Multi-Package UAV Delivery System

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Abstract

For a few years now, delivery companies have been developing a variety of package-delivery systems using drones. Such technologies will most likely be integrated and implemented into fully functioning autonomous Unmanned Aerial Systems (UAS) in the near future. However, the lack of studies on the effect of such a delivery system on the current National Airspace (NAS) traffic is unstudied. Moreover, storage and performance requirements to implement a fully autonomous delivery system have not yet been quantified. In this project we implemented a test bench to that uses terrain, building, and population data to build an environment in which a package delivery scenario may be run using quadcopters. We showed that how number of vehicle per warehouse, how soon the warehouse guarantee the package to be delivered, and on board storage required to run the system.

Figure 1: Amazon Prime Air Vehicle

Introduction

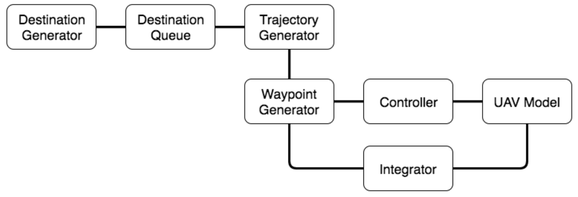
With growing interest to improve efficiency of package delivery, some companies, such as Amazon, Walmart, and Google, are strongly considering the use of Unmanned Aerial Systems (UAS) as carriers for the packages. In terms of the National Airspace (NAS), the traffic this would induce has been mostly unstudied. The Federal Aviation Administration (FAA) wants to regulate the air traffic in the NAS in the interest of the people. The companies trying to implement this delivery service want to maximize throughput while meeting time constraints. We propose a solution that meets the requirements of both the FAA and prospective companies using a multiple package per vehicle delivery scheme.

Approach

- Data Collection - In order to simulate a more realistic simulation environment we collected terrain, population, Walmart, and K-12 schools from San Jose. The data was provided from the United States Geological Survey (USGS), United States Census Bureau, Walmart.com, and Schooldigger.com, respectively.
- Initial Framework - The structure of the simulation focused around which warehouses were chosen to have a delivery fleet.
- Single Package Delivery - UAS vehicles reponded to one one request traversing to the destination and following the same path back to the warehouse.
- Multiple Package Delivery - UAS vehicles carrying multiple packages optimize which destinations to delivery to based on proximity to the first destination.

System Model

Upon a package request, the location of who placed the order is added to a queue. The queue is read whenever there is an available vehicle at the warehouse. Trajectories are then built from the warehouse to the destination, from the first destination to the second, and back to the warehouse. Once assigned a trajectory, the vehicle follows the reference points along the trajectory until returning to the warehouse to recharge. When in transit to the destination, the trajectory will keep the vehicle awway from the no-fly-zones defined around airports and above schools.



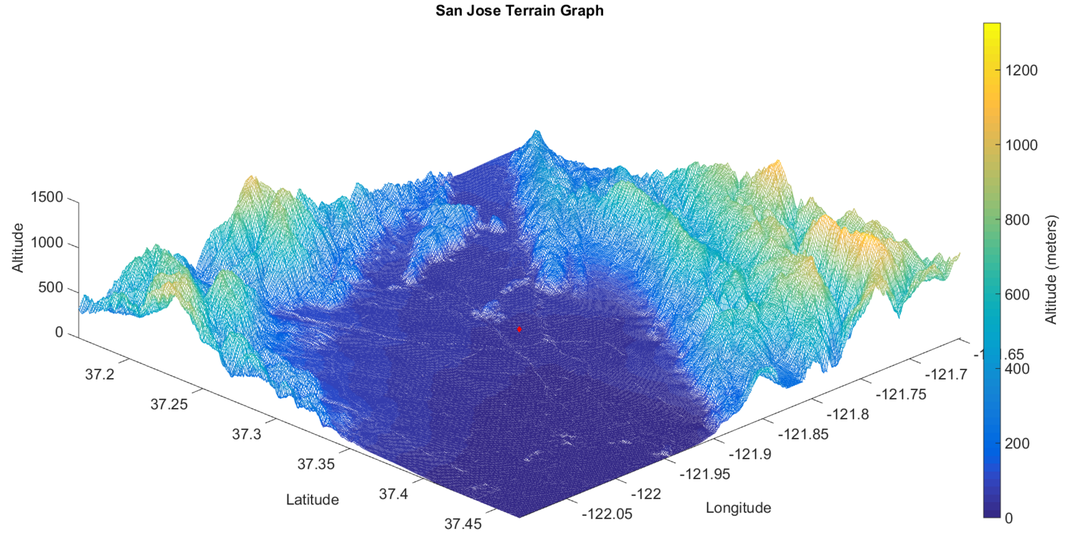


Figure 2: Figure caption

Results

For both 8 and 4 hours of simulated delivey time, the multiple package delivery scheme out performed the single package delivery scheme in overall performace and cost for the delivery service.

Table 1: My caption

	Simulation Time	Average Distance Traveled	Total N
One-Package	8 Hours	120 Km	121
	4 Hours		
Two-Packages	8 Hours		
	4 Hours		

By showing that more packages can be delivered when multiple packages are transported by one vehicle we prove that it woud be more cost efficient for a warehouse to invest in vehicles with larger payload capacity. Our simulations also shows that by using the right logic for which packages are assigned to which vehicle, we can ensure that deliveries are made within the time constraint set by the warehouse. We have proved our delivery concept as a success since we can deliver more packages in the same amount of time using the same number of vehicles while reducing the average distance each vehicle has to traverse.

Figure 3: Figure caption

Conclusion

Based off the simulations performed in the framework for multiple package delivery service using UAS vehicles, we have defined a functioning set of requirements in order to implement such a system.

References

[1]

[2]

[3] A. B. Dacidson Helen and J. M. Smith.