Resources

- Sahara drone
- Pycharm IDE
- PS5 controller
- Python 3.11
- Xbox One controller
- Mac M2 air
- PC running windows 11

Sprints

Sprint 1

Date: 11/6/2023

Attendees: Javier Cueto, Natalie Almonte, Angel Chavez

Start time: 2:30pm

End time: 2:45pm

After discussion, the velocity of the team was estimated to be TBD.

The product owner chose the following user stories to be done during the next sprint. They are ordered based on their priority.

- **As a drone operator, I want to be able to start and stop the drone flight easily, so I can control the drone's operation effectively.** *Assigned to: Javier Cueto*
- **As a user, I need to configure controller settings, so that I can use various types of game controllers with the drone.** *Assigned to: Angel Chavez*

- **As a drone operator, I want to adjust drone settings, to ensure the drone operates according to the requirements of different tasks.** *Assigned to: Javier Cueto & Angel Chavez*
- **As a user, I need to be able to access and modify application settings, so I can customize the UI according to my preferences.** *Assigned to: Javier Cueto*
- **As an operator, I need to configure network settings, to connect the drone to different networks and manage its online functionality.** *Assigned to: Javier Cueto*
- **As a user, I want to receive real-time feedback from the controller, so I can monitor the input I am providing.** *Assigned to: Angel Chavez*
- **As an operator, I need to see the current Wi-Fi SSID and IP address, so I can ensure the drone is connected to the correct network.** *Assigned to: Javier Cueto*
- **As a user, I want to easily connect to the drone's server, to ensure a stable connection for controlling the drone.** *Assigned to: Javier Cueto*
- **As a drone operator, I want an intuitive interface for controlling the drone, to reduce the learning curve and potential operational errors.** *Assigned to: Javier Cueto & Angel Chavez*
- **As a user, I need the application to be responsive to different screen sizes, so I can use it on various devices.** *Assigned to: Javier Cueto & Angel Chavez*

Sprint 2

Date: 11/20/2023

Attendees: Javier Cueto, Natalie Almonte, Angel Chavez

Start time: 2:30pm

End time: 2:45pm

The development team demonstrated a remarkable and efficient pace in project execution, completing the project within two agile sprints. The velocity, measured in terms of completed user stories and points, showed a consistent and sustainable level of productivity. Notably, there was an observable increase in the amount of work completed from the first to the second sprint, reflecting the team's growing proficiency and adaptability to the project demands. This steady and quality-focused approach underscores the team's commitment to agile principles and effective project management.

The product owner chose the following user stories to be done during the next sprint. They are ordered based on their priority.

- **As a drone operator, I want to be able to start and stop the drone flight easily, so I can control the drone's operation effectively.** *Assigned to: Javier Cueto*

- **As a user, I need to configure controller settings, so that I can use various types of game controllers with the drone.** *Assigned to: Angel Chavez*
- **As a drone operator, I want to adjust drone settings, to ensure the drone operates according to the requirements of different tasks.** *Assigned to: Javier Cueto & Angel Chavez*
- **As a user, I need to be able to access and modify application settings, so I can customize the UI according to my preferences.** *Assigned to: Javier Cueto*
- **As an operator, I need to configure network settings, to connect the drone to different networks and manage its online functionality.** *Assigned to: Javier Cueto*
- **As a user, I want to receive real-time feedback from the controller, so I can monitor the input I am providing.** *Assigned to: Angel Chavez*
- **As an operator, I need to see the current Wi-Fi SSID and IP address, so I can ensure the drone is connected to the correct network.** *Assigned to: Javier Cueto*
- **As a user, I want to easily connect to the drone's server, to ensure a stable connection for controlling the drone.** *Assigned to: Javier Cueto*
- **As a drone operator, I want an intuitive interface for controlling the drone, to reduce the learning curve and potential operational errors.** *Assigned to: Javier Cueto & Angel Chavez*
- **As a user, I need the application to be responsive to different screen sizes, so I can use it on various devices.** *Assigned to: Javier Cueto & Angel Chavez*

System Validation

Test Suites

These test cases are designed to methodically validate the functionality, compatibility, and accuracy of the Sahara Industrial Drone UI application, ensuring a reliable and user-friendly experience for operators.

01-UI Functionality Test Suite

- This suite focuses on verifying that the UI components function as intended, such as buttons responding correctly and screens displaying the appropriate information.
 - **01A-Button Functionality Test Suite**
 - Ensures that each button (like "Begin Flight", "Controller Settings") functions correctly and leads to the expected outcome.

02-Controller Input Test Suite

- Tests the application's ability to receive and process inputs from various controllers.
 - **02A-Controller Compatibility Test Suite**
 - Validates compatibility with different types of controllers (e.g., Xbox, PlayStation).

03-Network Settings Test Suite

- Ensures the network features, such as connecting to Wi-Fi or displaying the IP address, work correctly.
 - **03A-Network Information Accuracy Test Suite**
 - Confirms that network-related information (like Wi-Fi SSID and IP address) displayed in the UI is accurate and updates in real-time.

Test Cases

Test Case ID: 01-1

- **Test Case Description:** Verify the functionality of the "Begin Flight" button.
- **Test Steps:** Navigate to the main screen, select the "Begin Flight" button.
- **Pre-requisites:** The application is loaded and on the main screen.
- **Expected Result:** The application transitions to the flight control interface or indicates the drone is ready for flight.

Test Case ID: 01-2

- **Test Case Description:** Validate the responsiveness of the "Controller Settings" button.
- **Test Steps:** From the main screen, select the "Controller Settings" button.

- **Pre-requisites:** The application is loaded and on the main screen.
- **Expected Result:** The application displays the controller settings interface.

Test Case ID: 02-1

- **Test Case Description:** Test Xbox controller compatibility.
- **Test Steps:** Connect an Xbox controller, navigate to controller settings, and test various inputs.
- **Pre-requisites:** Xbox controller is available and compatible with the system.
- **Expected Result:** All inputs from the Xbox controller are recognized and processed correctly by the application.

Test Case ID: 02-2

- **Test Case Description:** Test PlayStation controller compatibility.
- **Test Steps:** Connect a PlayStation controller, navigate to controller settings, and test various inputs.
- **Pre-requisites:** PlayStation controller is available and compatible with the system.
- **Expected Result:** All inputs from the PlayStation controller are recognized and processed correctly by the application.

Test Case ID: 03-1

- **Test Case Description:** Validate the display of the current Wi-Fi SSID.
- **Test Steps:** Access the "Network Settings" and view the displayed SSID.
- **Pre-requisites:** The device is connected to a Wi-Fi network.
- **Expected Result:** The SSID displayed in the UI matches the Wi-Fi network the device is connected to.

Test Case ID: 03-2

- **Test Case Description:** Check accuracy of displayed IP address.
- **Test Steps:** In "Network Settings", verify the displayed IP address.
- **Pre-requisites:** The device is connected to a network with an assigned IP address.
- **Expected Result:** The IP address displayed in the UI matches the device's actual IP address.

Glossary

This glossary provides clarity on technical terms and project-specific jargon, aiding in the understanding of the Sahara UI Drone Link Project report.

1. **Agile Development:** A method of software development emphasizing incremental progress, flexibility, and collaboration. Used by the project team for structuring their work into sprints.
2. **Drone:** An unmanned aerial vehicle (UAV) used for various industrial applications. Central to the project's focus.
3. **Kivy Framework:** An open-source Python library used for developing applications that make use of innovative user interfaces, such as multi-touch apps.
4. **Multi-threaded Architecture:** A programming architecture that allows multiple threads (sequences of programmed instructions) to be executed concurrently, enhancing the application's efficiency and responsiveness.
5. **Python 3.11:** The version of the Python programming language used in this project, known for its simplicity and readability.
6. **Sprint:** A set period during which specific work has to be completed and made ready for review, a key concept in Agile methodologies.
7. **User Interface (UI):** The space where interactions between humans and the drone occur, through graphical elements like buttons and screens.
8. **User Story:** A tool used in Agile software development to capture a description of a software feature from an end-user perspective.
9. **Velocity:** In Agile project management, this refers to the amount of work a team can complete in a single sprint, often used to plan and estimate future work.
10. **Wi-Fi SSID:** Stands for Service Set Identifier, it's the name of a wireless network, used in the project for connecting the drone to networks.
11. **Game Controllers (Xbox One controller, PS5 controller):** Input devices used for gaming, adapted in this project for controlling drones.
12. **IP Address:** A unique string of numbers separated by periods that identifies each computer using the Internet Protocol to communicate over a network.
13. **PyCharm IDE:** An Integrated Development Environment used for Python programming, offering code analysis, a graphical debugger, and other tools.
14. **Mac M2 Air:** A model of Macintosh laptops by Apple, known for its advanced processing capabilities, used by the team for development.
15. **Windows 11:** An operating system by Microsoft, used as a platform for running the drone application.

16. **Real-time Feedback:** Immediate information provided by the system in response to user inputs or actions, crucial for effective drone control.
17. **Product Owner:** In Agile development, the individual responsible for defining features and priorities for the development team.
18. **Command Prompt Instructions:** A command-line interface used to interact with a computer program, mentioned as a more traditional and less user-friendly method of controlling drones.

Appendix

Appendix A – UML Classes

Classes:

1. DroneApplication

- Attributes:
 - **currentScreen: String**
 - **connectedDrone: Drone**
- Methods:
 - **start()**
 - **stop()**
 - **connectToDrone()**

2. Drone

- Attributes:
 - **status: String**
 - **batteryLevel: Float**
 - **currentSpeed: Float**
 - **altitude: Float**
- Methods:
 - **startFlight()**
 - **stopFlight()**
 - **updateStatus()**

3. ControllerInput

- Attributes:
 - **controllerType: String**
 - **connectionStatus: Boolean**
- Methods:
 - **receiveInput()**

- **processInput()**

4. **UIComponent** (Abstract Class)

- Attributes:
 - **position: Position**
 - **size: Size**
- Methods:
 - **display()**
 - **hide()**

5. **Button** (Inherits from UIComponent)

- Attributes:
 - **label: String**
 - **onClickAction: Function**
- Methods:
 - **click()**

6. **Label** (Inherits from UIComponent)

- Attributes:
 - **text: String**
- Methods:
 - **updateText(newText: String)**

7. **NetworkManager**

- Attributes:
 - **currentSSID: String**
 - **ipAddress: String**
- Methods:
 - **connectToNetwork(ssid: String)**
 - **disconnectFromNetwork()**
 - **getNetworkStatus()**

8. **SettingsManager**

- Attributes:

- **controllerSettings: ControllerSettings**
- **networkSettings: NetworkSettings**
- Methods:
 - **updateControllerSettings(newSettings: ControllerSettings)**
 - **updateNetworkSettings(newSettings: NetworkSettings)**

9. **ControllerSettings**

- Attributes:
 - **sensitivity: Float**
 - **layout: String**
- Methods:
 - **applySettings()**

10. **NetworkSettings**

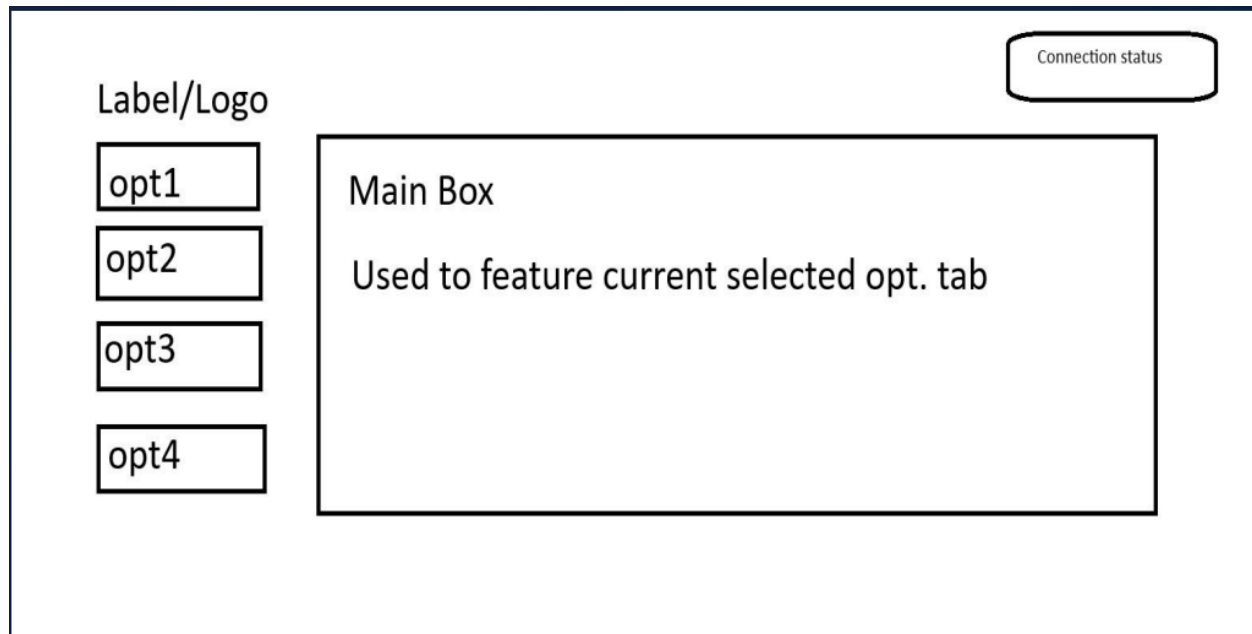
- Attributes:
 - **preferredNetwork: String**
 - **autoConnect: Boolean**
- Methods:
 - **applySettings()**

Relationships:

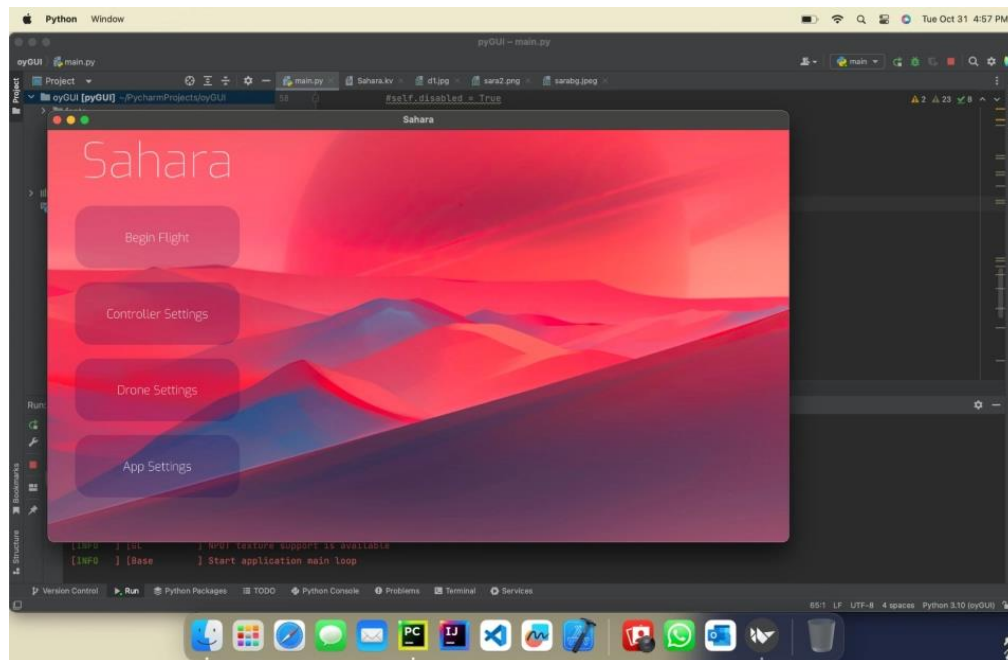
- **DroneApplication** has a **Drone**, manages **UIComponents** (like **Buttons** and **Labels**), uses **NetworkManager** and **SettingsManager**.
- **ControllerInput** interacts with **Drone** to control the flight and settings.
- **SettingsManager** aggregates **ControllerSettings** and **NetworkSettings**.

Appendix B - UI design

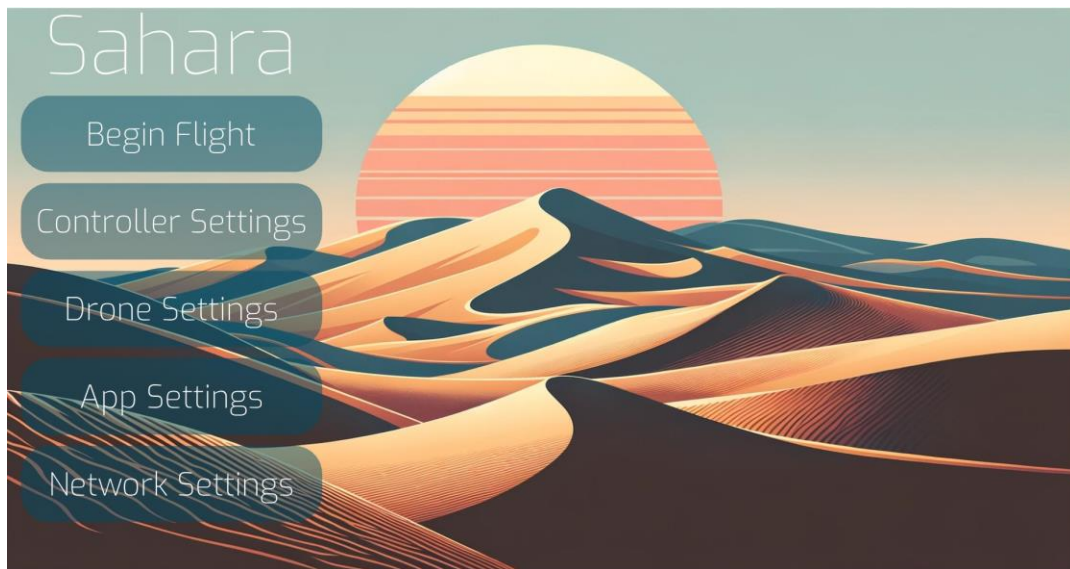
- Initial design schematic



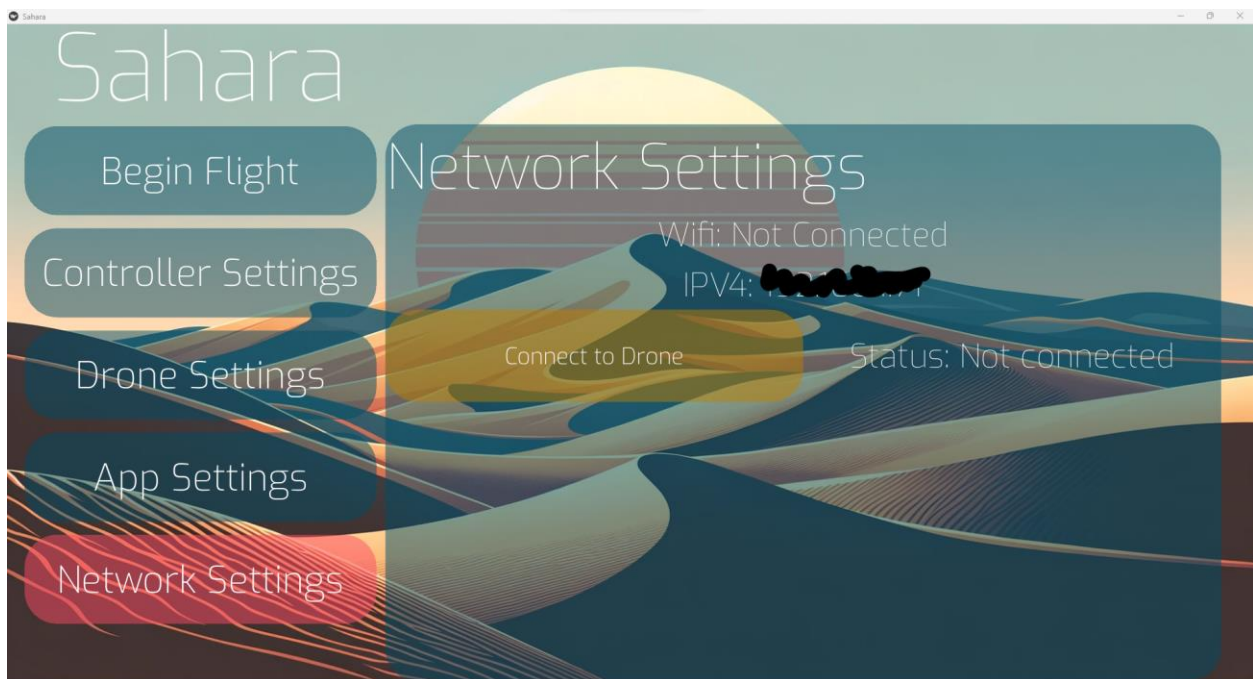
- **Main page First iteration**



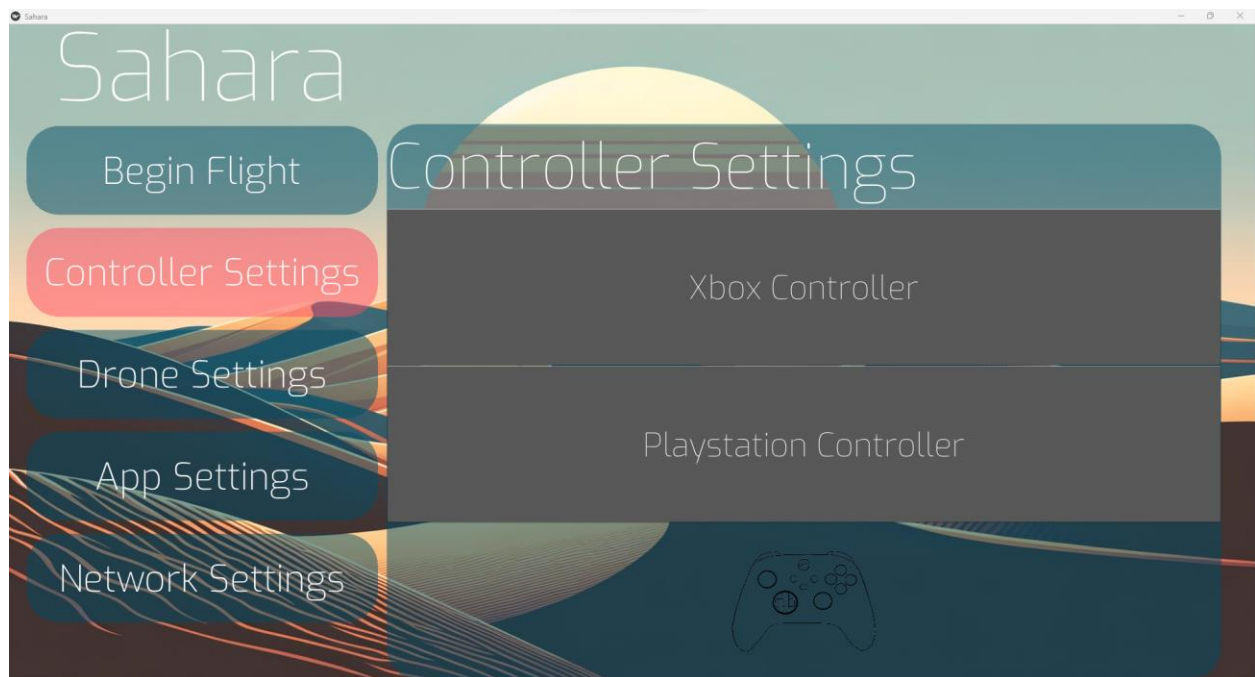
- **Main page Final iteration**



- **Network Settings**



- **Controller settings**



Appendix C - Sprint Review Reports

Sprint 1 & 2

Date: 11/6/2023

Attendees: Javier Cueto, Natalie Almonte, Angel Chavez

Start time: 2:30pm

End time: 2:45pm

Accepted Stories

- **As a drone operator, I want to be able to start and stop the drone flight easily, so I can control the drone's operation effectively.**
- **As a user, I need to configure controller settings, so that I can use various types of game controllers with the drone.**
- **As a drone operator, I want to adjust drone settings, to ensure the drone operates according to the requirements of different tasks.**
- **As a user, I need to be able to access and modify application settings, so I can customize the UI according to my preferences.**
- **As an operator, I need to configure network settings, to connect the drone to different networks and manage its online functionality.**
- **As a user, I want to receive real-time feedback from the controller, so I can monitor the input I am providing.**
- **As an operator, I need to see the current Wi-Fi SSID and IP address, so I can ensure the drone is connected to the correct network.**
- **As a user, I want to easily connect to the drone's server, to ensure a stable connection for controlling the drone.**
- **As a drone operator, I want an intuitive interface for controlling the drone, to reduce the learning curve and potential operational errors.**
- **As a user, I need the application to be responsive to different screen sizes, so I can use it on various devices.**

Backlogged Stories

1. **As a drone operator, I want a dashboard that displays real-time telemetry data (like altitude, speed, battery life), so I can monitor the drone's status during flight.**
2. **As a user, I need the ability to customize the control layout, so I can arrange the interface according to my personal preferences and ease of use.**

3. **As an operator, I want the UI to have a night mode, to reduce eye strain and enhance visibility in low-light conditions.**
4. **As a safety officer, I need clear visual and auditory alerts for critical warnings (like low battery, signal loss, proximity alerts), so I can promptly respond to potential hazards.**
5. **As a novice user, I would like an interactive tutorial or guided mode when I first use the application, to help me understand how to operate the drone effectively.**
6. **As an experienced operator, I want the ability to create and save custom flight profiles (like patrol routes, survey patterns), so I can quickly execute routine missions.**
7. **As a user, I need multi-language support in the UI, to ensure that operators of different linguistic backgrounds can use the application.**
8. **As a fleet manager, I want to be able to manage multiple drones from the same interface, to streamline the control process for a fleet of drones.**
9. **As a technician, I need easy access to diagnostic tools and logs within the UI, to troubleshoot and maintain the drone efficiently.**
10. **As a user, I want a responsive touch interface for tablet and smartphone control, to operate the drone remotely without needing a traditional PC setup.**

Appendix D – Documentation

Introduction - <https://youtu.be/b9mweUipHQU>

Demo Video - <https://youtu.be/HMH0d-CJGKk>

References

Kivy Course - Create Python Games and Mobile Apps

<https://www.youtube.com/watch?v=l8Imtec4ReQ&t=1284s>

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