3 Design

Team: sdmay22-33

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3.1 Design Context

3.1.1 Broader Context

Our design is targeted to include the collaborative surveillance of an area by a set of drones. It will include reasoning about different types of collaboration as well as the tradeoffs between energy expenditure and drone lifetime and responsiveness. This design could be used in a variety of scenarios such as wildfire surveillance, crime monitoring, infrastructure inspection, crop analysis, etc.

Area	**Description**	**Examples**
Public health, safety, and welfare	**Improving surveillance capabilities can yield more effective emergency responses to various situations.**	**Locating survivors of natural disasters.** **Crime monitoring and alerting in Abu Dhabi** **https://www.newscientist.com/article/2284387-dubai-police-will-use-citywide-network-of-drones-to-respond-to-crime/**

Global, cultural, and social	**The project will not conflict with any particular ethnic or racial group.**	**To the contrary, infield experiments will be conducted under strict safety protocols, and the development of the system will not require interactions that will violate any sensitivity of societal groups.**
Environmental	**Our project aims to have only positive environmental impacts.**	**Can be used to improve crop analysis or wildfire management** **Traffic monitoring can improve management (in terms of orchestrating lamps and stops), thereby potentially decreasing the vehicular resources used.** **More efficient energy usage will cut down on power used to fuel our system as well**

Economic	**The project is expected to have positive economic impacts in both rural and urban settings.**	**Large scale field monitoring can improve yield of plants by assigning watering and pesticide spraying.** **Crime and traffic monitoring can help in more effective management of resources (e.g., police and firefighters), as well as other forms of emergency response.**

3.1.2 User Needs

Planners must be able to test the assignment of fixed drones versus floating drones. They must also reason about the size of the cells for the geographic regions to be assigned to a fixed drone. Planners need to investigate various operational scenarios through the simulation software. Lastly, they need to comply with safety regulations regarding the competent uses of the drones.

Domain experts need to provide suggestions to planners in terms of range parameters. An example of this could be agricultural experts specifying wider portions of fields because changes may not be as frequent in certain areas. Police officers could specify smaller regions to monitor during social events and rush hours. Domain experts must also provide details on the terrain and standard weather conditions of an area for optimal drone flight.

3.1.3 Prior Work/Solutions

There has been a lot of literature in the last decade about use of drones in various application domains [1,3]. In addition, there has been numerous research works addressing various aspects of effective coverage and energy use of drones [2].

However, to our knowledge there has been no system that can enable domain experts irrespective of their specific domain to have a flexible system that will:

1. Investigate different collaborative policies for a fleet of drones.
2. Verify the results with an actual set of drones (and vice versa).

3.1.4 Technical Complexity

The project design will include various algorithms that must be implemented into the simulation desktop application, such as determining flight paths, battery usage, range, etc.. The design will also include a user interface that must be flexible enough to provide the user the specification of several parameters of the target domain (e.g., the dimensions of the field to be monitored or a map of the city to be monitored, etc.) as well as a visualization of the outcome of the simulation analysis (e.g., graph with the energy expenditure, leftover battery life) in real time. The in field testing of the drones will have to be completed in a restricted environment to comply with safety regulations.

3.2 Design Exploration

3.2.1 Design Decisions

The design must consider financial constraints when selecting and purchasing the physical drones used for testing. We will determine the type of framework that will be used to store/visualize data. We will examine the extensibility/scalability of the solution (e.g., how easy it will be to add other algorithms and parameters to the design). Lastly, we will also consider what framework we must use for the communication between the desktop application and the server.

3.2.2 Ideation

Drones Purchasing Decision Parameters:

- **Average Flight Time/Battery Life -** Minimize time when a system is not available
  - How much energy it stores
  - How much time it takes to charge

- **Cost Per Drone -** Need to consider cost of the system in any situation
  - Ranging from 500 to 1000 dollar per drone

- **Camera quality** - Depending on the use, the camera may need to be a higher quality
  - HD/4K
  - Recording capability
  - Camera zoom capability
  - Camera maneuverability

- **Range** - Some applications of the simulation may take place over a large area
  - Max altitude capability
  - Max distance from controller

- **Durability/resistant to damage** - May be used in dangerous situations
  - Waterproofing for rain
  - Max height to fall without damage
  - Prevent signal interference

- **Accuracy of GPS data** - How accurately flight paths can be tracked
  - Average error from GPS location

- **Size and Weight** - Maneuverability, more ‘tight’ controls as well as storage
    - Wind resistant
    - Lightweight

- **Speed** - How fast its tasks will be done
    - Top speed

3.2.3 Decision-Making and Trade-Off

When we decide on a programming language to use, our main criterion will be the available packages/libraries for each language and how they could be used in the design. For the drones purchase, we will consider factors such as the average flight time and the maximum data transmission distance. For the development framework, we must consider data visualization and communication tools. These decisions have not yet been made at the time of writing.

3.3 Proposed Design

3.3.1 Design Visual and Description

Drones will be purchased and used for testing so that the database can store accurate information such as battery expenditure and flight time for the drone model we choose. A server will contain the database storing that information and will communicate with the desktop simulation to provide accurate data that a user can use to simulate a fleet of drones communicating with one another to optimally survey an area with consideration to drone battery expenditure. The system can be visualized in figure 1 below.

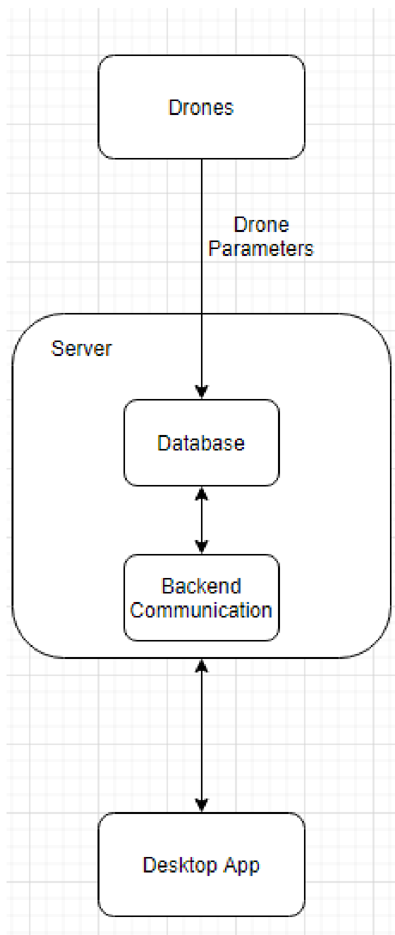

Figure 1:

Communications between drones, backend server, and desktop application

3.3.2 Functionality

Users of our design will be able to control the drones to move in specific and various ways, as well as verify the actual paths taken. For example, an agricultural expert could choose an optimal path for watering and pesticide application, as well as being able to compare real flight paths to the expected flight paths after completion. Our current design addresses these functional needs in a basic way, but needs more detail into how exactly flight paths will be tracked, as well as how large of a distance the drones will be able to cover.

3.3.3 Areas of Concern and Development

Our current concerns for the design include the scalability and validity of our solution. How easy will it be to add additional features and parameters to the solution to address more complex and diverse problems? How reliable will data verification be with only a small fleet of drones? To address these concerns, in the second semester we will proceed with agile development and try to devise multiple testing scenarios. This will allow us to efficiently and effectively deal with these concerns as they arise.

NOTE: The following sections will be included in your final design document but do not need to be completed for the current assignment. They are included for your reference. If you have ideas for these sections, they can also be discussed with your TA and/or faculty adviser.

3.4 Technology Considerations

Highlight the strengths, weakness, and trade-offs made in technology available.

Discuss possible solutions and design alternatives

3.5 Design Analysis

- Did your proposed design from 3.3 work? Why or why not?
- What are your observations, thoughts, and ideas to modify or iterate over the design?

3.6 Design Plan

Describe a design plan with respect to use-cases within the context of requirements, modules in your design (dependency/concurrency of modules through a module diagram, interfaces, architectural overview), module constraints tied to requirements.

References

[1] Small Flying Drones: Applications for Geographic Observation

[2] https://www.mdpi.com/2504-446X/3/1/4

[3] Science, technology and the future of small autonomous drones