4 Design

4.1 Design Context

4.1.1 Broader Context

Our broad context is to provide a platform for drone users to simulate flight patterns from a variety of routing and scheduling algorithms. By providing a frontend web application to users, simulation becomes a much easier process for customers of our project, with no downloads being required. Drone enthusiasts will be able to visualize different flight patterns for drones cutting down costs on real world testing, which can be expensive. In addition, they can estimate certain values such as min/max/avg service time when a fleet of drones is tasked with surveillance of an area of interest.

Area	**Description**	**Examples**
Public health, safety, and welfare	Customers- 1. By providing a virtual service that emulates how drones follow example flight patterns, we mitigate potential safety concerns when testing with physical drones. 2. Completely eliminating the need for actual drones and allowing virtual simulation negates the risk to physical property and people.	Customers- Fire Fighters (In terms of getting reports of how the fire is spreading.) Delivery and Pickup Drones
Global, cultural, and social	Some of our groups of interest include emergency personnel, agriculture companies, and geographical surveyors. These groups typically value robustness, reliability, and accuracy above all. Our project will reflect these aims by providing a platform which allows for faster testing of drones resulting in a fleet which is more reliable, accurate, and adaptable than one that had not used our system.	Testing algorithms to guide police personnel to critical areas. Testing algorithms to survey land efficiently.
Environmental	1. By reducing the need for use of physical drones while testing fight algorithms, we effectively reduce the carbon footprint the drones create. Tests can be run tens to hundreds of times requiring tons of power to run these drones and allow them to fly in the air. 2. While running the server for our web application will also take a significant amount of power, compared to flying drones, it saves energy in the long run. By saving test results with specific parameters, we reduce the time the server needs to be computing flight data	One can simulate a spreading of a disease in both urban/human settings as well as agricultural settings - and the project will help investigate surveillance approaches for efficient monitoring.

	and instead we can display previous runs containing the exact same parameters.	
Economic	Customers- 1. When providing a virtual service we completely eliminate the need for physical drones. This provides thousands of dollars in savings for the users of our application. Simulating different phenomena also allows users to better prepare their drones for different environments, making them more cost-effective and reliable.	Any profession in which a fleet of drones could assist in detecting, monitoring and responding to phenomena of interest.

4.1.2 Prior Work/Solutions

Previous Examples

The previous student led group's design document can be found [here](https://sdmay22-33.sd.ece.iastate.edu/docs/33FinalDesignDoc.pdf) (https://sdmay22-33.sd.ece.iastate.edu/docs/33FinalDesignDoc.pdf)

- [1] Emad Ebeid, Martin Skriver, Kristian Husum Terkildsen, Kjeld Jensen, and Ulrik Pagh Schultz. 2018. A survey of Open-Source UAV flight controllers and flight simulators. Microprocess. Microsystems 61 (2018), 11–20.
- [2] Z. Fu, Y. Mao, D. He, J. Yu, and G. Xie. 2019. Secure Multi-UAV Collaborative Task Allocation. IEEE Access 7 (2019), 35579–35587. https://doi.org/10.1109/ACCESS.2019.2902221
- [3] Hailong Huang and Andrey V. Savkin. 2018. Towards the Internet of Flying Robots: A Survey. Sensors (Basel, Switzerland) 18, 11 (19 Nov 2018), 4038. https://doi.org/10.3390/s18114038
- [4] Aakif Mairaj, Asif Iqbal Baba, and Ahmad Y. Javaid. 2019. Application specific drone simulators: Recent advances and challenges. Simul. Model. Pract. Theory 94 (2019), 100–117

Most of the simulators focus on examining the parameters of a single drone during service, or a fixed setting of collaboration among a fleet of drones. Our project aims to be more flexible/extensible in terms of combining not only multiple collaborative algorithms but also generation of (spatio-temporal) occurrences of phenomena of interest.

Pros of our Solution

- The main thing that our project will do differently from competitors is that it will be more accessible than other solutions.
- This application will be web based, so anybody with an internet connection will be able to access it.
- Previous solutions are custom built and do not offer similar accessibility.

Cons of our Solution

- The visualization will most likely not be as advanced as our competitors.
- To use our application you will have to adhere to our version of the input files.

4.1.3 Technical Complexity

From the technical side, our project has three components, backend, fronted and a database. We will also have an API, implemented through Spring Boot, which will allow the components to communicate with each other. The frontend will be a web client, and will communicate with our backend to store and retrieve information from the database as needed.

1. Backend: The backend will have to retrieve data from the database and be able to update the information within the database as needed. The backend will also be able to run the simulations and return a file with the simulation results to the frontend. The backend will also be used to implement user authentication.
2. Frontend: The frontend will have 3 main functionalities
    a. User Authentication: Login screen for the user, processed through the backend. Allows user to save personal simulations for a later use.
    b. Event Selection: Screen with input options for setting up the simulation.
        i. List of options for the algorithms
        ii. List of options for event phenomena
    c. Event Visualization: Screen with input options for viewing the simulation
        i. List of options for which simulation results to display
        ii. Visualizing drone flight
3. Database: Database will have different tables according to the information we need stored
    a. Users: Username and Password
    b. Simulations: Run files of previous simulations to reduce overhead on duplicate simulations.

Internal Complexity

1. Four interfaces between components
    a. Frontend to Backend: Providing User Data, Providing Event Conditions
    b. Backend to Frontend: Providing visualization file after simulation is run, sending notifications.
    c. Backend to Database: sending visualization files to be stored.
    d. Database to Backend: returning visualization files when requested.
2. Research of new technologies
    a. Many people within the team will need to learn technologies that they have never used before.

External Complexity

The goal of this project was to exceed the industry standards of drone simulation technology. Currently most drone simulation applications are custom made and this application is being developed to be more accessible to more people. This puts us on the forefront of new technologies within the field. This project will also have components of most industry projects such as, error handling, user authentication, notification system, optimization, Input/Output Processing, etc.

4.2 Design Exploration

4.2.1 Design Decisions

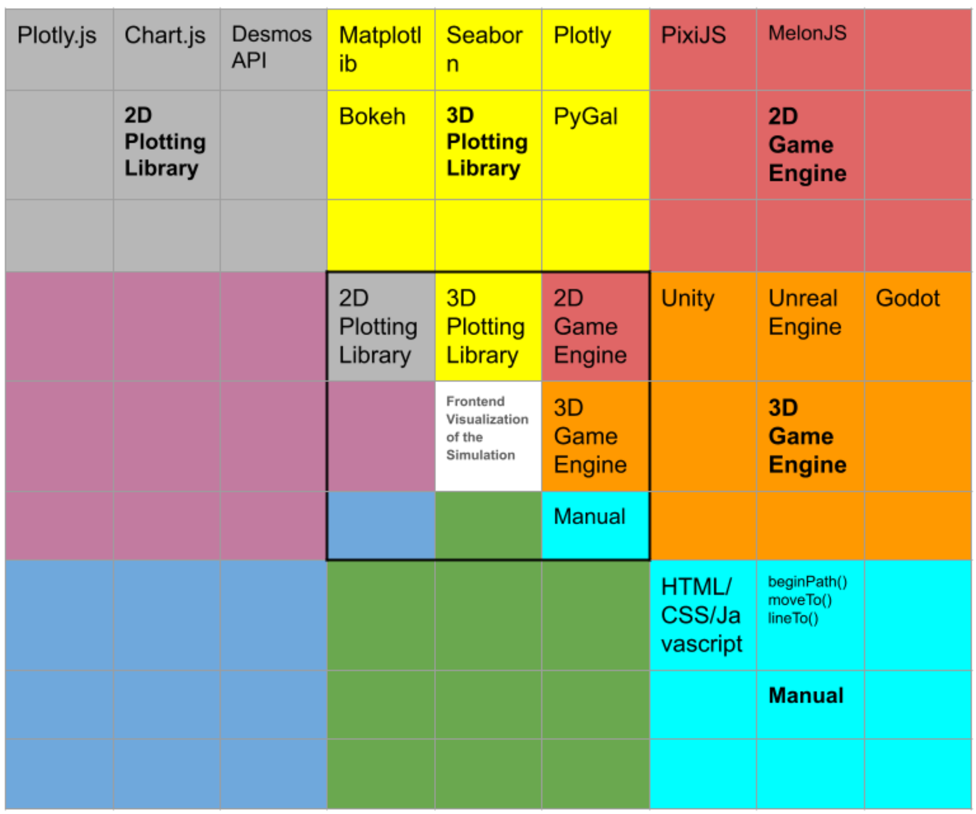
List key design decisions (at least three) that you have made or will need to make in relation to your proposed solution. These can include, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, features, etc. Describe why these decisions are important to project success.

Frontend		
Problem	**Description**	**Options**
User Interface	Determine which library or framework to use (if at all) for UI components of the application.	React Angular Plain HTML/CSS/JS
Simulation Visualization	Determine if a 2D Plotting Library is more effective for simulation visualization, and if so which.	Plotly.js Chart.js Desmos API None
	Determine if a 2D Game Engine is more effective for simulation visualization, and if so which.	PixiJS MelonJS None
Architecture Pattern(s)	Determine which design philosophies are most appropriate for the frontend.	MVC
Backend		
Framework; Client-Server Communication	Determine which language/framework for the server to use to communicate with the frontend.	Spring Boot (Java) Node.js (JavaScript) Flask (Python) Django (Python)
Architecture Pattern(s)	Determine which design philosophies are most appropriate for the backend.	MVC
Database		
Database Manager	Determine which type of database to use and which database manager.	MySQL Oracle MongoDB
Simulation File		
File Structure	Determine how data should be	Binary

	stored in a file.	JSON
File Transfer	Determine which protocols are necessary for file transfer.	HTTP Requests Socket.IO

4.2.2 Ideation

For at least one design decision, describe how you ideated or identified potential options (e.g., lotus blossom technique). Describe at least five options that you considered.



In order to decide how to implement the frontend visualization for the simulation, we debated many possible solutions for this problem. We began by identifying the problem at hand and started brainstorming possible solutions for the problem. Then we utilized previous parts of the design document to help develop a potential list of ideas. Using various resources such as the requirements or user needs we were able to develop a list of potential ways to solve the problem. Further research on the internet helped to expand our list of options and allowed us to settle on a final set of possible solutions.

After our research and brainstorming we landed on using a 2D plotting library, 3D plotting library, 2D game engine, 3D game engine, or to draw it manually. After having our overall approaches figured out we then did further research into each category for more specific approaches into our problem. This led us to a list of libraries or applications that can help accomplish our task and enabled us to further evaluate our choices. We then weighed these options against each other in the following section to help make our final decision.

4.2.3 Decision-Making and Trade-Off

Demonstrate the process you used to identify the pros and cons or trade-offs between each of your ideated options. You may wish you include a weighted decision matrix or other relevant tool. Describe the option you chose and why you chose it.

Options	Ease of Use	Experience	Platform Maturity	Performance	Total
Weight	30%	20%	20%	30%	100%
2D Plotting Library	4	3	3	3	3.3
3D Plotting Library	2	3	3	3	2.7
2D Game Engine	3	1	3	5	3.2
3D Game Engine	2	1	4	4	2.8
Manual	1	4	4	4	3.1
Final Decision	2D Plotting Library				