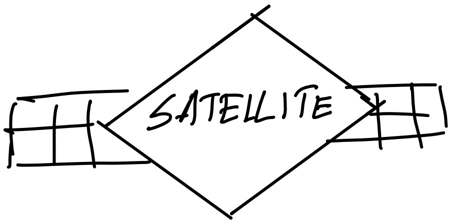
1(A)

LIDAR

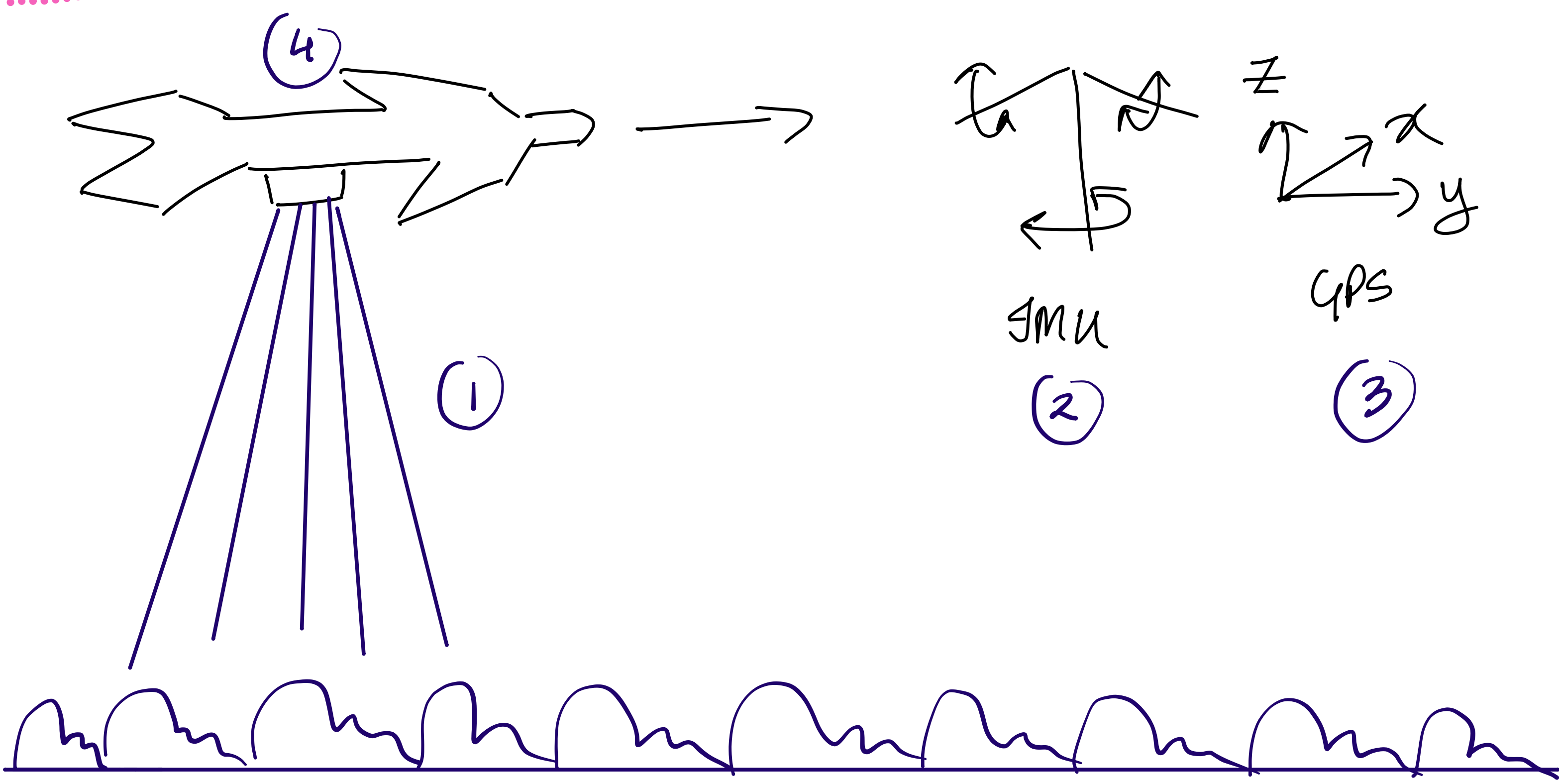
Light Detection and Ranging

3 types: of Data collection

1) From space
2) From Ground
3) From air



Data collection Process:

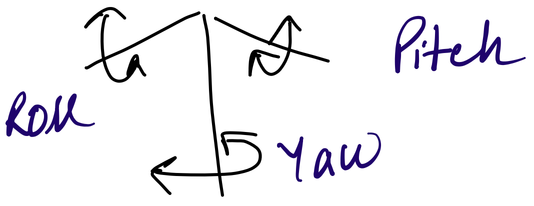


4 components of a LIDAR system:

1. The LIDAR unit within the aircraft sends LASERS and receives it as well. LASERS are sent in the green light and IR range as they reflect back strongly. It also records the angle at

which the laser left and use this data along with the time recorded for the laser taken to reflect.

(2) Inertial Measurement Unit (IMU):

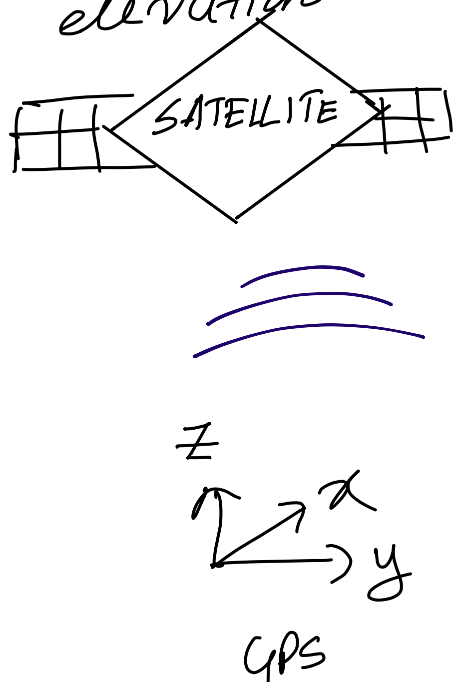


IMU

These are recorded at the IMU. These account for the turbulence in the air in various directions and these changes are recorded during data collection.

(3) GPS (Global Positioning System):

This is a necessary component as it gives a precise location of the aircraft and also the altitude data is available from such co-ordinates which is necessary in ground elevation calculation.



④ Computer :

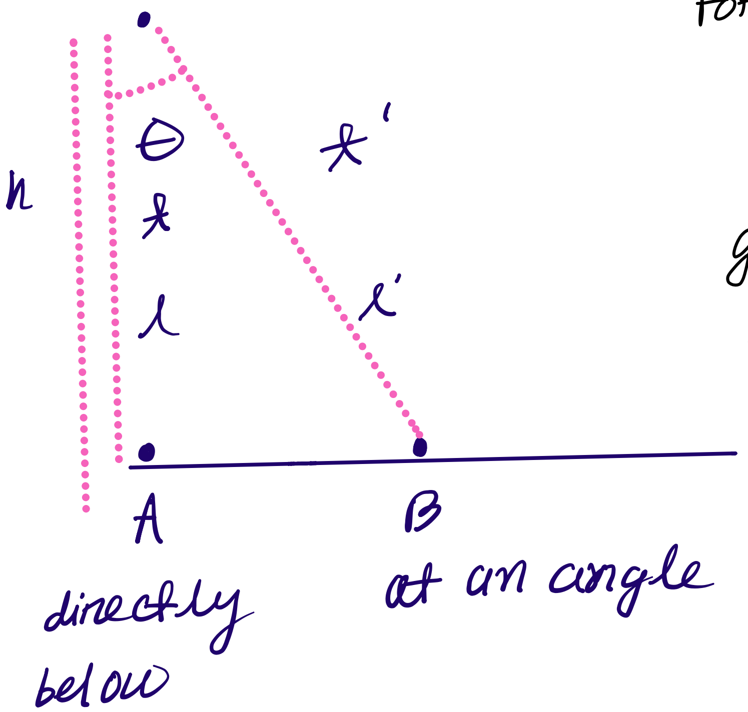
The time required to return, (t)

The angle at which light left, (θ)

The IMU data of turbulent movement. (R, P, Y)

The GPS co-ordinates (X, Y, Z) ⟶ (attitude) (l)

Ground elevation :



for A ⇒

$$l = \left(\frac{c \times t}{2}\right)$$

ground elevation

$$\Rightarrow h - l \Rightarrow h - \left(\frac{c \times t}{2}\right)$$

for B ⇒

$$l' = \left(\frac{c \times t'}{2}\right)$$

⇒ angle adjustment

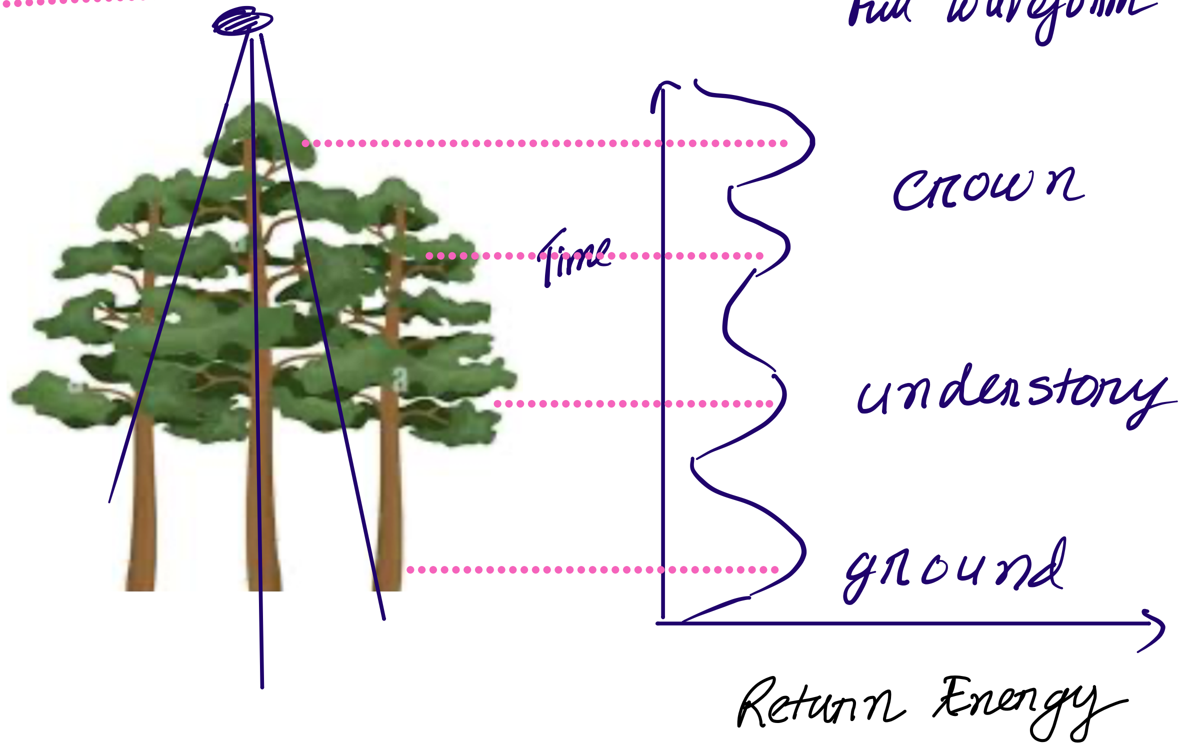
$$l'' = l' \sin\theta$$

ground elevation

$$\Rightarrow h - l' \sin\theta$$

$$\Rightarrow h - \left(\frac{c t'}{2}\right) \sin\theta$$

Layer Detection:



As light passes through various sections of the layers, its intensity changes and layers are detected.

IMU:

Inertial Measurement Unit

Typically with 3 components -> sensors

1) Accelerometer - 3 axis
2) Gyroscope - 3 axis
3) Magnetometer - 3 axis

$\left.\right\}$ 9 axis

The information from these sensors are combined using sensor fusion algorithm to obtain useful data.

Accelerometer:

Provides precise acceleration measurements sums up three-axis acceleration

Gyroscope:

Measures rotation (3D)

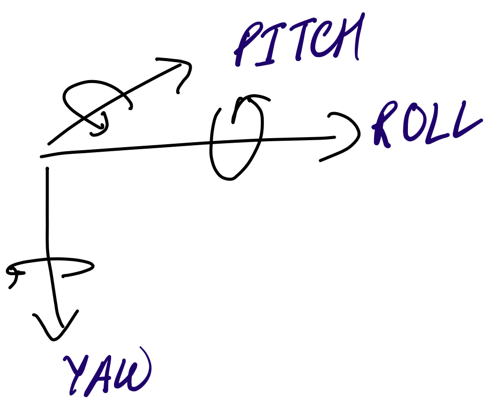
Magnetometer:

Basically compass, detects local and global magnetic fields (3D)

Sensor Fusion:

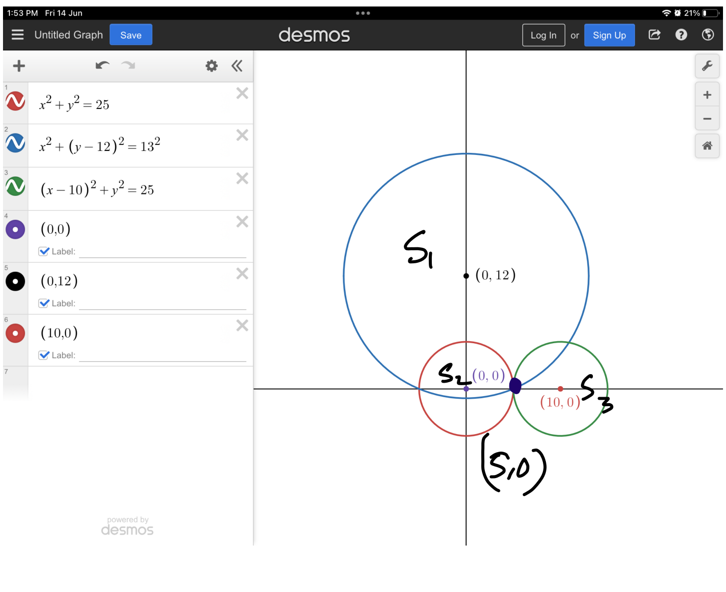
Example: Attitude Heading Reference System (AHRS)

Combines sensor data to calculate pitch, roll, Heading (Yaw)



These are complex algorithms designed to obtain data for Pitch, Roll, Heading from the accelerometer, gyroscope and magnetometer.

GPS:
Global Positioning System
It uses a method called trilateration.



Suppose that the object is in the marked region of the graph (5,0)
And 3 satellites are at $S_1(0,12)$, $S_2(0,0)$, $S_3(10,0)$ and distance from the satellites are 13, 5, 5 respectively.
The distances were measured by sending microwave signals and receiving them measuring the time taken, $r_1 = \frac{ct_1}{2}$, $r_2 = \frac{ct_2}{2}$, $r_3 = \frac{ct_3}{2}$
From the position of the satellite and the distance between them and the object, we get three equations of circle, by solving we get the co-ordinates of that object.

This is a 2D generalization; in reality we get a sphere when distance between 2 points are known, hence 3 satellites produce two points and another satellite is needed to know the exact location.

These satellites revolve the earth two times a day and continuosly interacts with a GPS receiver.

<u>5 main GPS uses:</u>

1) Location
2) Navigation
3) Tracking
4) Mapping
5) Timing

Odometry:

Odometry is a very useful tool. It provides the absolute position of your robot's tracking center in 2D space. The location of the tracking center is dictated by the placement of your tracking wheels. This means that you can account for error that is created during movement. If one of the movements of your bot is off, the next movement will correct for that, as long as you tell your bot to move to absolute positions on the field.

That being said there are some limitations. Odometry can often drift, which can lead to small error that builds up over time. Teams often solve this problem by aligning their robot against a wall, and then resetting the robot's position in the odometry.

Your robot needs some way to track its position. This can be achieved in multiple ways. The main things you need are:

- a way to track the robot's movement forwards and backwards
- a way to track the robot's movement side to side
- a way to track the robot's rotation

Odometry is the compound change in position of the robot over time. Essentially, the final position can be calculated as the sum of all of the movements up to that point. The move often the change in position is calculated, the more accurate the position is.

Besides this, there are some complicated math involved to calculate rotation of the robot which I intend not to get into.

B.

I will be inclined to use wheel odometry and IMU for the following reasons:

1. As the terrain is unknown, I would need to track the movement of the rover from its internal sensors as used in wheel odometry and IMU sensors (magnetometer, gyroscope, accelerometer).
2. We cannot use GPS efficiently in a Mars Rover due to the lack of a global magnetic field of Mars, we can only use the magnetometer on the surface detecting the local magnetic field to know which direction we are headed calculating the 'roll' data from the fusion of sensor data from the IMU receivers/sensors.
3. To know the position of our rover we would need live changes in our direction using the accelerometer and adjusting for any shocks/obstacles faced on the journey by using the gyroscope than GPS which is used conventionally and an IMU implements various fusion algorithms to procure these data.
4. Therefore due to being independent i.e not needing an external satellite which is not feasible in this situation, wheel odometry and IMU are to be used together to track our rover in the upcoming European Rover Challenge.

I will use LIDAR along with IMU to obtain terrain data as I have only LIDAR technology at my disposal for data collection of the terrain.

Problems may arise when the magnetometer may start accumulating changes and lose track and same for the tracker wheel of the wheel odometry system.

Apart from this, this combination is the ideal choice for the upcoming European Rover Challenge.