Autonomous Landing of a UAV: First Report

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Abstract

One crucial aspect of autonomous flight is a safe landing, especially in cross winds. During this project, I will investigate how a Lidar system (a range laser) can be used to assist the flight of a commercial drone. The overall aim is to design a low-cost control system which allows for safe autonomous landing of the drone.

1. Background

LIght Detection And Ranging systems (aka Lidar) have first successfully been used in the 1970's for submarine detection from an aircraft. However, airborne applications have been kept pretty much at a minimum up until the recent past, due to high costs. It wasn't until cheap commercial drones have become more ubiquitous, that the Lidar has been explored further (applications include, Agriculture, Environmental conservation, obstacle avoidance, for instance). In 2015, USD 300million have been spent on drones that use Lidar. The Lidar market is expected to rise to over $ 1 billion by 2020; that is an increase of 20% each year.[1]
A safe landing is an important part that surrounds flying a drone, whatever the application. With Lidar technology becoming cheaper and more ubiquitous, this project will be a nice opportunity to research how it can assist the landing process.

2. Defining the problem

Some parts that surround the landing of a vehicle are

- selecting the landing zone
- whether to land vertically or not
- at what speed to descent
  and others...

The landing process I have in mind looks a little like this:
First the drone decelerates until it is stationary and elevates or descent to a specific height above the ground (the ground will be horizontal and static). Next, it starts descending vertically. Initially a little faster, and gradually slower as it approaches the ground.

3. Approach

The idea is to purchase a commercial drone and a Lidar system and use them to construct the desired control system. Here is a very rough breakdown of the steps I will expect:

1. Assemble the drone
   The objective here is to minimize the weight for the drone to easily be able to support the weight of the Lidar and possibly other sensors and gadgets in the future.
2. Interface it with the Lidar
3. Design the control system
   initially in an environment without cross winds
4. Extent control system
   ie. test it in a regular environment ***with*** *cross winds*
5. Explore further possibilities in which the Lidar can assist flight (if time permits)

With regards to the latter point, possible extensions are to

- add a validation system which lets the drone decide whether a specific location is suitable to land on
- reinforce the stabilization of the drone in wind
- land on non-horizontal surfaces

4. Testing

The 3rd and 4th point on the previous section will be a loop between testing and designing. However, flying a drone is subject to regulations as it imposes a safety hazard. The Civil Aviation Authority has set the following rules:[2]

- Drone must be within eye-sight
- It mustn't endanger any person or property through negligence or recklessness of the pilot
- Not be flown within 150 metres of a congested area or 50 metres of another vehicle

In addition, drones have been banned from all Royal Park with the exception of Hampstead Heath.[3]
Conclusion: As long as I a behave within the regulation, I will be able to use Hampstead Heath as a testing site.

The most important component in this project is the Lidar system. Therefore the next part of the report I will give a brief description of a typical system..

5. LIDAR

A typical Lidar system has the following main components:

- Lasers
- Photodetector / Receiver
- GPS receiver
- inertial meausrement unit (IMU)
- Computer/Data storage device

The system exerts pulses of light into its surrounding, measures the time it takes until the reflection of the laser is detected and then evaluates the distance using:

$$Distance = SpeedofLight * \frac{TimeofFlight}{2} \quad (1)$$

The rate at which the system exerts laser pulses is between 20,000 and 150,000 per second[4] The system can then build a map of its surroundings where each reflection is one point in space. Figure 1 shows what a typical map looks like. The colours serve as a contour map, telling you how far away the respective obstacle is.
The laser itself is categorised by its wavelength. Lidar typically use lasers that are in the near-infrared region of the sepctrum (ie. around 1000 nanometers), as these are particularly useful for terresstial mapping. The problem is that light in this region can easily be absorbed by our eyes.[5] Therefore, to make the system "eye-safe", the power at which it operate must be limited. This comes at a cost of range. For perspective, the Lidar lite V3, a popular commercially avaiable Lidar system uses lasers of wavelength 905nm, operates at 1.3 watts and has a range of 40 meters.[6] The photodetector, as the name suggests, is responsible for detecting the signals that are being reflected to the system. Generally, the higher the frequency, the better the resolution that can be achieved. Finally, the position and orientation of the system will change slightly in the time that a laser is emitted and received. To account for this, the system uses GPS to obtain geographcial data, and an IMU to obtain its orientation. With this information, the location from which the laser pulse has been reflected, can be accurately calculated.

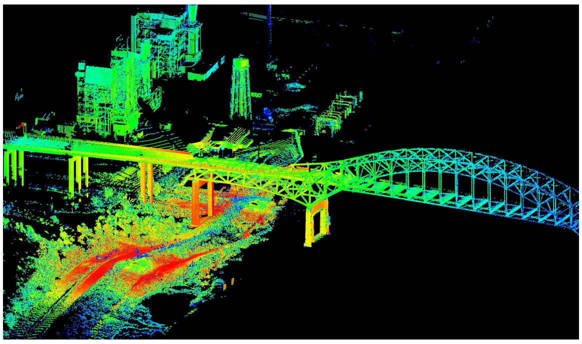


Figure 1:

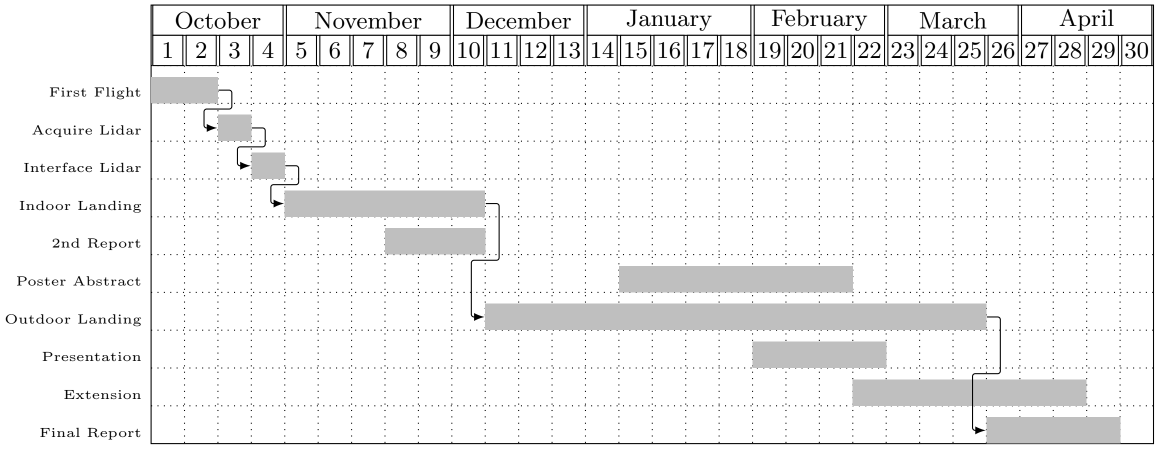
6. Declaration

'I, Sergio Azizi, confirm that the work presented in this report is my own. Where information has been derived from other sources, I confirm that this has been indicated in the report'.

7. bibliography

[1] https://www.dronezon.com/learn-about-drones-quadcopters/uav-lidar-applications-services-technology-systems/
[2] http://www.techweekeurope.co.uk/e-regulation/fly-drones-london-158901
[3] http://www.camdennewjournal.com/dronesban
[4] http://www.lidar-uk.com/what-is-lidar/
[5] https://en.wikipedia.org/wiki/Laser-safety
[6] http://www.robotshop.com/uk/lidar-lite-3-laser-rangefinder.html

Progress so far...



Currrently, I am at the first stage "First Flight". On page 1, in the *approach* section I stated that minimizing weight in one objective for this first stage. Therefore I decided to, instead of buying a ready drone, purchase each part seperately (frame, flight controller, motors, speed controllers, and others) and assemble a custom made one.
Next, I reproduced the frame in Catia. Below is a snapshot of what the drone looks like at this moment.
The flight controller is a printed circuit board that takes in information from onboard sensors. I have chosen one which is programmable within the Arduino Environment.
So far I haven't been able to do the configuration yet, which is necessary in order to finish the assembly and start flying the drone. To do this I first need to bind my transmitter and receiver. I suspect the latter has a defect, so before I can proceed, first I need to wait for the replacement receiver to arrive. As seen in the Gantt chart, I am planning to finish this step by mid-October.
My current target is to have a landing system which works indoors in the absence of cross winds, before the second report is due in the first week of december.