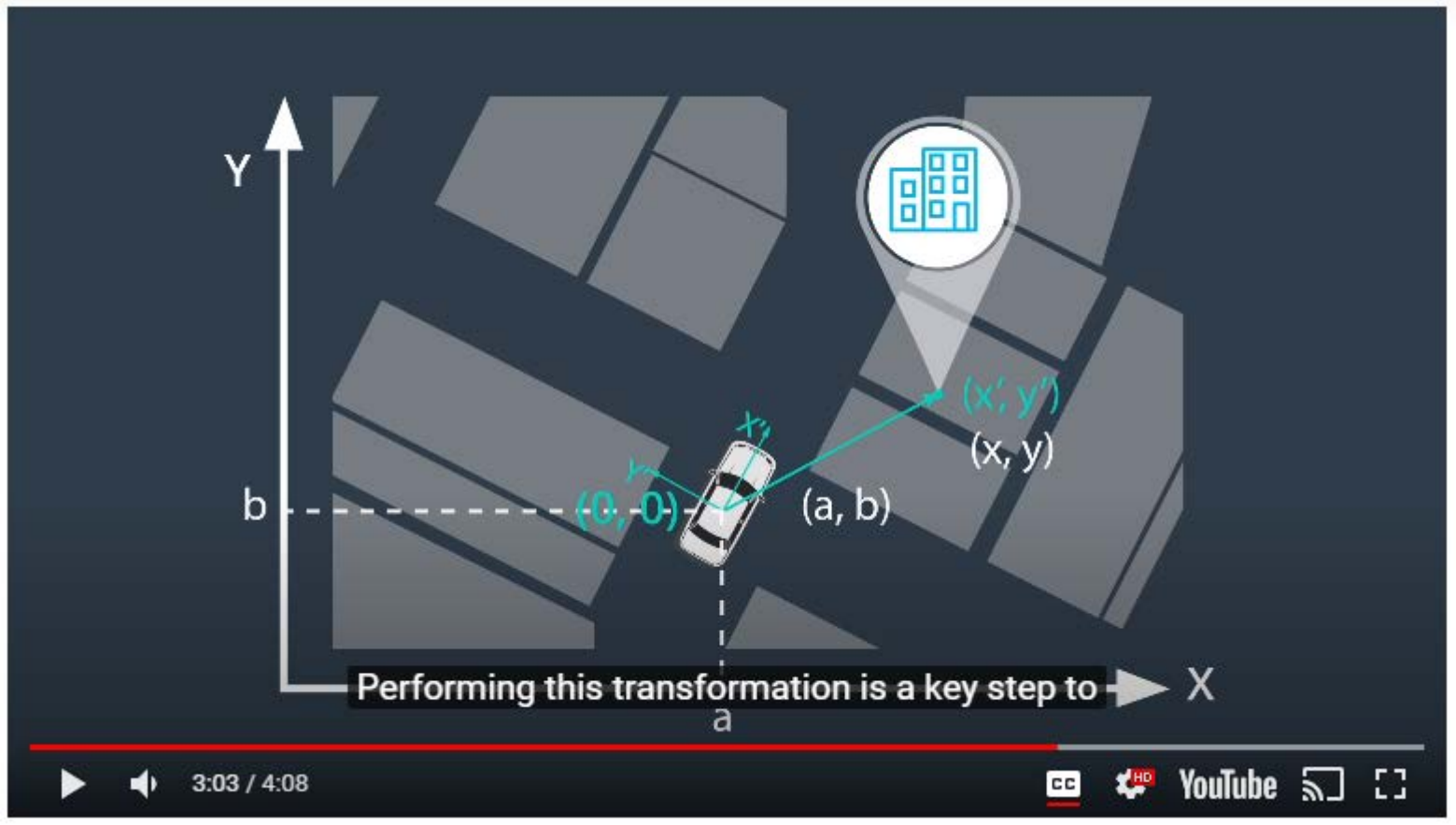
Intro to Localization

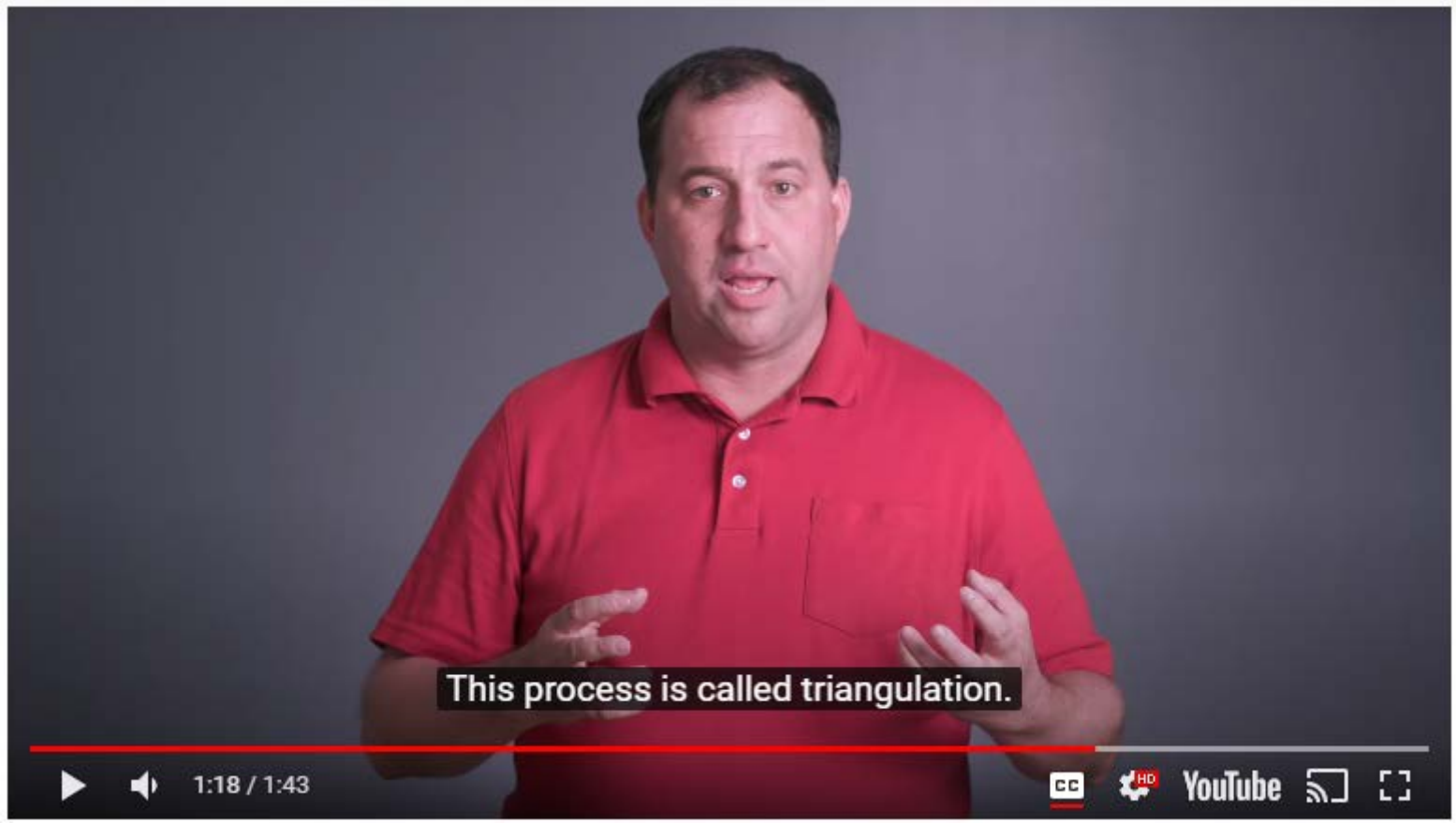

Y
b
(0, 0)
x'
y'
(x', y')
(x, y)
(a, b)
a
X
Performing this transformation is a key step to
3:03 / 4:08
YouTube

Do some exploration in Apollo's github repo, and write down the inputs for the localization module.

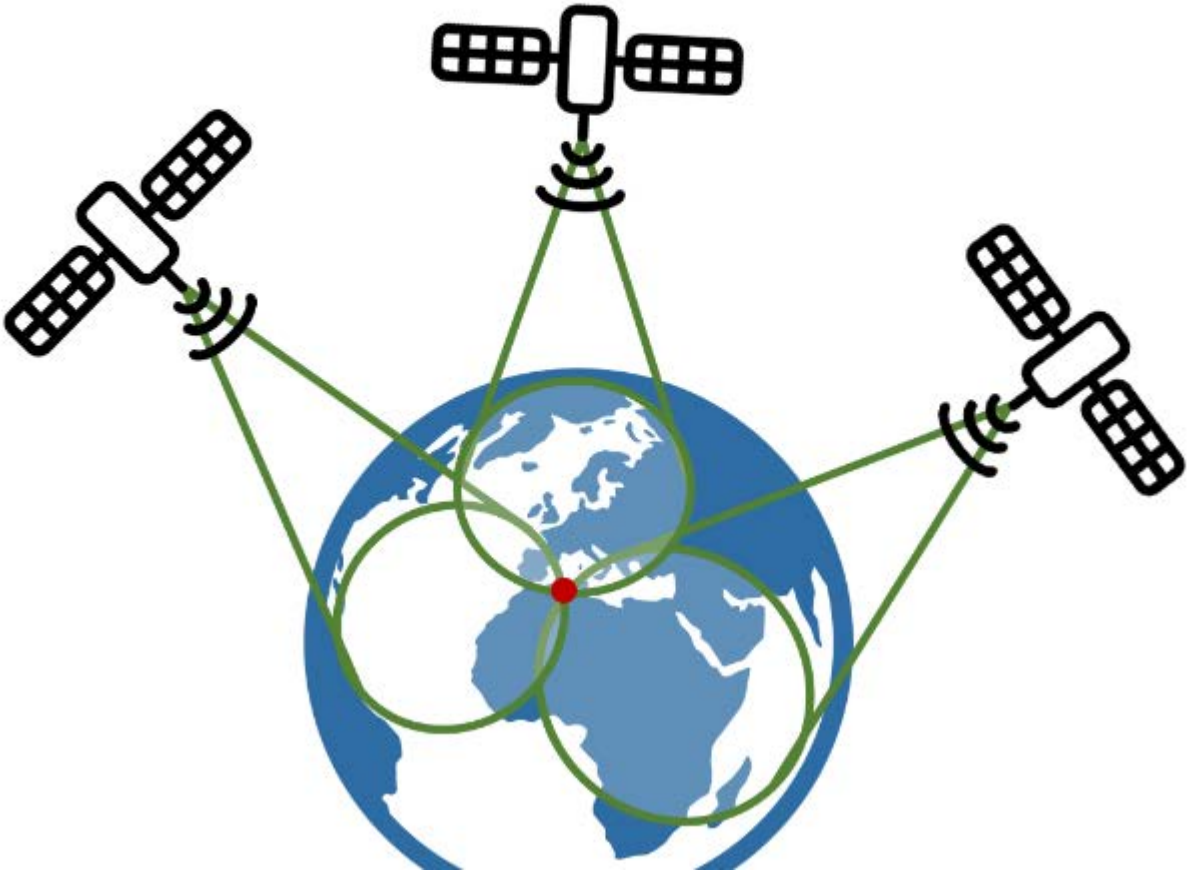
The RTK (Real Time Kinematic) based method which incorporates GPS and IMU (Inertial Measurement Unit) information
The multi-sensor fusion method which incorporates GPS, IMU, and LiDAR information.

SUBMIT

a street light and you measure your position as 55 meters from that street light.


This process is called triangulation.
1:18 / 1:43
YouTube

Correct! The answer is the same as the question in two-dimensional plane. In real life, however, GPS uses the another satellite to confirm the attitude measurement. In total, there are 4 satellites to determine your location all the time.

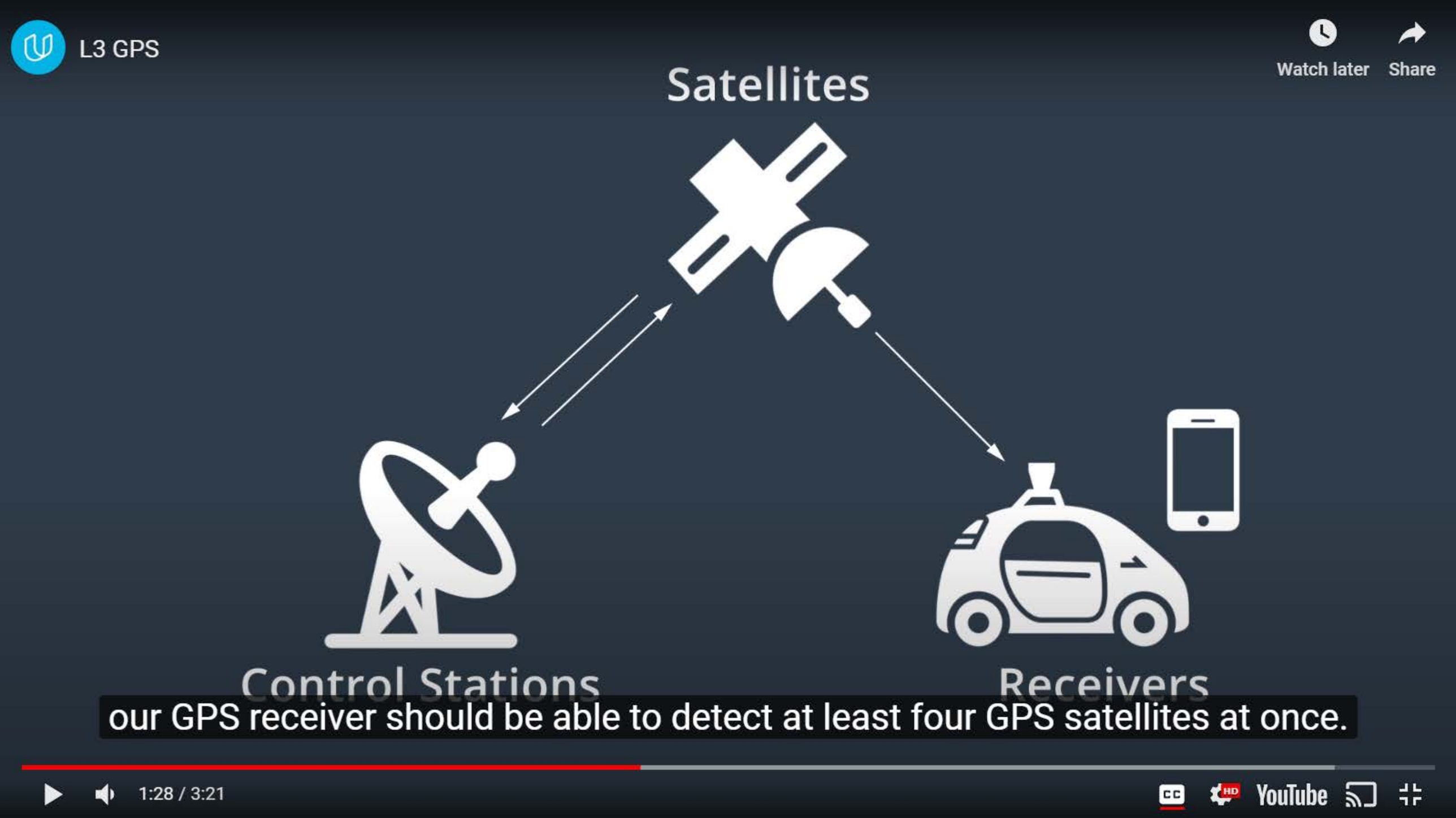


QUESTION 1 OF 3

If we were at any location on the earth, at least how many satellites would we need to know where we are? (In this situation, you can ignore the altitude)

- 2
- ✓ 3
- 4
- 5

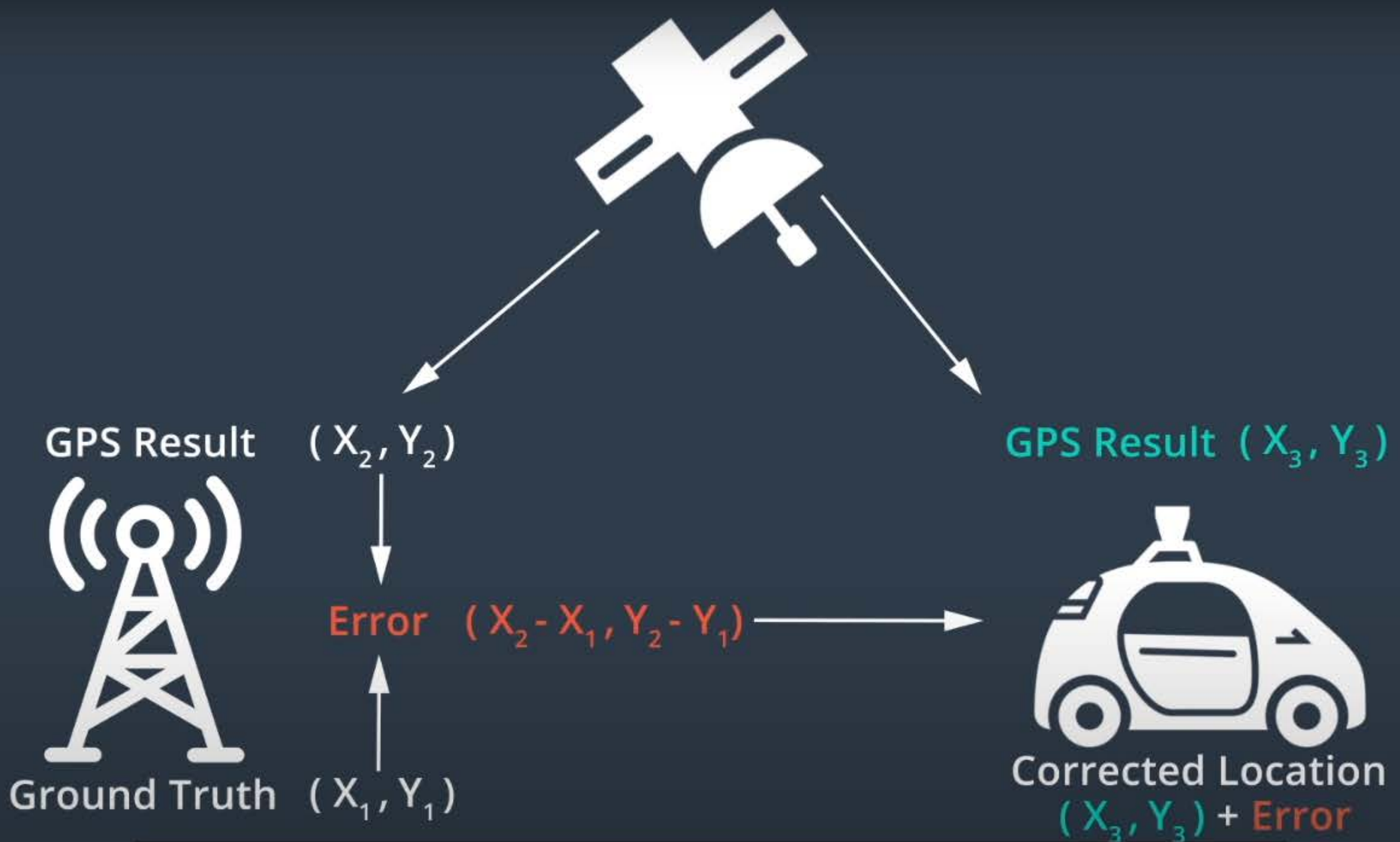

The generic term for this type of system is Global Navigation Satellite System or GNSS.
0:18 / 3:21
CC
HD
YouTube


L3 GPS
Watch later
Share
Satellites
Control Stations
Receivers
our GPS receiver should be able to detect at least four GPS satellites at once.
1:28 / 3:21
YouTube

Therefore, every satellite is equipped with a highly accurate atomic clock.

Ground Truth (X_1, Y_1)

Each base station knows its own precise Ground Truth location.



which use it to adjust their own location calculations.


L3 GPS
Watch later
Share
GPS Pros and Cons
√ Accurate with RTK
× Poor Performance in Urban Area and Canyons
× Low Frequency Update
around 10 hertz or 10 updates per second.
3:14 / 3:21
YouTube

QUESTION 2 OF 3

How much time does it take for GPS to give an update? Choose a number in seconds.

- ✓ 0.1s
- 1s
- 0.01s

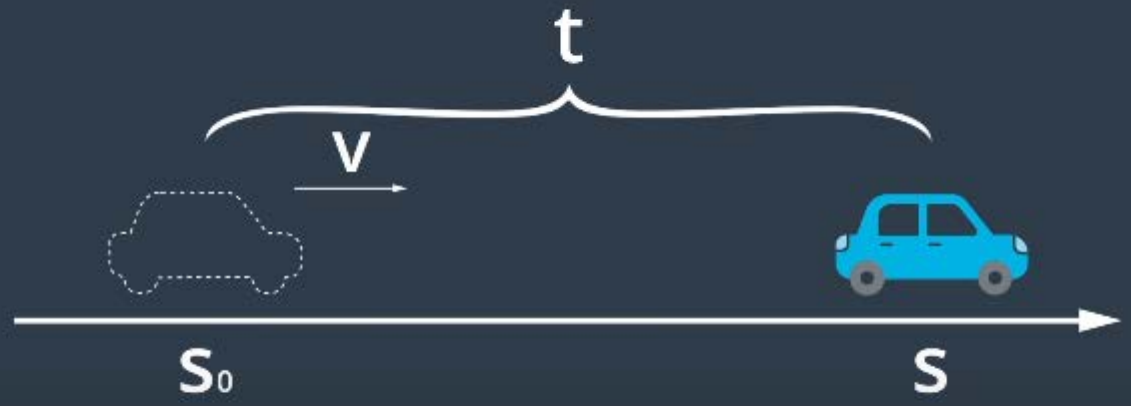
SUBMIT

✓

In the period of time you calculated above, what's the distance that a car driving at 60km/h will travel? Fill a number in meters.

1.67m

RESET



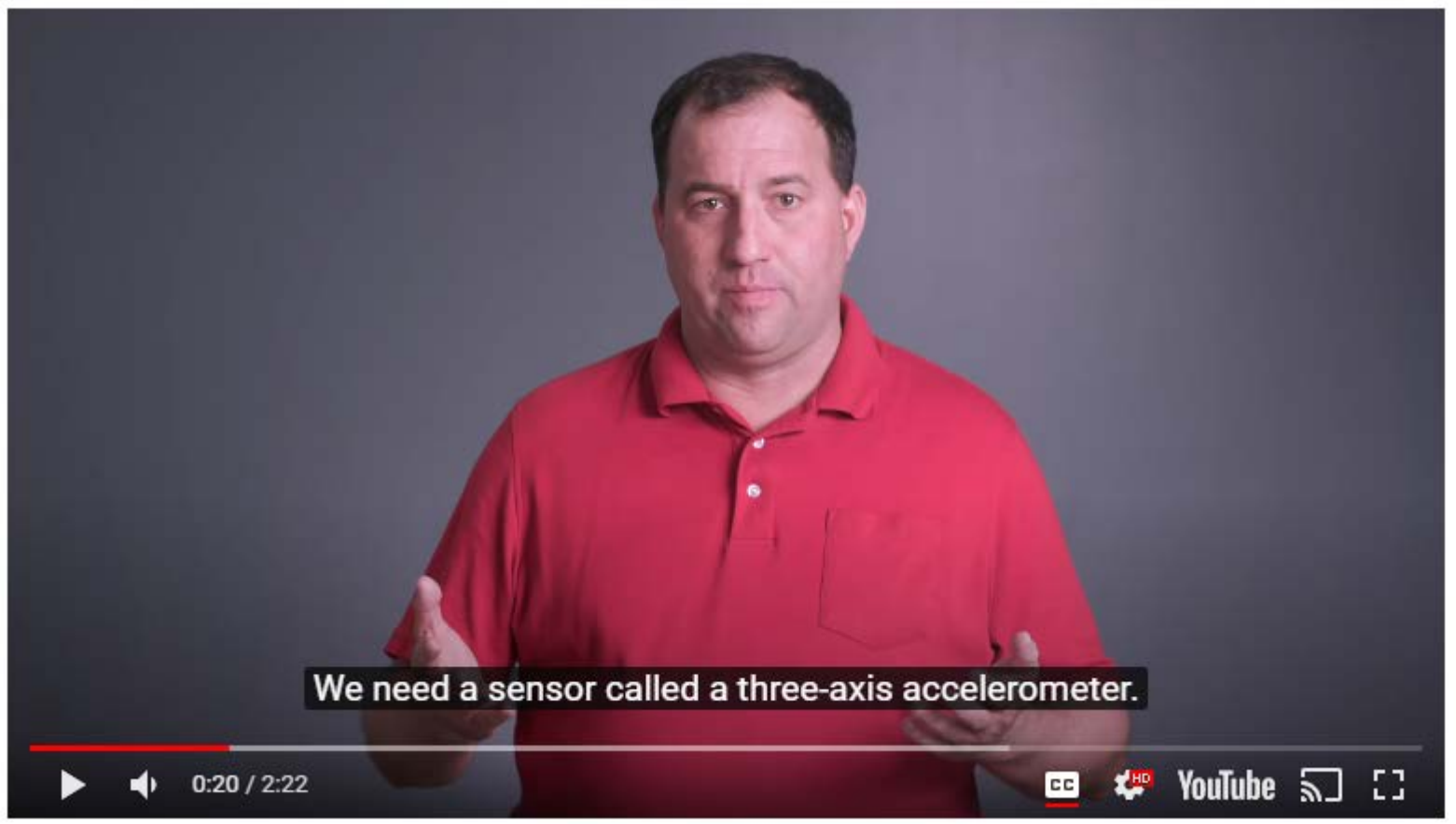
$$s = s_0 + vt$$

Start with the initial location and then multiply velocity and time.

QUIZ QUESTION

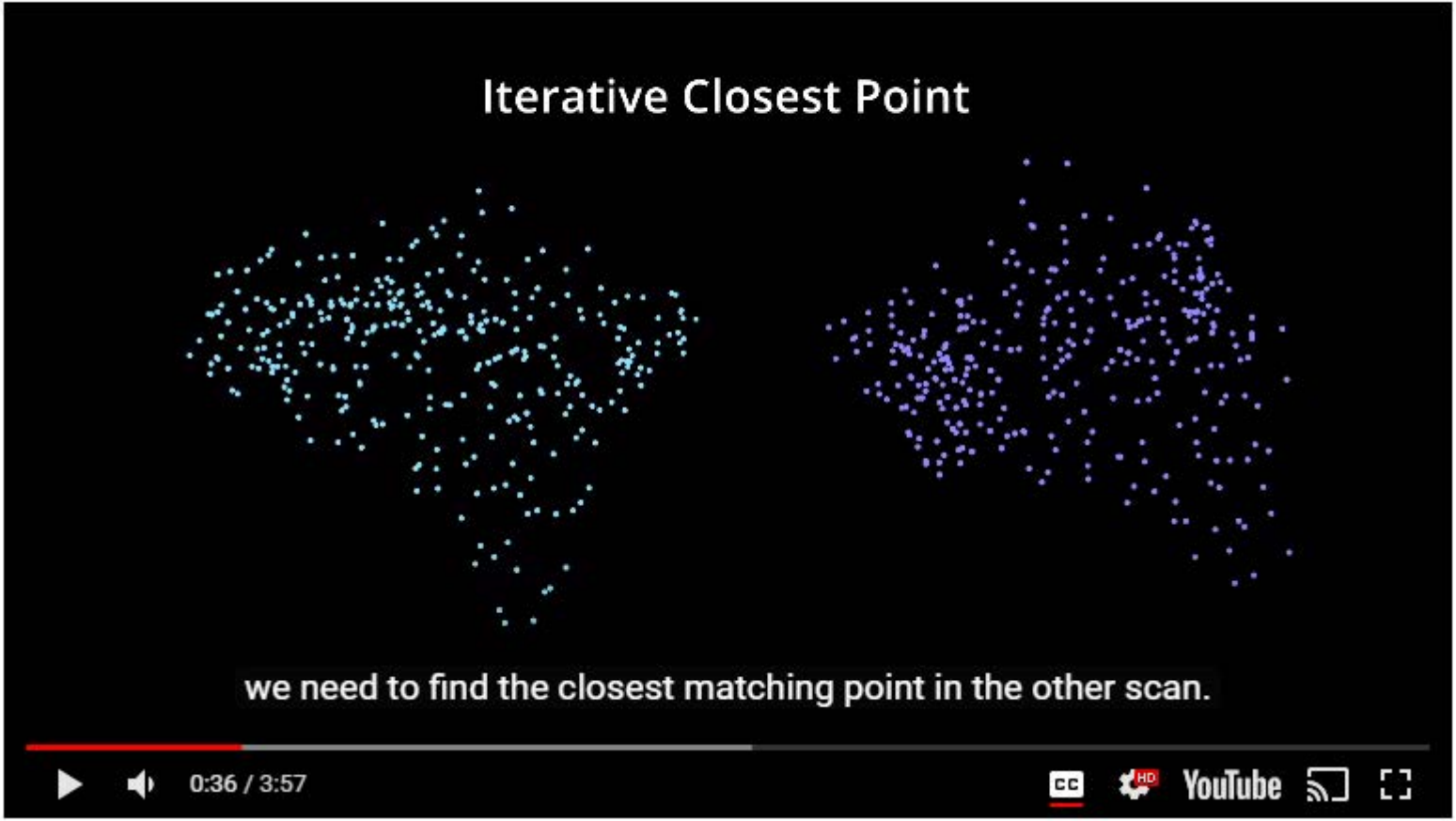
If I give you the initial velocity v0 of a car, and give you the acceleration a and the time t of running, can you tell me the velocity v of the car now?

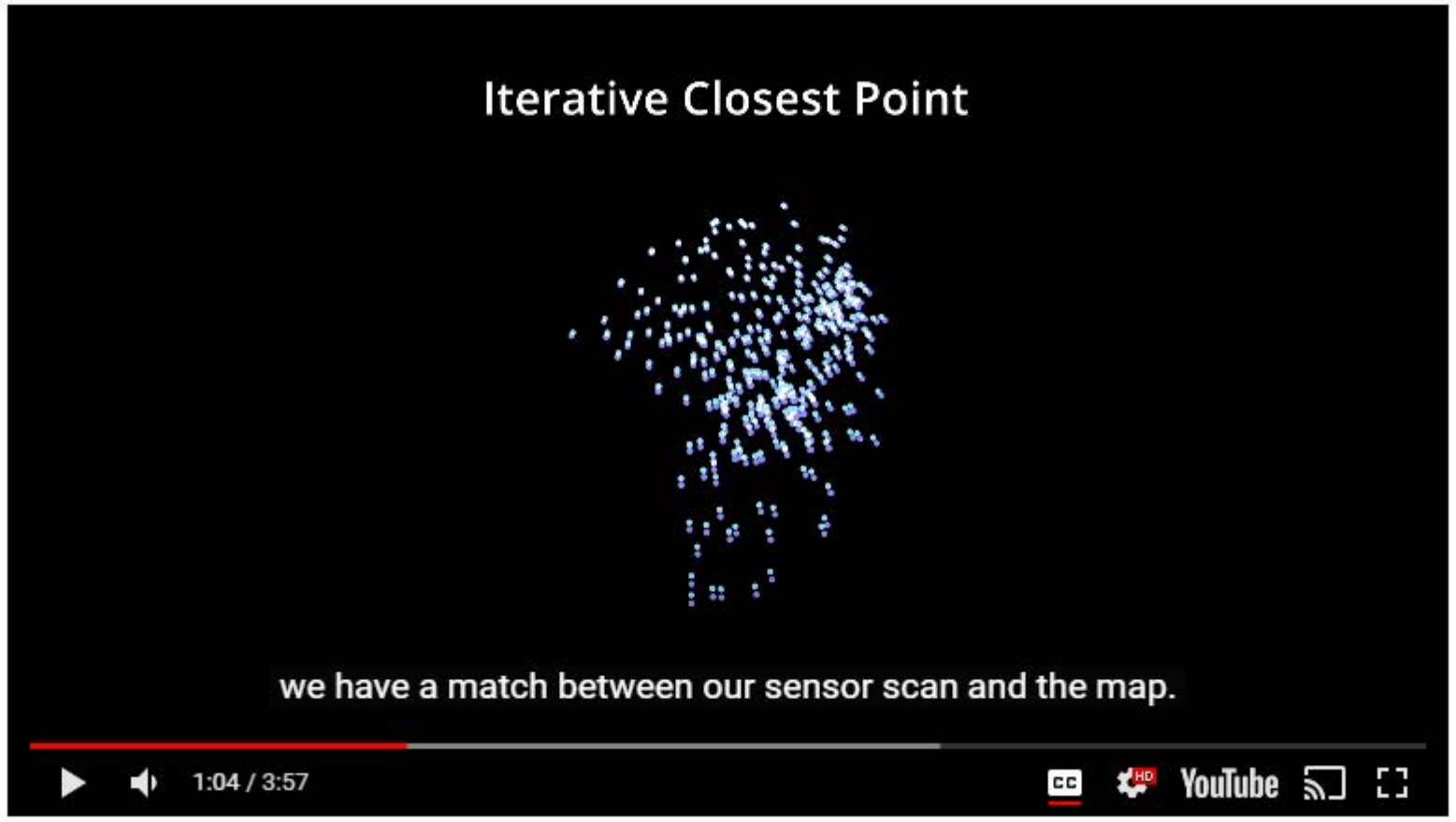
- at
- v0 - at
- ✓ v0 + at
- v0 + a


We need a sensor called a three-axis accelerometer.
0:20 / 2:22
YouTube

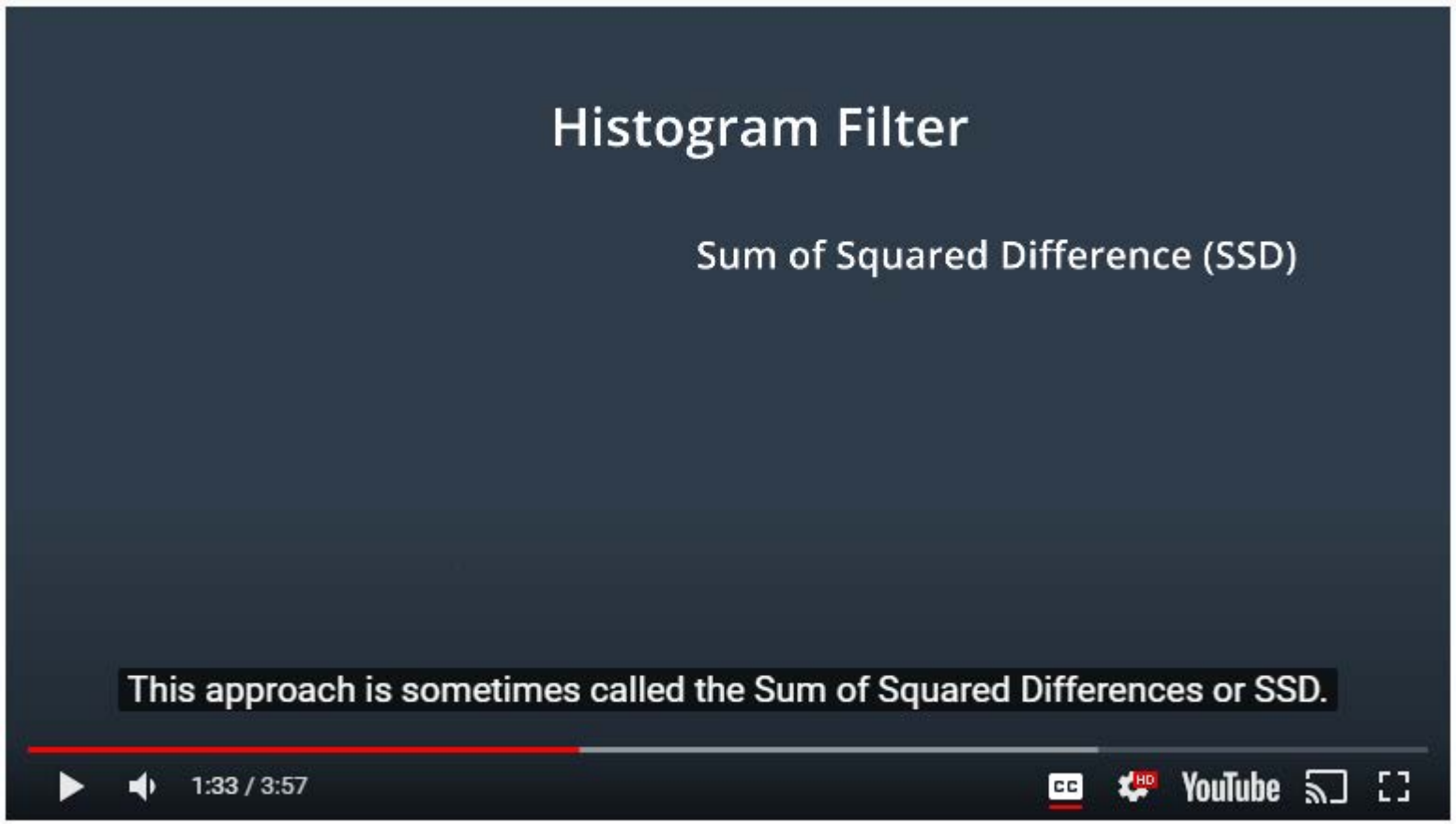

3D Gyro
This translation requires another sensor called a gyroscope.
0:51 / 2:22
YouTube


3D Gyro
Spin Axis
the three-axis gyroscope is always fixed to the world coordinate system.
1:03 / 2:22
YouTube

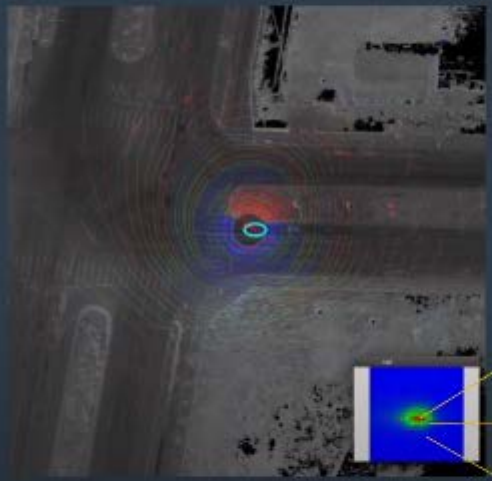

Iterative Closest Point
we need to find the closest matching point in the other scan.
0:36 / 3:57
YouTube


Iterative Closest Point
we have a match between our sensor scan and the map.
1:04 / 3:57
YouTube


Histogram Filter
Apollo uses the Histogram Filter algorithm.
1:28 / 3:57
YouTube


Histogram Filter
Sum of Squared Difference (SSD)
This approach is sometimes called the Sum of Squared Differences or SSD.
1:33 / 3:57
YouTube

Histogram Filter



Sum of Squared Difference (SSD)

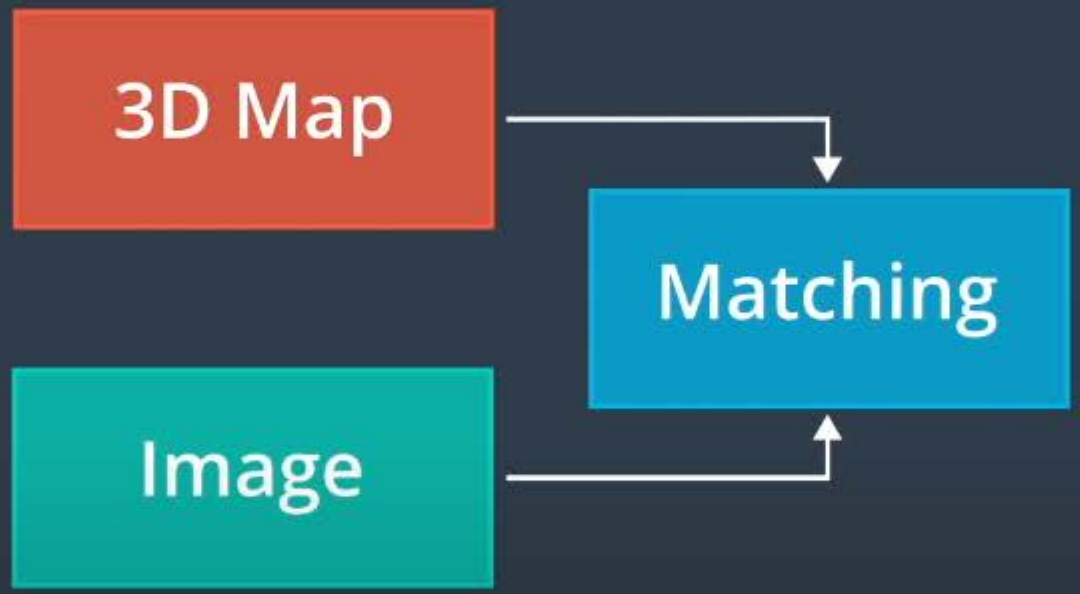
$$d(u,v) = \sum_{(x,y)} (f(x,y) - t(x-u, y-v))^2$$

In this example, green indicates moderate alignment.

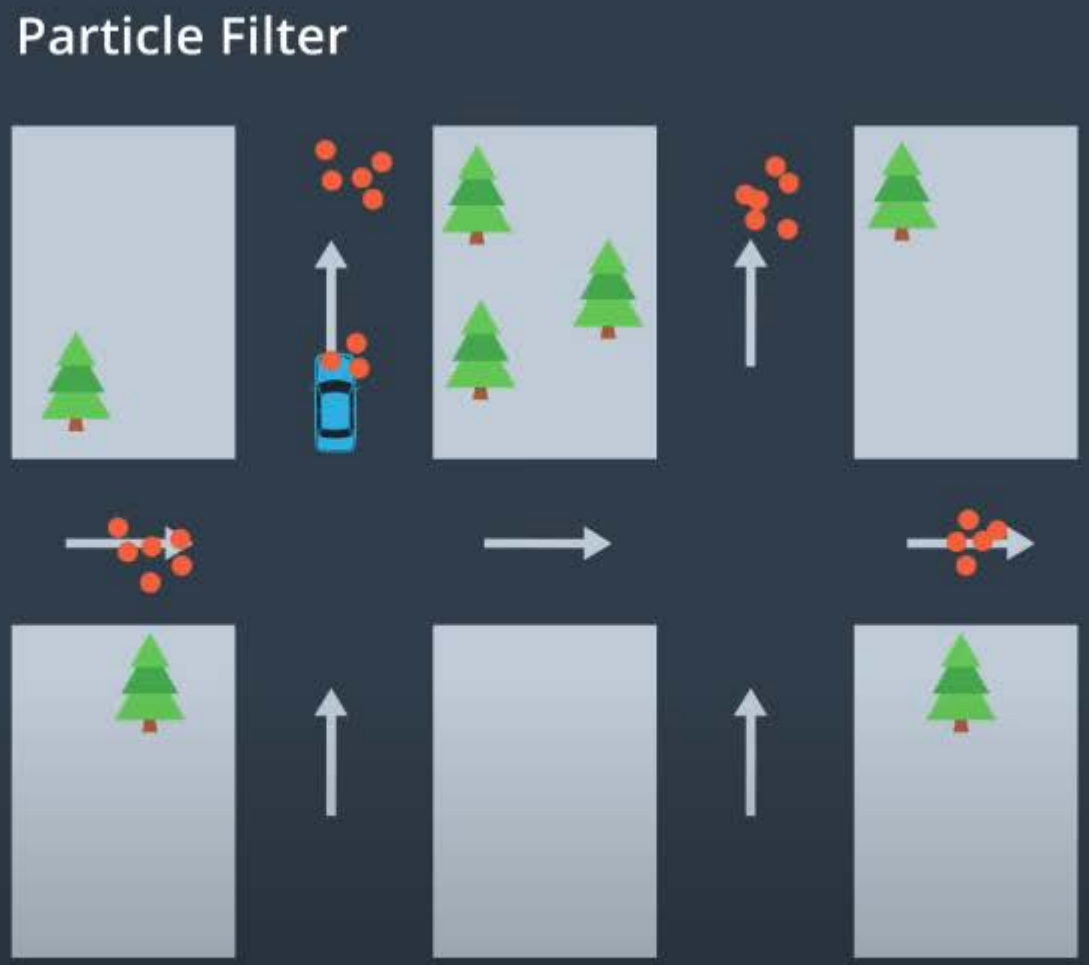
QUIZ QUESTION

which of the following will produce error when matching point cloud measurement with HD map?

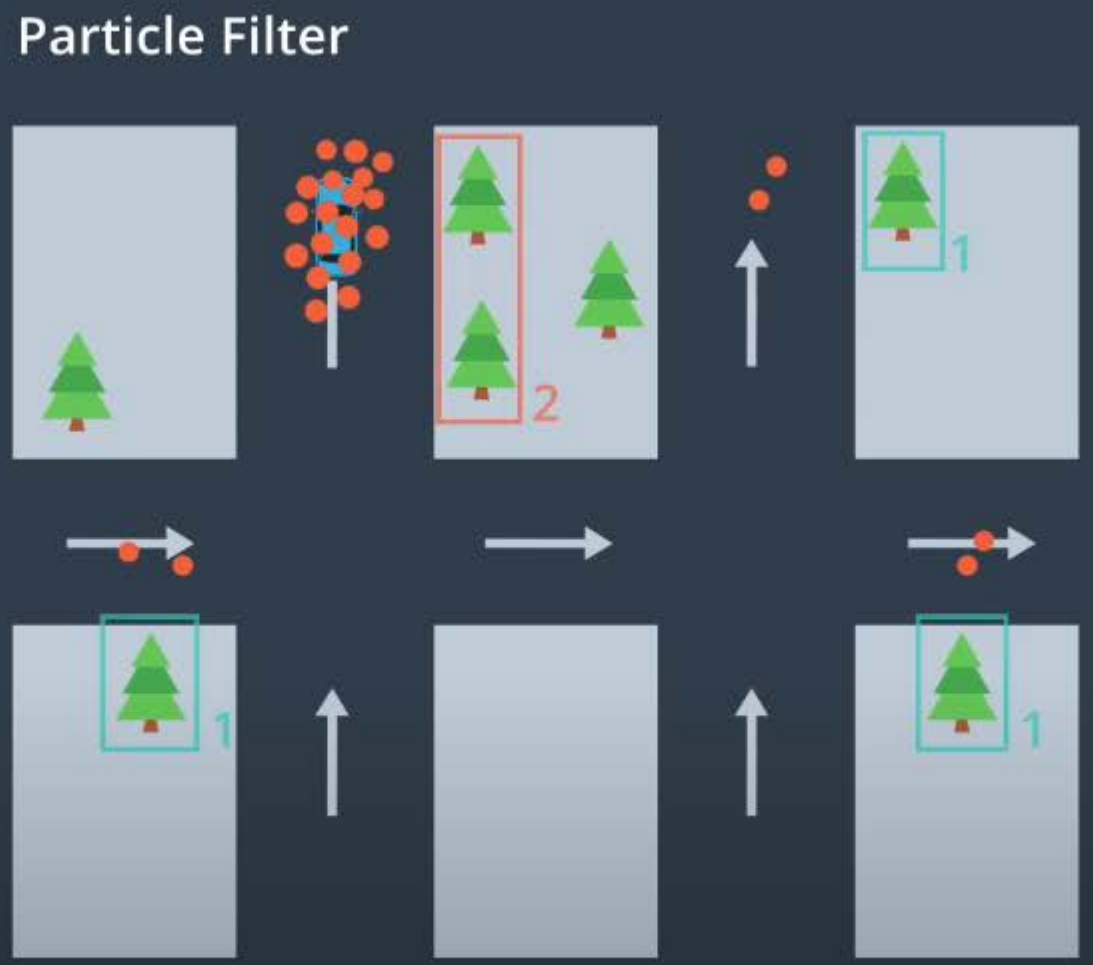
- The number of points collected by LiDAR
- Moving objects such as cars, pedestrians, etc.
- The transformations of point cloud measurement
- Error produced by LiDAR itself



data can localize much better than camera images alone.

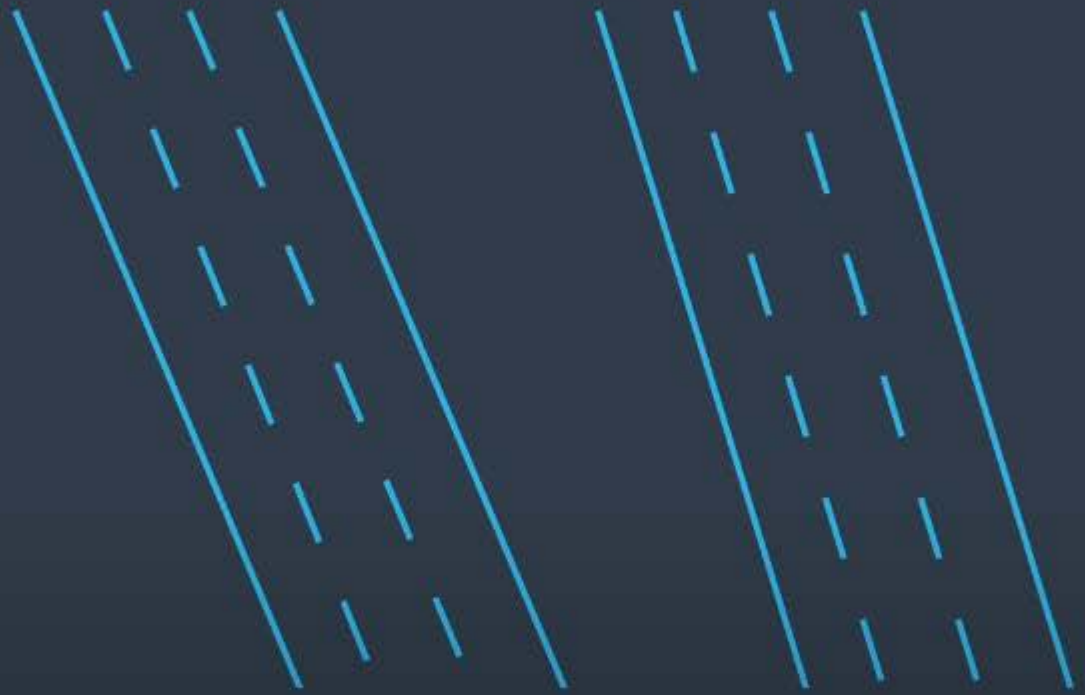


We use probability to determine which point is



two trees in a row on the right hand side of the vehicle.

Lane Detection



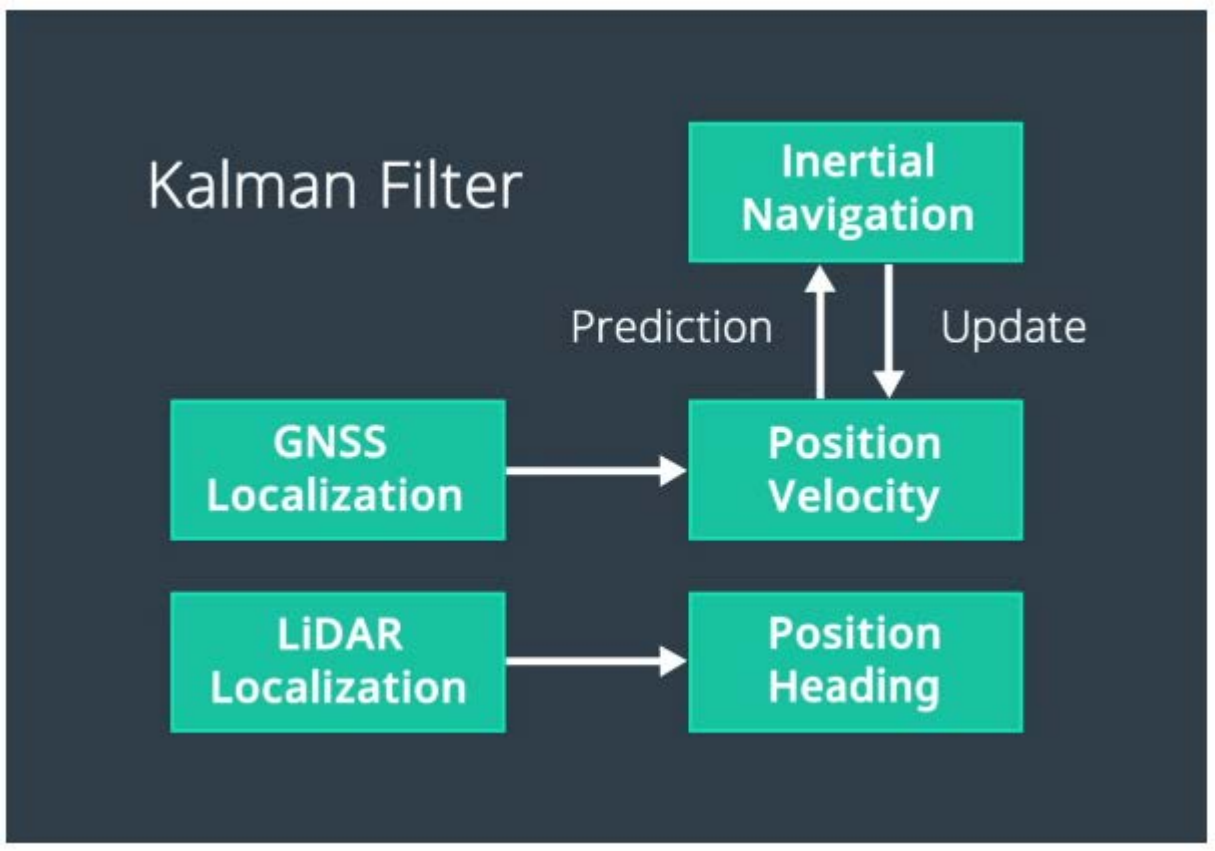
Blue represents lane lines from two different locations on the map.

Lane Detection

Red represents the lane lines observed by the vehicle camera.

Lane Detection

The red lines match the blue lines on


Kalman Filter
Inertial Navigation
Prediction
Update
GNSS Localization
Position Velocity
LiDAR Localization
Position Heading