Problem Statement and Goals: Mechatronics Engineering

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Table 1: Revision History

Date	**Developer(s)**	**Change**
24-09-2022	Ali and Zaid	Initial Revision
26-09-2022	Winnie and Fady	Edits
...	...	...

1 Problem Statement

1.1 Problem Description

The struggle of finding a parking spot in a busy parking lot is an issue that many visitors and organizers face. The hassle of finding a parking spot results in a loss of time for the visitors, a wastage of vehicle energy, and causes frustration for visitors. All of these issues result in lost revenue and/or productivity for all stakeholders, visitors and organizers. Parking lot sizes often cannot be increased without planning and investment. Given that the number of parking spots is often a constraint, utilizing the existing parking spaces efficiently is critical to minimizing the negative impacts of this issue.

Existing solutions sometimes involve a designated person, a parking lot officer, who helps to communicate parking spot availability to visitors. Of course, the primary drawback is that the operator being a person often cannot see or monitor large swaths of the parking lot accurately. Other solutions involve installing vehicle counters in the parking lot. These vehicle counters are installed either at the entrance/exits or throughout the parking lot, such as a distributed system of cameras. These solutions are expensive and involve installations at precise locations, and thus require greater investment for organizers. Vehicle counter technology thus does not fulfill the need for many outdoor, seasonal, temporary, and/or cheaper organizers. Examples include provincial/national parks, concerts, and religious places of worship where the highest demand for this solution is only for a certain period of time.

1.2 Project Description

ParkingLotHawk is an aerial drone that will fly above the parking lot to gather information about slot availability and general parking lot status. The parking lot authorities will be able to access and visualize this information from an application on their Personal Computers (PCs). The parking lot authorities will command the ParkingLotHawk only through an application running on their PC. From the PC application, the operator will be able to launch the drone, move the drone to a specific location, or land the drone. When given a location to investigate, the drone will autonomously fly toward the location without the Operator's input. During flight, the operator will receive a live video feed from the drone's camera, as well as other valuable parking lot information.

1.3 Environment

The only technology available in the typical environment is the Operator's Computer. Mobile and internet data may or may not be available in the parking lot, thus to use internet for communication requires cannot be used for communication. The environment also contains a parking lot to investigate.

1.4 Inputs and Outputs

The inputs to the product include a parking lot to explore and user commands (launch, move to a location, and land).

At the minimum, the solution should output a live video stream of what the solution is currently investigating. This type of information is extremely intuitive to operators, conveys where the solution is currently, and can give them confidence that the solution is not crashing/malfunctioning.

Other helpful but optional outputs include the location of available parking lots and a past trace of the drone's location labeled with whether they were occupied or unoccupied.

1.5 Stakeholders

The primary stakeholder is Parking Lot Monitors, this may be a parking lot officer, a designated security guard, or any other members part of the organizer's team. They will be utilizing the solution to attain as much accurate and useful data about the status of their parking lot.

Furthermore, organizers who will purchase the solution would like it to be cost-effective, but still useful for their use cases.

Visitors who will be parking in the parking lot are also stakeholders. The visitors would like to not be disturbed by the solution while they are driving. Furthermore, visitors may have privacy concerns and must be assured that any solution is not recording them.

2 Goals

Refer to Table 2 that determine the minimum viable products for the given problem.

Table 2: Goals for ParkingLotHawk

Goal	Importance
Ease of Use: Parking lot operators should not require technical knowledge or extensive training to operate the device.	The operator will likely be an hourly employee who changes frequently. They may have other duties and minimal technical education. Thus a good solution must be easy to use and easy to learn.
Cost-effective: Something durable enough to survive crashes. Cheap and simple to build.	Organizers would like the solution to be cost-effective so that their budget can be spent elsewhere. Furthermore, in case the solution is damaged, they would like to be able to purchase the product again. Simplicity ensures that a new solution can be quickly built-in case of permanent damage.
Safe for visitors. Ideally, the drivers should not be aware of the solution's operation. The drivers should not be affected during driving. Visitors should not be recorded. The drone should not touch or damage the property of visitors.	To ensure safety, Visitors should focus all their attention on the parking lot. They should not have to adjust their driving due to the solution. Furthermore, the solution should not record the visitors, so that their privacy is not compromised.
Speed: the drone should launch, move and land quickly. When the operator sends the command to launch the solution, the solution should start giving information as quickly as possible.	Operators will usually launch the solution during busy times. Thus they would like to be able to receive as much data as quickly as possible to resolve the congestion. There should therefore be a small launch and move time. They also want to be able to land quickly, so that the operator can collect the drone to proceed back to their other duties.
Little to no blind spots: There is a minimal section of the parking lot that the solution cannot visualize or display information about.	The Operator ideally should not be constrained in which parts of the parking lot they can and cannot know about. During busy times, every parking spot is important.
Valuable data is gathered and received quickly and efficiently: Ability to visualize and gather information on multiple parking spots in real-time. When the boundary of the parking lot is detected, the drone does not investigate outside of the parking lot.	The state of the parking lot changes quickly, as vehicles enter and leave, therefore the ability to learn about the latest state of significant chunks of the parking lot as quickly as possible is beneficial. Therefore the ability to monitor multiple spots is important. However, exploring beyond the parking lot boundary will not yield valuable data. Therefore the solution should be smart enough such that it does not exit or explore beyond the parking lot boundaries.

3 Stretch Goals

Stretch Goals are listed in Table 3.

Table 3: Stretch Goals for ParkingLotHawk

Goal	Importance
Weatherproof: Ability to operate in rainy, snowy, and other extreme weather scenarios.	These situations are common in Canada and are often the times when the operator would like to avoid going outside.
Ability to land at multiple points in and around the parking lot.	The operator will be able to start and stop the drone at multiple places, rather than having to always launch and land the solution at the same spot.
Create a occupancy map of occupied/unoccupied spots in the parking lot.	If the solution was able to create and maintain a live occupancy map, the operator would not have to keep track/remember of the occupancy themselves. The operator's understanding of the parking lot may be subject to human error or be very limited as they may have other tasks to focus on rather than observing the solution for long periods of time.
Highlight available parking spots in the parking lot.	If the solution was able to create and maintain a live parking spot map, the operator would not have to keep track of the parking spots themselves. They could also use this information to tell visitors where to go to park their cars.
Offer an autonomous mode that explore the parking lot without the operator manually having to choose the next location to explore.	An autonomous mode would help the operator quickly explore the parking lot, and make the drone more usable for the operator as the operator does not have to manually choose the next explore location.
Convey if there is a traffic jam or an extremely busy area.	This can help the operator prevent accidents and/or conflict between the visitors. The operator may also have been given specific instructions from the organizers to resolve such jams.