Laboratory 2 for ABE 424

Total points: 100

In this laboratory, we will collect data from a UAS and process it in a field setting. The learning outcomes are:

1. Understand and learn to operate a commercial off the shelf Unmanned Aerial Vehicle (Drone)
2. Understand the limitations and physical characteristics of a UAS
3. Differentiate between a fixed wing and a rotary wing UAS
4. Understand the history of quadrotor UAS
5. Learn how to plan waypoint missions using Google Earth and other commercially available mapping tools
6. Learn how to use the apps provided by the manufacture or third party to execute waypoint missions
7. Collect imagery using drones
8. Process imagery and present a report
9. Understand and learn to operate a ground robot
10. Understand sensing systems on the ground robot
11. Learn how to use the ground robot system for autonomous navigation

Data for the lab: https://uofi.box.com/s/am0x4c5sllsyv0sabnujlebvunvzrjvk

Questions for the lab report and points:

Q1: Differentiate between a fixed wing and rotorcraft UAS indicating their weaknesses and strengths. What are some commercially available examples? What applications can you think of these different UAS. (5 points)

Q2: Draw a trade-off diagram indicating the choice of the UAS based on mission endurance, mission range, payload capacity, and mission altitude (5 points)

Q3: What is FAA Part 107? Why is knowing this important? What is a remote pilot in command? (5 points)

Q4: What are waypoints? What apps are available for programming waypoint missions on the DJI drone? How does one program waypoint missions? (5 points)

Q5: In which airspace the South quad in the University of Illinois- Urbana Champaign located? What is the protocol to fly in that airspace? Who needs to be informed of for any UAV activity? (5 points)

Q6: How can Unmanned Aerial Vehicles be used for precision Agriculture and improve crop yield? (10 points)

Q7: What is the difference between Ackermann steering and skid-to-turn steering. What are the benefits and disadvantages of one vs the other? (10 points)

Q8: Why did the ground robot use GPS for navigation? Why couldn't it just use LiDAR? (10 points)

Q9: The figure below shows a slice of field with a rectangular grid path. The squares show the footprint of the camera on two side by side passes. Not all camera footprints are shown. Note the overlap and sidelap variables denoted there.

The UAS is expected to be able to fly for 25 minutes, with 5 minutes reserved for take-off and landing maneuvers. The UAS speed is 5 m/s in cruise flight for the remaining 20 minutes of active data gathering time of the UAS. The UAS is equipped with a camera with the following parameters:

CMOS sensor width: 13.2 mm
CMOS sensor height: 8.8 mm

Image Pixel Width = 5472 px
Image Pixel Height = 3648 px

Focal Length = 8.8 mm

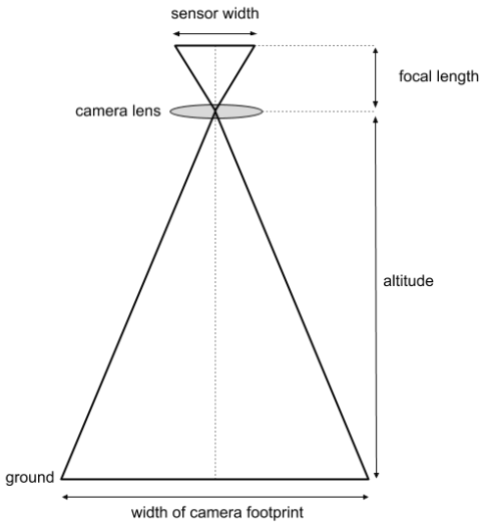
The equation for determining the camera footprint and resolution is:

$$Pixel\ Resolution(cm/px) = \frac{Senor\ Width(mm)x\ Altitude(m)x100}{Focal\ Length(mm)x\ Image\ Pixel\ Width(px)}$$

$$Pixel\ Resolution(cm/px) = \frac{Senor\ Height(mm)x\ Altitude(m)x100}{Focal\ Length(mm)x\ Image\ Pixel\ Height(px)}$$

$$Camera\ Footprint\ Width(cm) = Pixel\ Resolution(cm/px) * Image\ Pixel\ Width(px)$$

$$Camera\ Footprint\ Height(cm) = Pixel\ Resolution(cm/px) * Image\ Pixel\ Height(px)$$

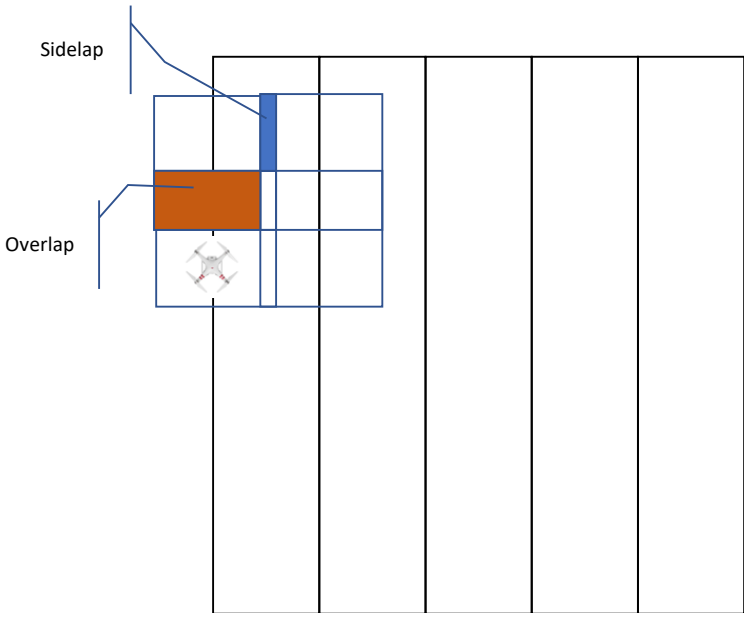


Q9.1. What are the (4 different) altitudes that the UAS needs to fly to achieve the followings desired pixel resolutions 0.69 cm/px, 1.37 cm/px, 2.06 cm/px, 2.74cm/px?

Note: You may end up with 8 altitudes due to the unsymmetrical sensor profile, in that case, pick the higher one. (10 points)

Q9.2. A UAS is used to collect data in a rectangular field of dimensions 200 m x 400 m.

Write a script to find the maximum sidelap to complete the data gathering mission in the 20 minutes of active data gathering time at 5 m/s velocity while maintaining the desired pixel resolutions listing in Q9.1 and maintain the overlap at 50%(15 points)



Q10: Imagery data was collected using the UAS mentioned in Q9.

Q10.1 Write a script to extract the meta data of the images collected. Your script should report the following details from each image (10 points)

a. Latitude
b. Longitude
c. Altitude

Q10.2 Write a script to generate a file listing the waypoints in the order that UAV that flew from the metadata of the images collected. (10 points)

Bonus Question:
Q10.3 Write a report with processed data presenting any field anomalies you found using the data. The report should present a tiled or a stitched image of the field and indicate anomalies on the field that you found. What are some of the challenges in dealing with the data that you faced? If you think the data you are presented with is not sufficient, please include the data you think is necessary to generate the Tiled/Stitched image (15 points)