



Touch



Touch



Sight

Hearing



Touch



Sight

Touch



Hearing



Sight



Taste

Touch



Hearing



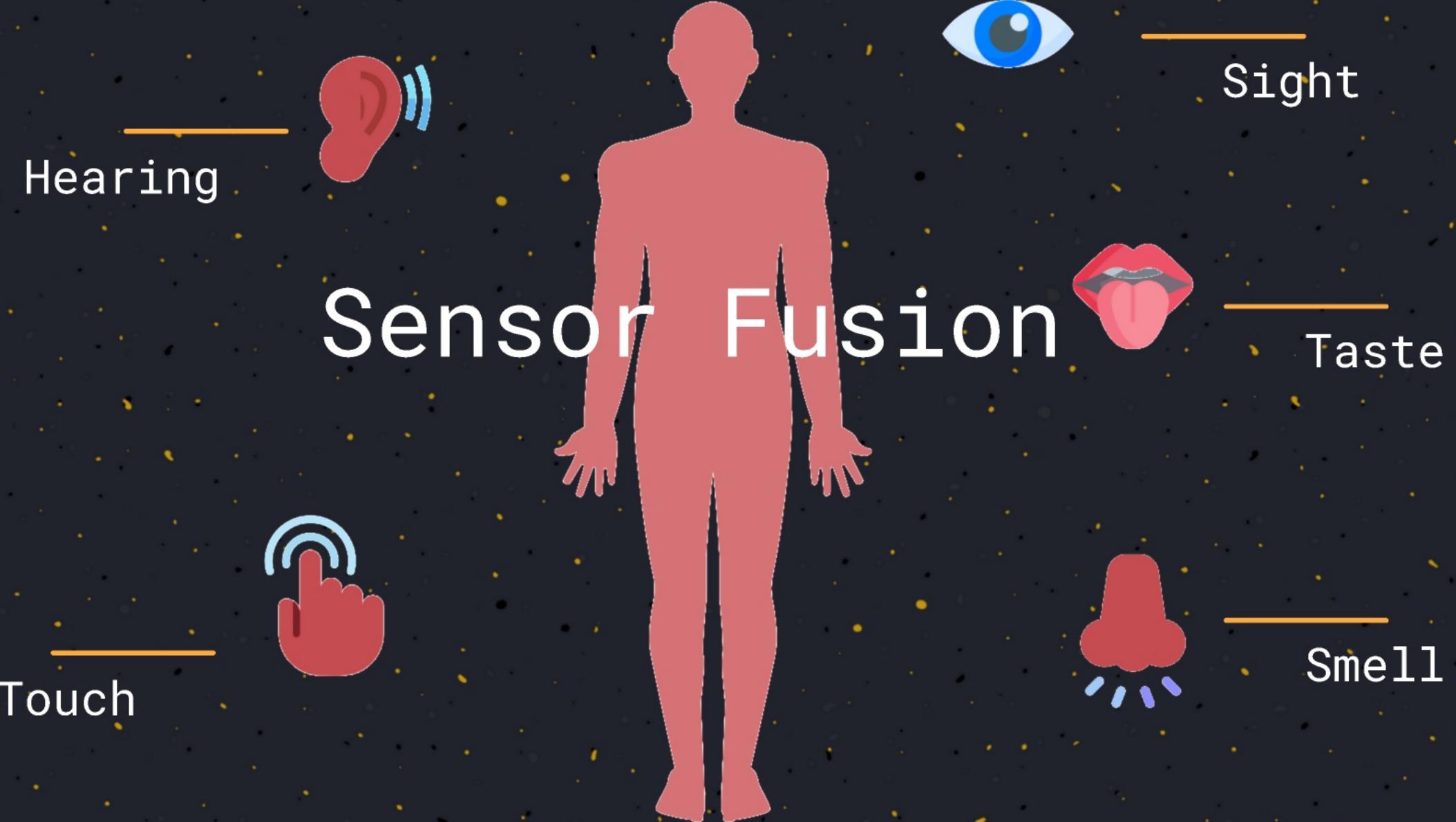
Sight



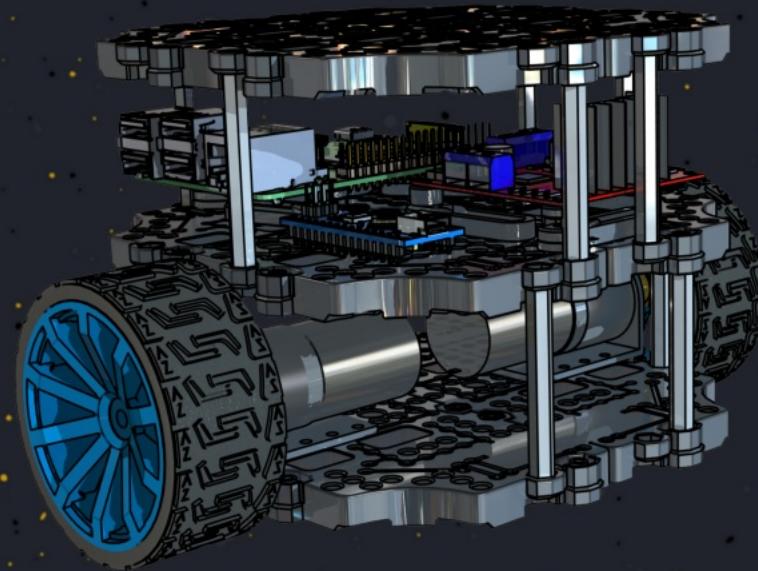
Taste



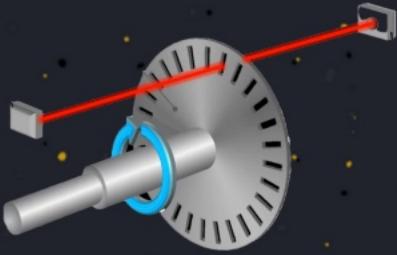
Smell



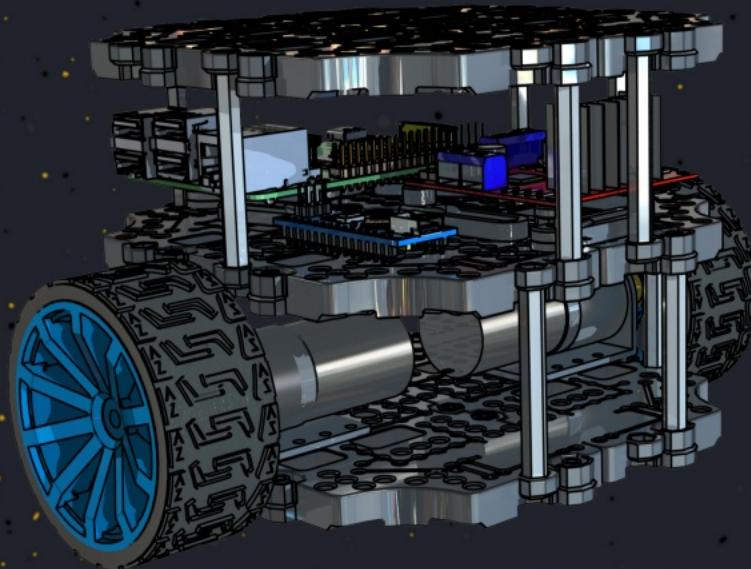
Sensor Fusion



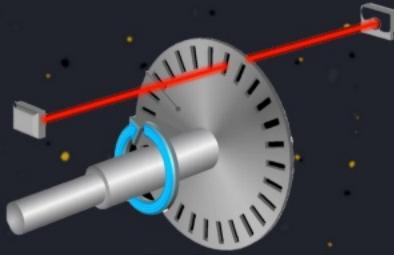
Sensor Fusion



Encoder



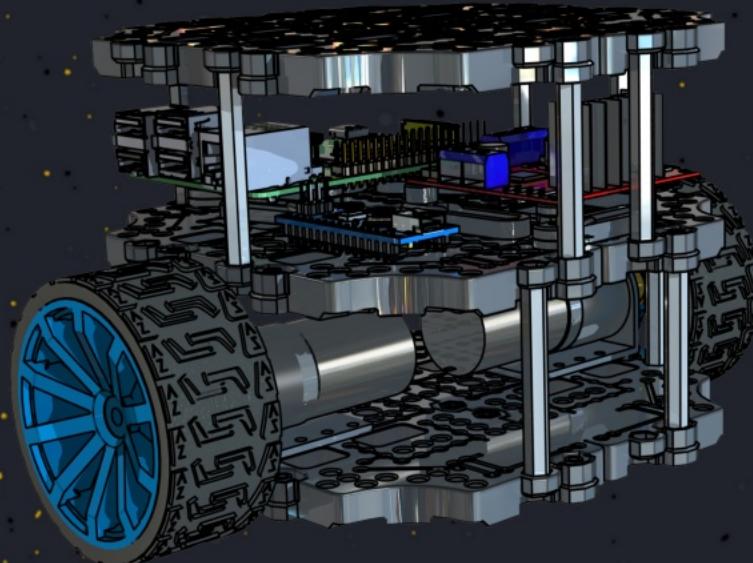
Sensor Fusion



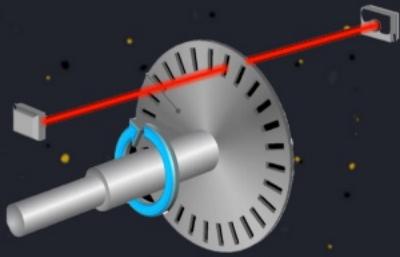
Encoder



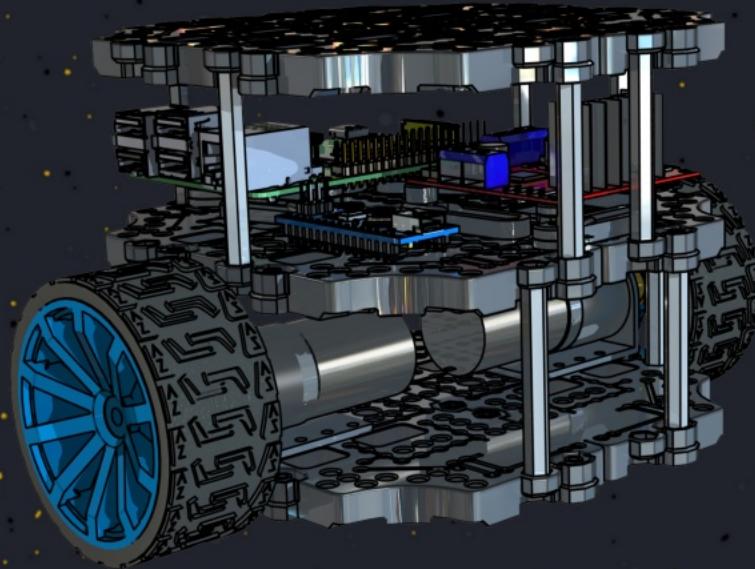
Gyroscope



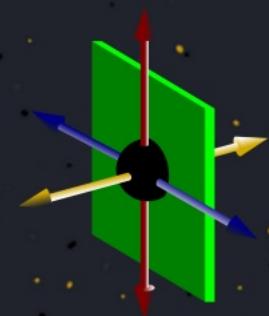
Sensor Fusion



Encoder

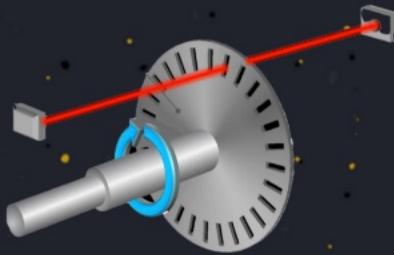


Gyroscope

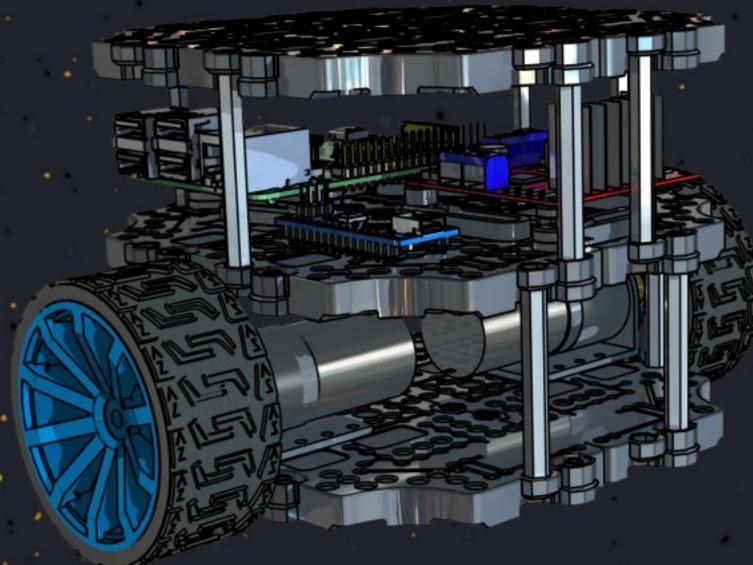


Accelerometer

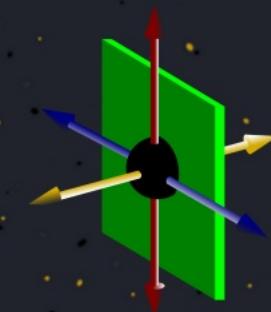
Sensor Fusion



Encoder



Gyroscope

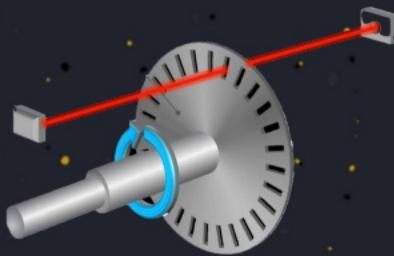


Accelerometer

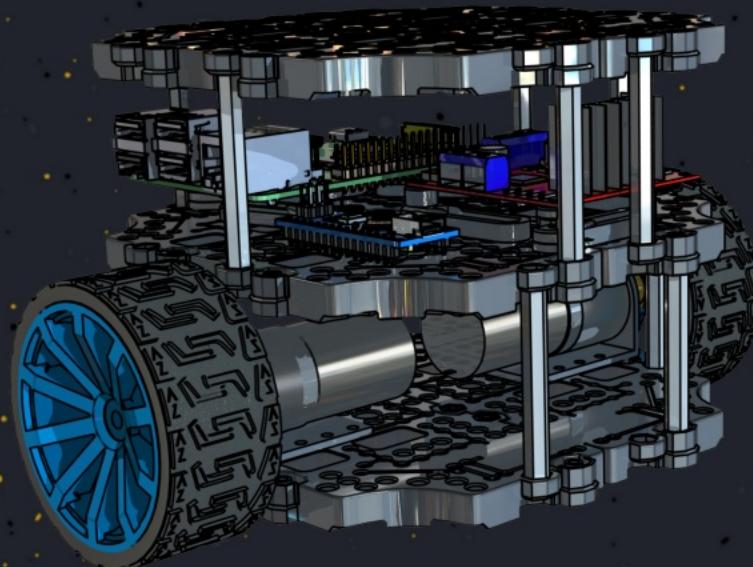


Camera

Sensor Fusion



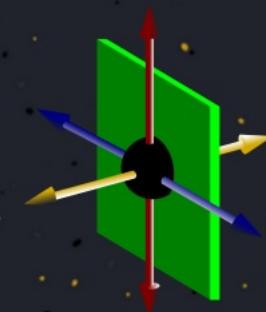
Encoder



Laser



Gyroscope

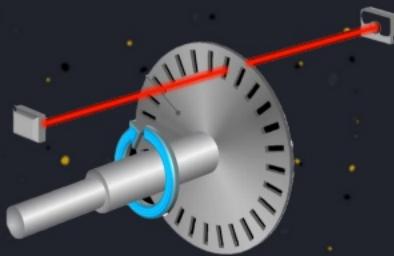


Accelerometer



Camera

Sensor Fusion



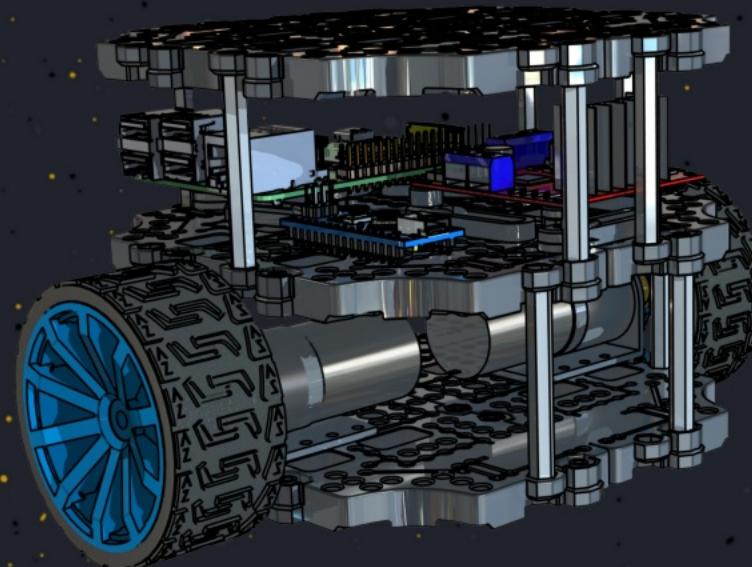
Encoder



Gyroscope



Accelerometer



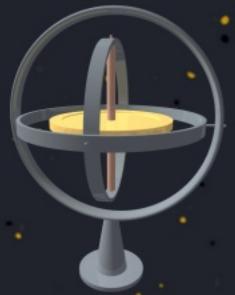
GPS



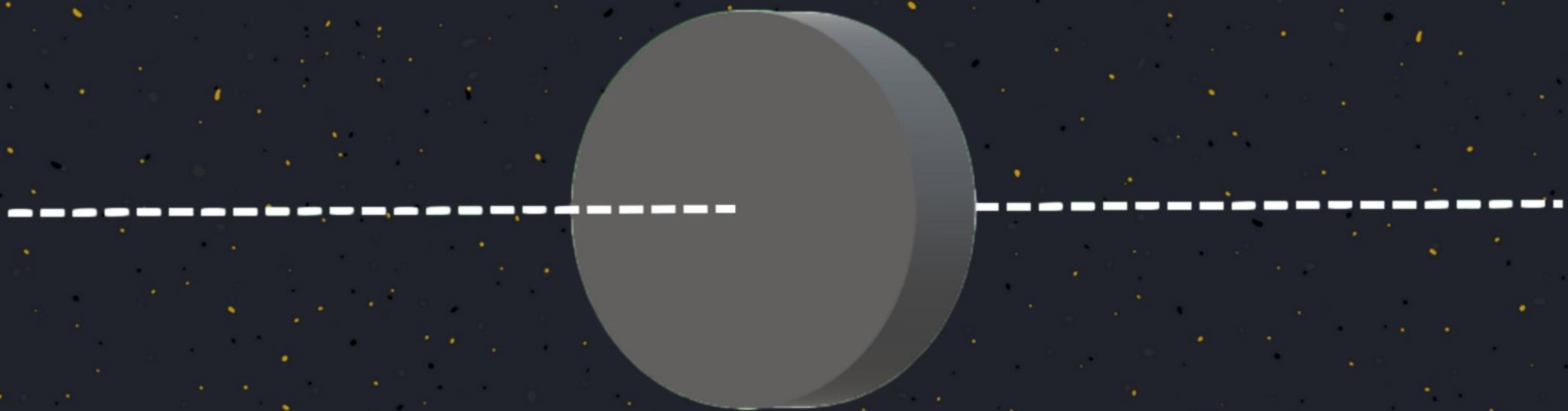
Laser

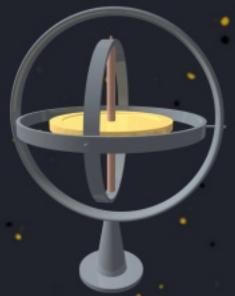


Camera

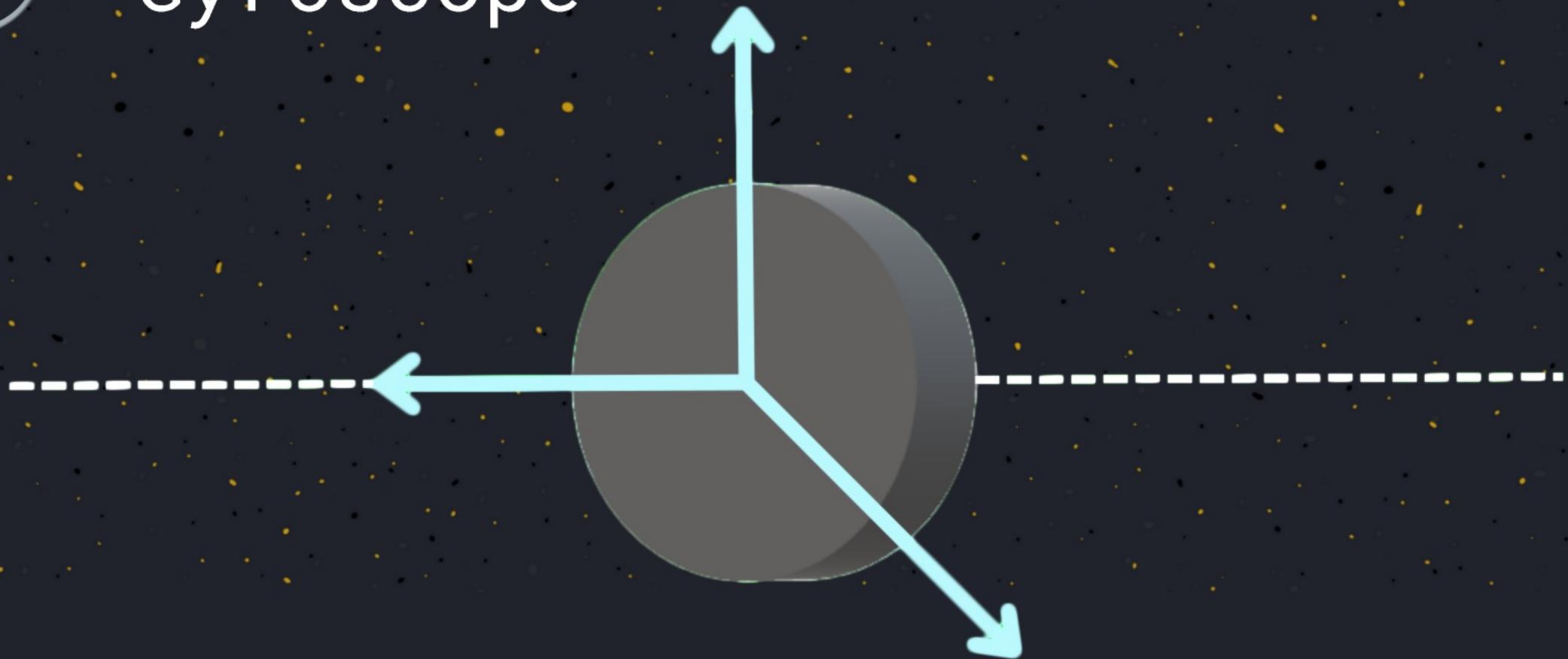


Gyroscope



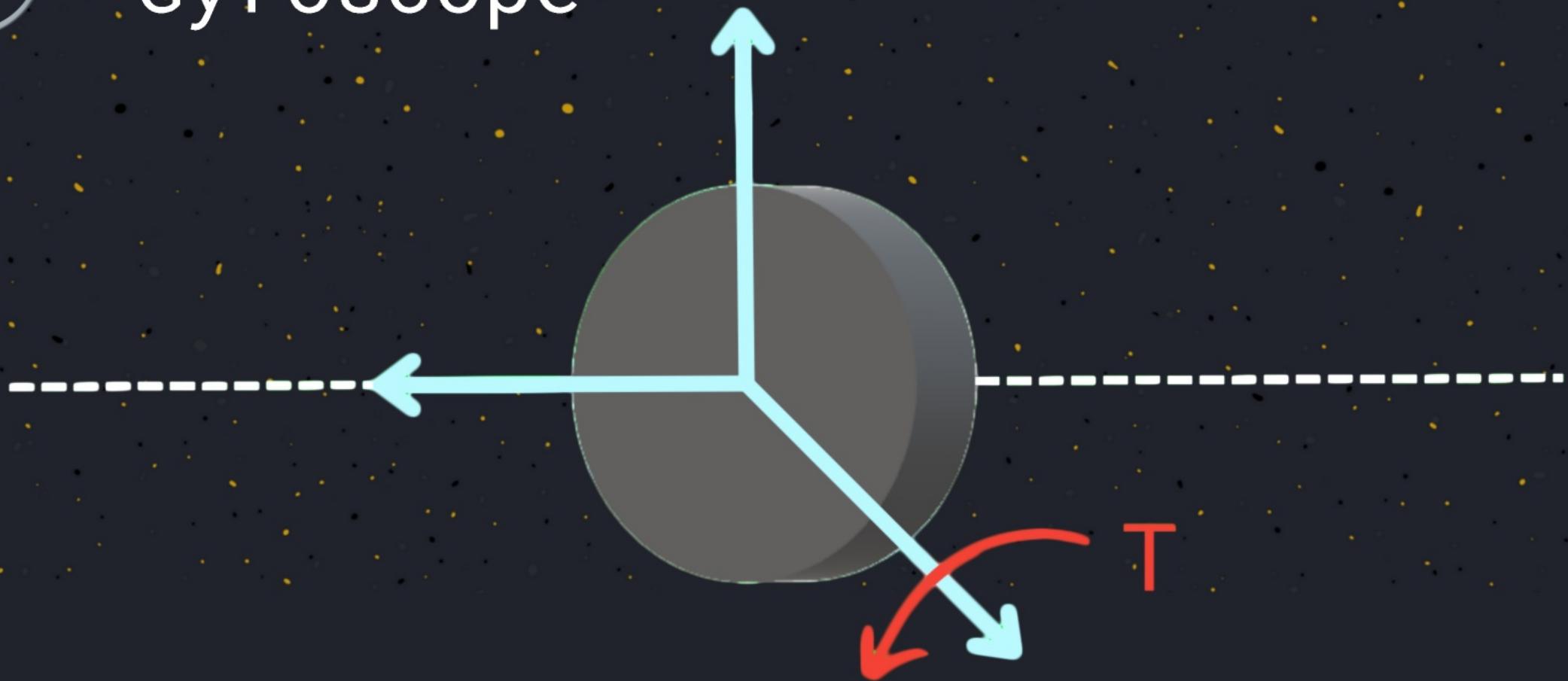


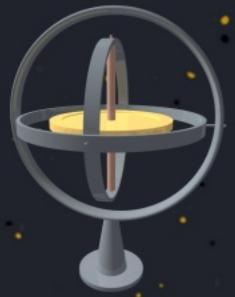
Gyroscope





Gyroscope

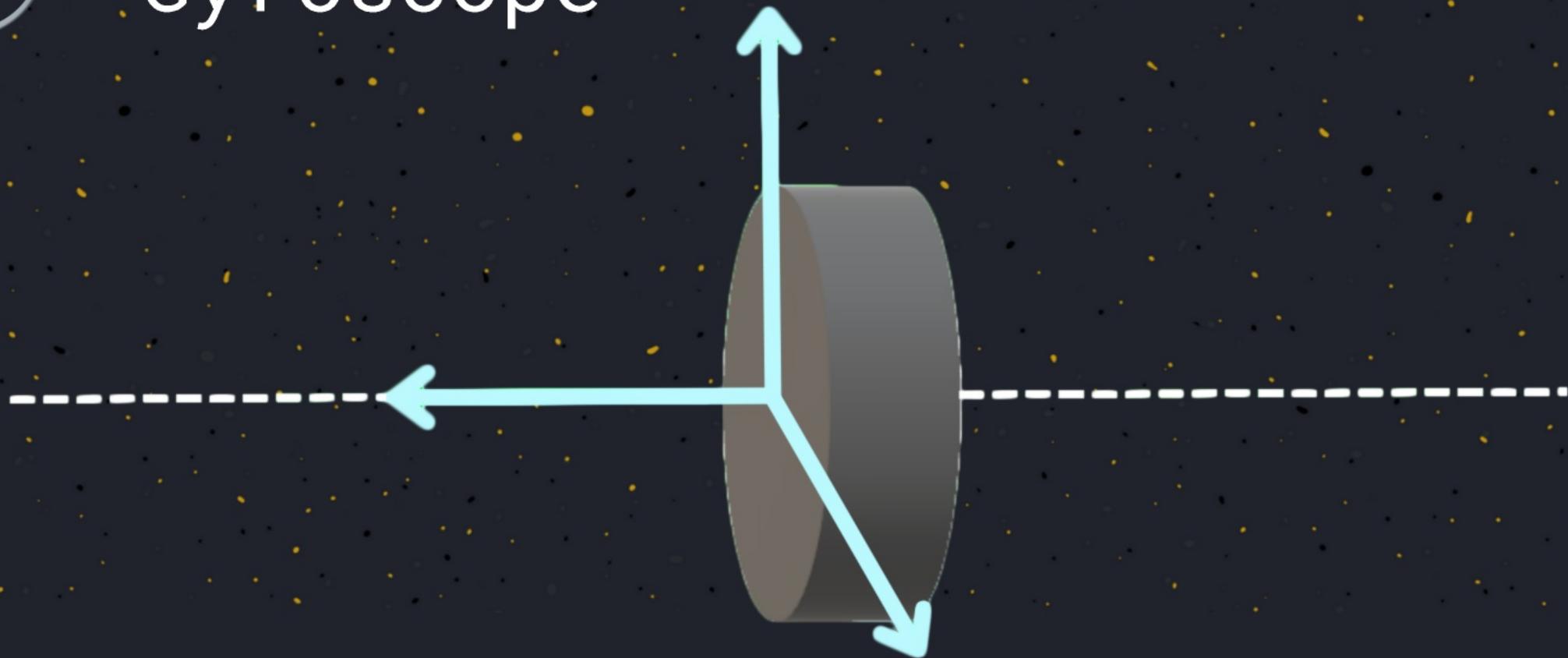


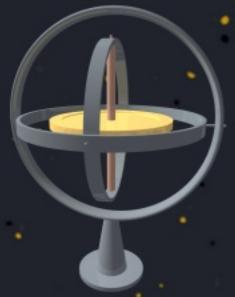


Gyroscope



Gyroscope

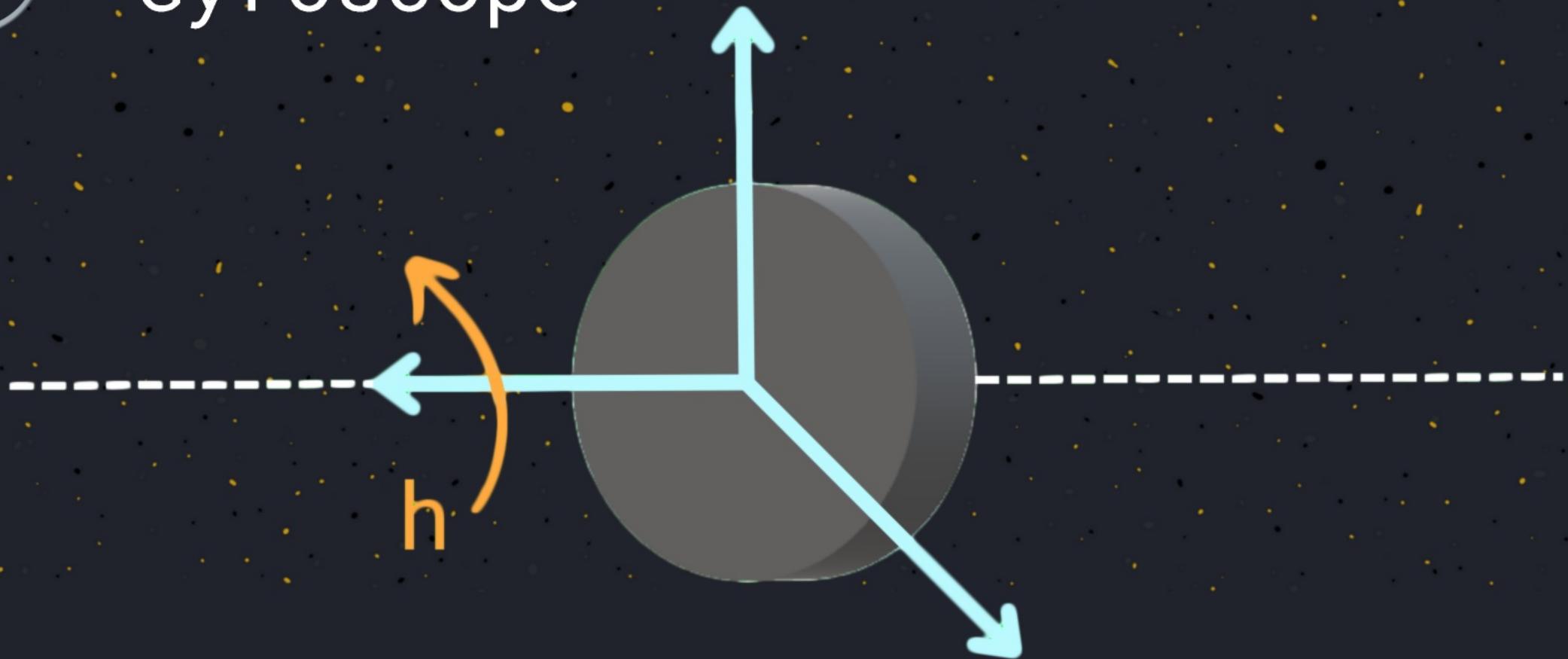




Gyroscope

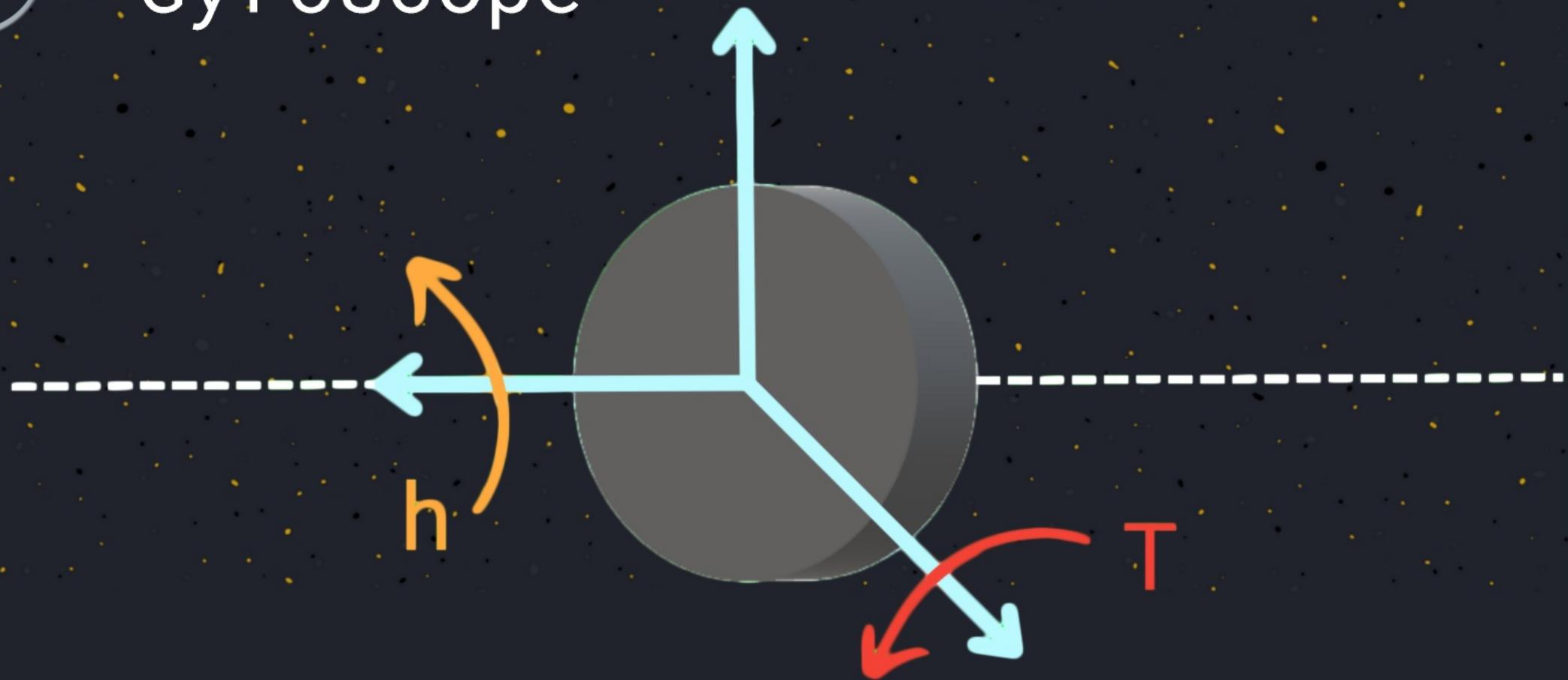


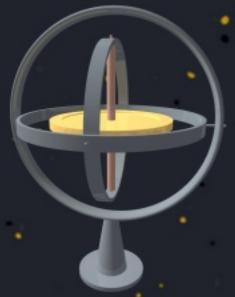
Gyroscope





Gyroscope

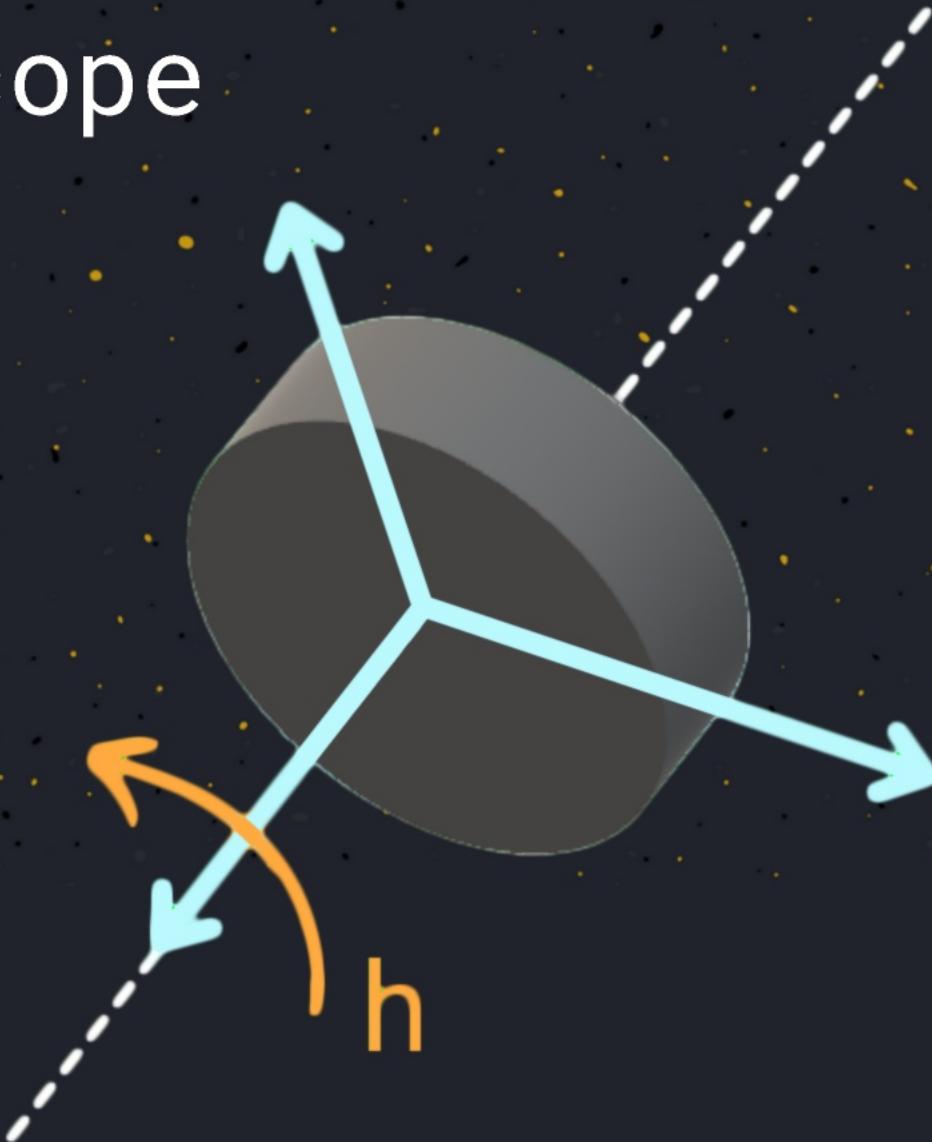


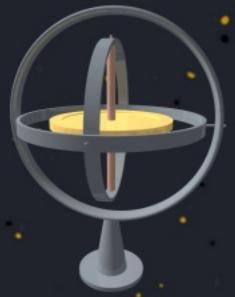


Gyroscope



Gyroscope

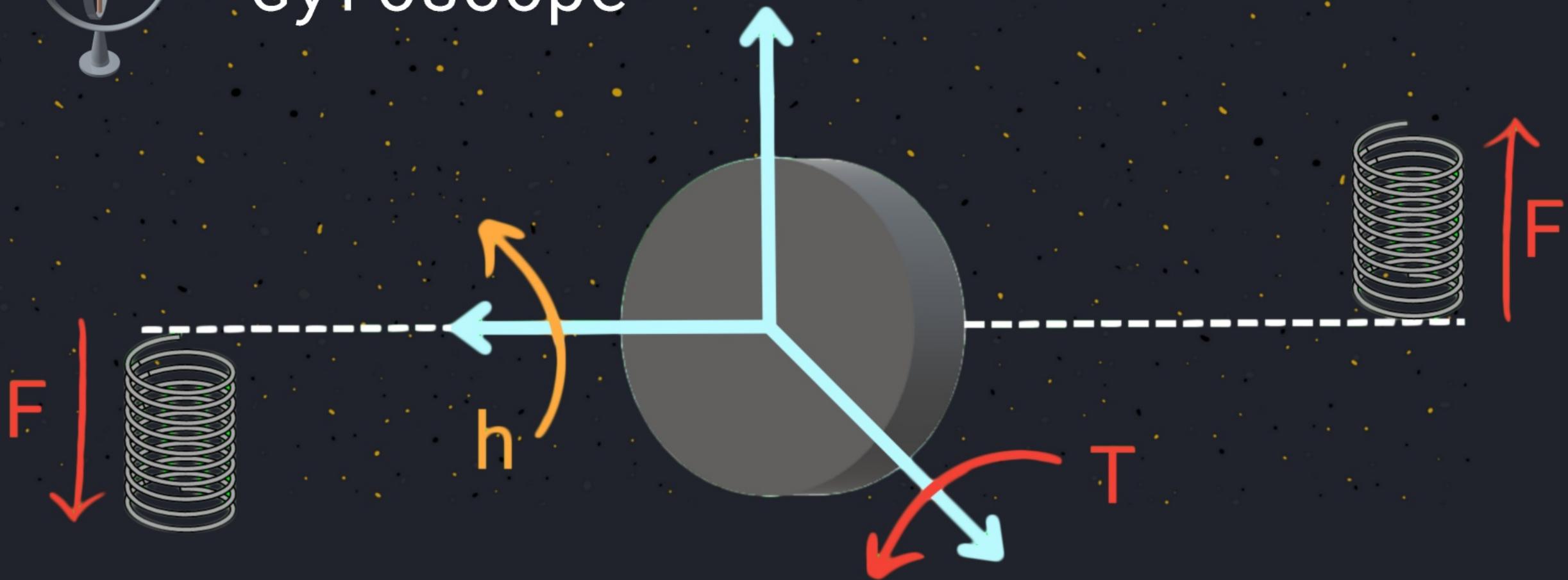


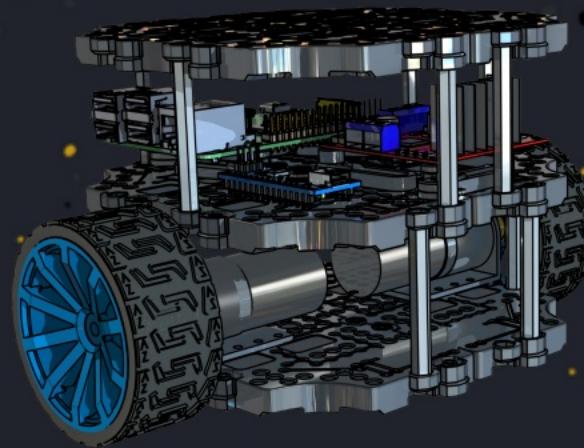


Gyroscope



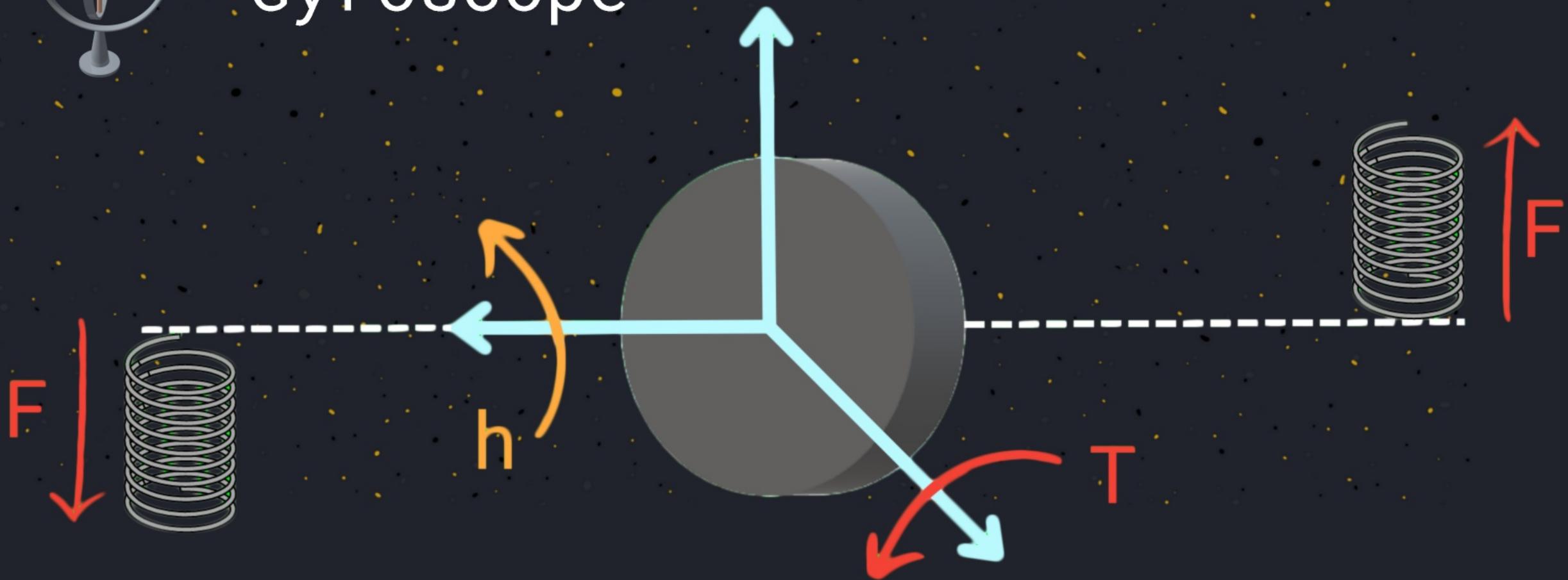
Gyroscope



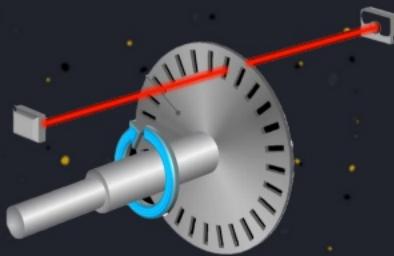




Gyroscope



Sensor Fusion



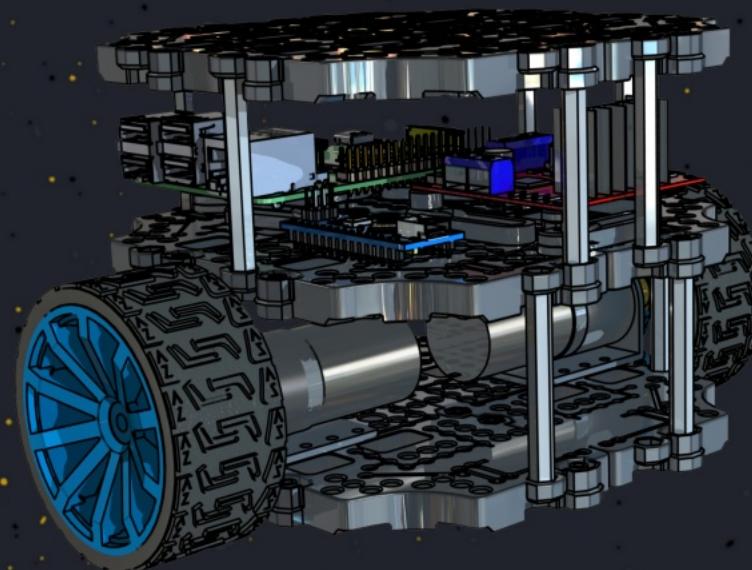
Encoder



Gyroscope



Accelerometer



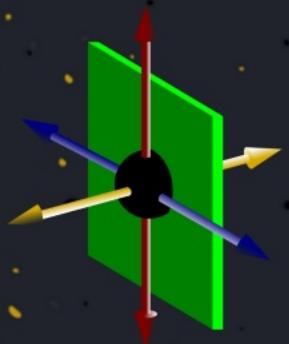
GPS



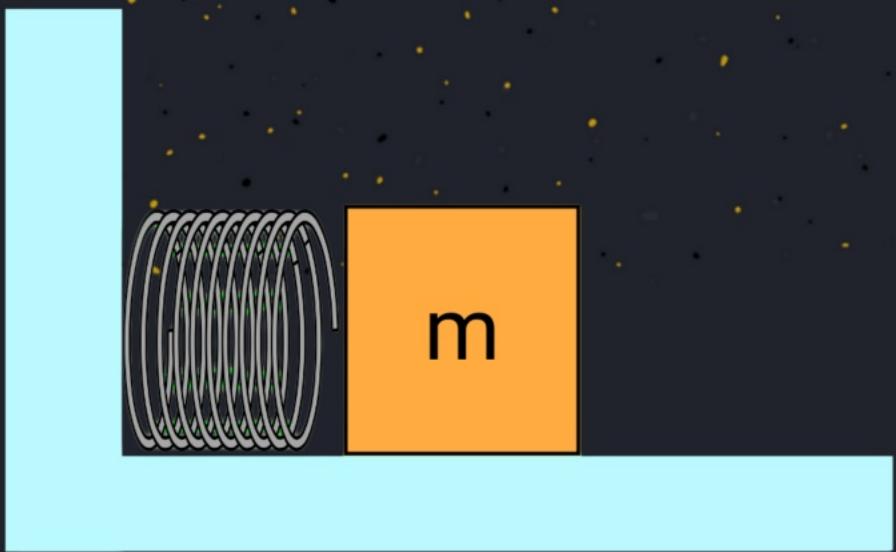
Laser

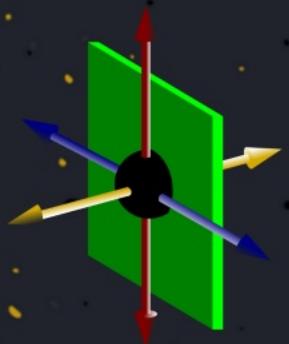


Camera

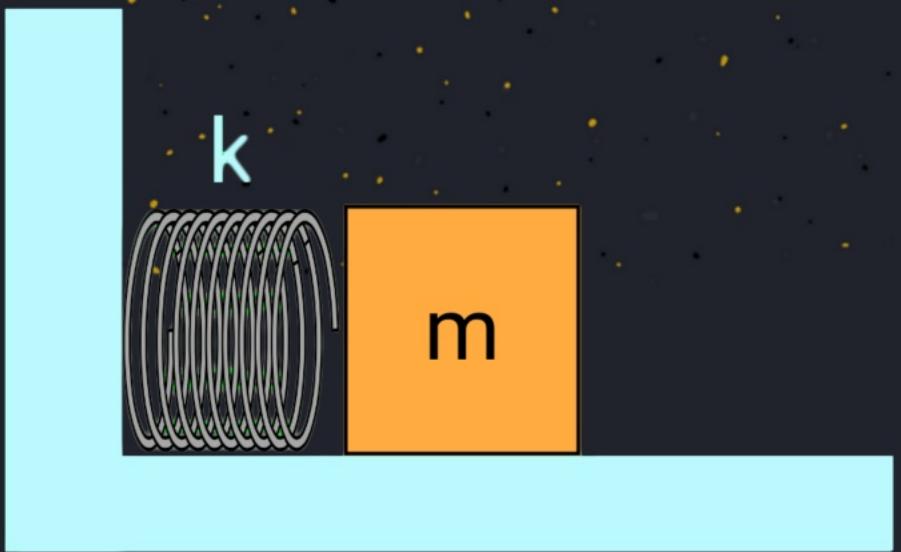


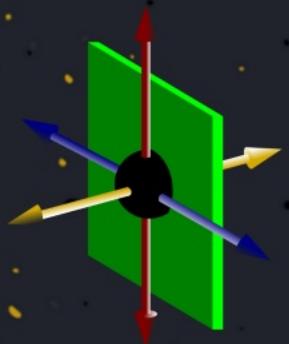
Accelerometer



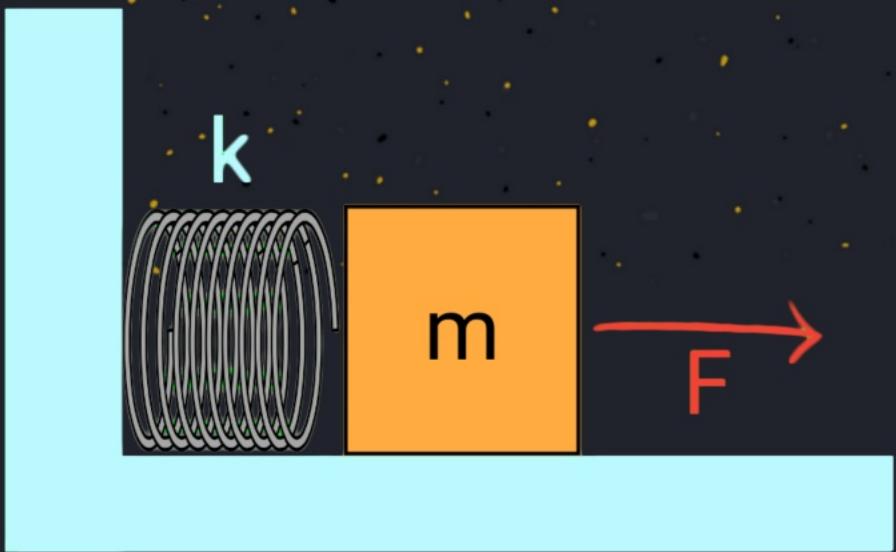


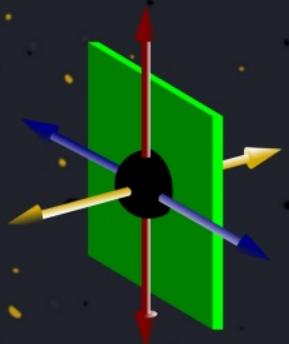
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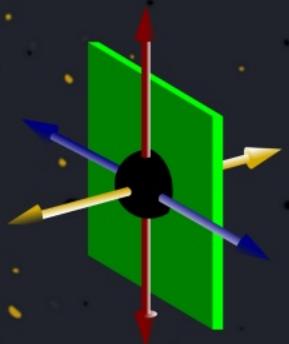


Accelerometer

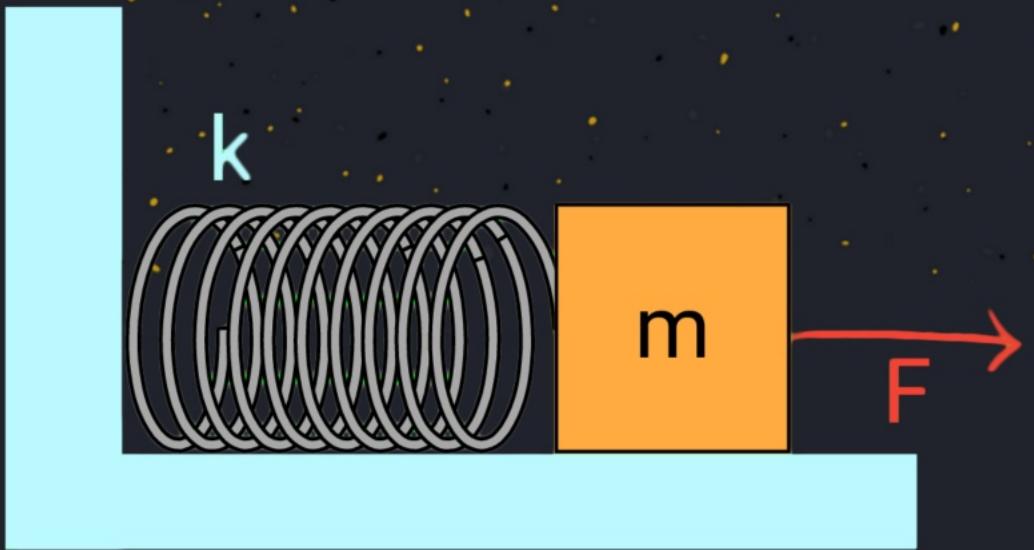


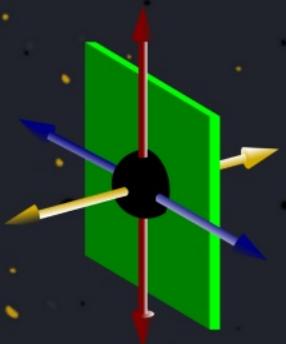


Accelerometer

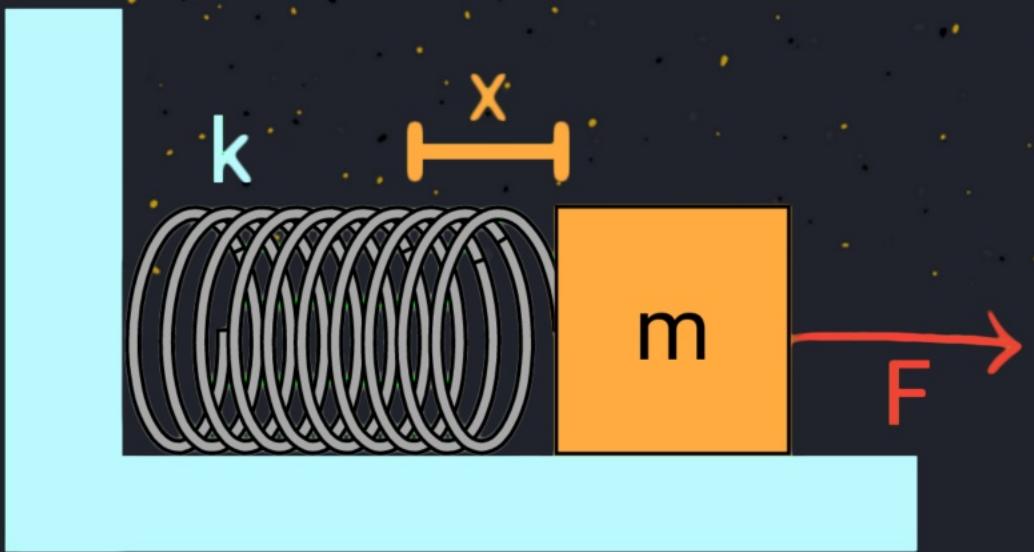


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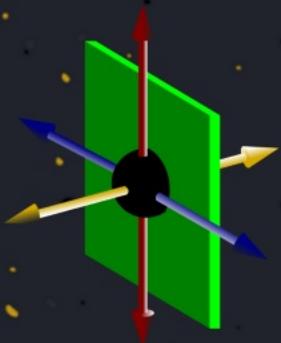




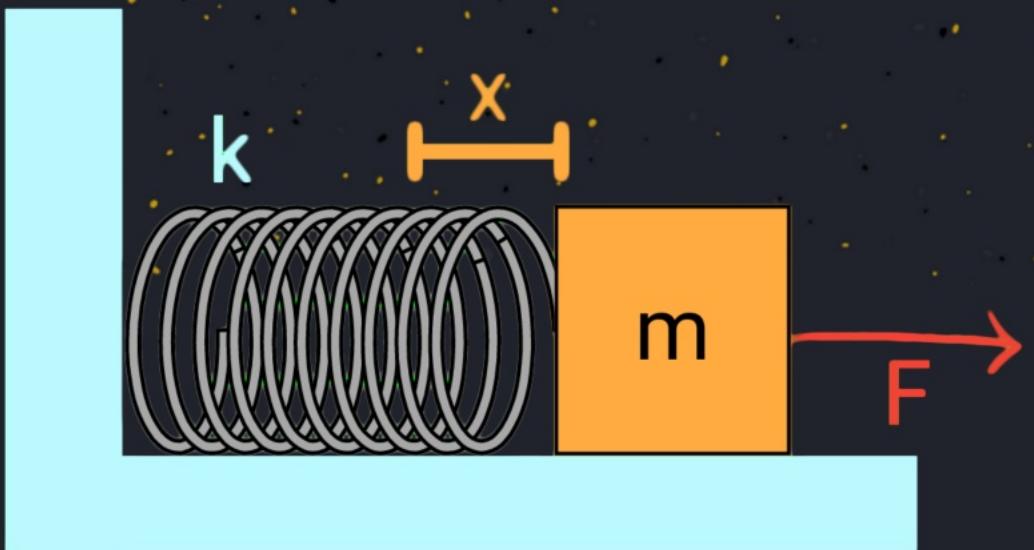
Accelerometer

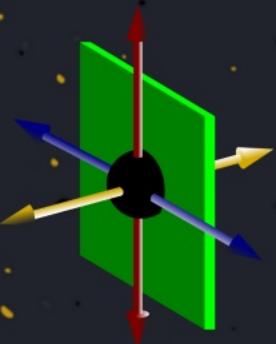


$$F = m \cdot a$$



Accelerometer

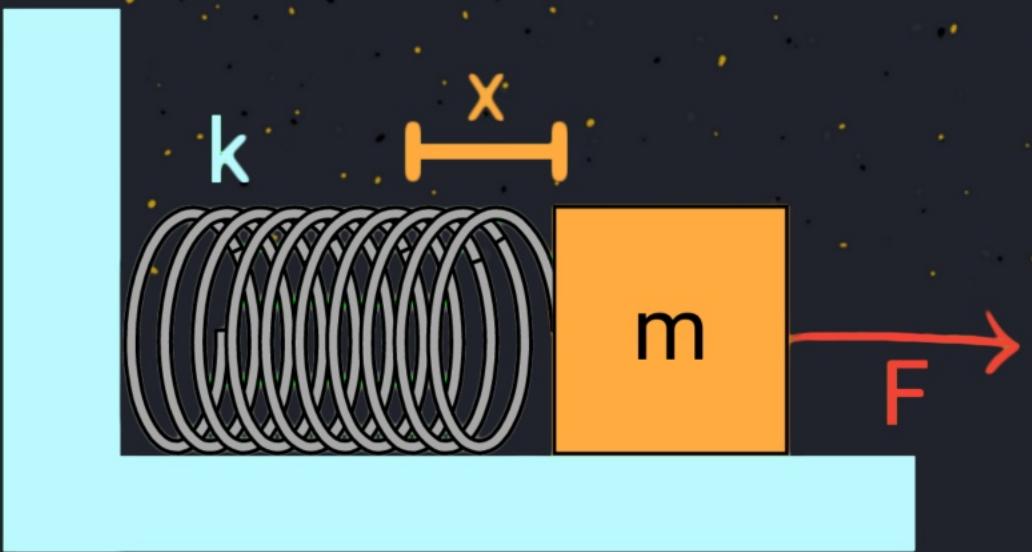


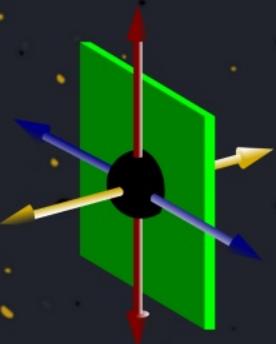


Accelerometer

$$F = m \cdot a$$

$$F = m \cdot a = F_S$$



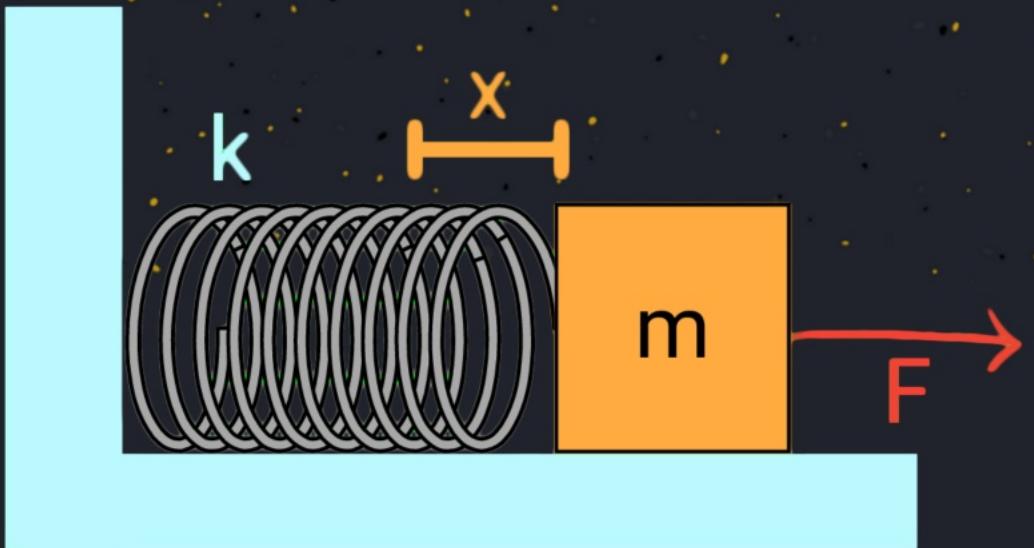


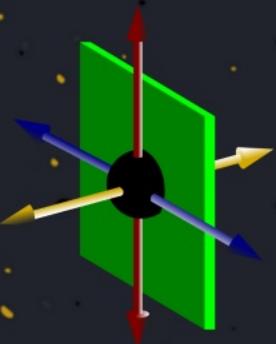
Accelerometer

$$F = m \cdot a$$

$$F = m \cdot a = F_S$$

$$F_S = k \cdot x$$





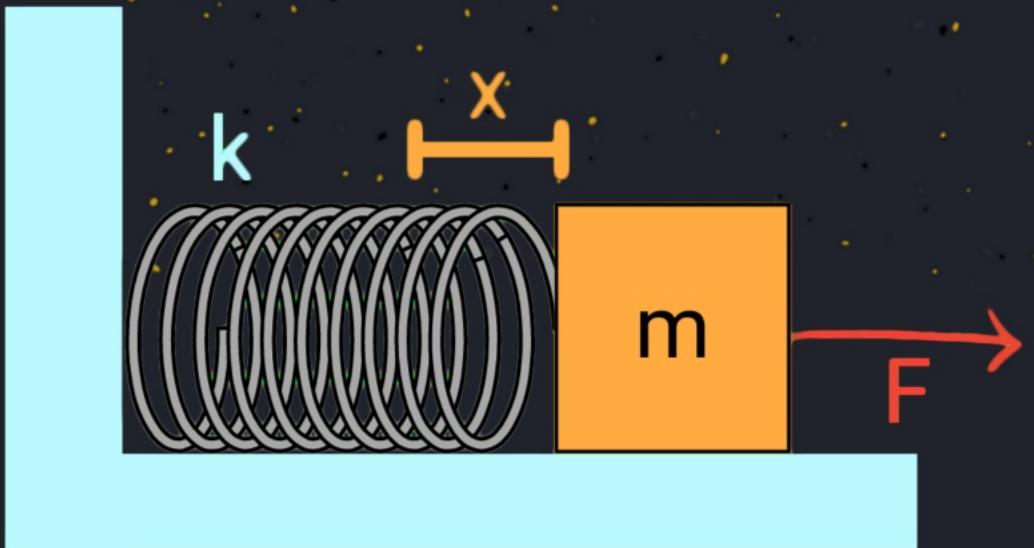
Accelerometer

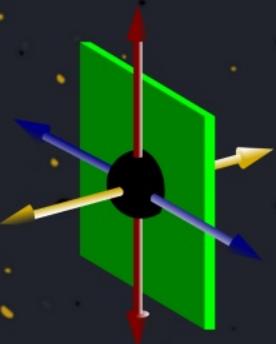
$$F = m \cdot a$$

$$F = m \cdot a = F_S$$

$$F_S = k \cdot x$$

$$m \cdot a = k \cdot x$$





Accelerometer

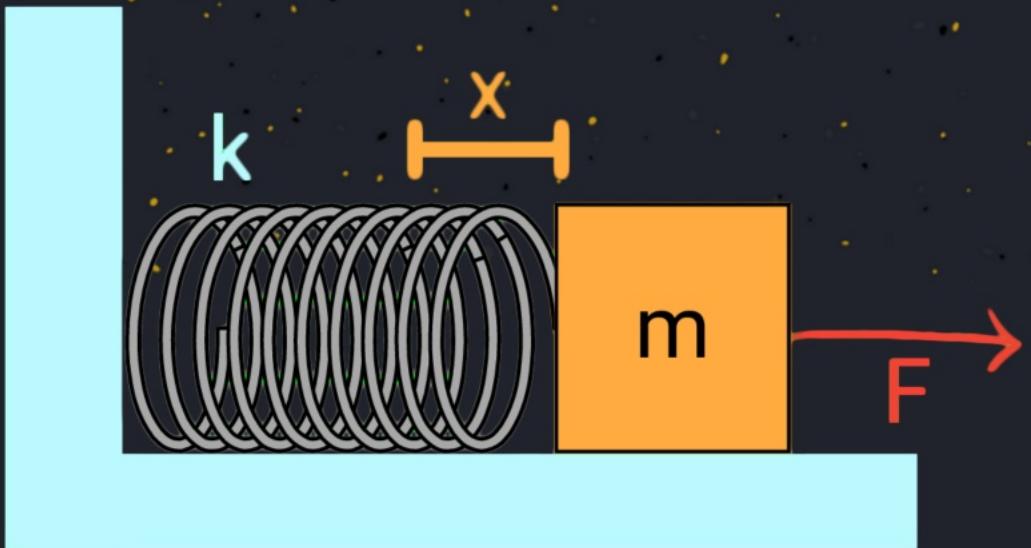
$$F = m \cdot a$$

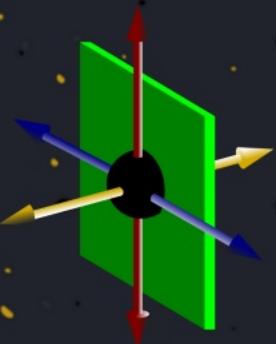
$$F = m \cdot a = F_S$$

$$F_S = k \cdot x$$

$$m \cdot a = k \cdot x$$

$$a = \frac{k}{m} \cdot x$$





Accelerometer

$$F = m \cdot a$$

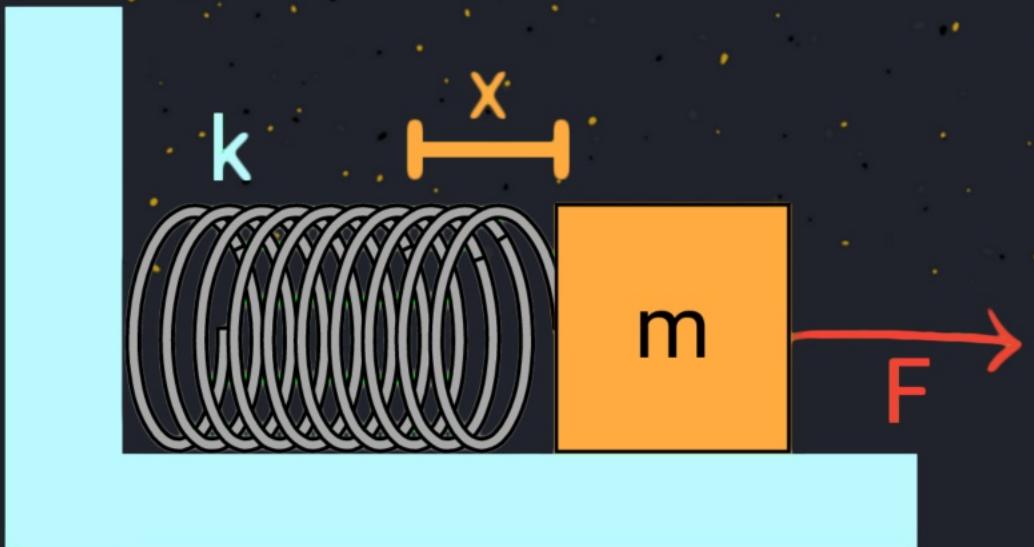
$$F = m \cdot a = F_S$$

$$F_S = k \cdot x$$

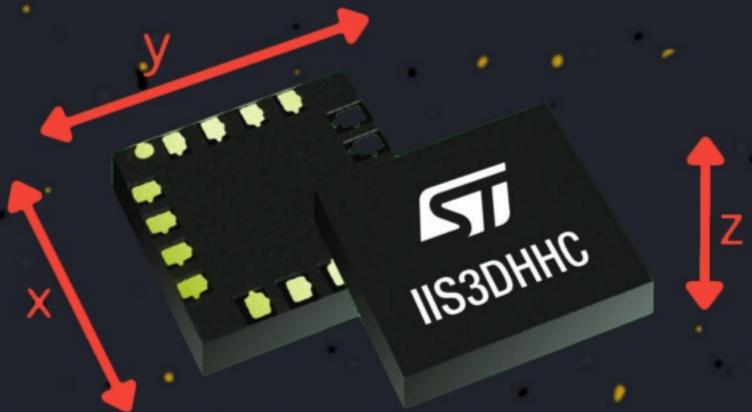
$$m \cdot a = k \cdot x$$

$$a = \frac{k}{m} \cdot x$$

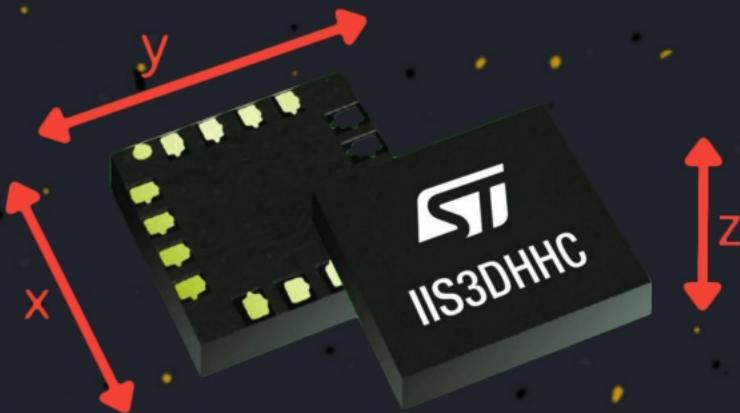
$$a = f(x)$$



Accelerometer



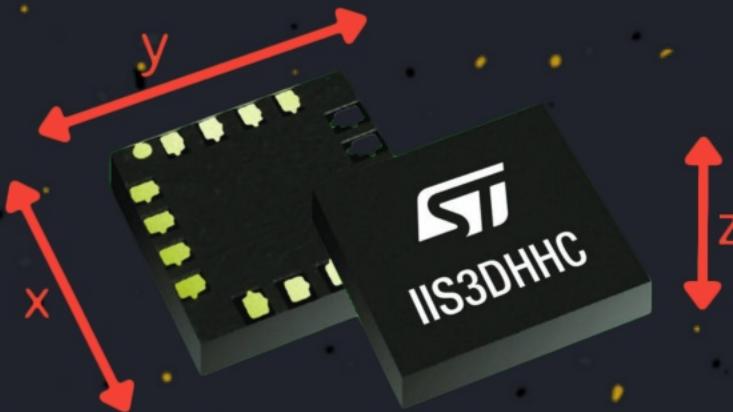
Accelerometer



Gyroscope



Accelerometer

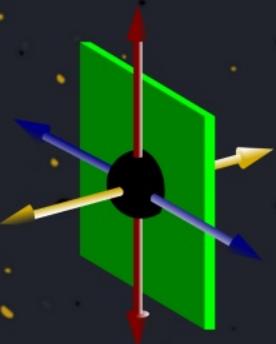


Gyroscope



Inertial Measurement Unit (IMU)





Accelerometer

$$F = m \cdot a$$

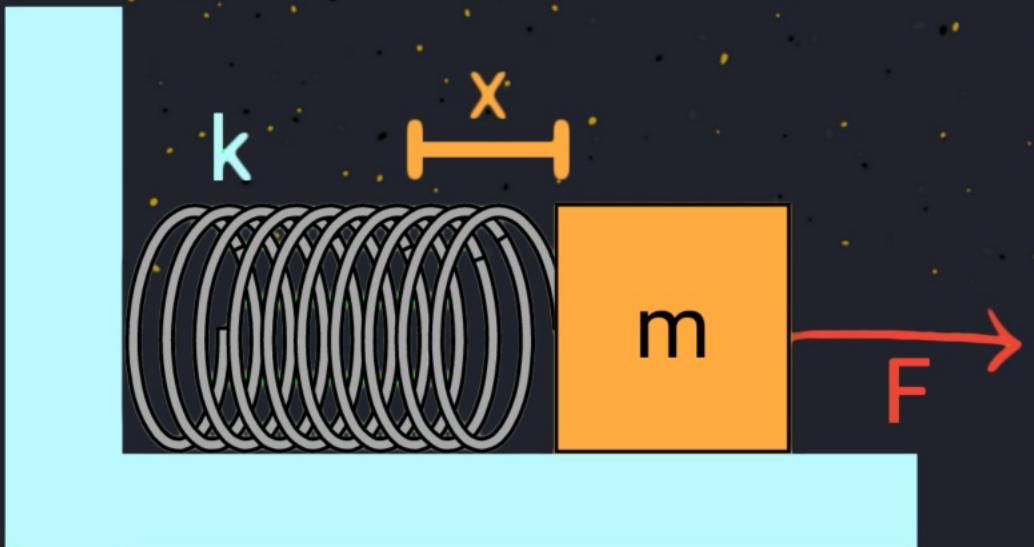
$$F = m \cdot a = F_S$$

$$F_S = k \cdot x$$

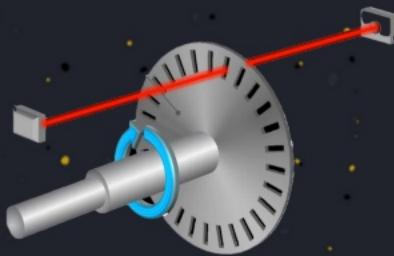
$$m \cdot a = k \cdot x$$

$$a = \frac{k}{m} \cdot x$$

$$a = f(x)$$



Sensor Fusion



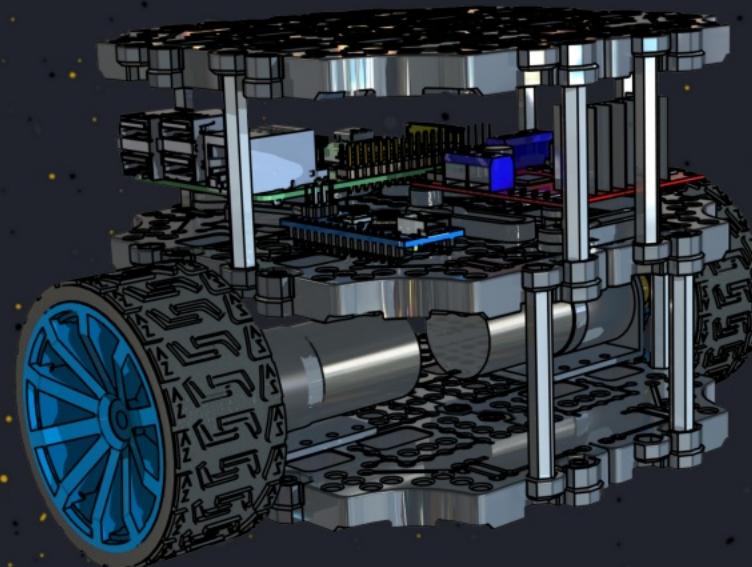
Encoder



Gyroscope



Accelerometer



GPS



Laser



Camera

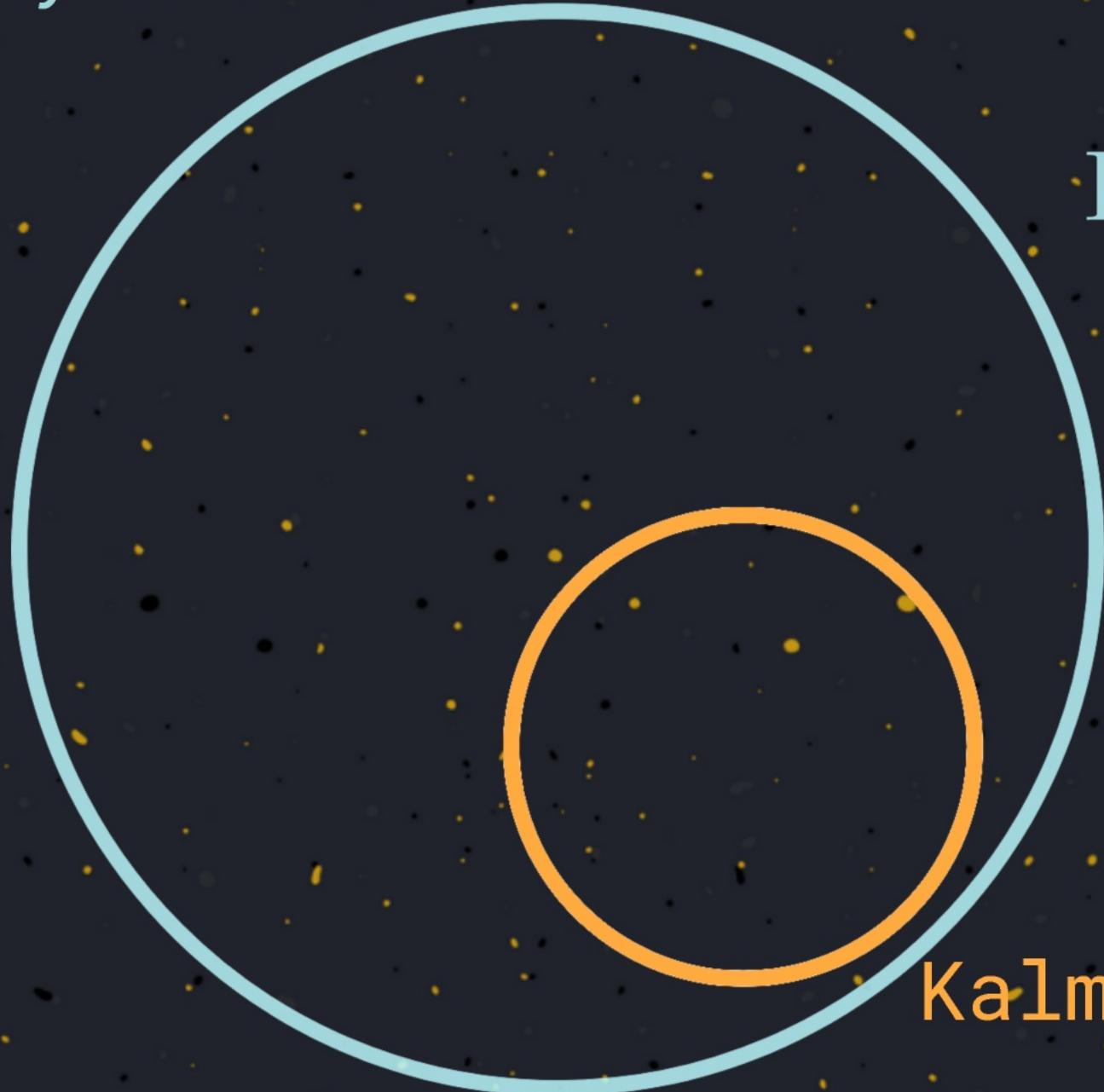
Bayes Filters



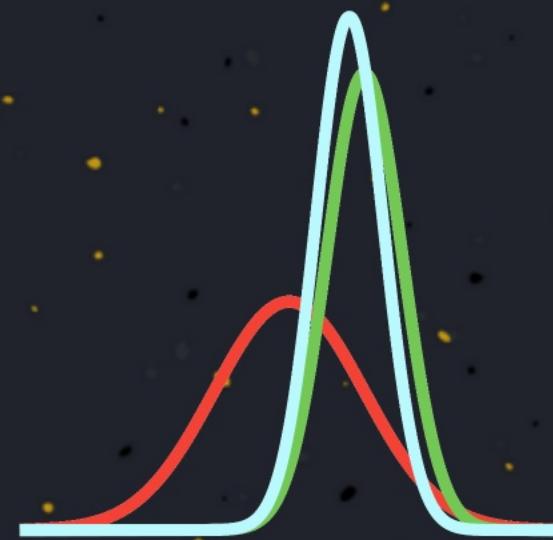
$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)}$$

Kalman Filter

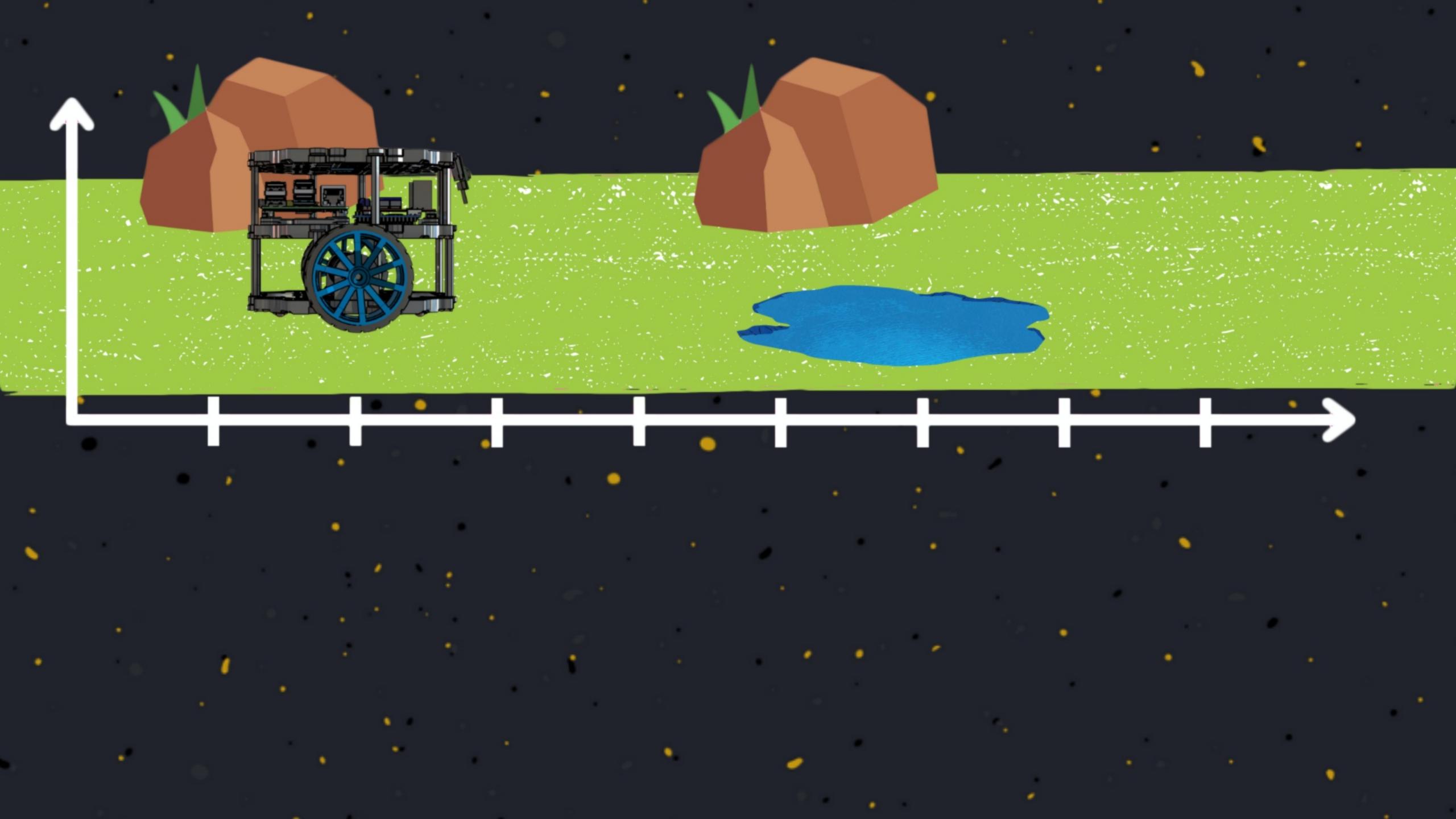
Bayes Filters

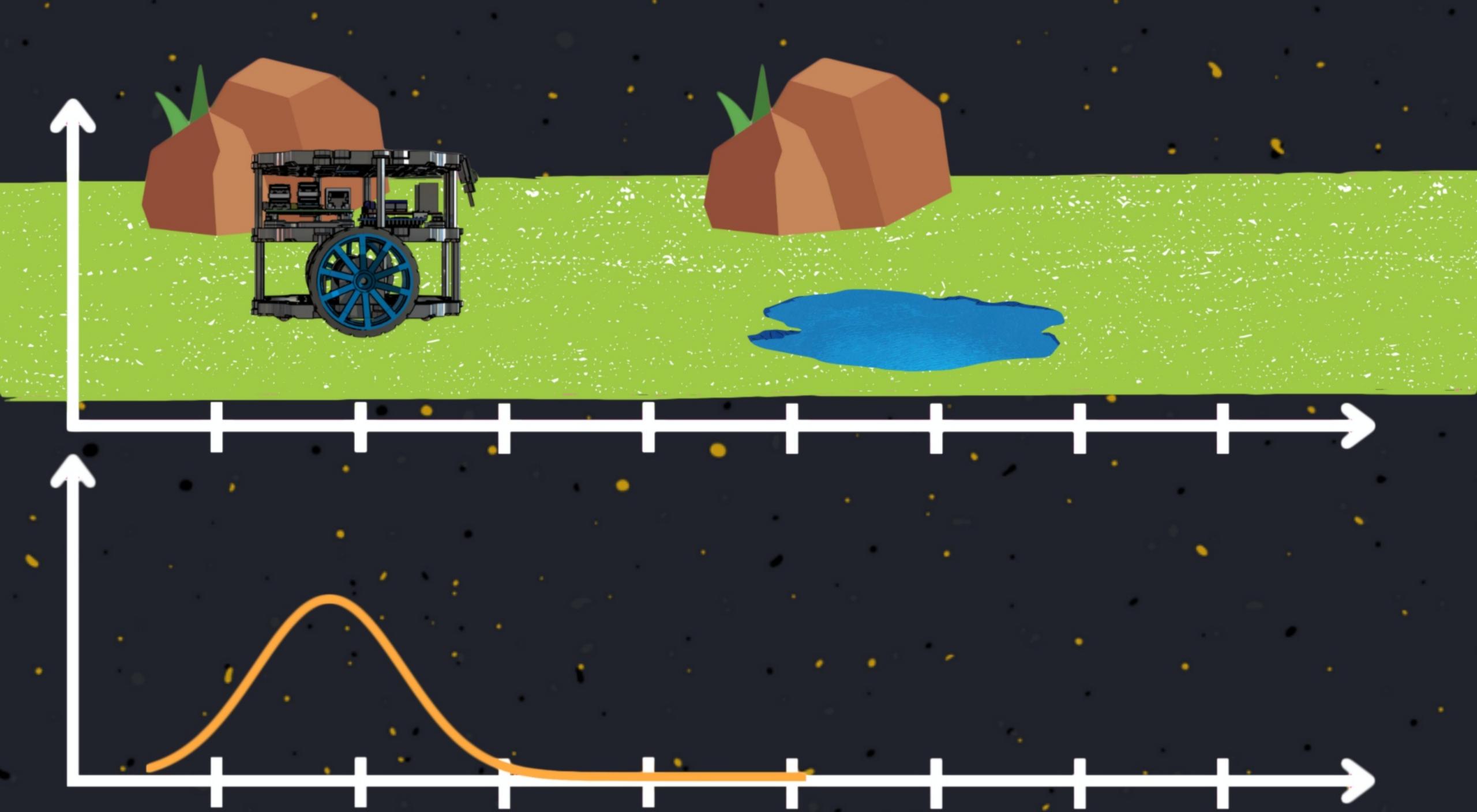


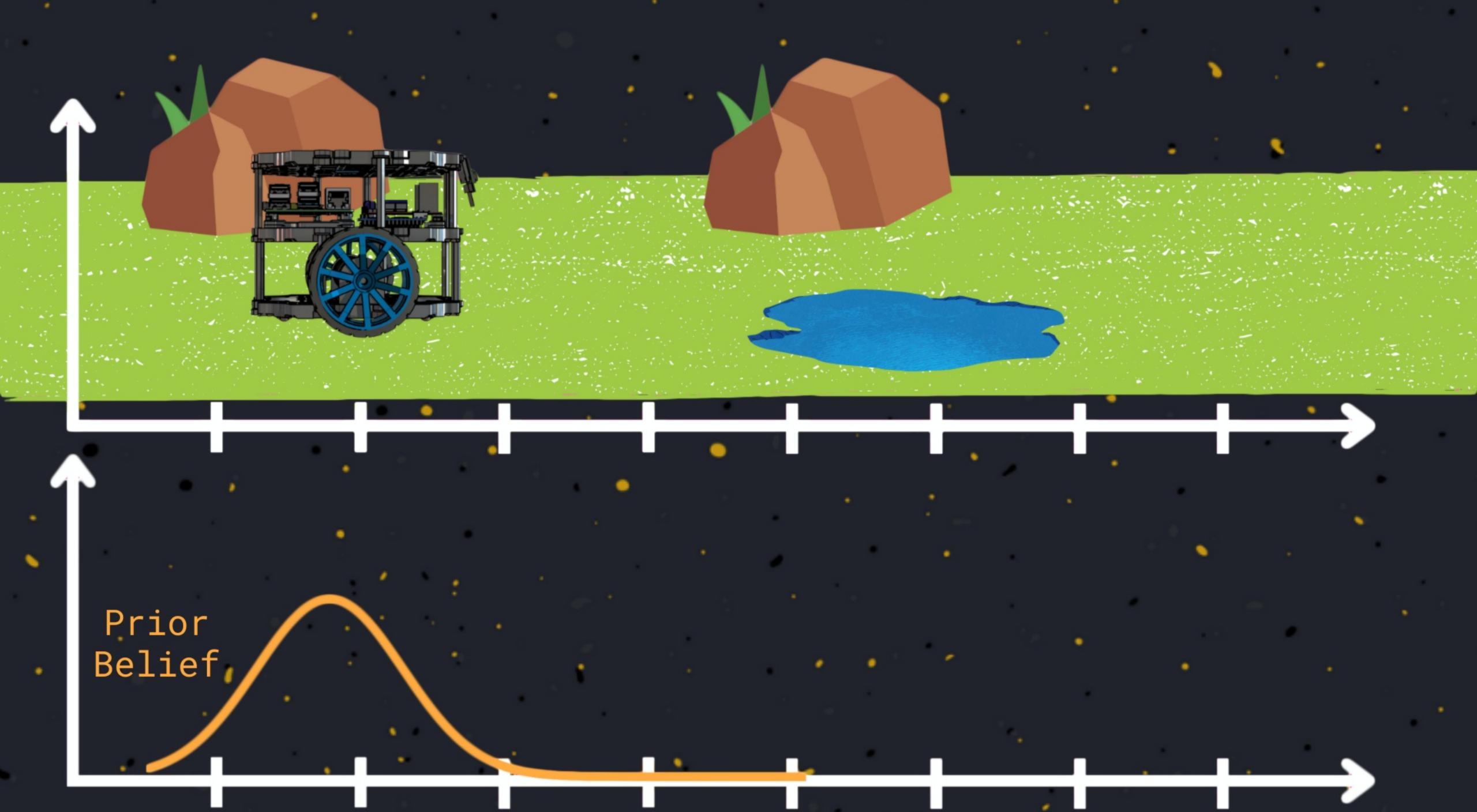
$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)}$$

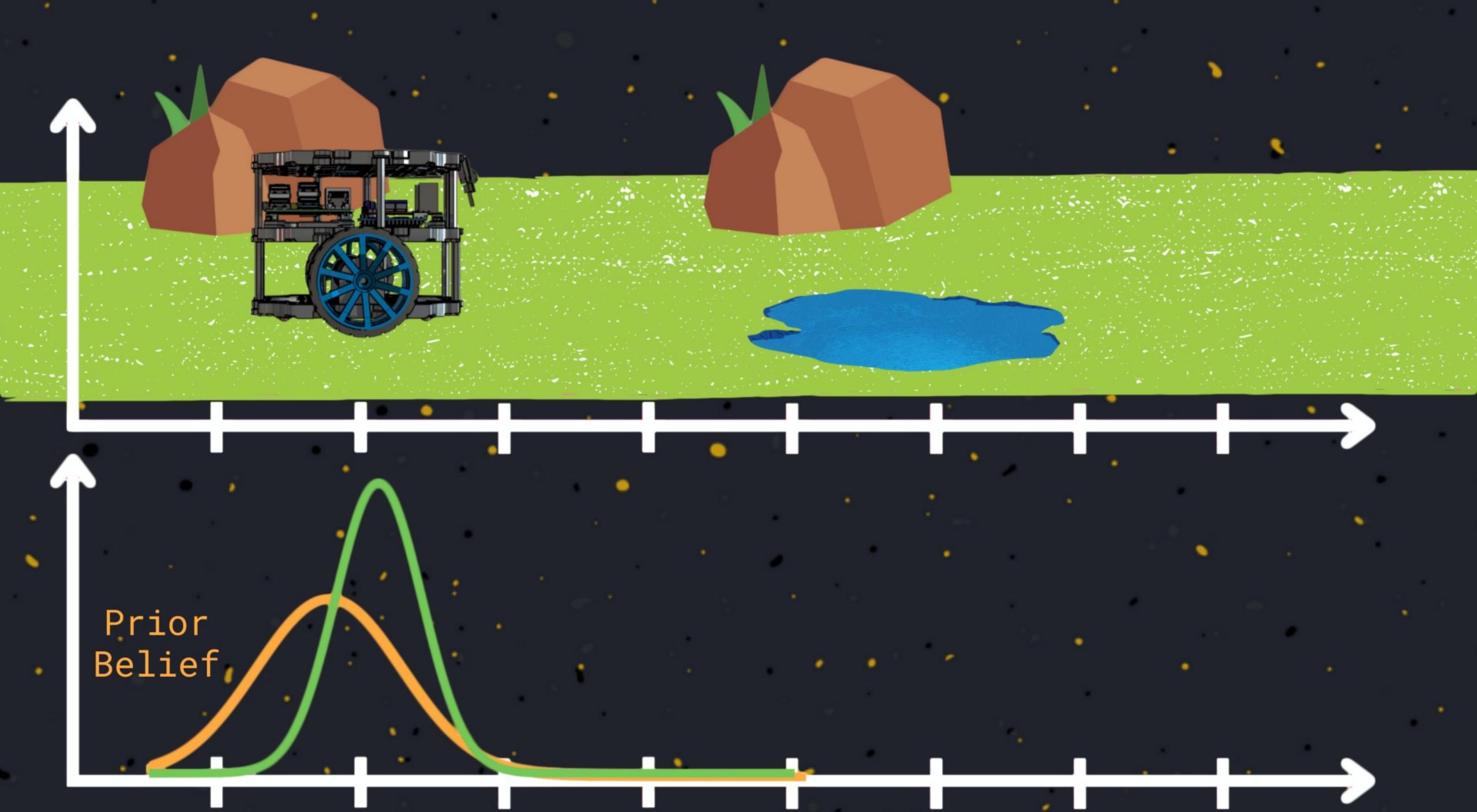


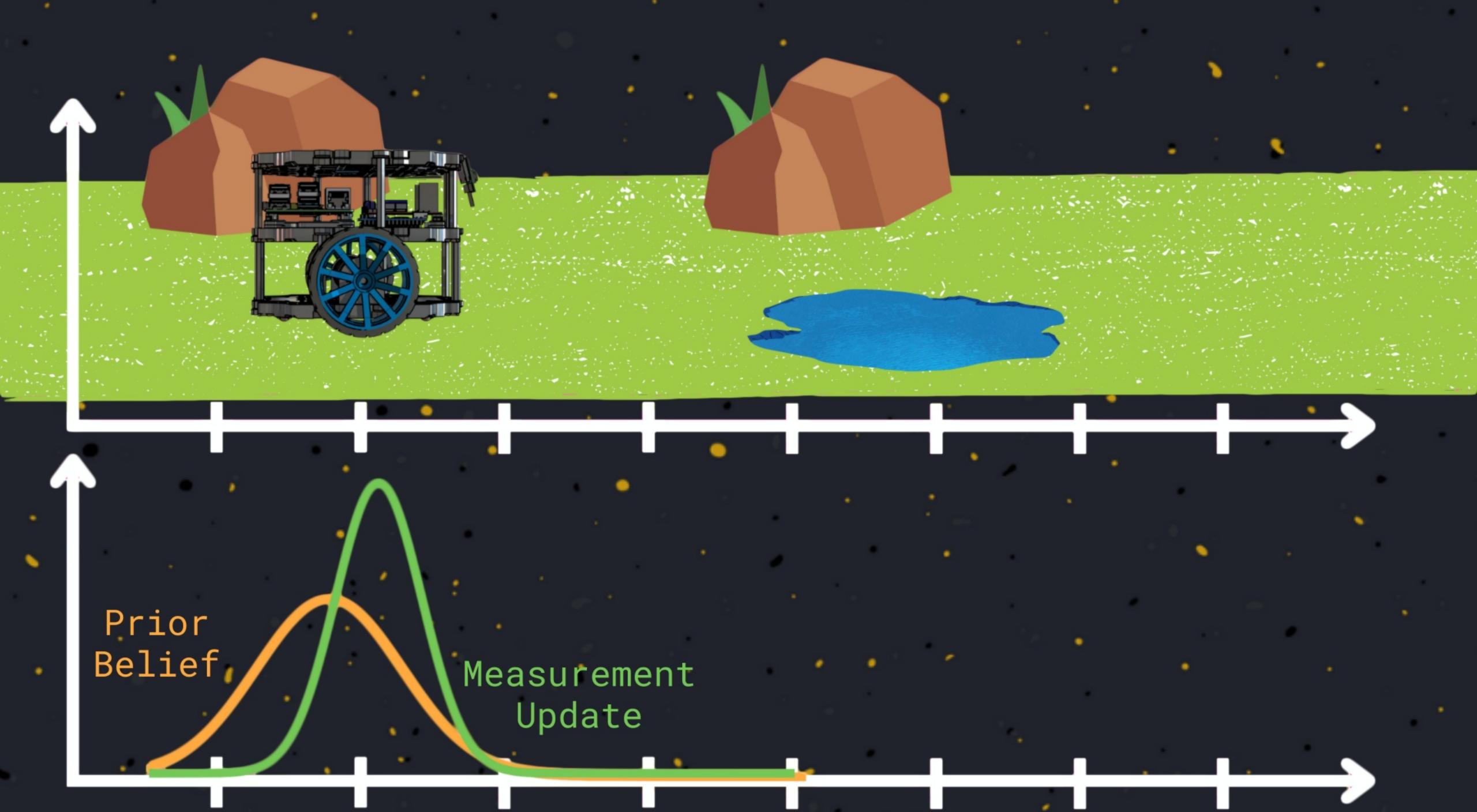
Kalman Filter

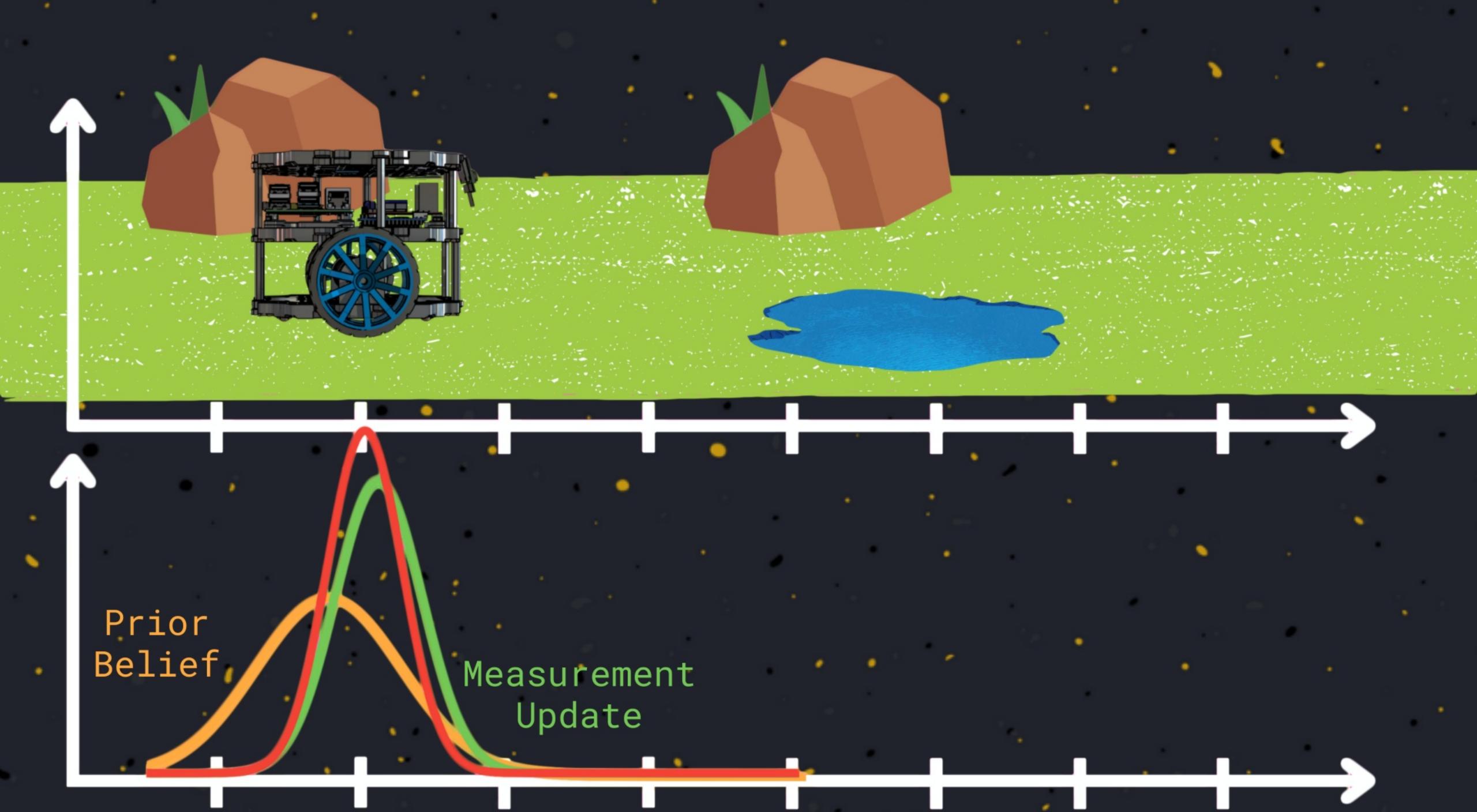


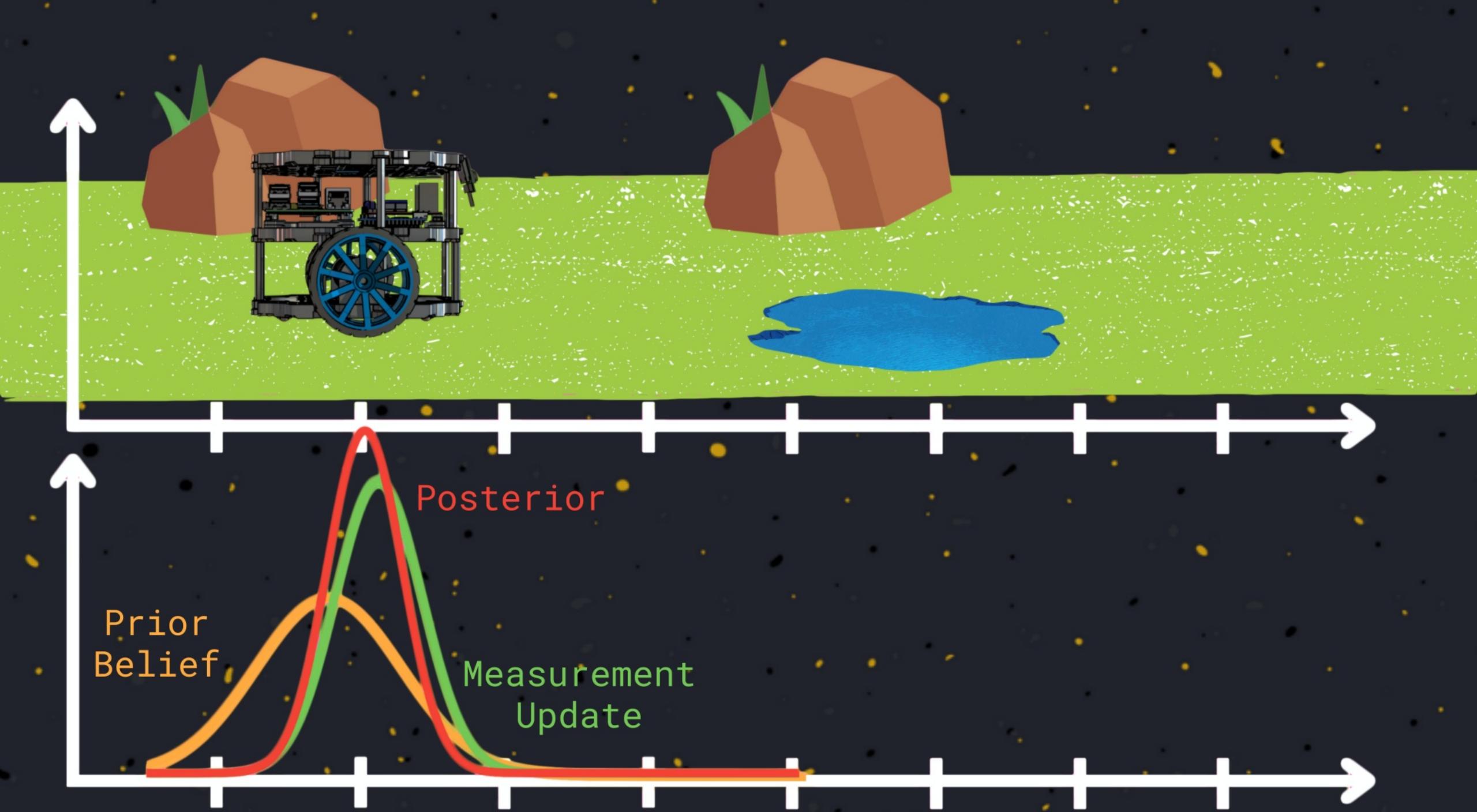


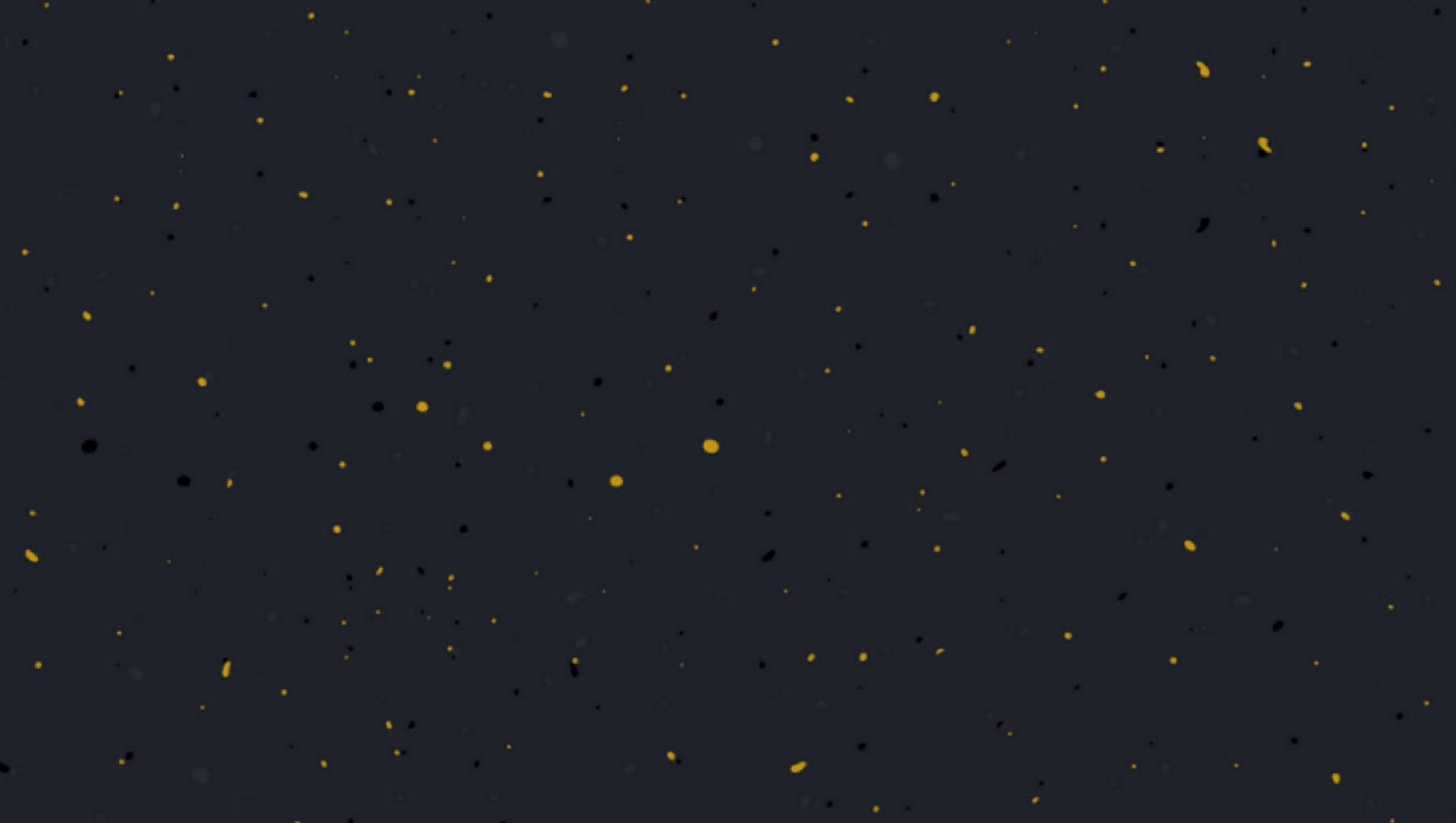


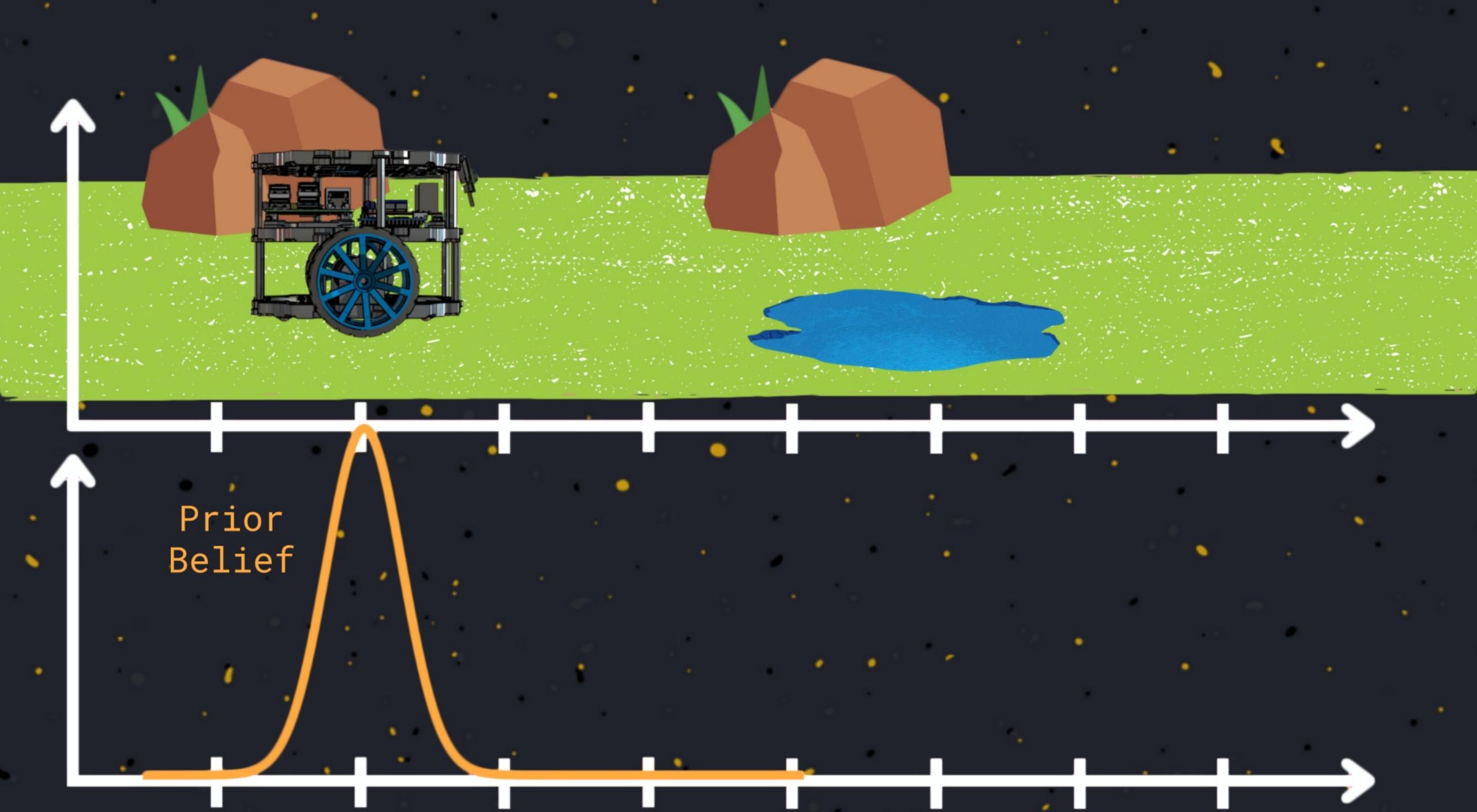


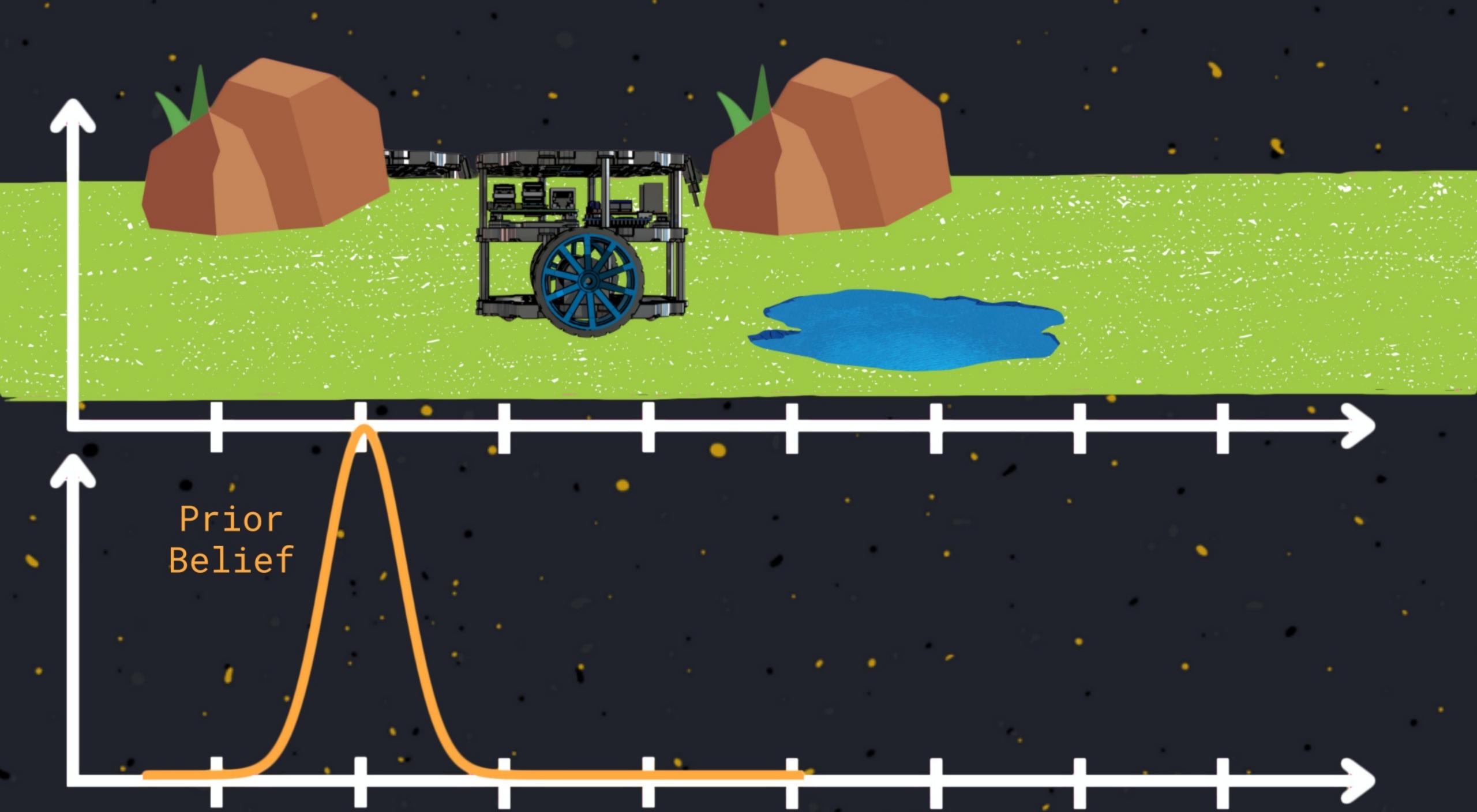


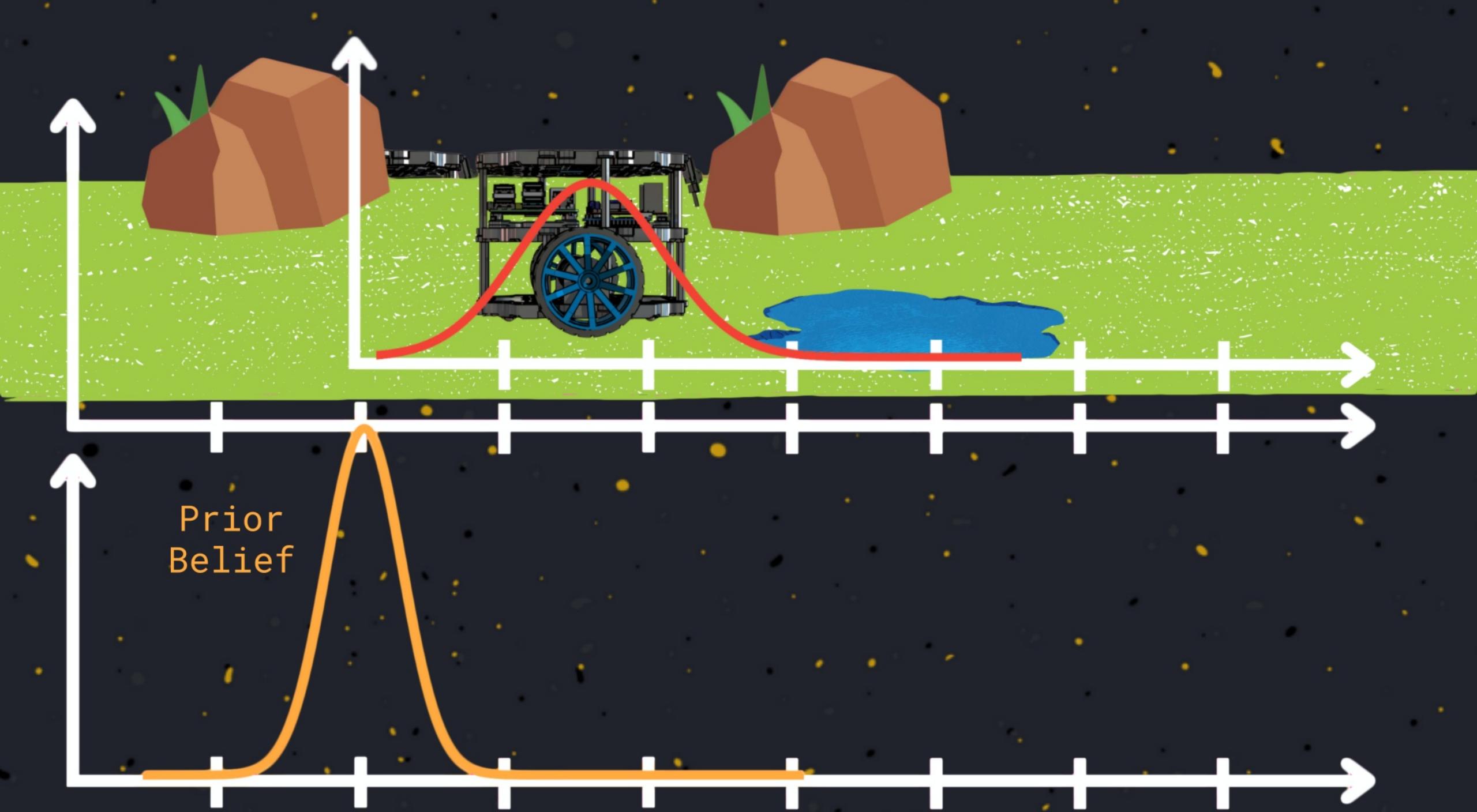


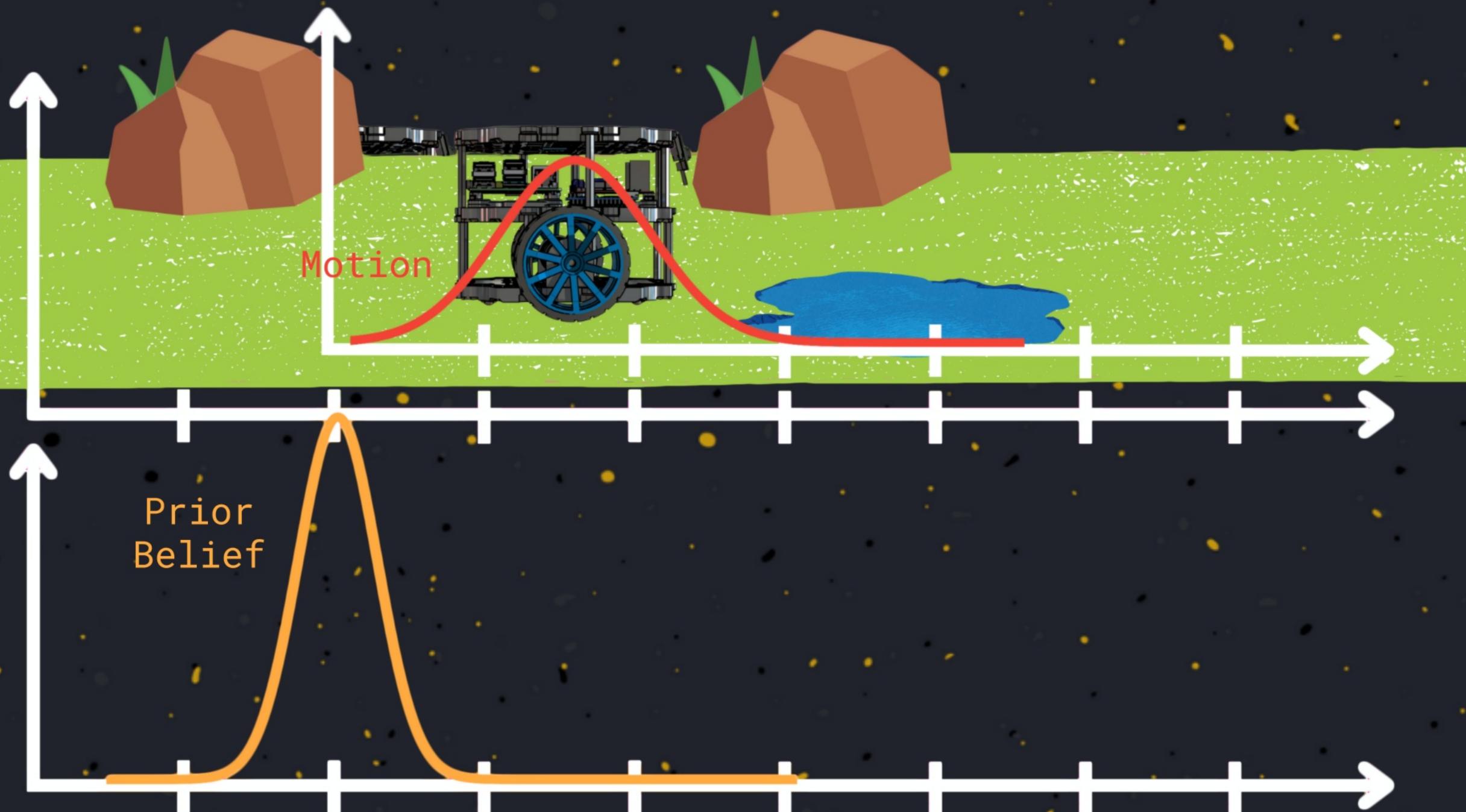


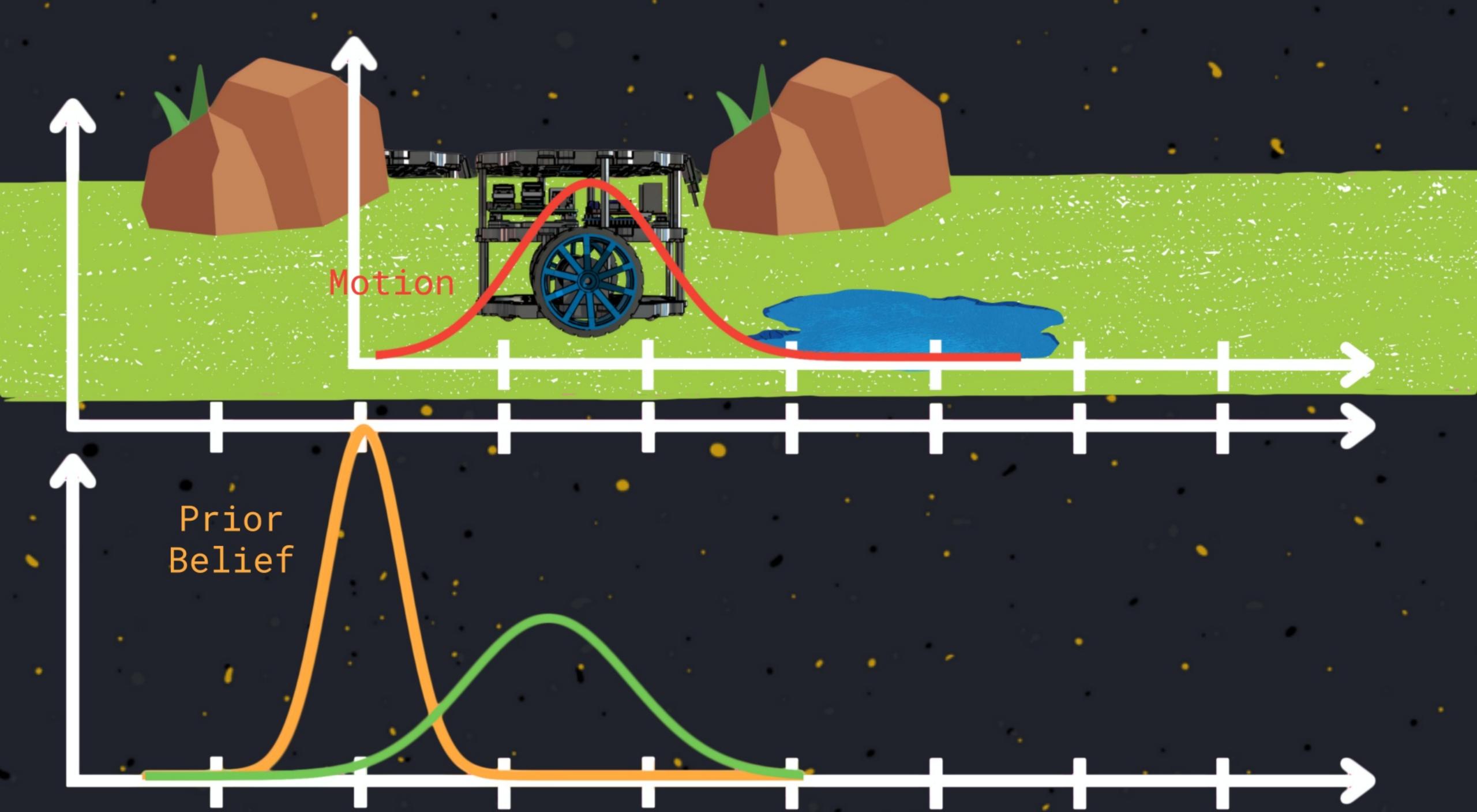


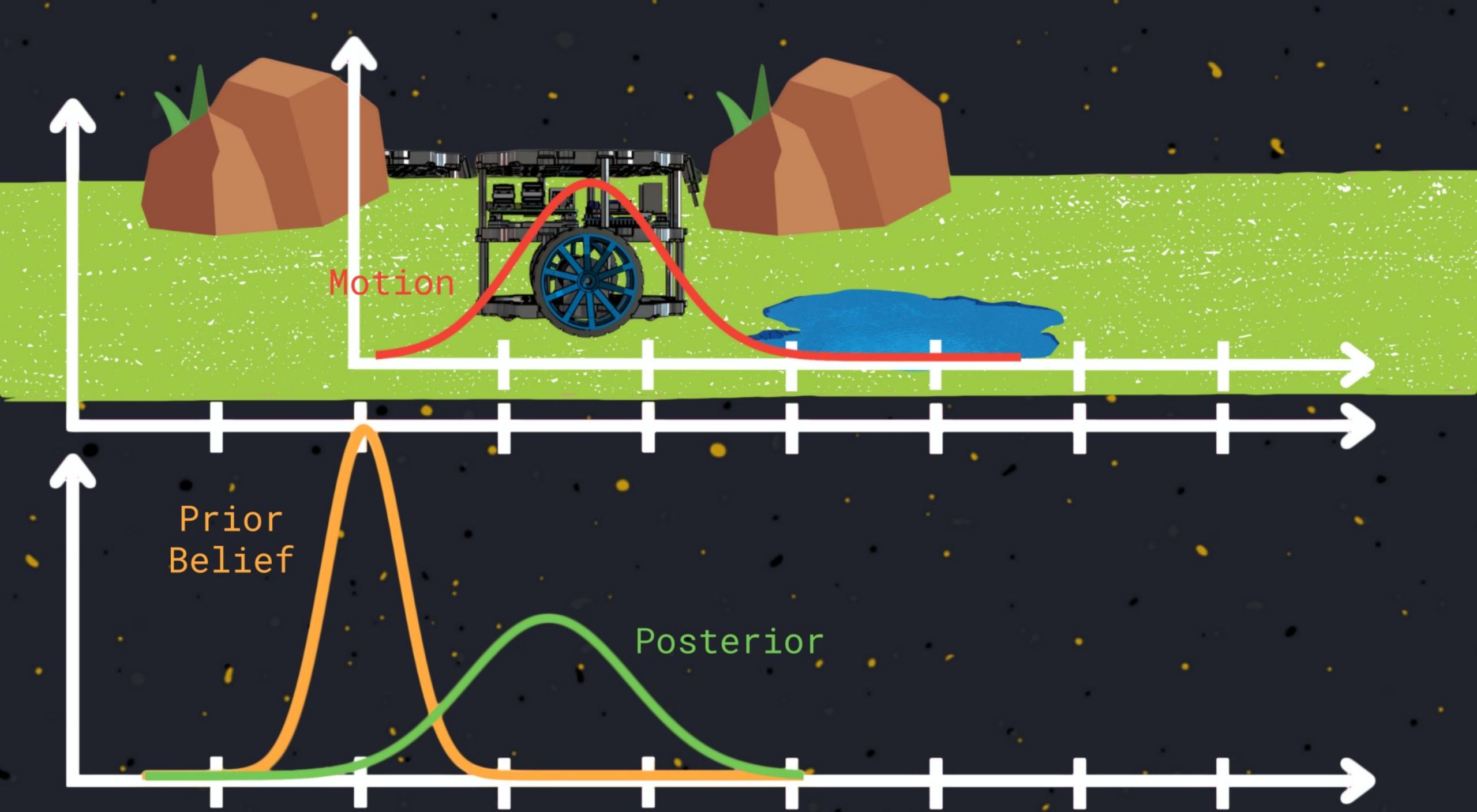












Initial Estimate

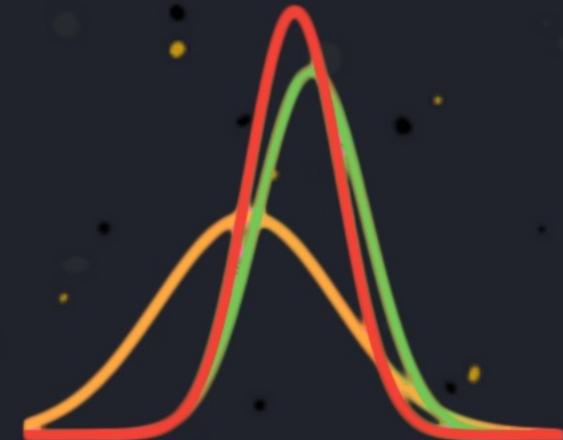


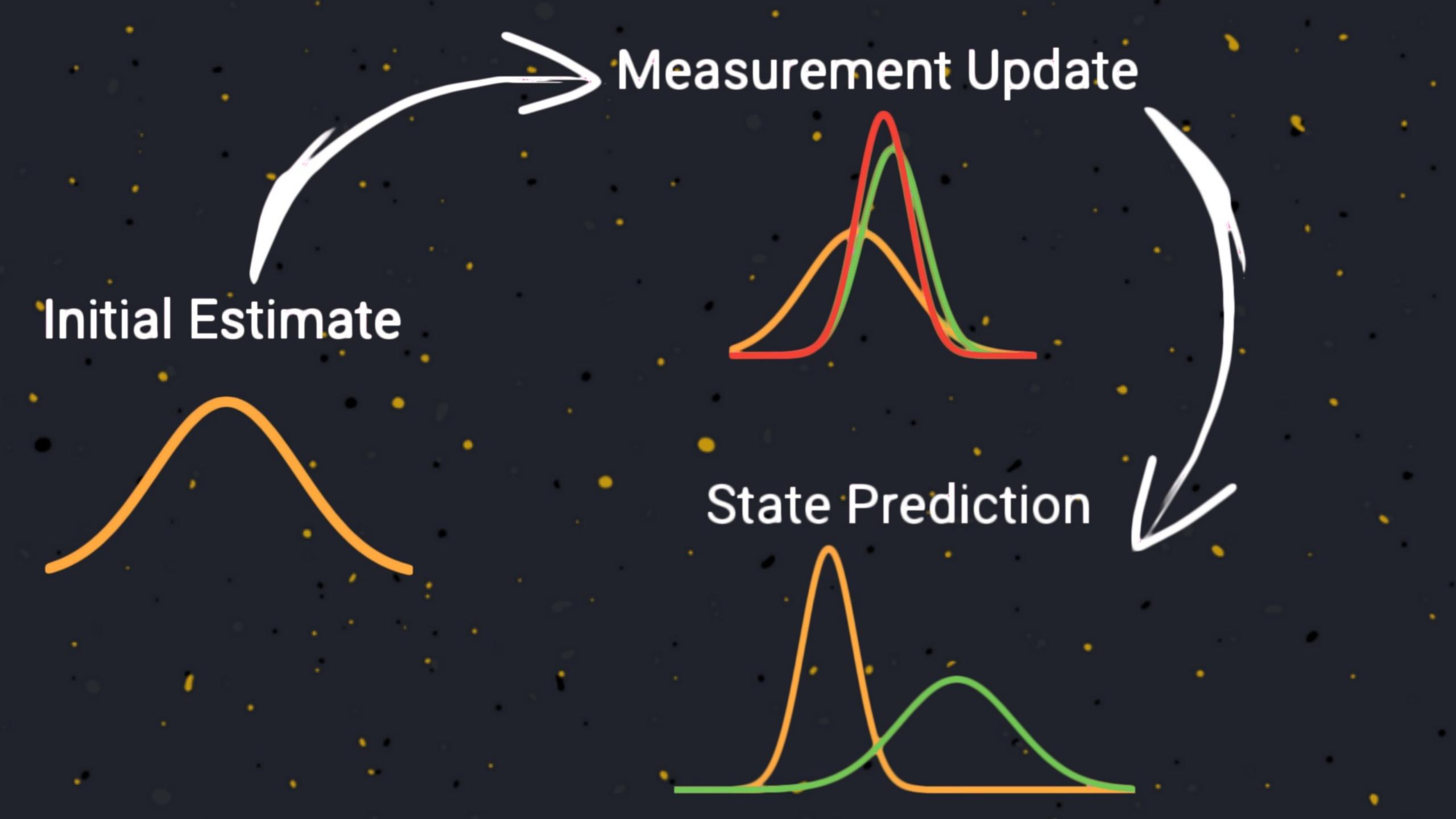


Initial Estimate



Measurement Update



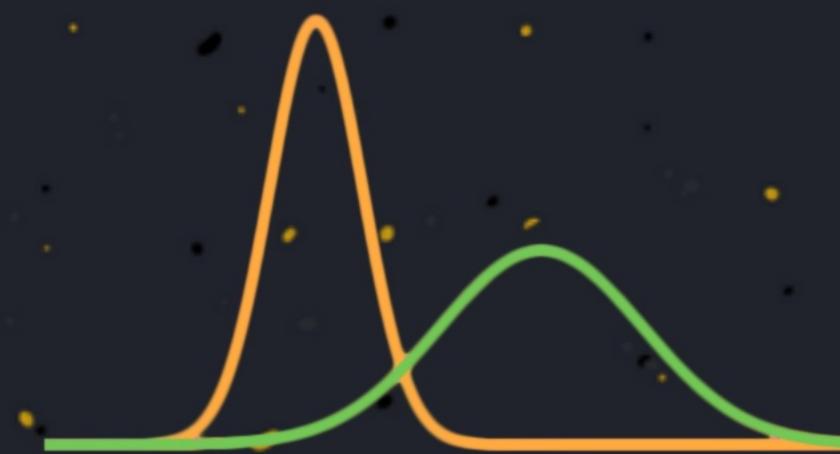


Measurement Update

Initial Estimate



State Prediction

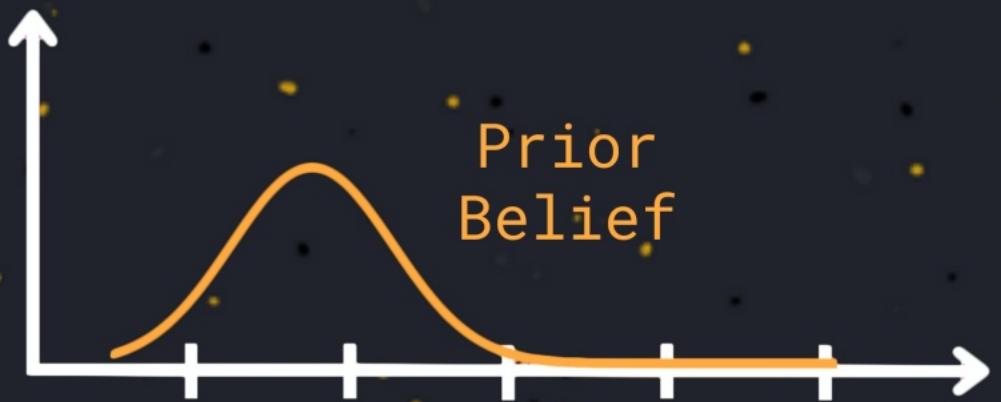


Measurement Update

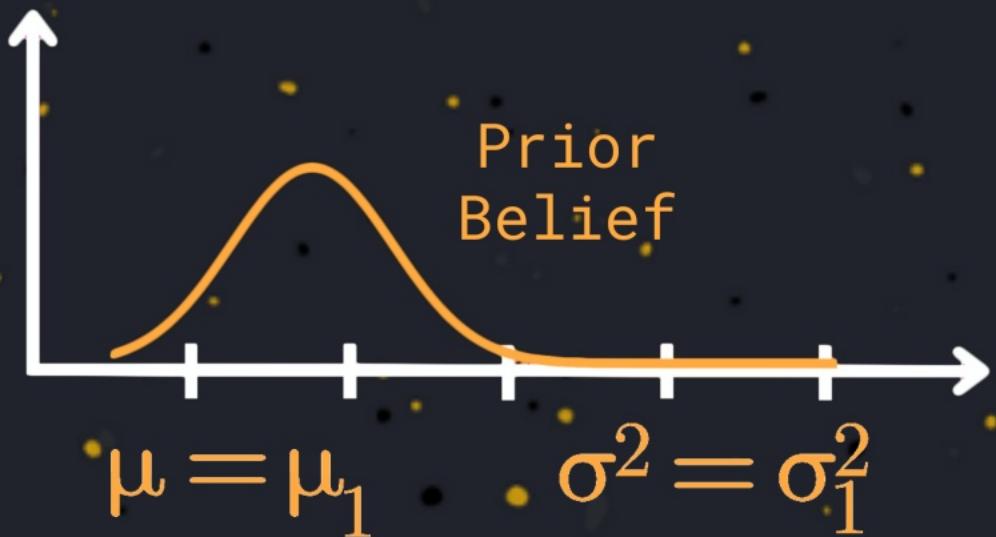
Initial Estimate

State Prediction

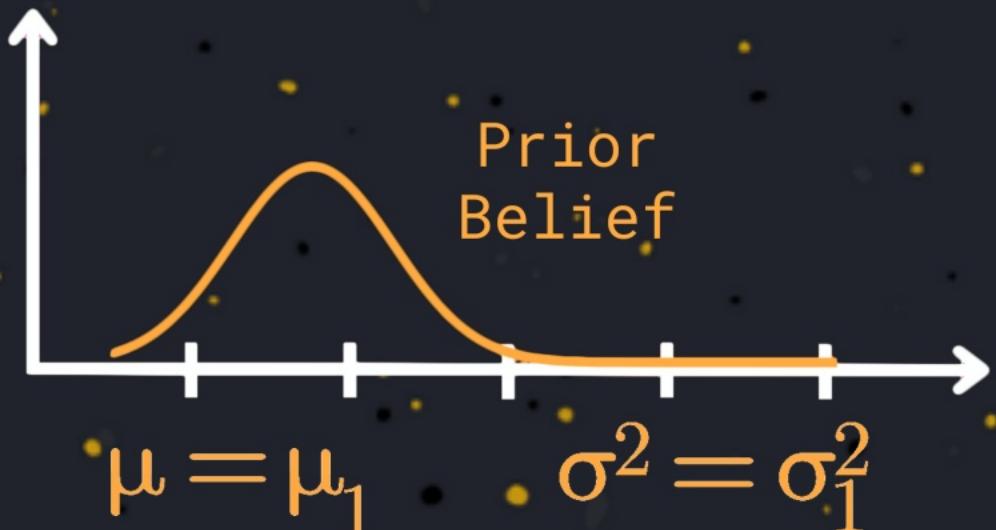
Measurement Update



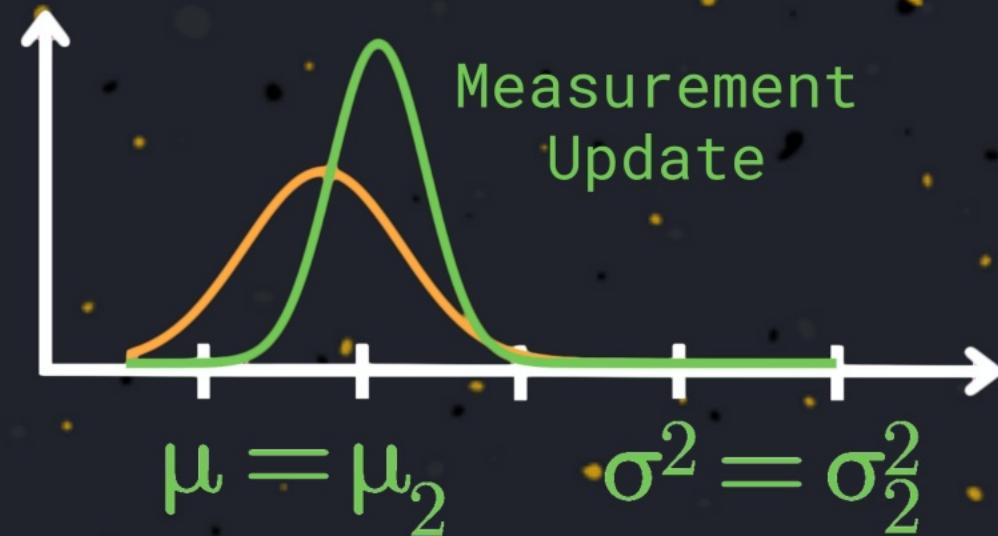
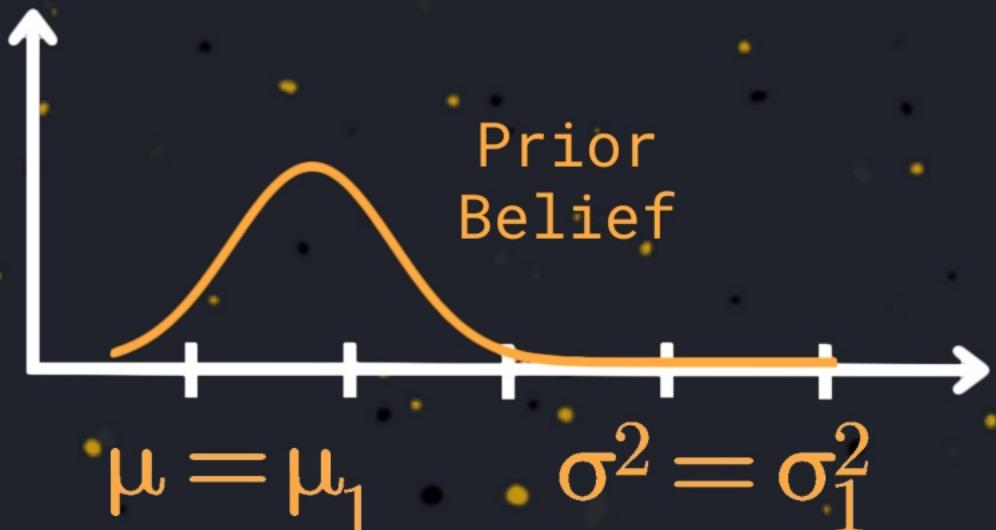
Measurement Update



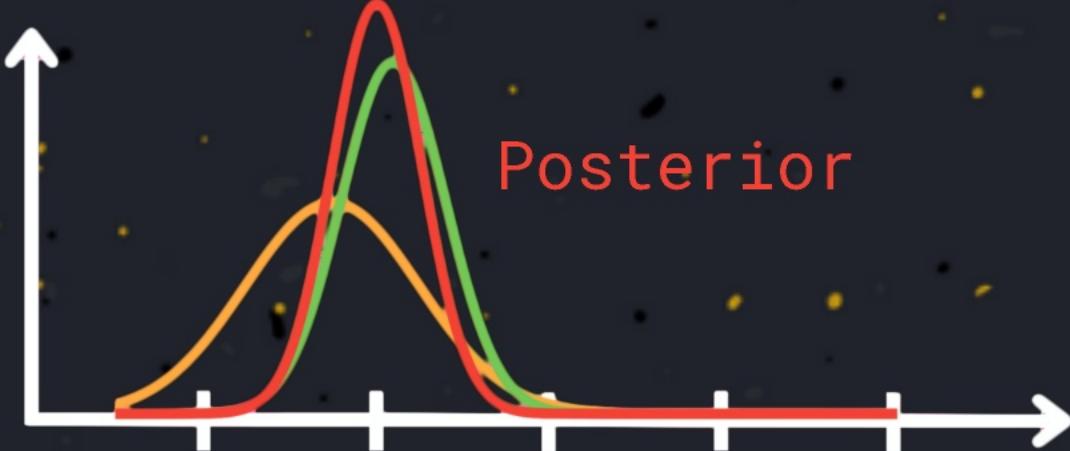
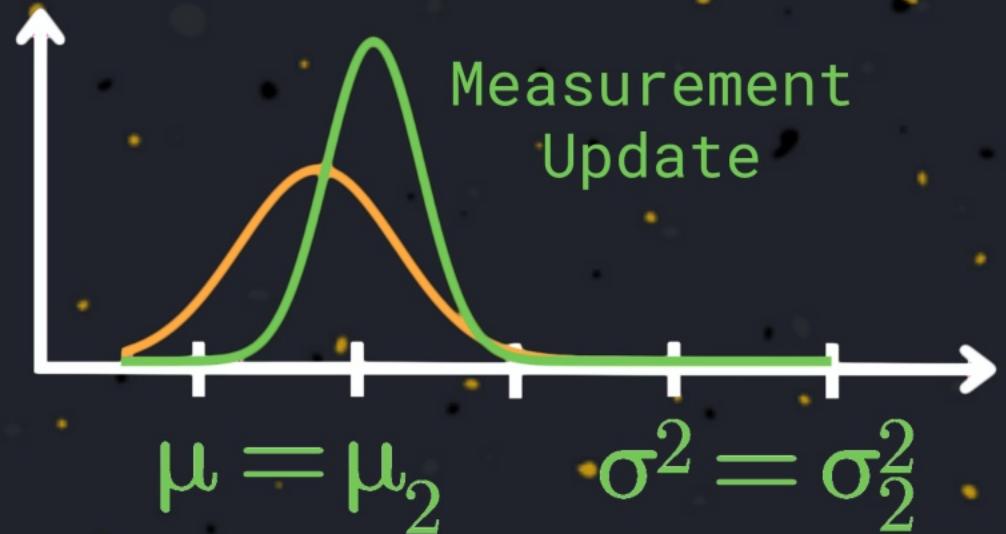
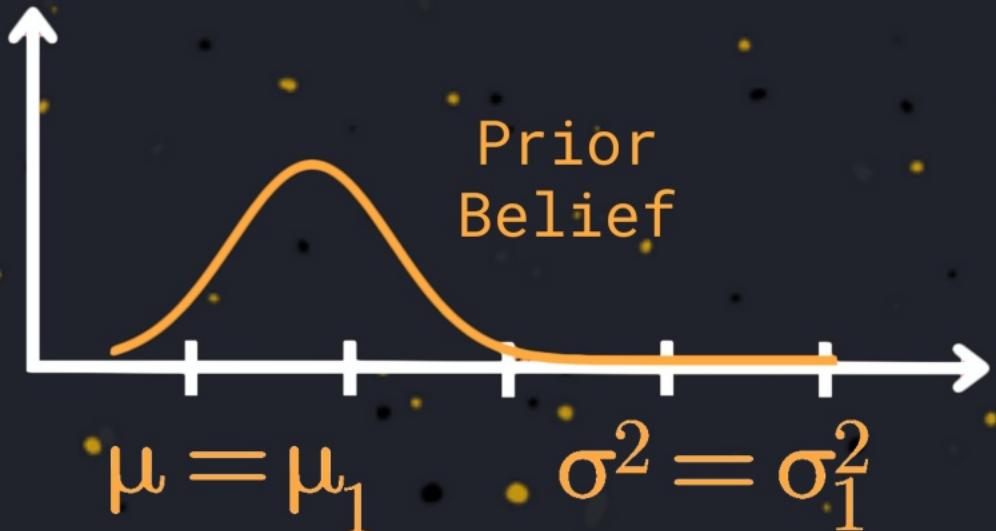
Measurement Update



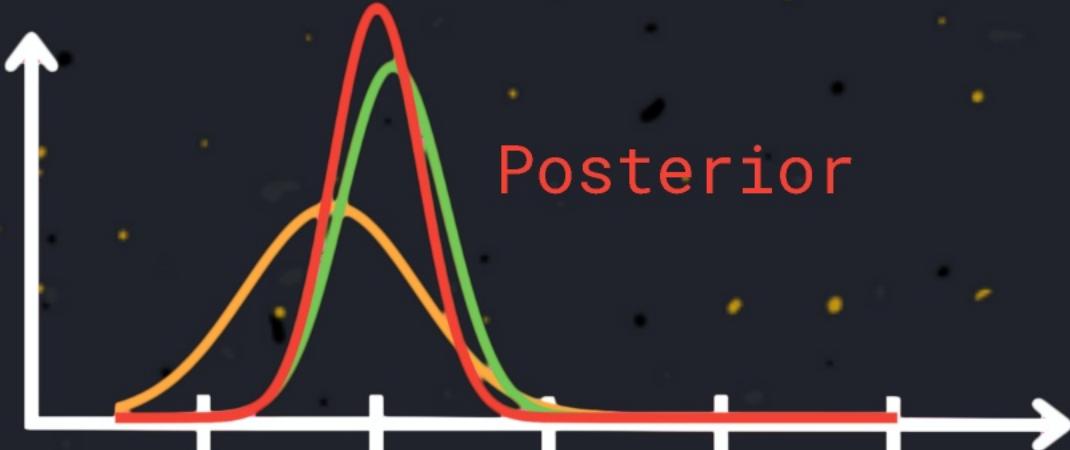
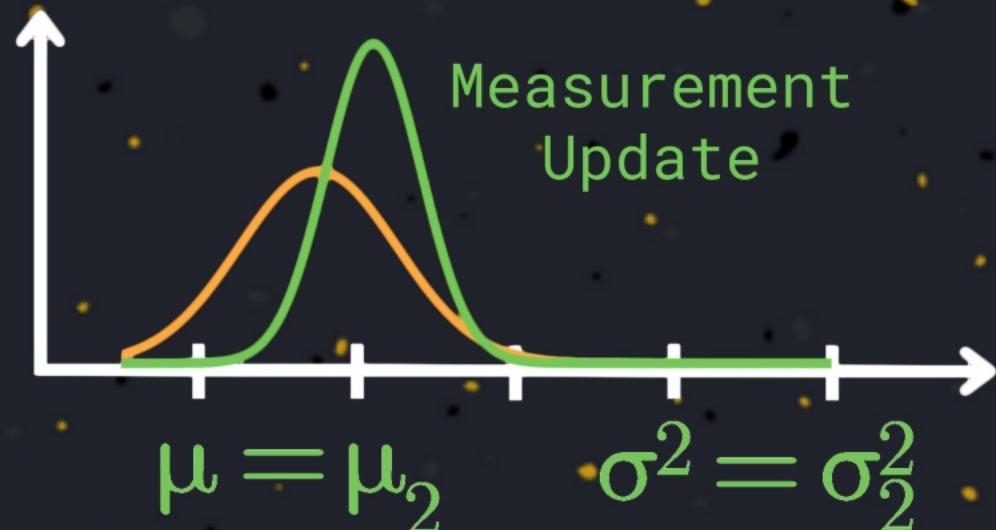
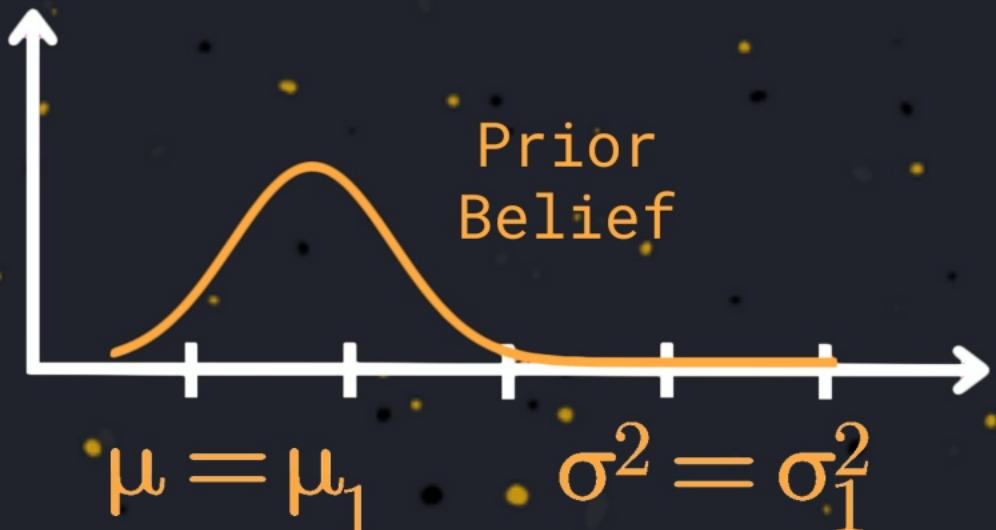
Measurement Update



Measurement Update



Measurement Update



$$\mu_3 = \frac{\sigma_2^2 \cdot \mu_1 + \sigma_1^2 \cdot \mu_2}{\sigma_2^2 + \sigma_1^2}$$

$$\sigma_3^2 = \frac{1}{\frac{1}{\sigma_2^2} + \frac{1}{\sigma_1^2}}$$

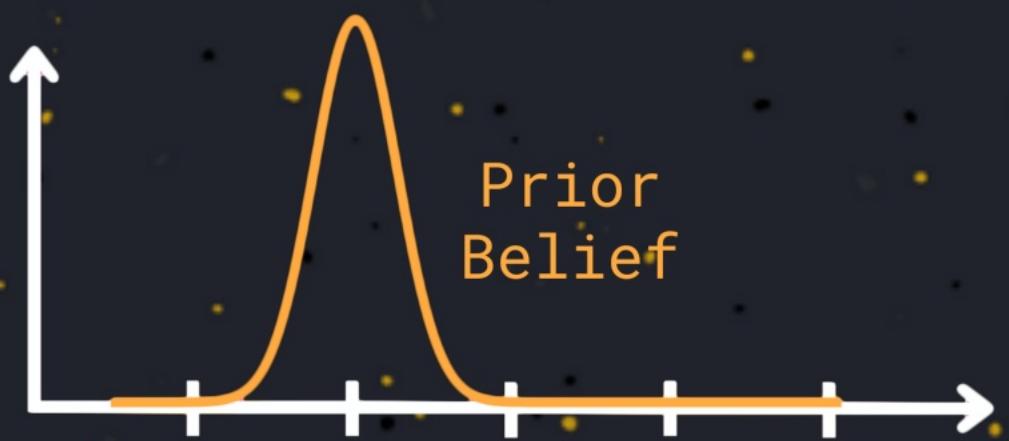
Measurement Update

Initial Estimate

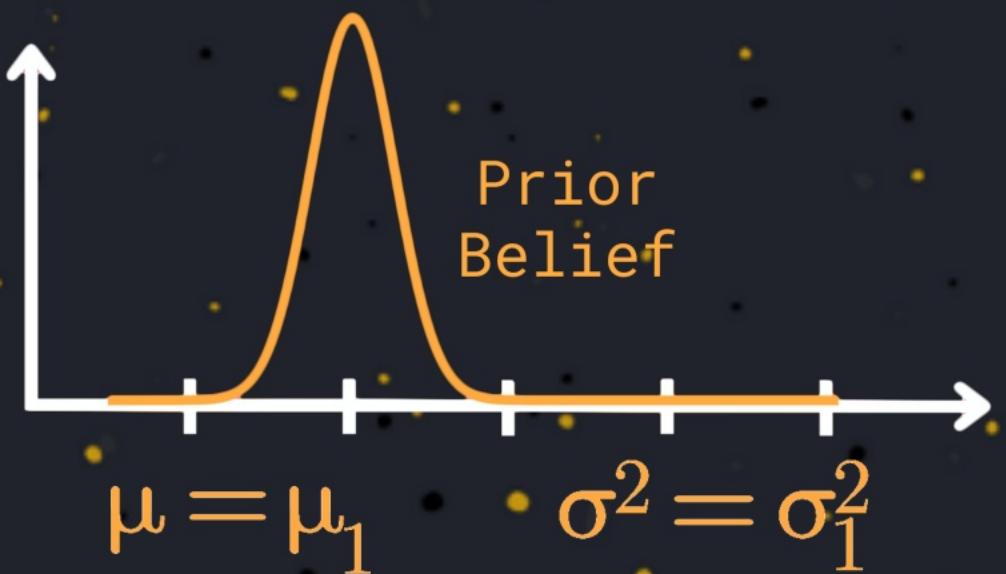
State Prediction



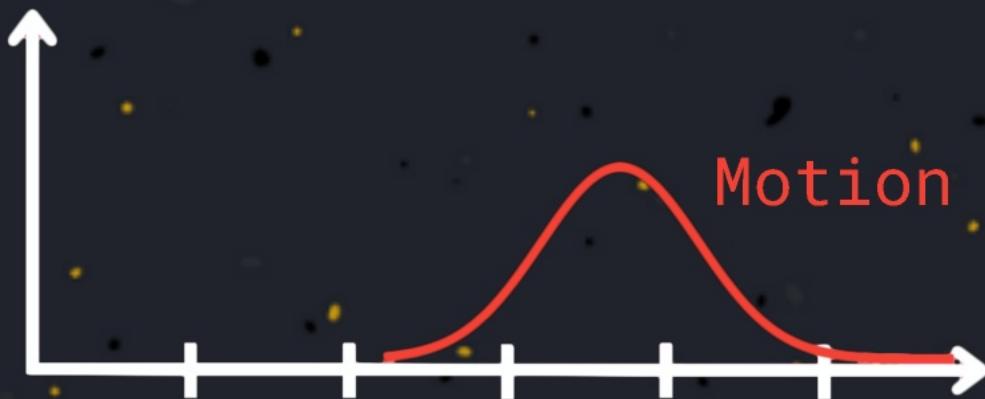
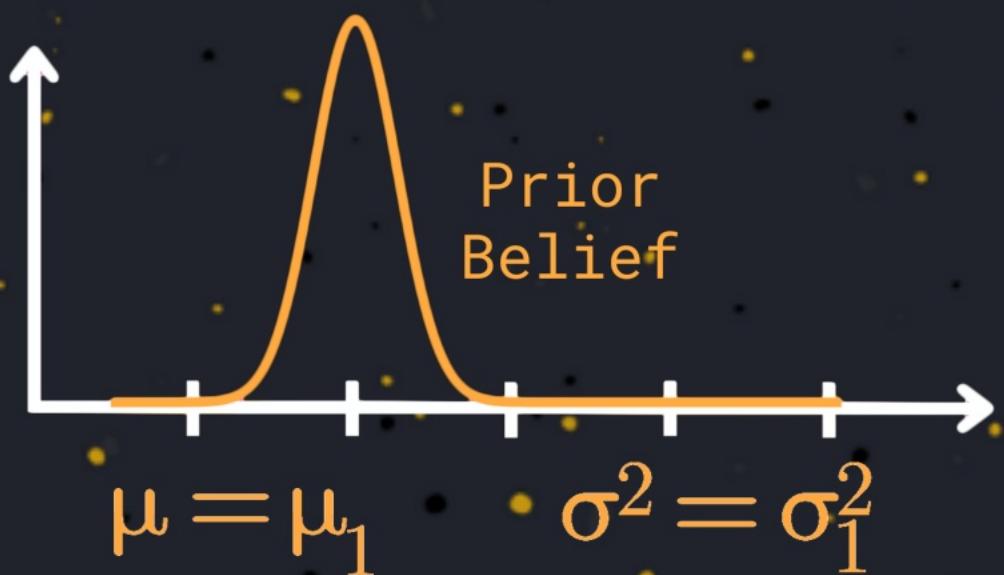
State Prediction



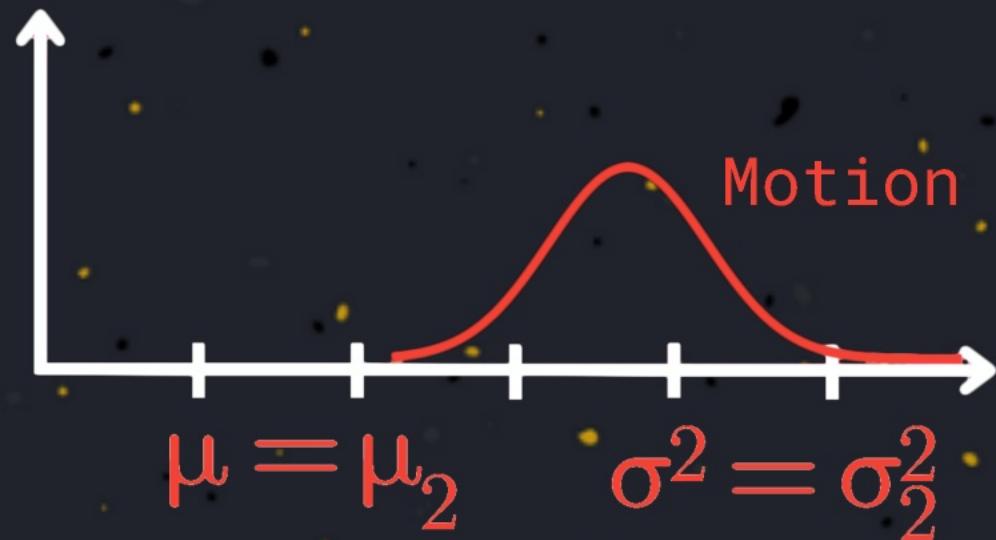
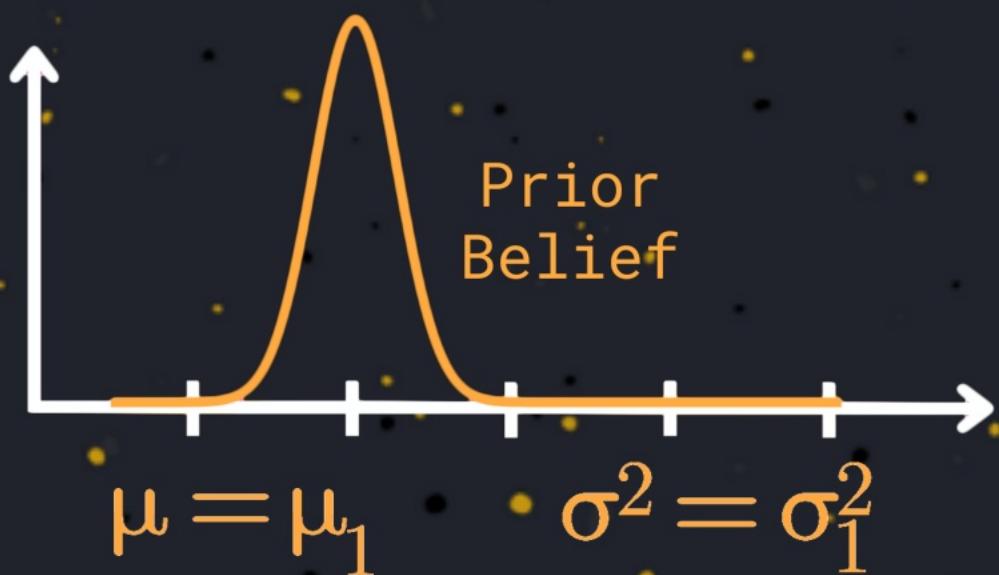
State Prediction



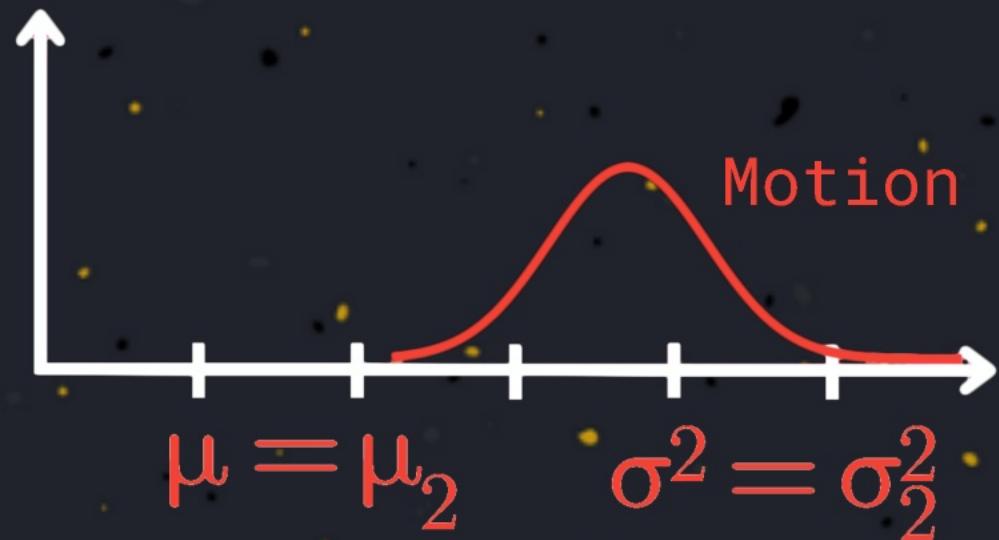
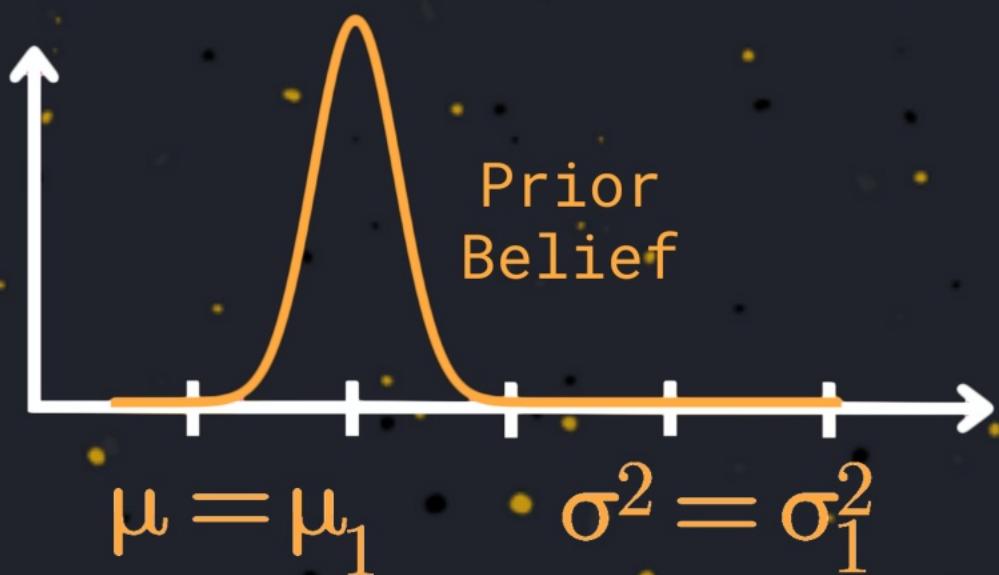
State Prediction



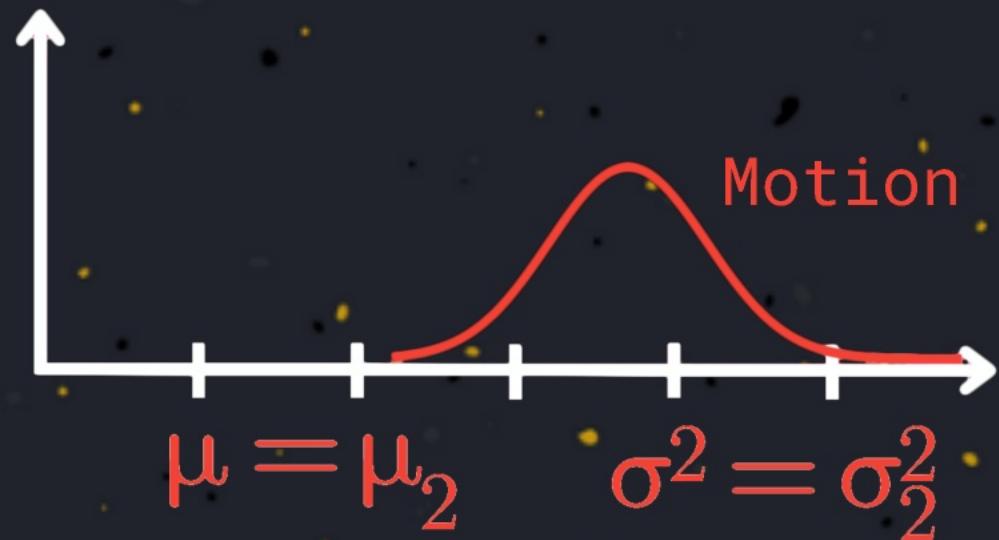
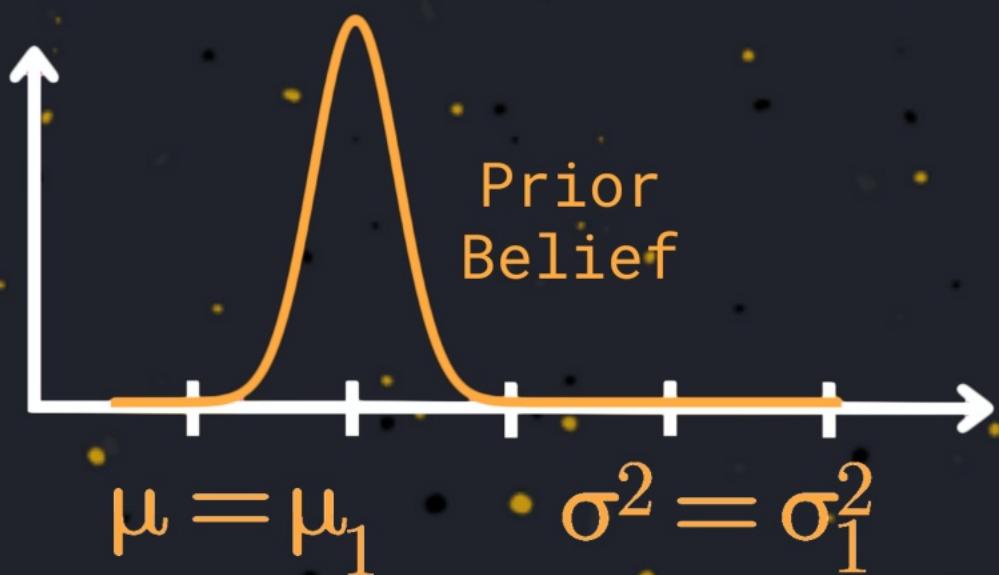
State Prediction



State Prediction



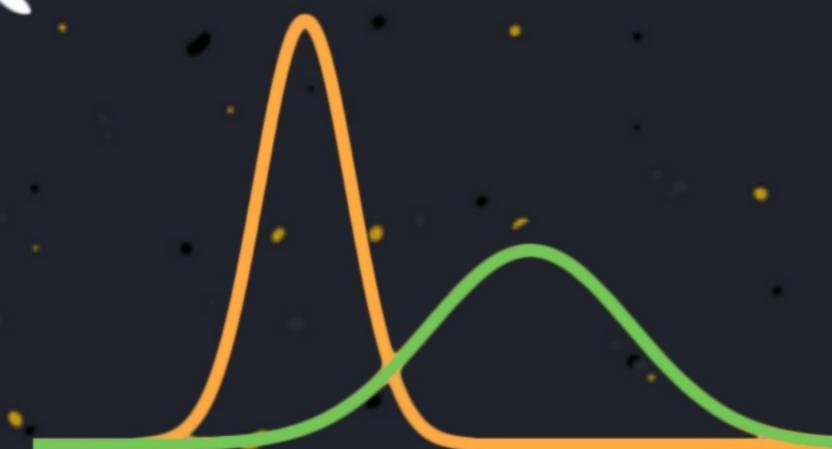
State Prediction

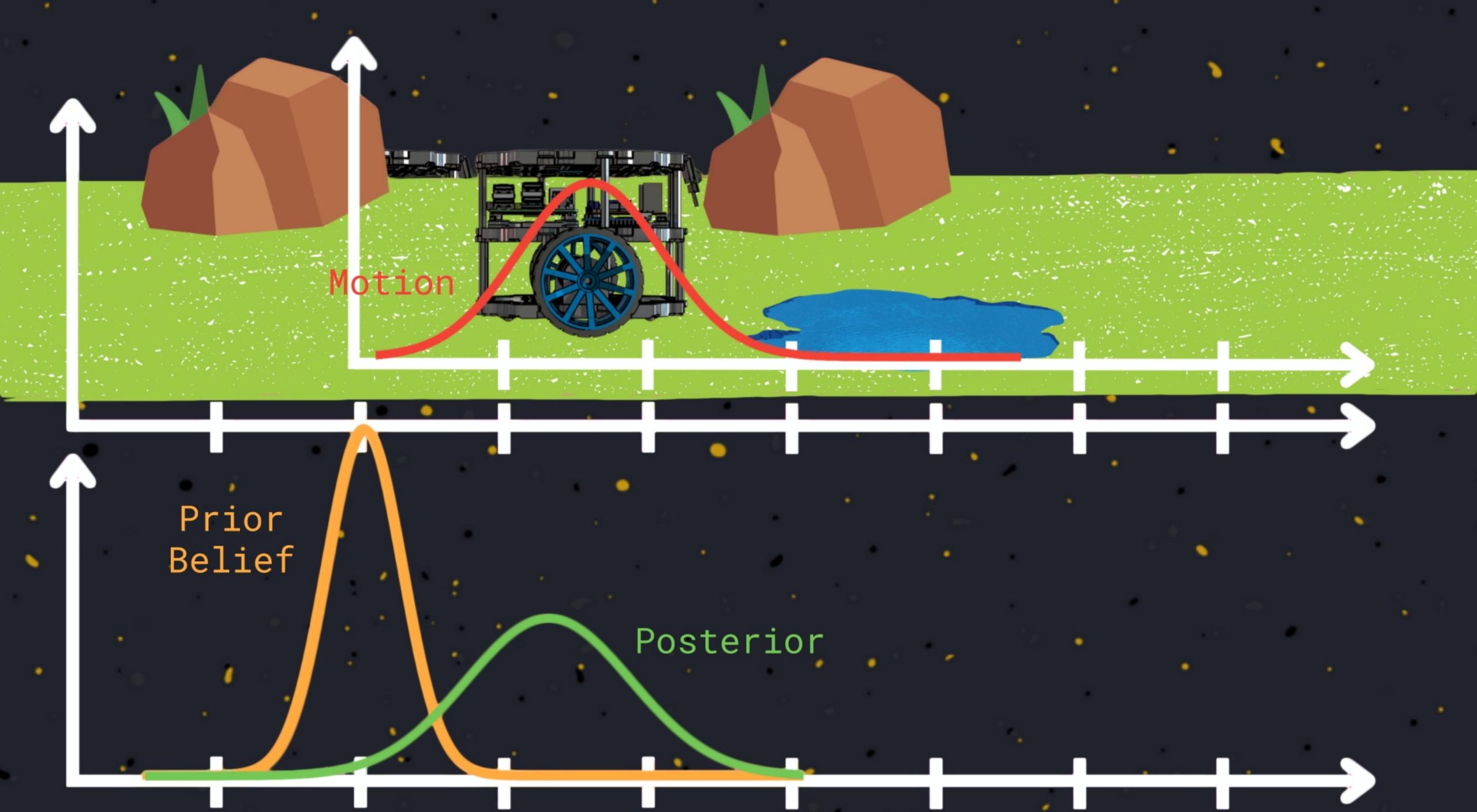


Measurement Update

Initial Estimate

State Prediction

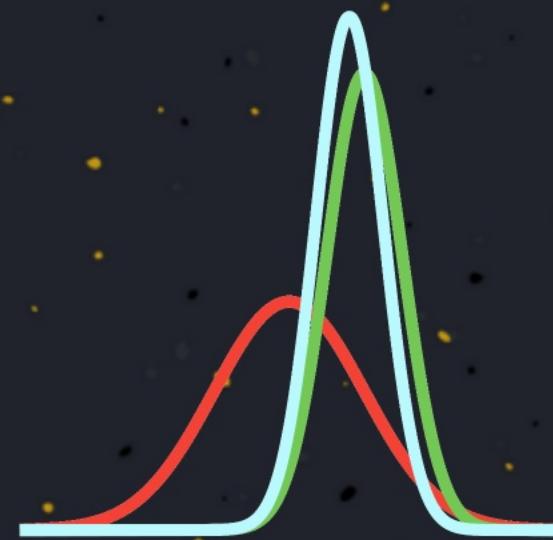




Bayes Filters

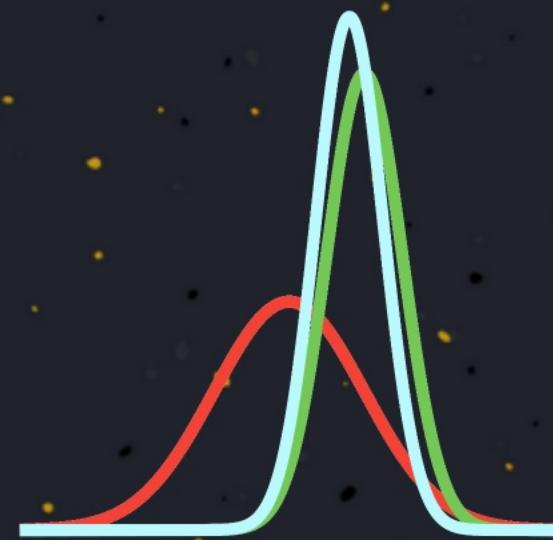
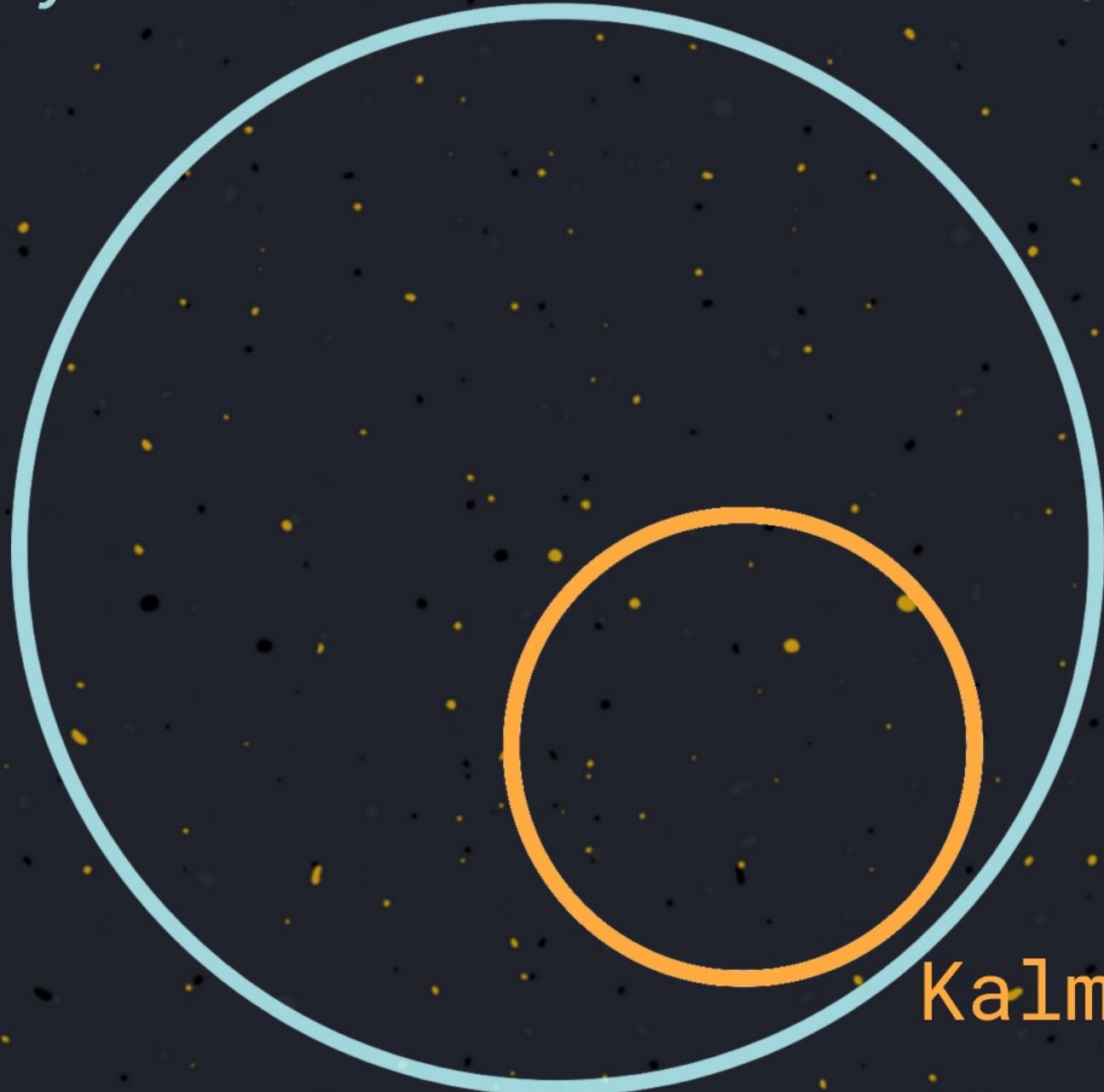


$$P(A|B) = \frac{P(B|A) \cdot P(A)}{P(B)}$$



Kalman Filter

Bayes Filters

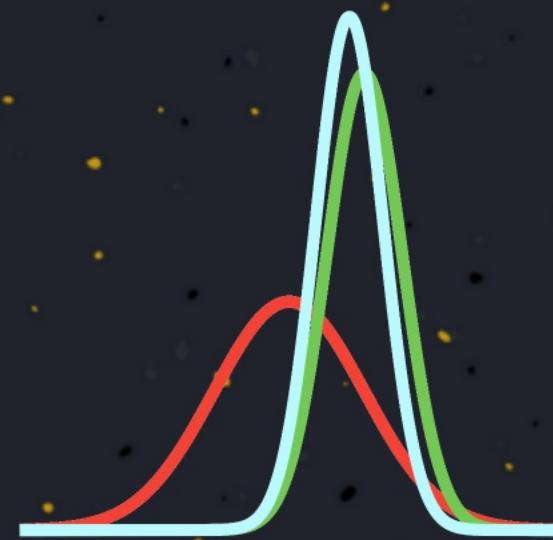


Kalman Filter

Bayes Filters



- Linear Systems
- Gaussian Distributions

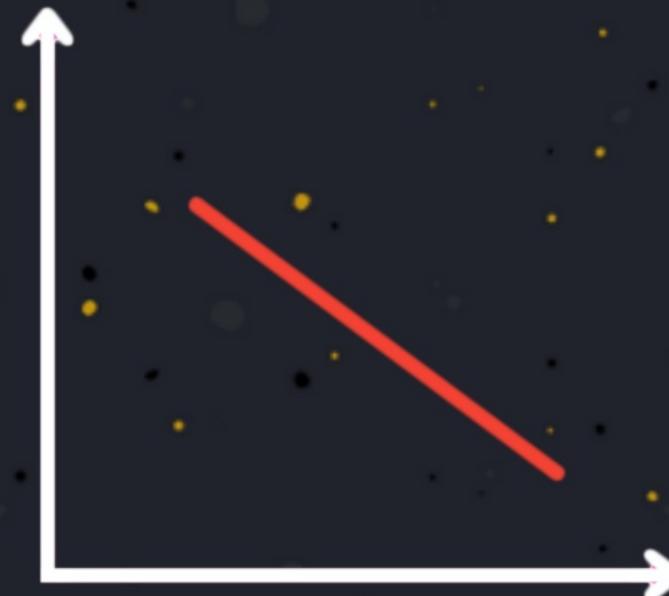
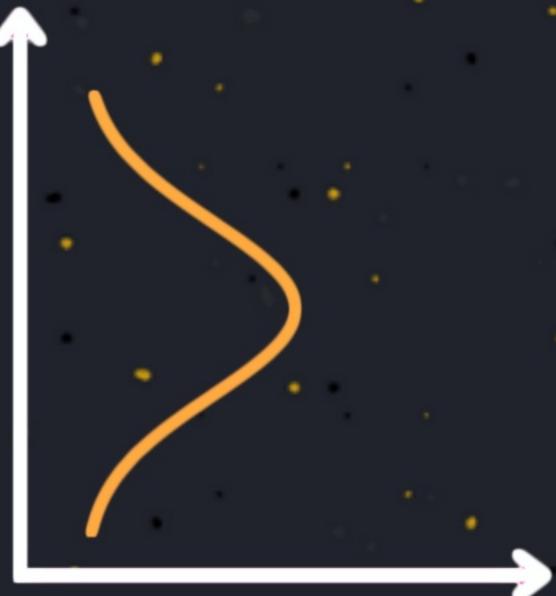


Kalman Filter

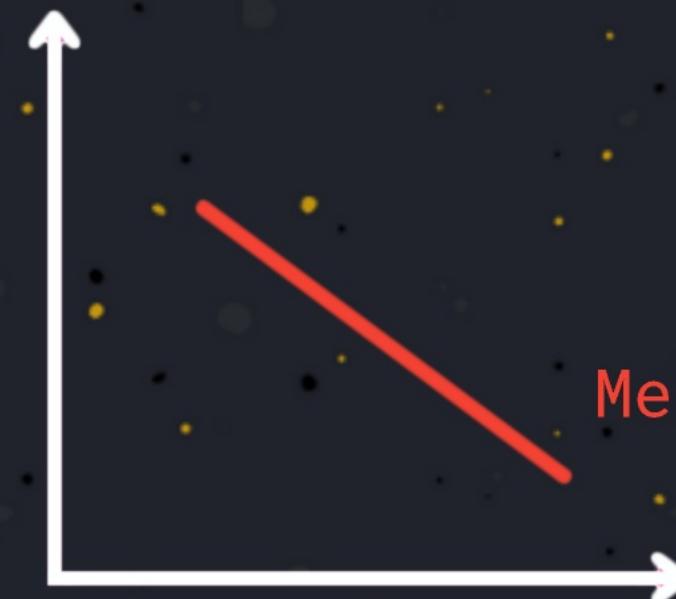
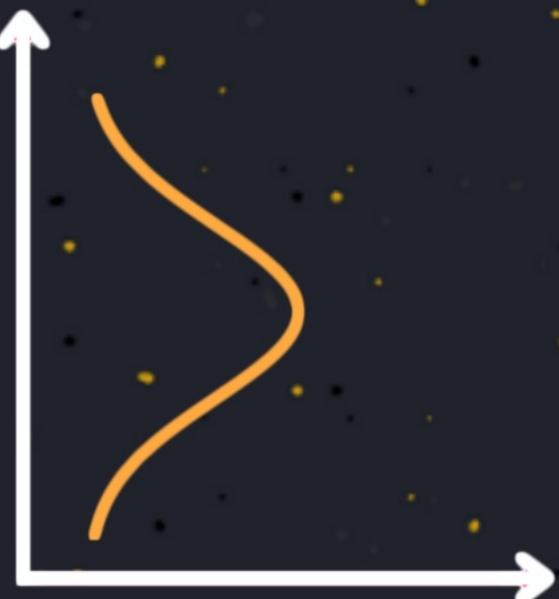
Extended Kalman Filter - EKF



Extended Kalman Filter - EKF

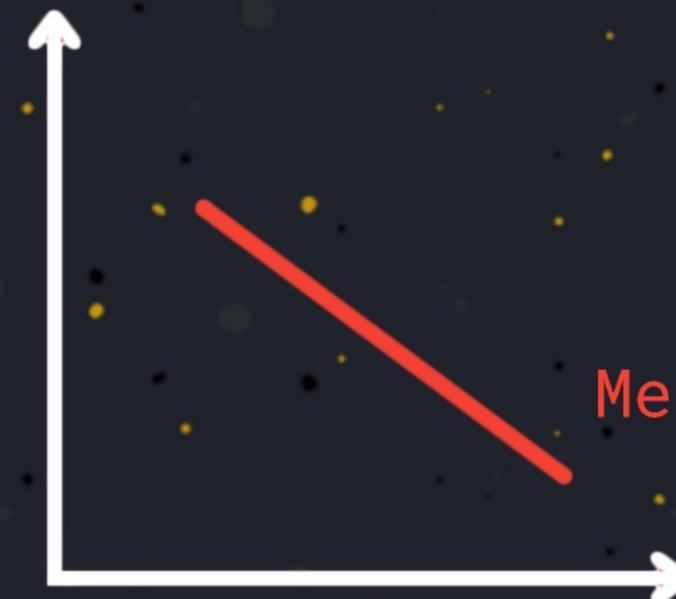
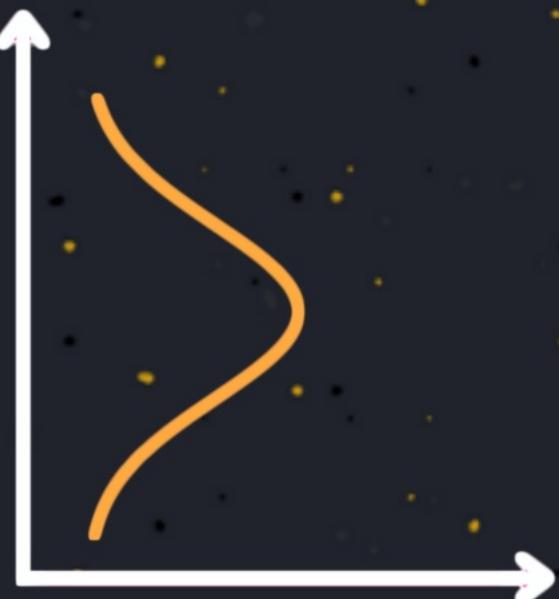


Extended Kalman Filter - EKF

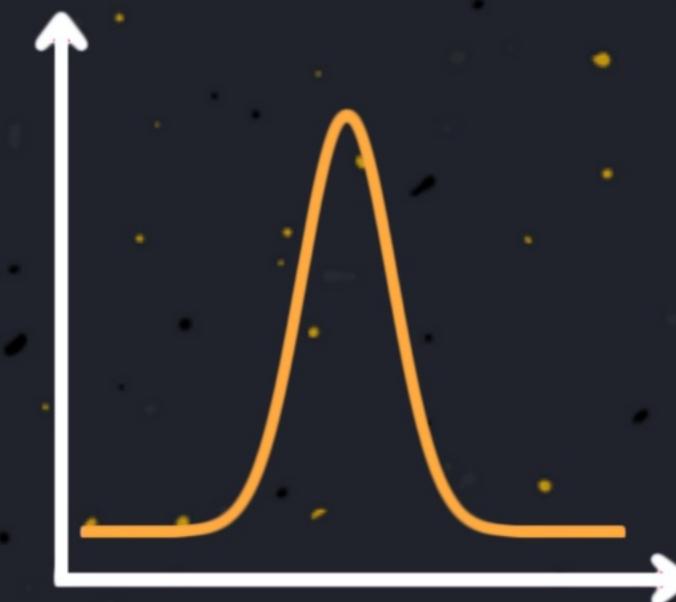


Motion
or
Measurement

Extended Kalman Filter - EKF



Motion
or
Measurement



Extended Kalman Filter - EKF

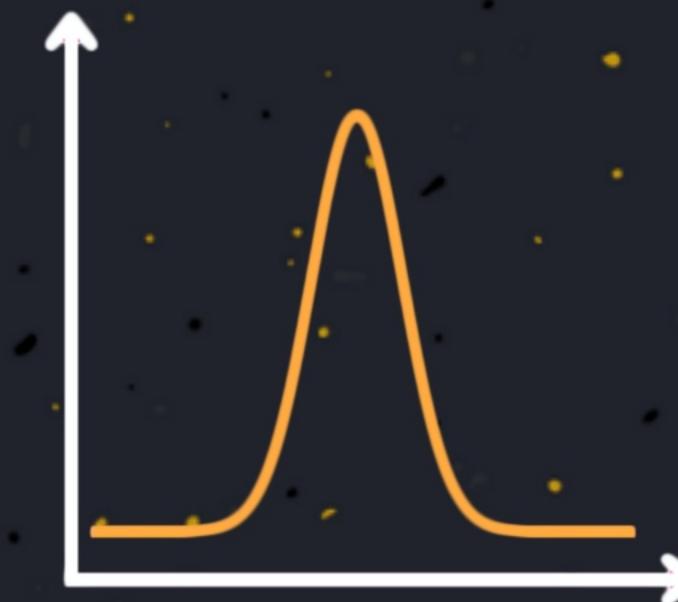
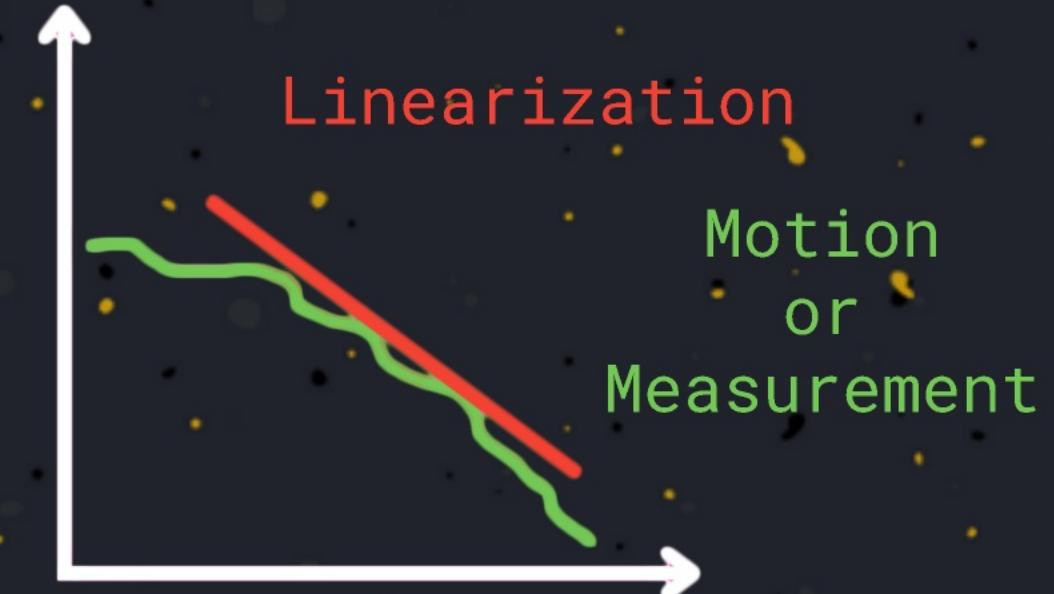
Extended Kalman Filter - EKF



Extended Kalman Filter - EKF

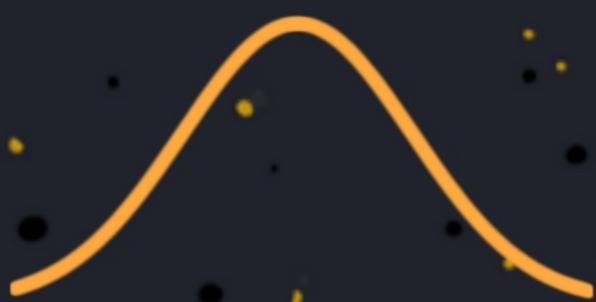


Extended Kalman Filter - EKF

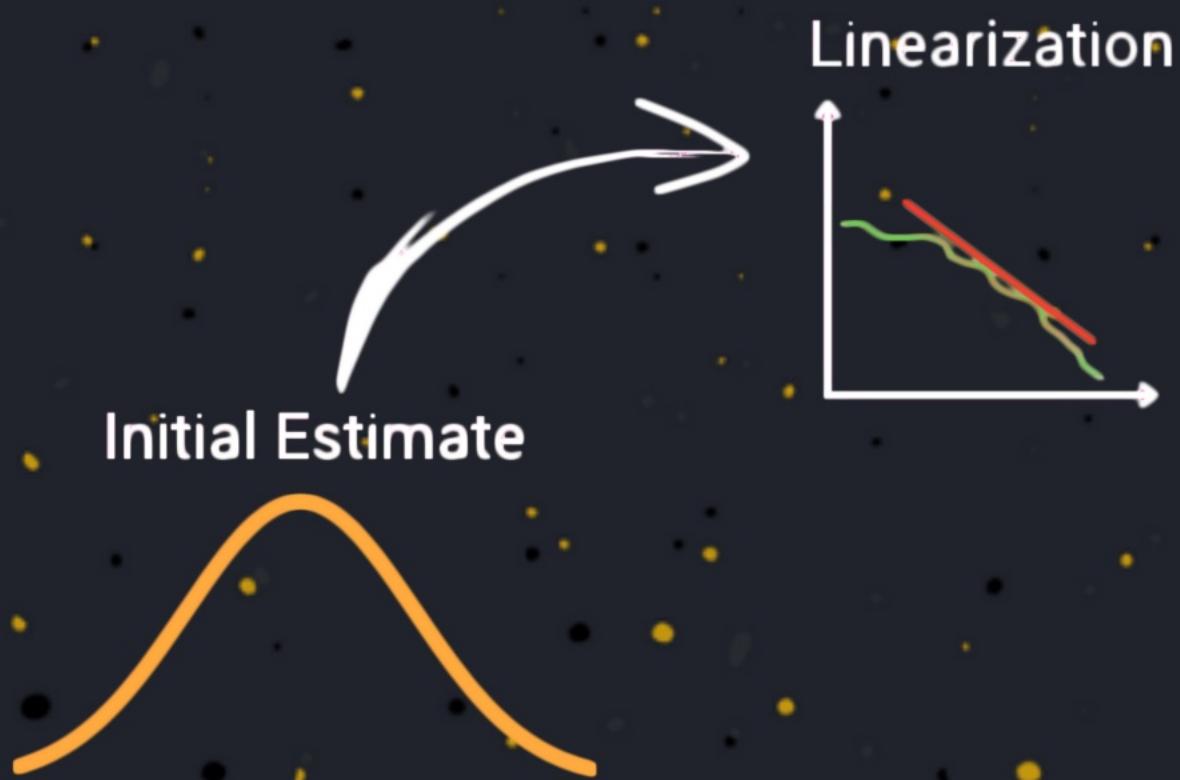


Extended Kalman Filter - EKF

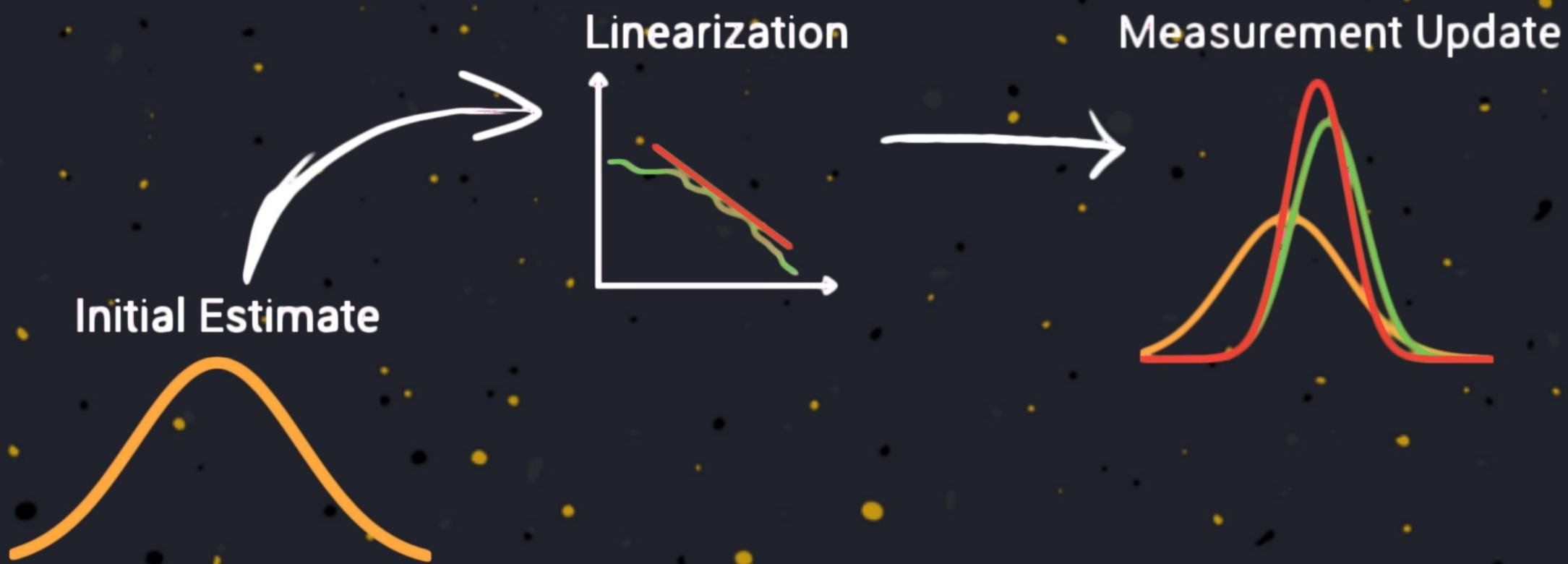
Initial Estimate



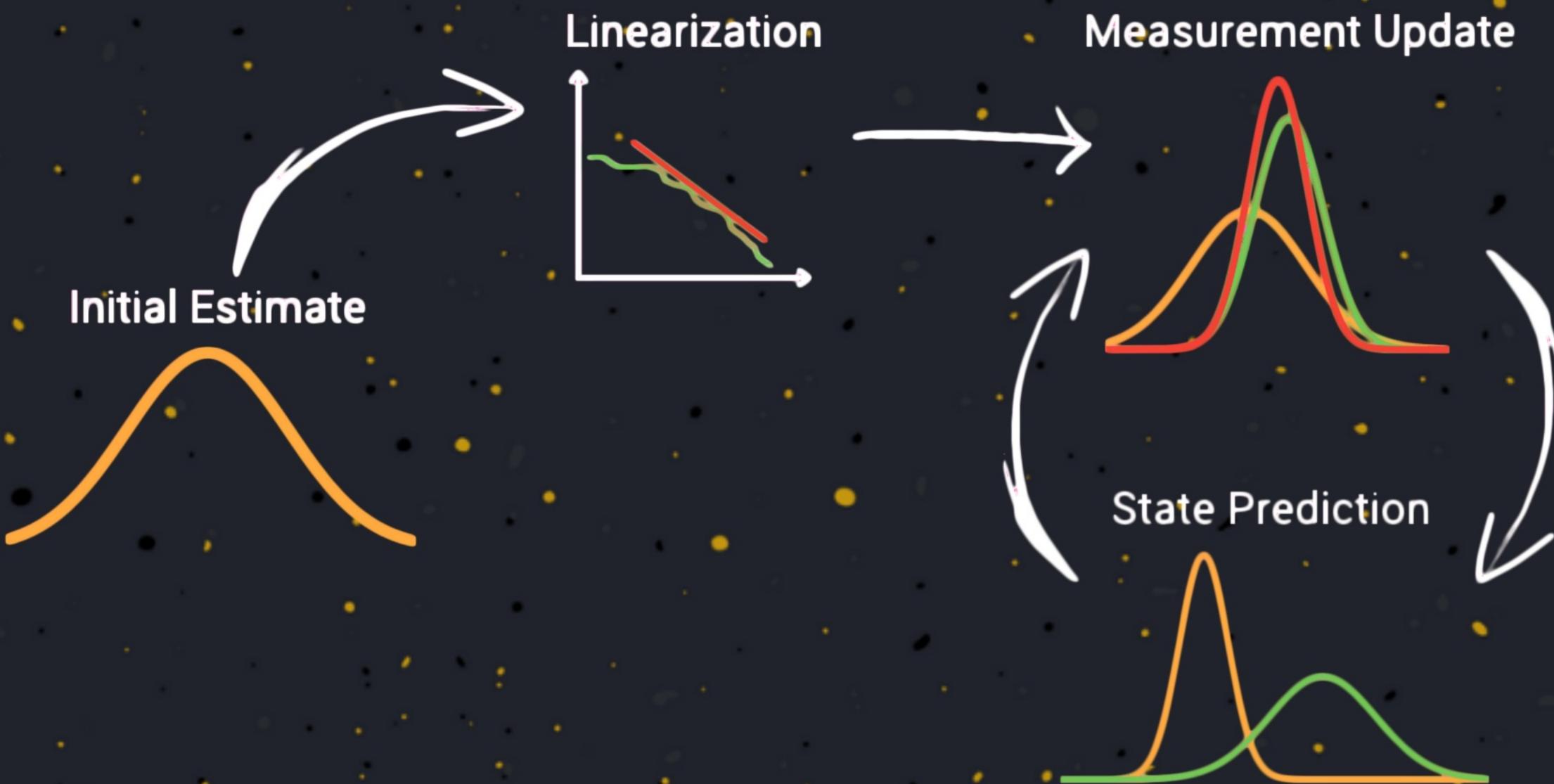
Extended Kalman Filter - EKF



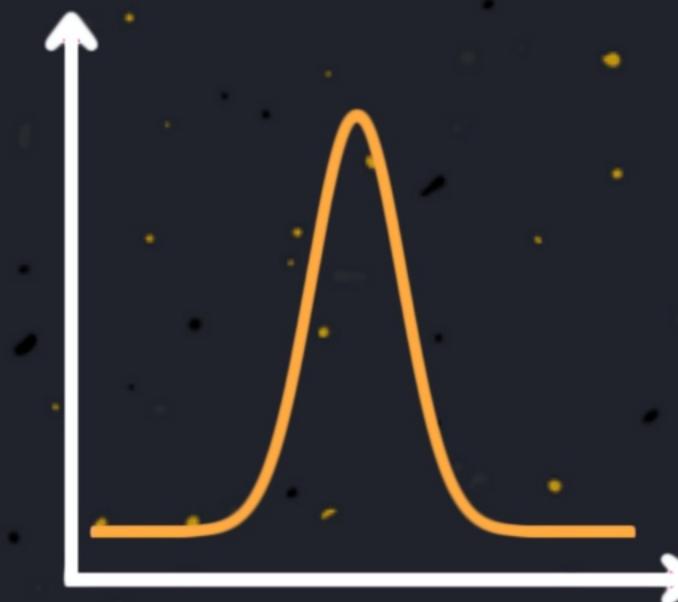
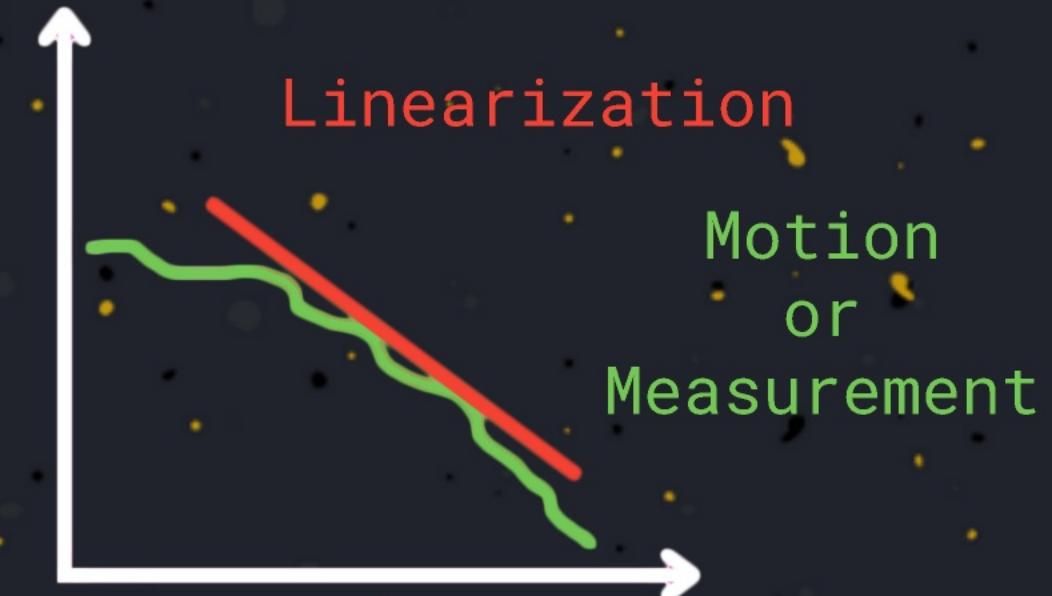
Extended Kalman Filter - EKF



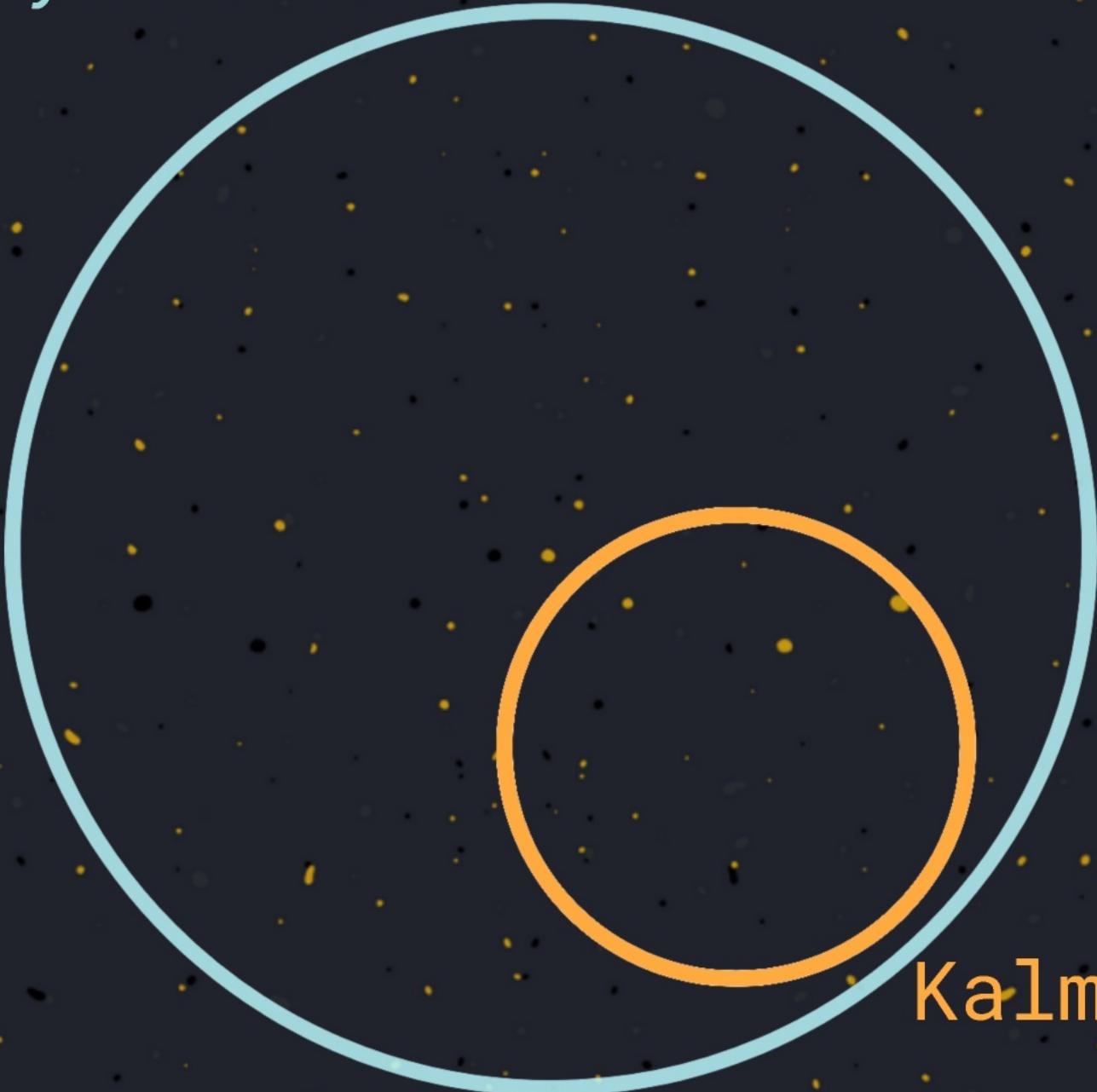
Extended Kalman Filter - EKF



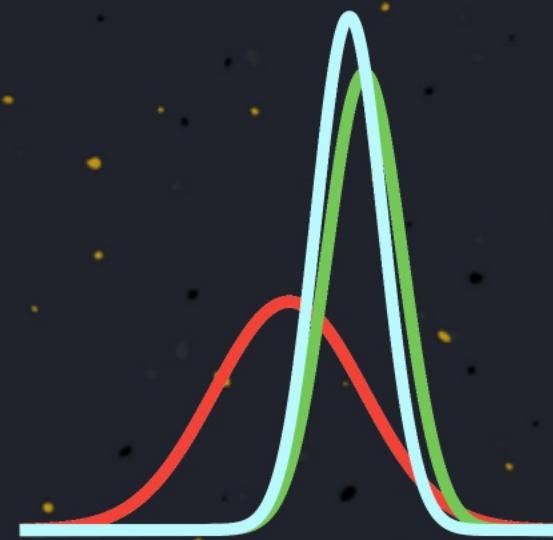
Extended Kalman Filter - EKF



Bayes Filters

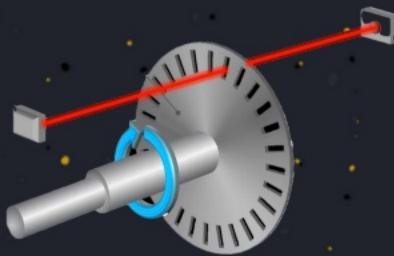


- Linear Systems
- Gaussian Distributions



Kalman Filter

Sensor Fusion



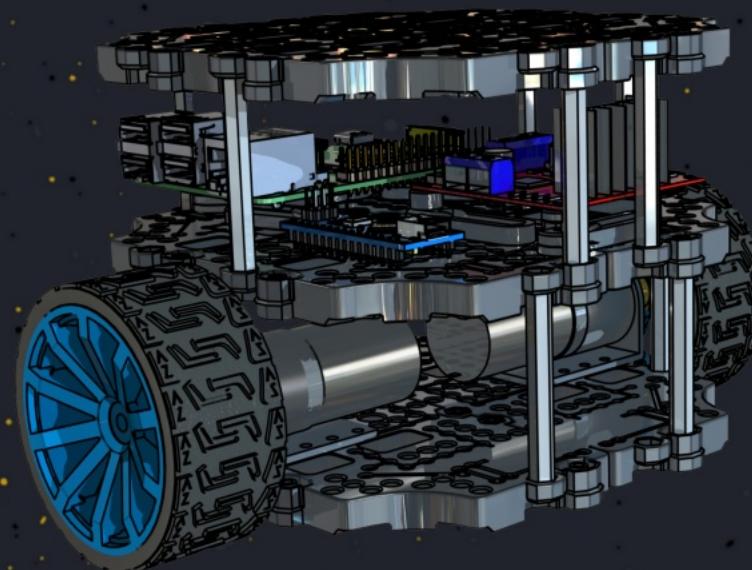
Encoder



Gyroscope



Accelerometer



GPS



Laser



Camera

