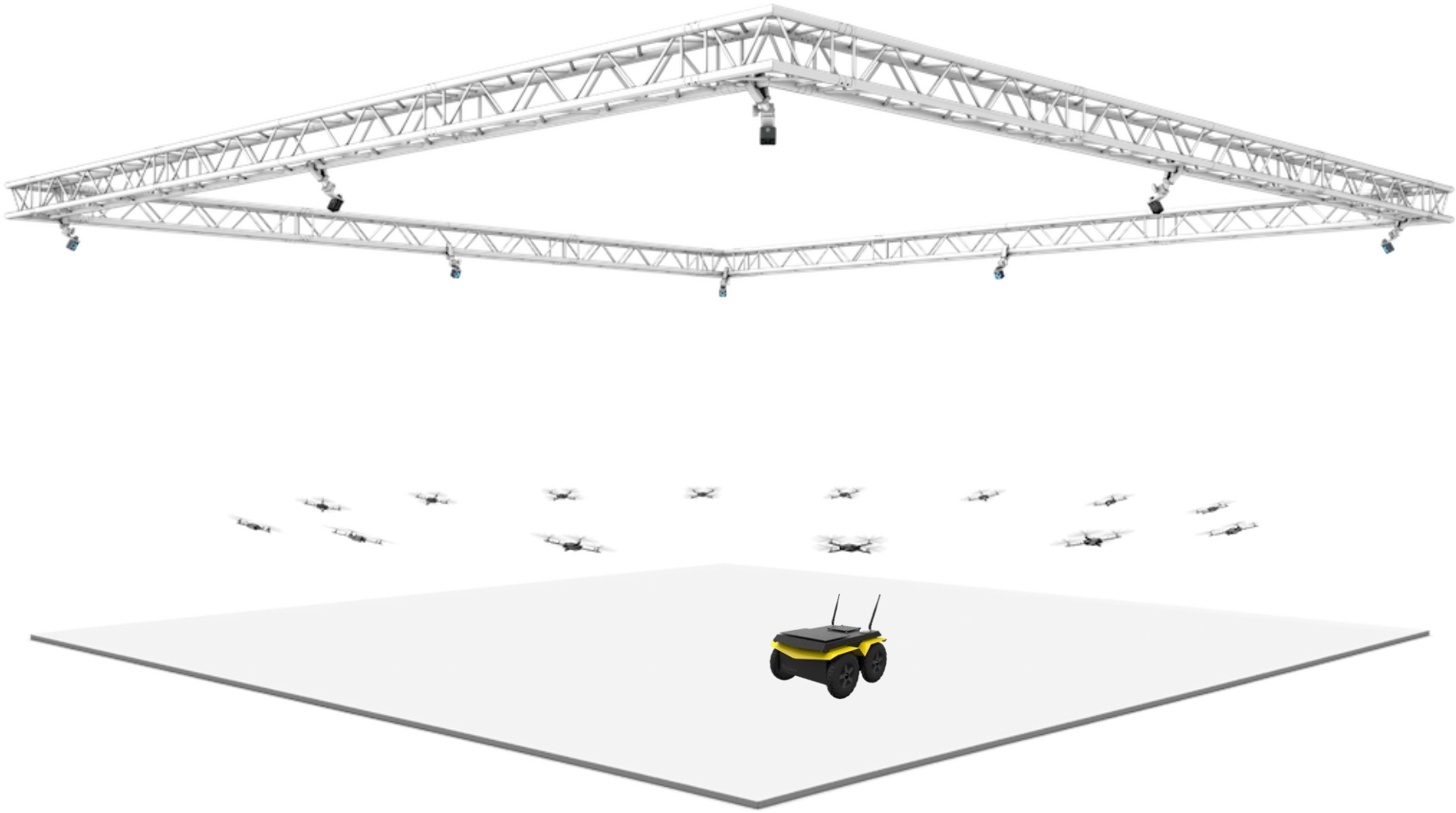
SLAM Intro

Laboratory of AI and Robotics (LAIR)

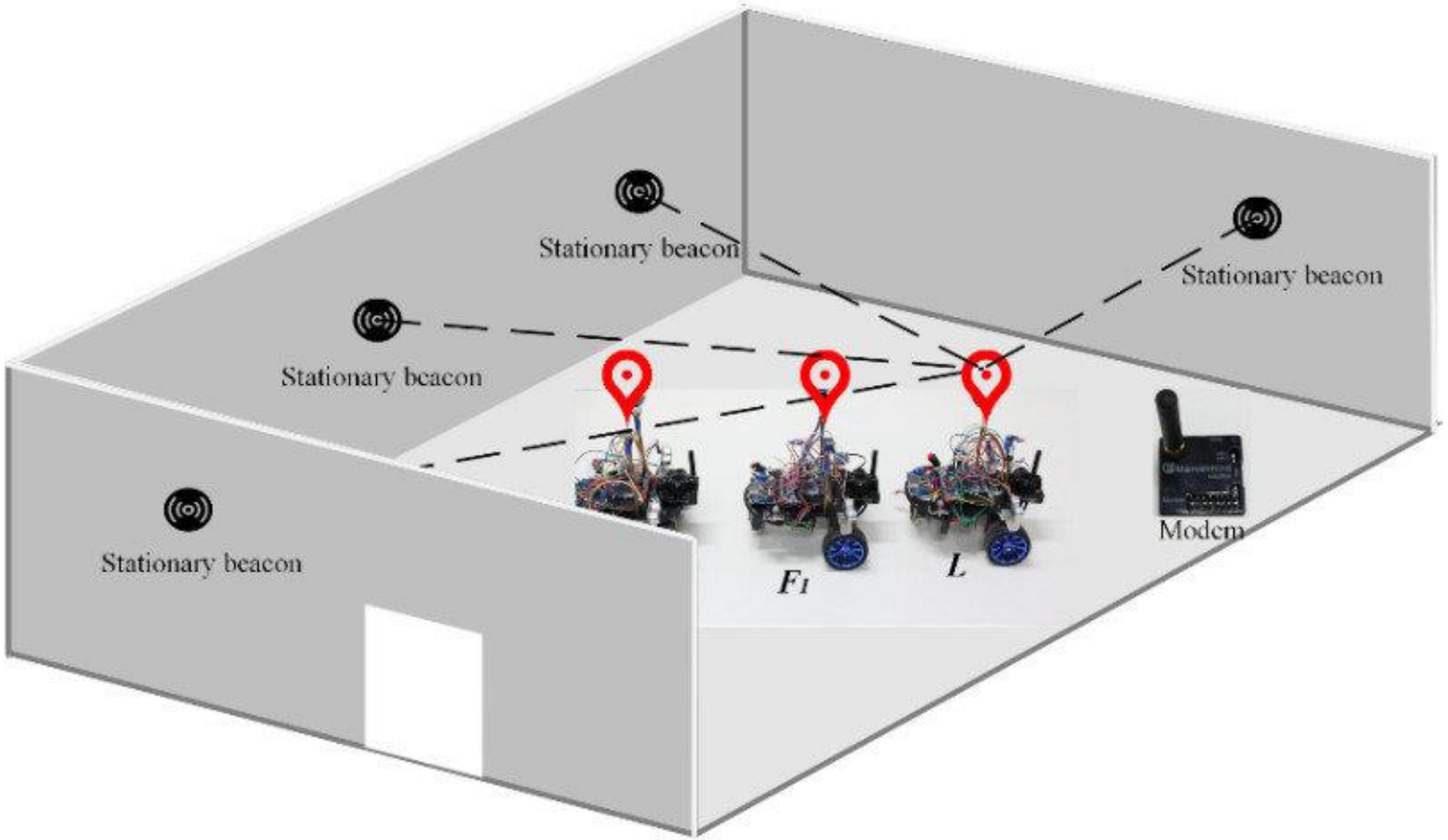
Hyeonwoo Yu

How do we know where the robot is?

Measurement model: Global

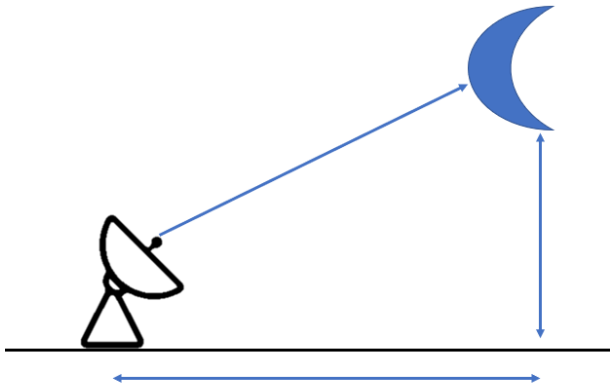


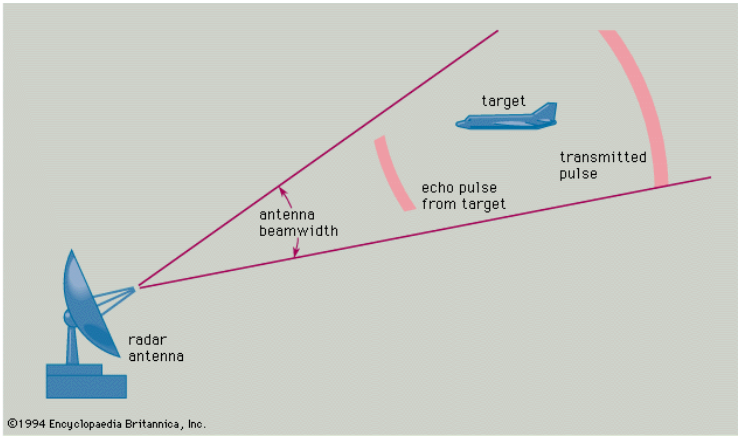
Measurement model: Global

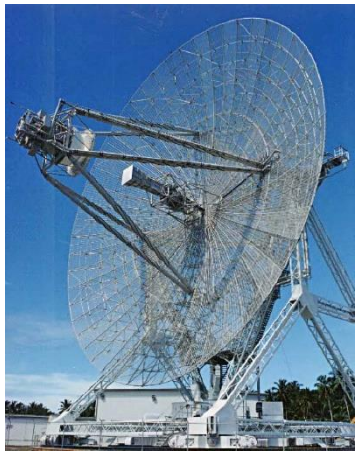


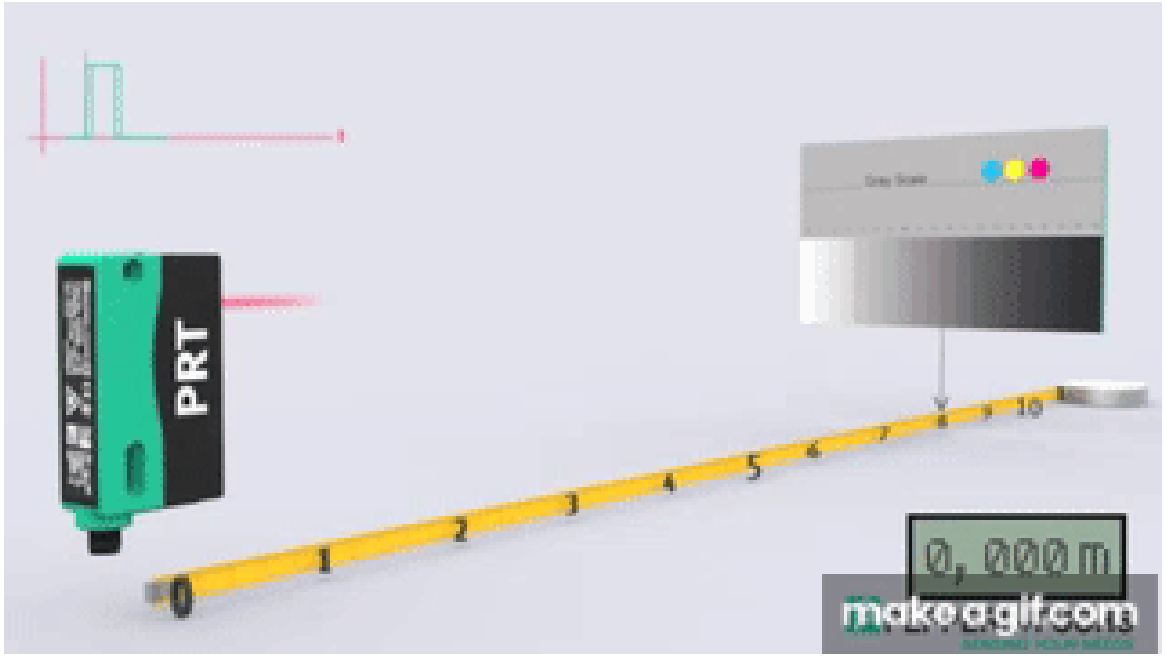
Measurement model: Global

Measurement model: sensors

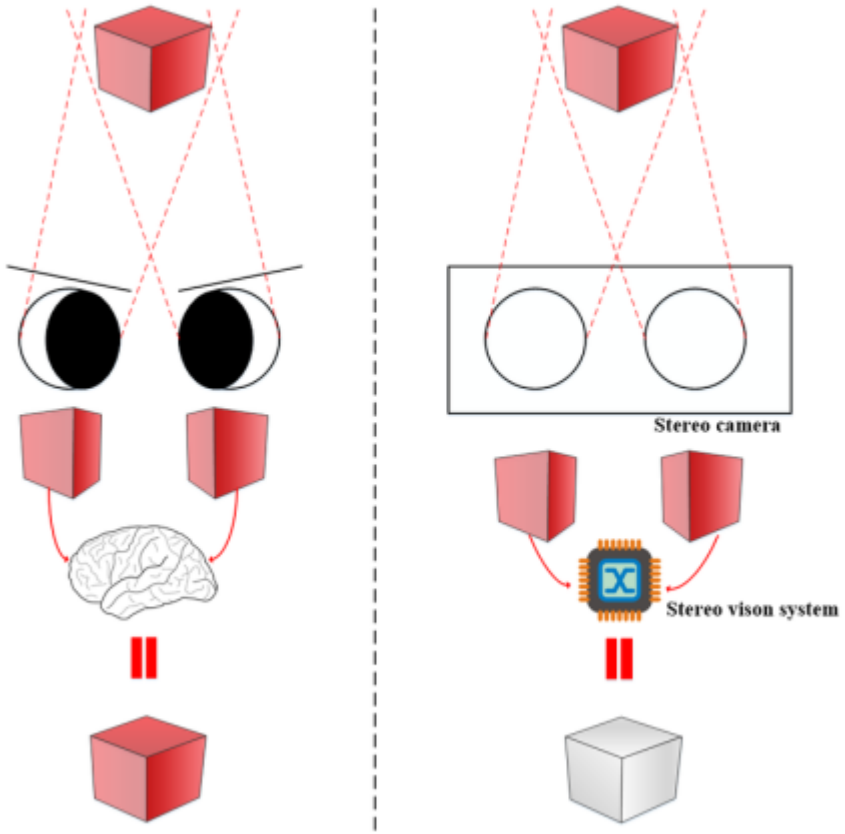


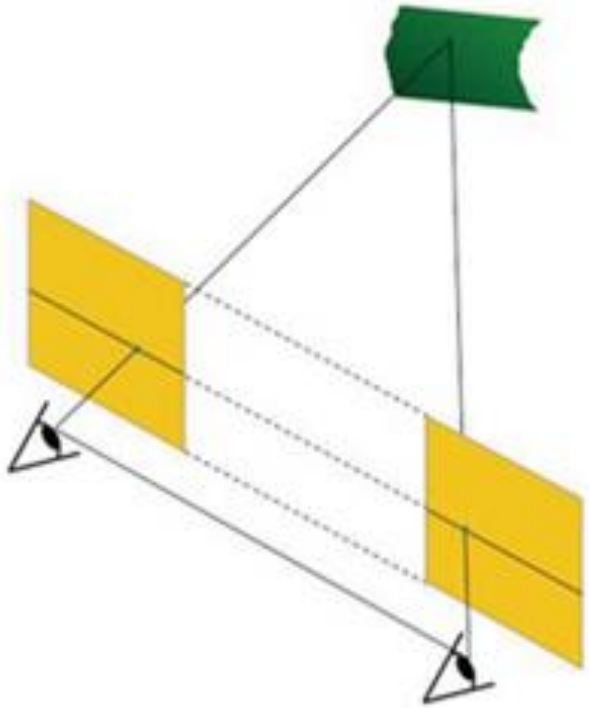


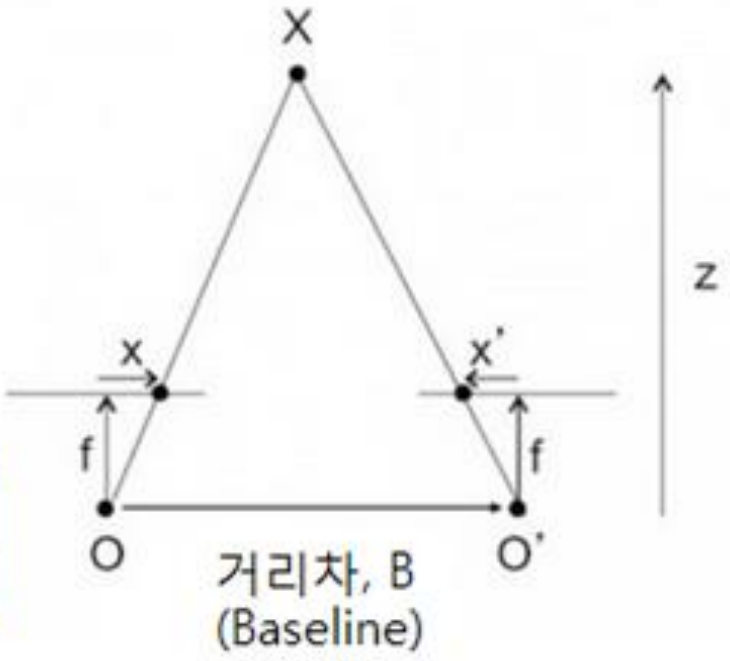




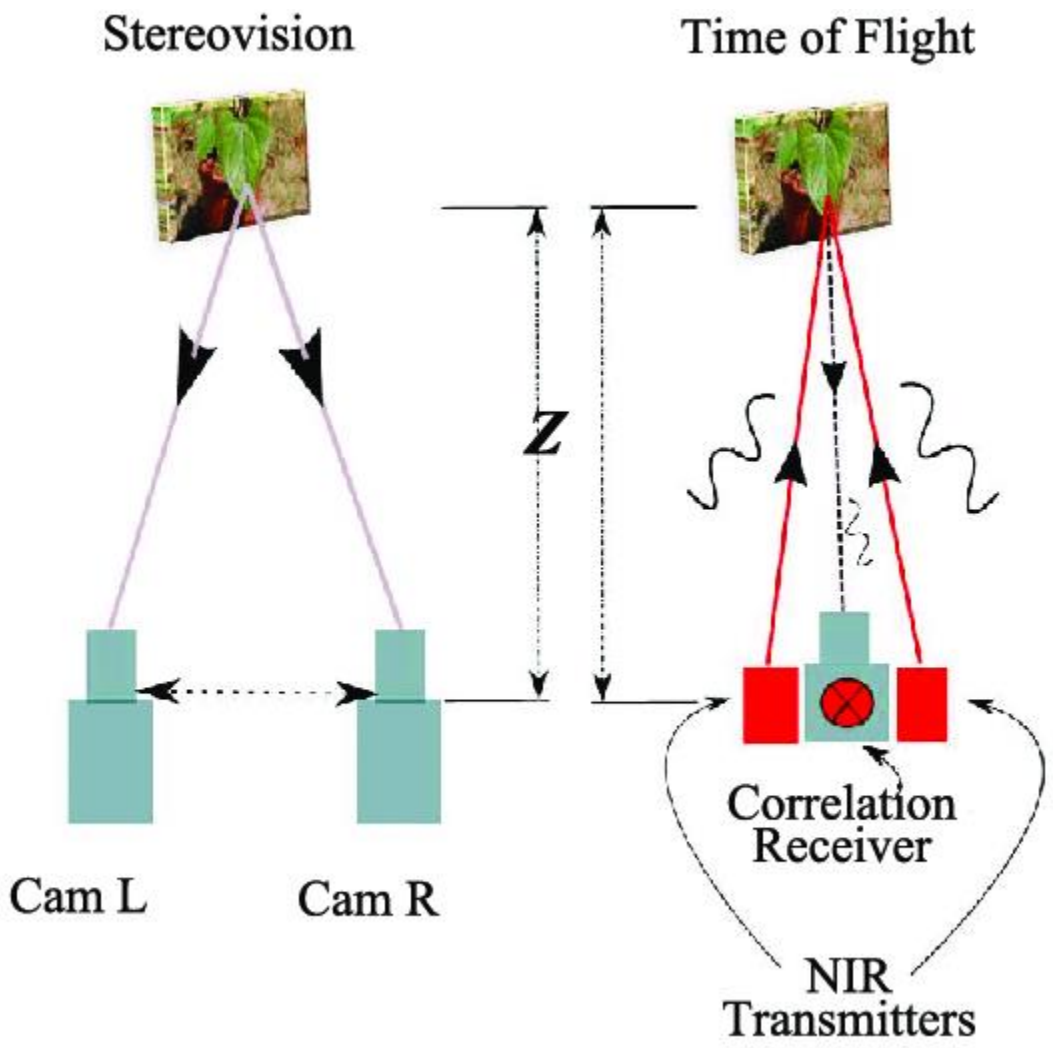
Measurement model: sensors



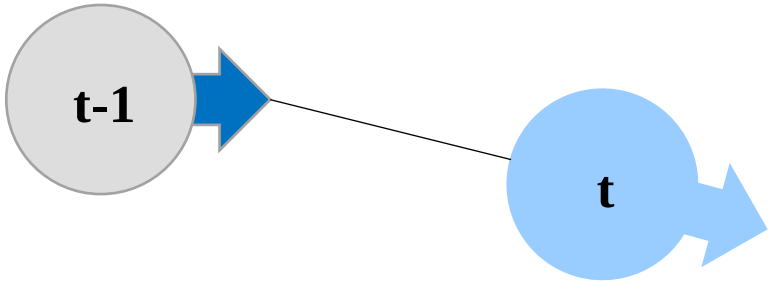




Measurement model: sensors

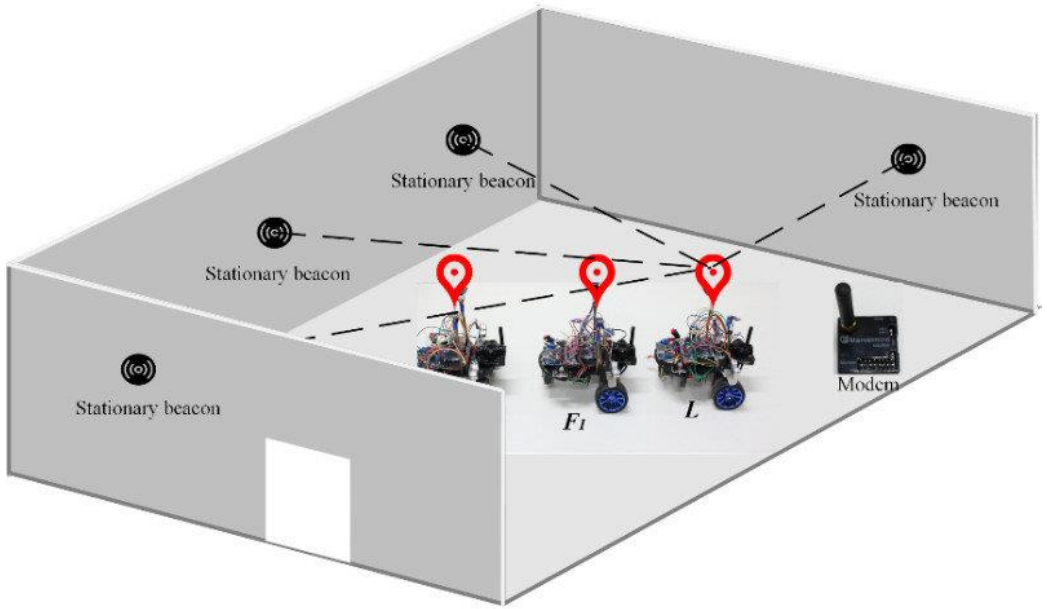


Measurement model: sensors



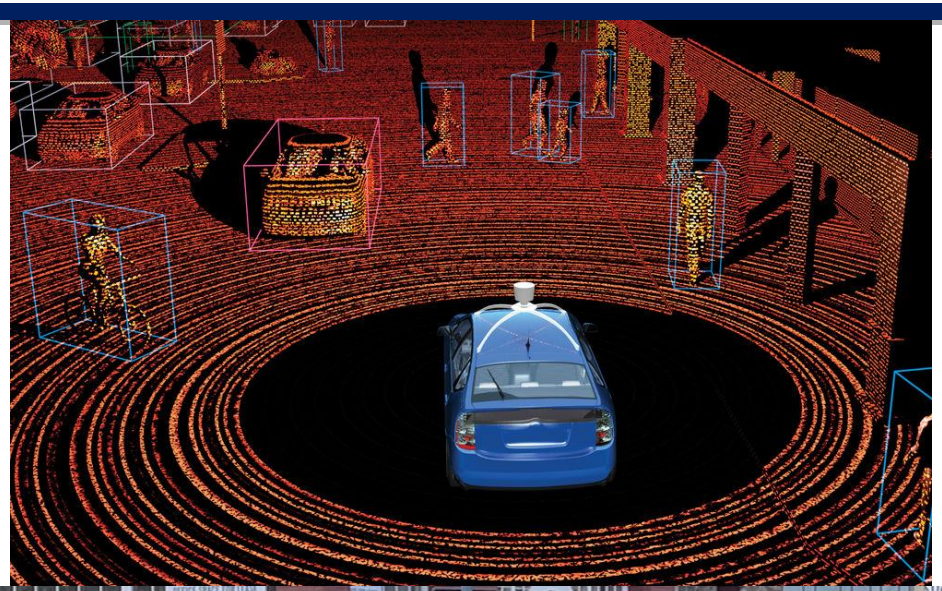
$$z_t = h(x_t) + \delta_t$$

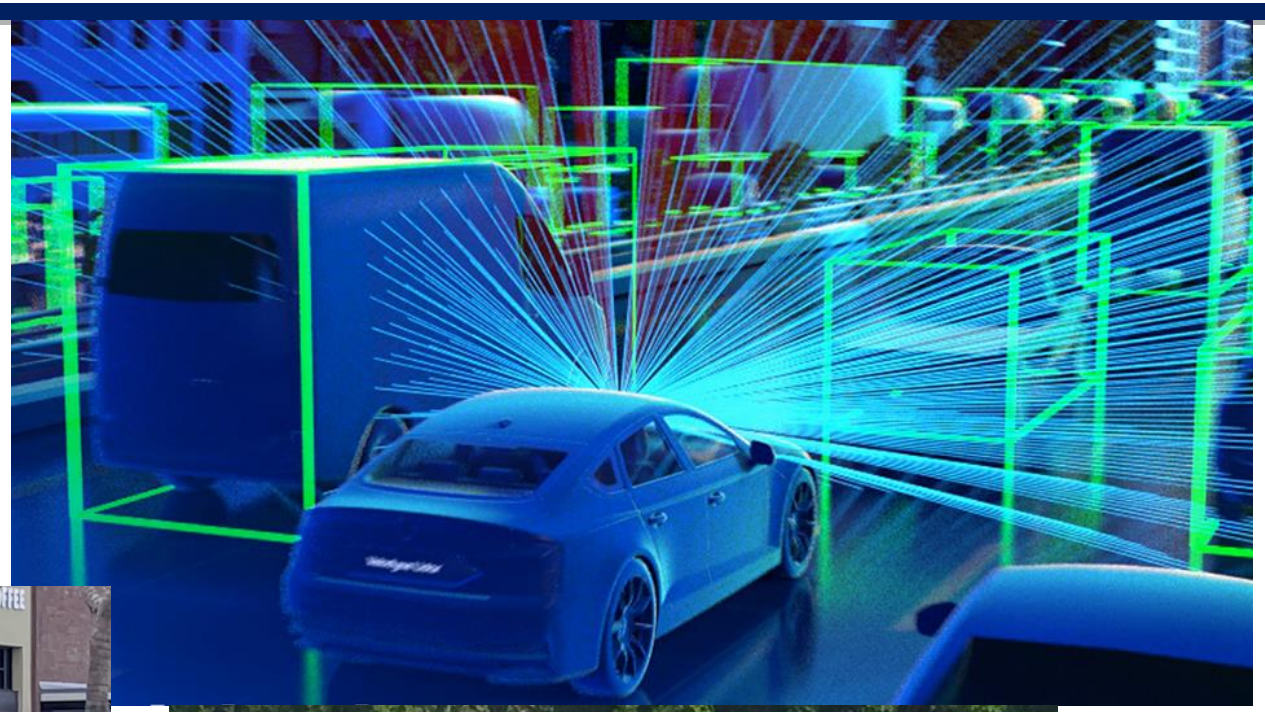
(measurement)



Measurement model: Robot

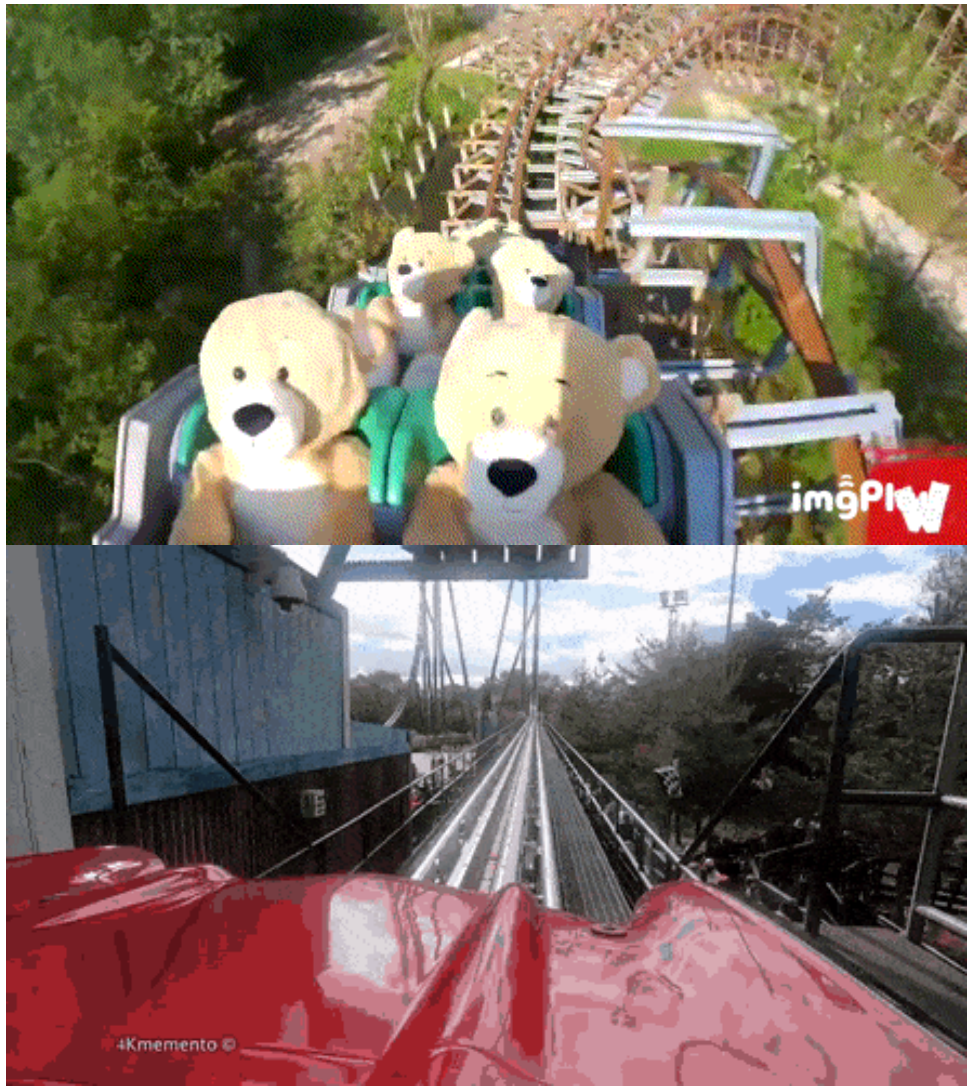
Measurement model: Robot



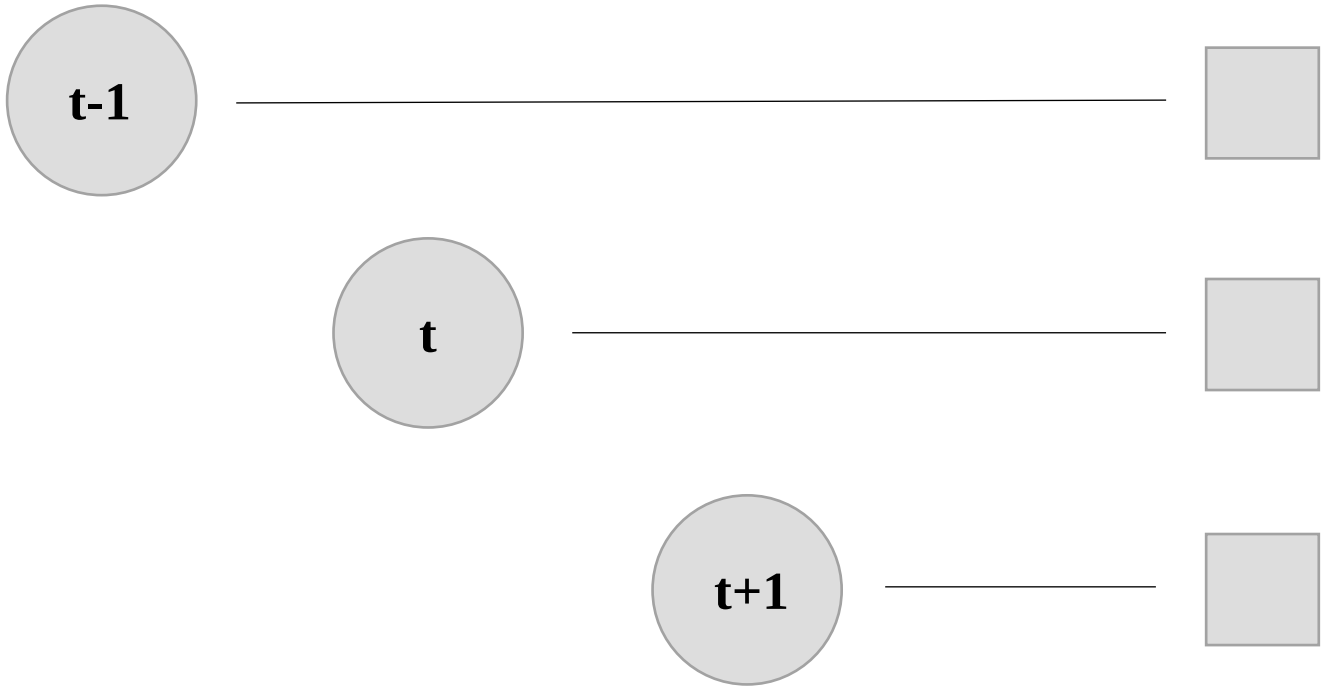


Measurement model: Robot

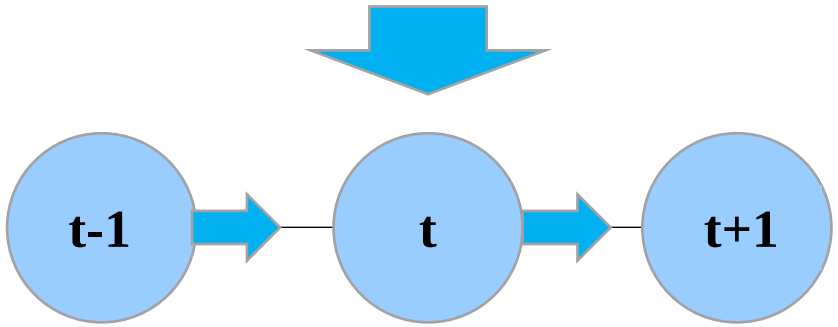
How do we recognize our movement?



Measurement model: Robot

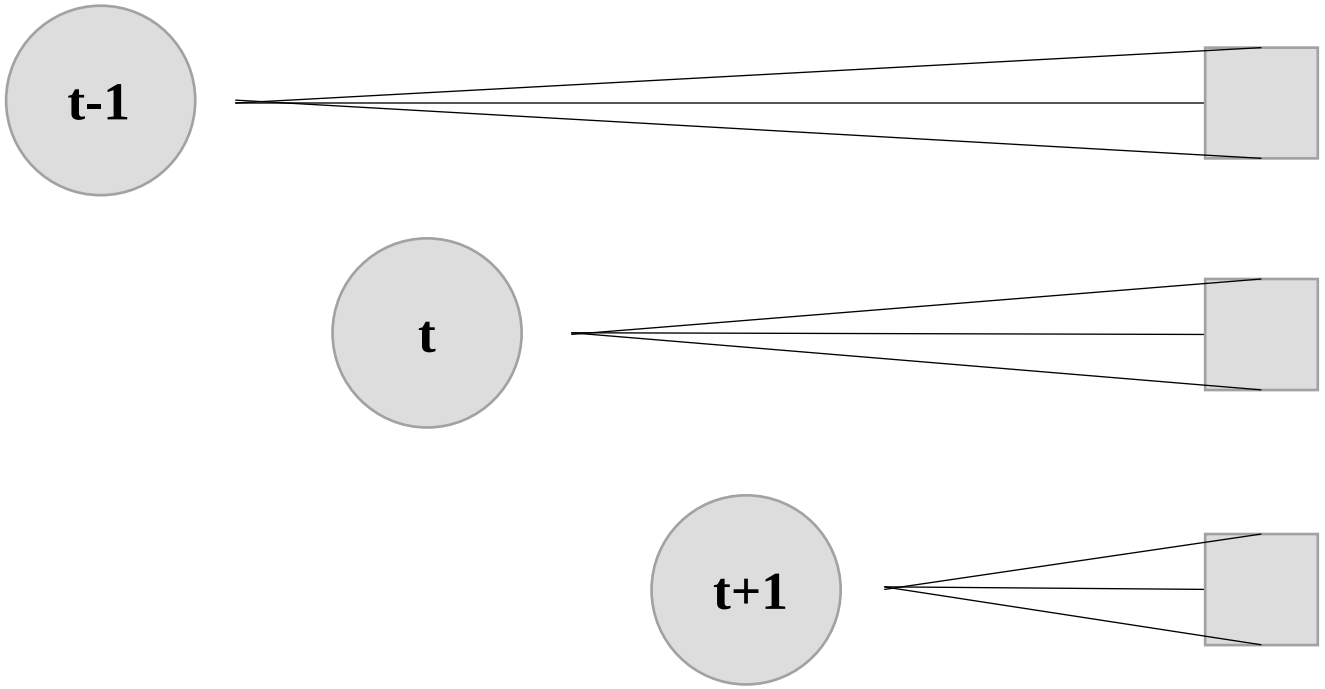


Measurement

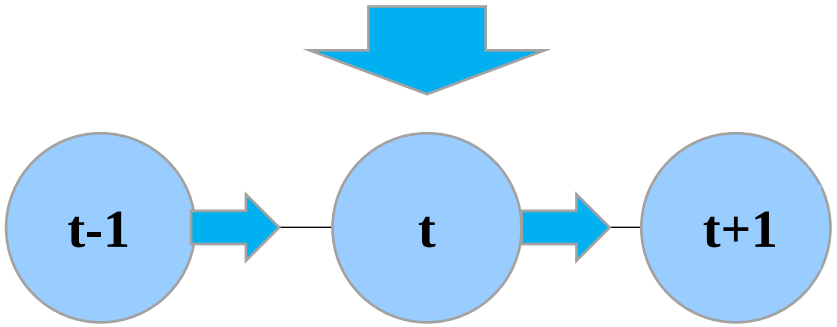


Trajectory Estimation

Measurement model: Robot

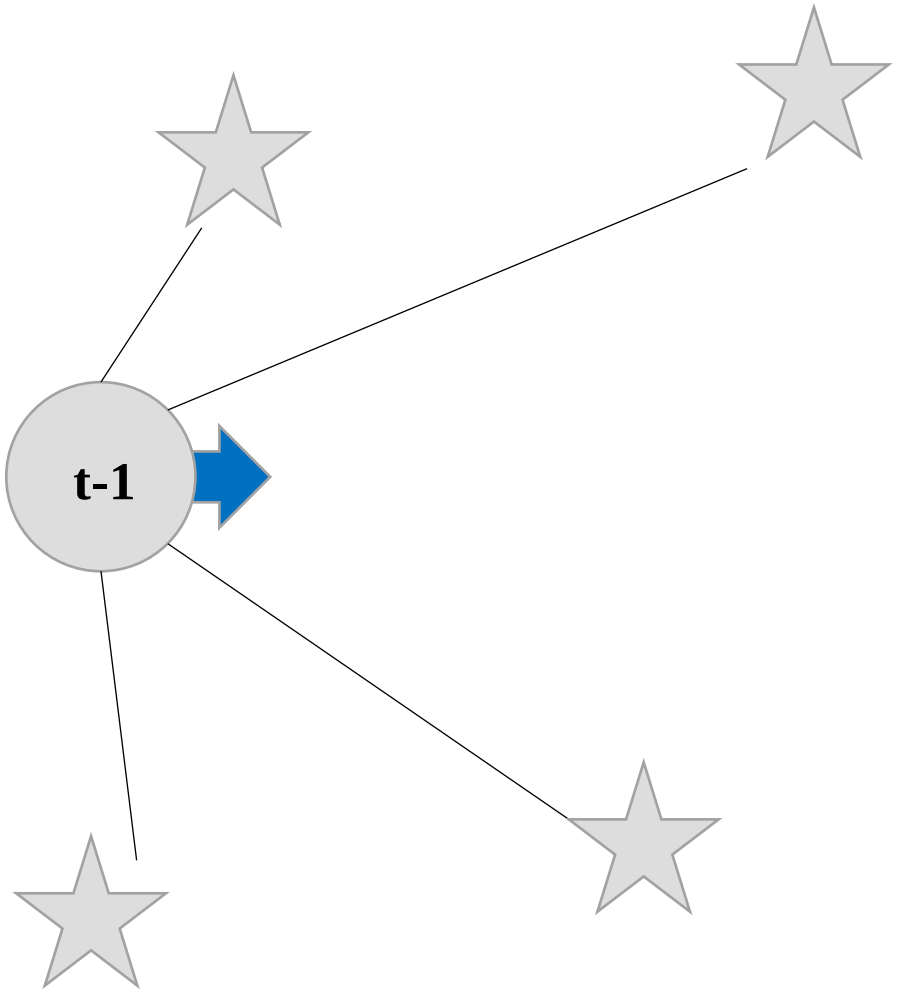


Measurement



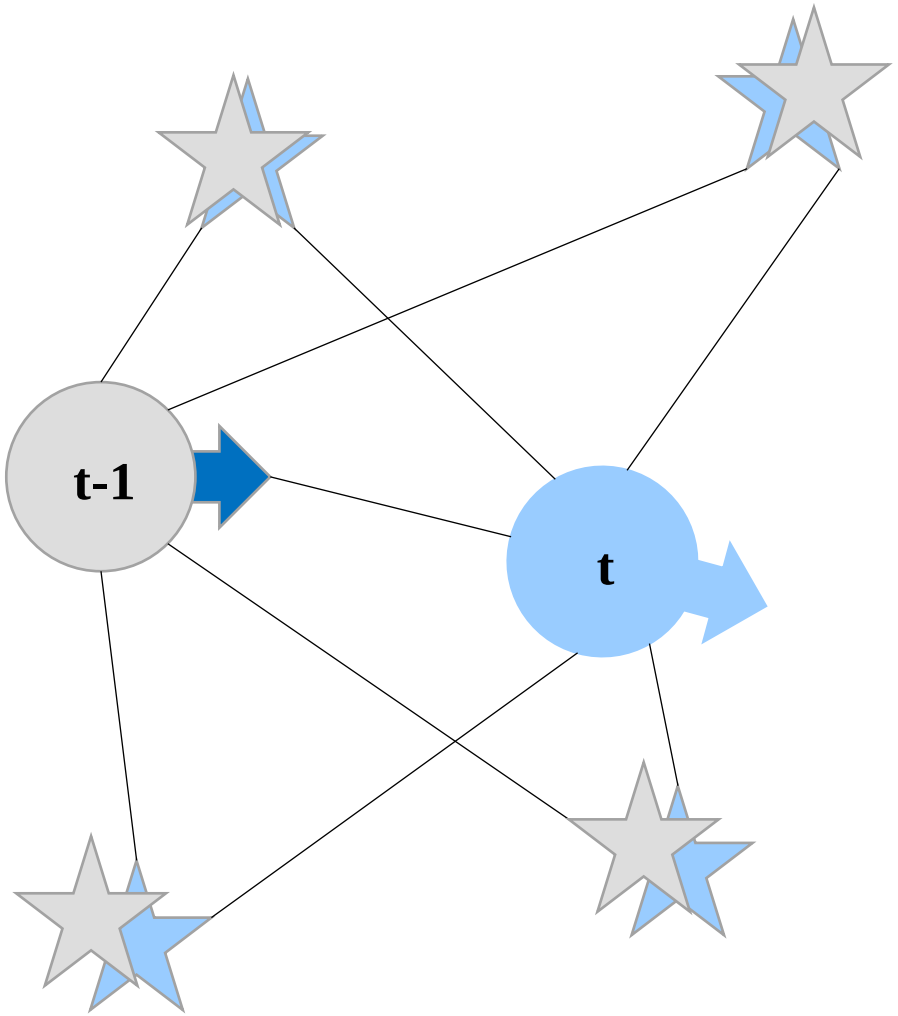
Trajectory Estimation

Measurement model: Robot



☆: Measuring robot pose from the ground truth poses of nearby landmarks
→Measuring robot pose by measuring poses of nearby landmarks

Measurement model: Robot



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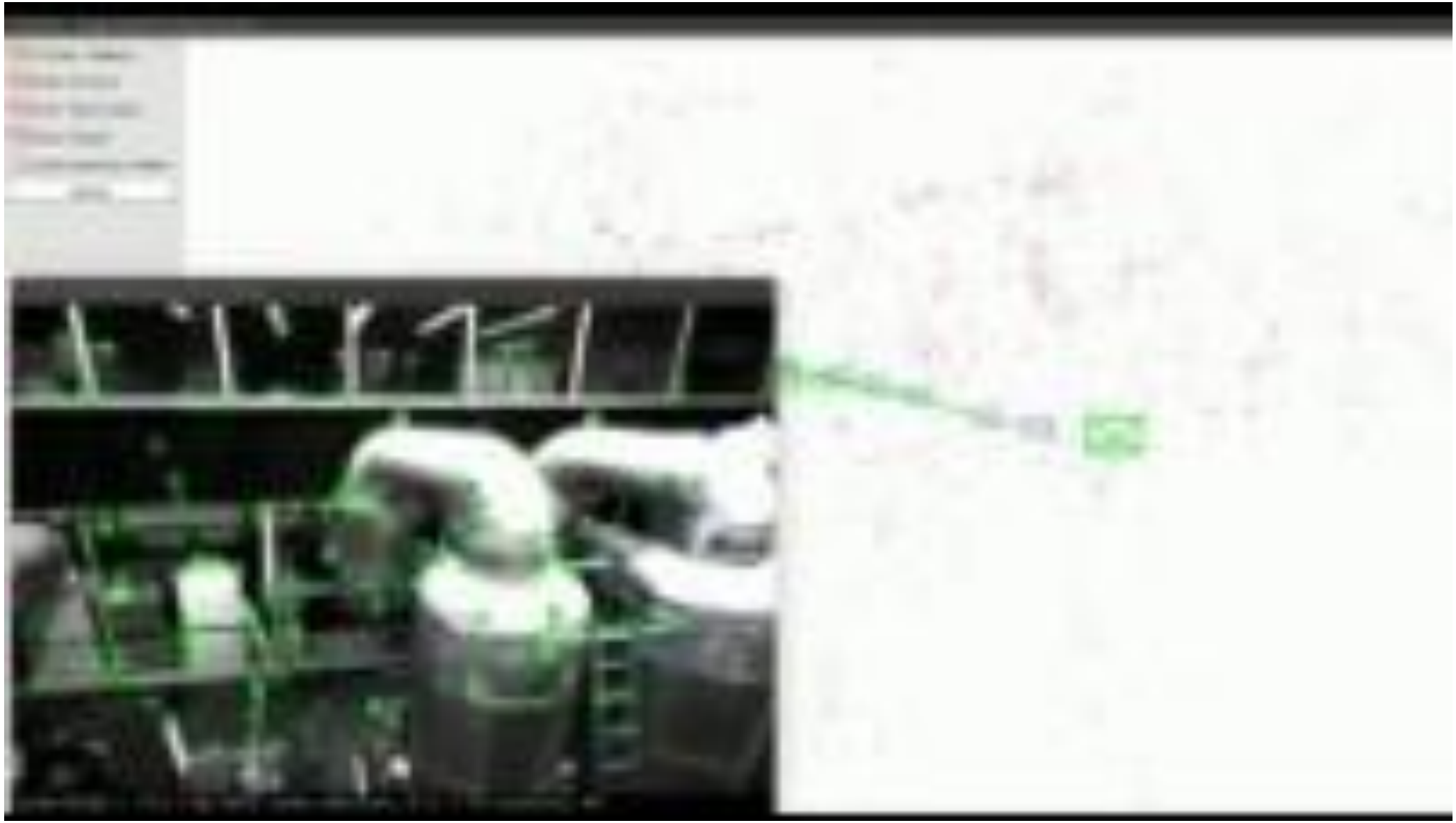
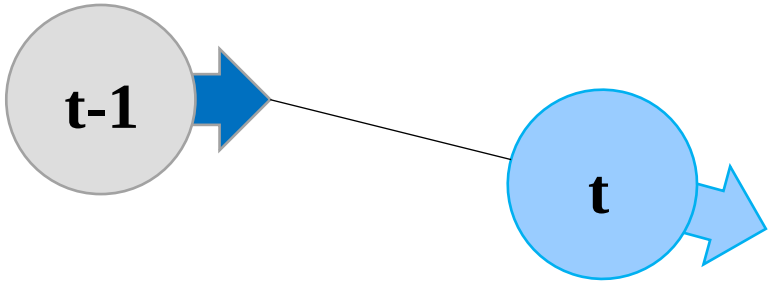
Measurement model: Robot



Measurement model: Robot

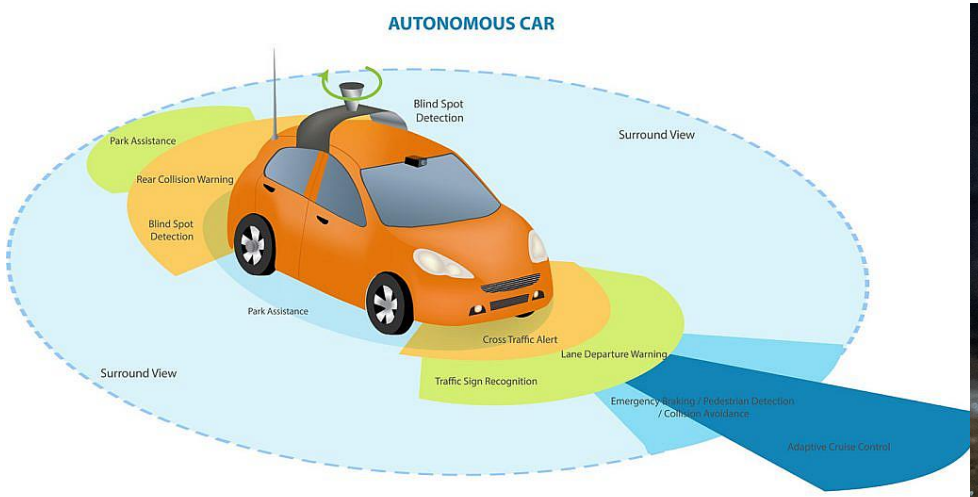
EKF and robot trajectory

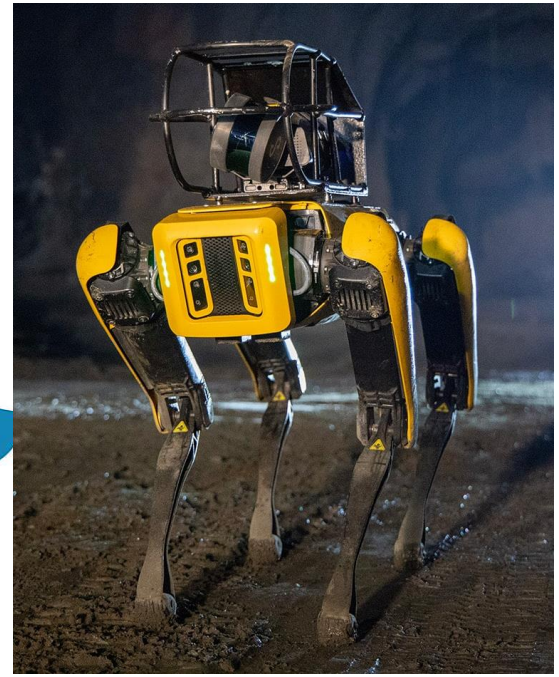


$$z_t = h(x_t) + \delta_t$$

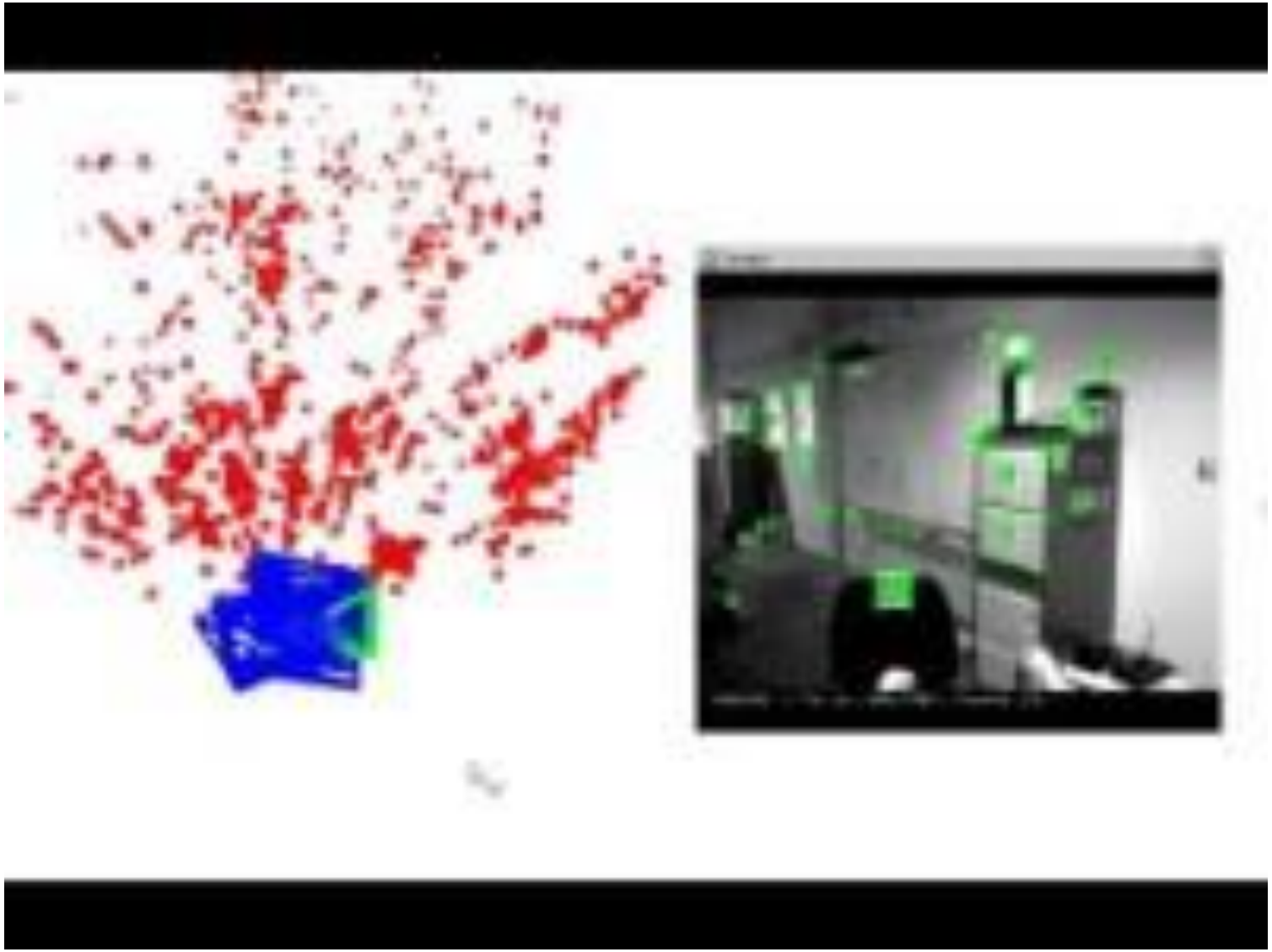
(measurement)

Global coordinate system
(measurement model *h*)

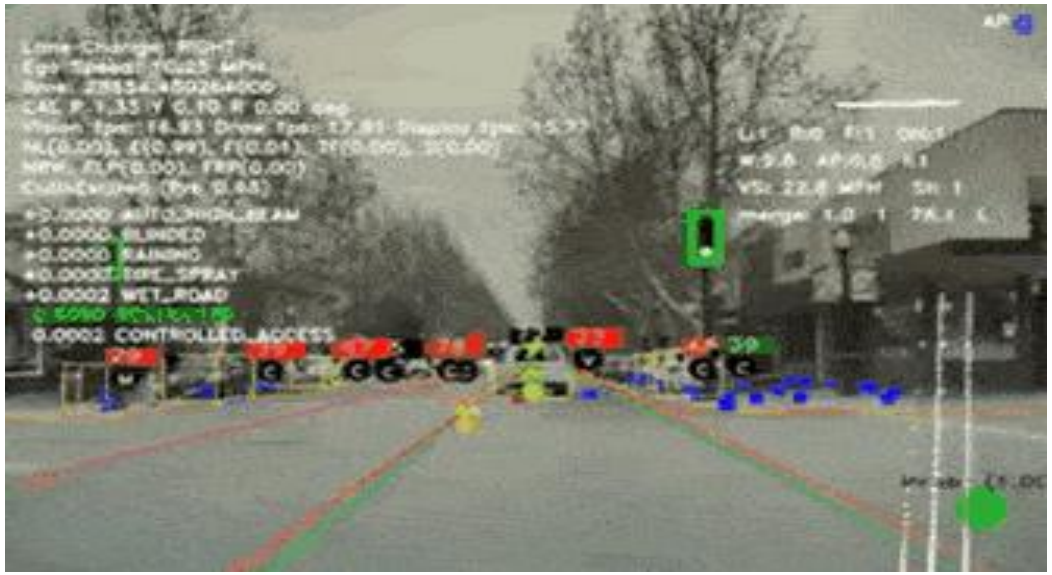


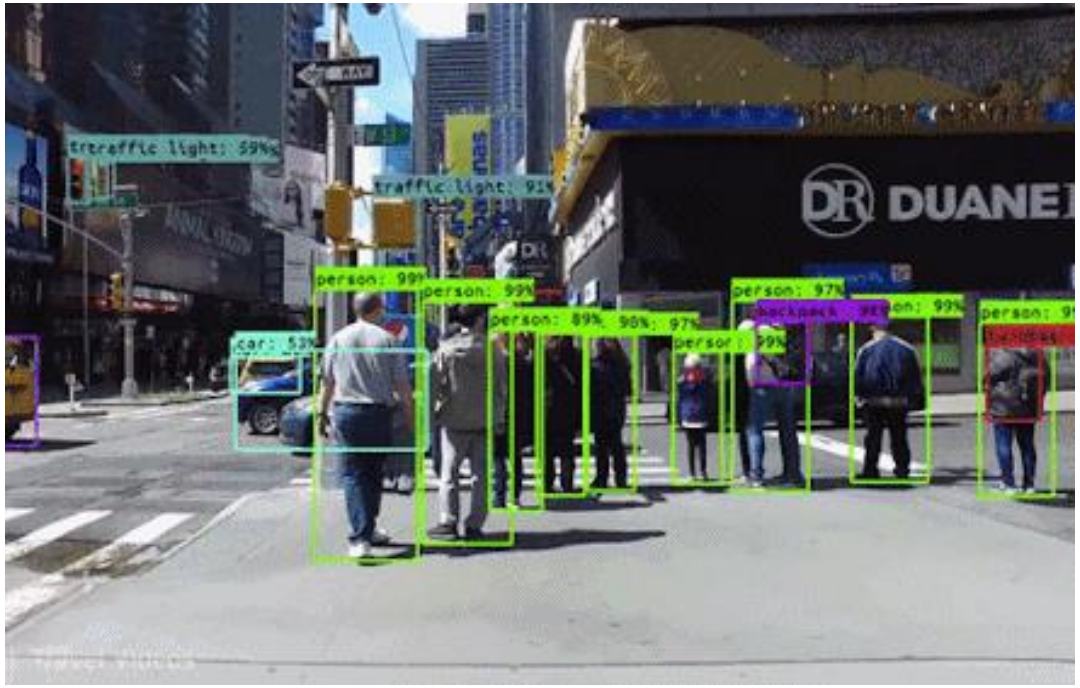


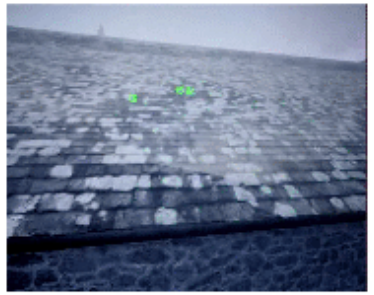
Measurement model: sometimes failed!

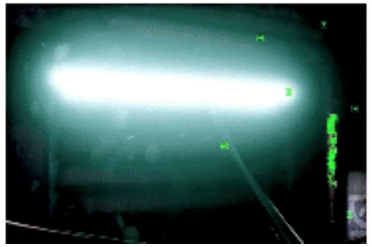


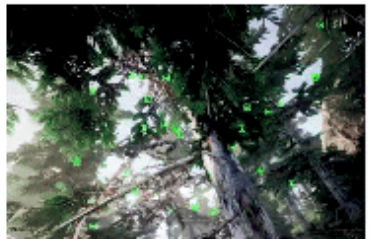
Measurement model: sometimes failed!

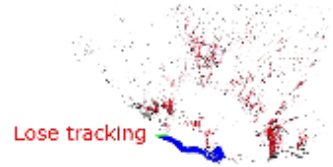




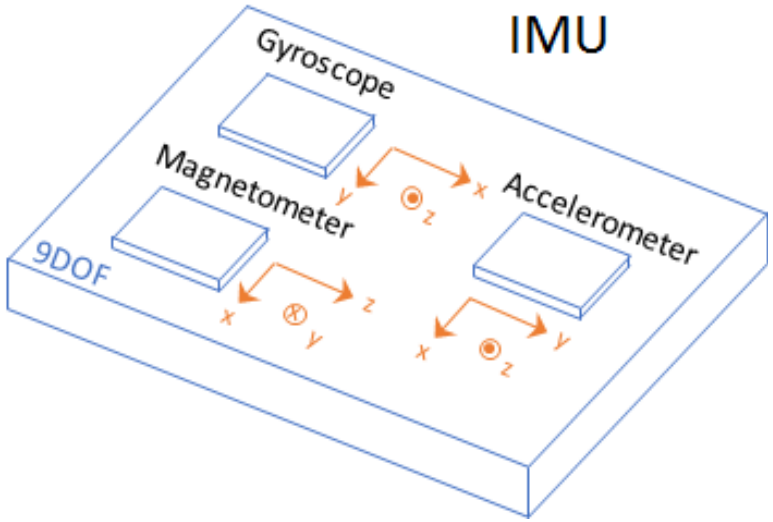


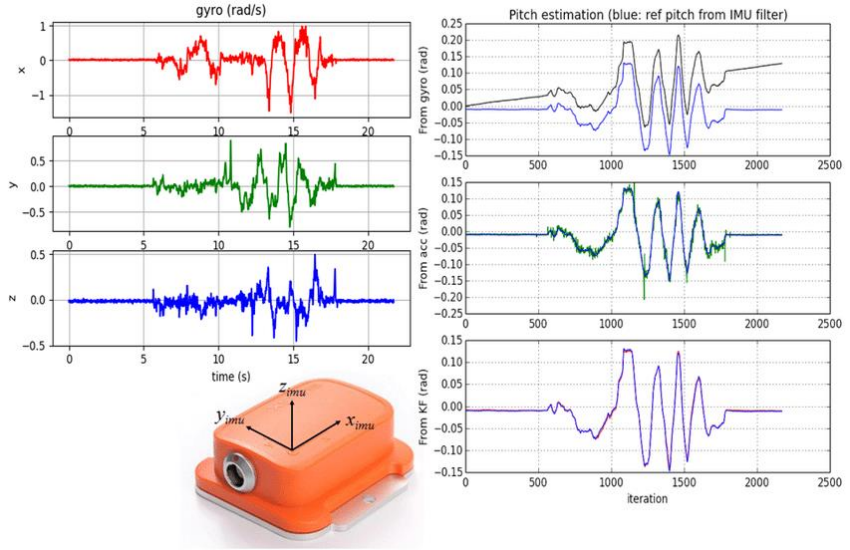


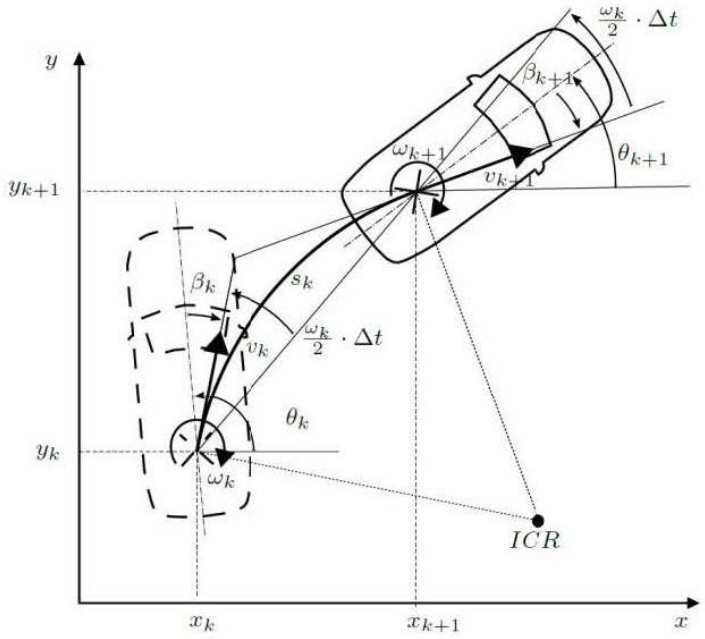


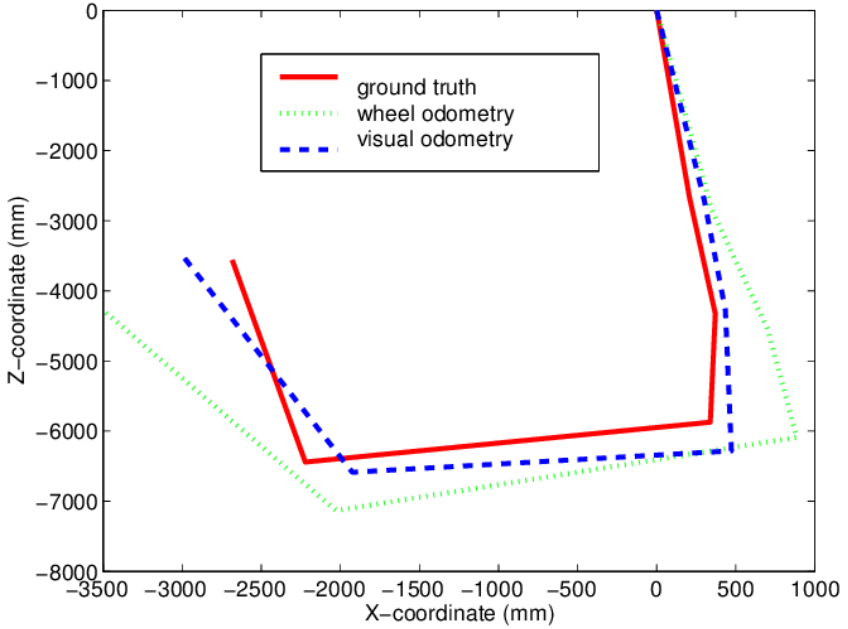


Odometry


IMU
Gyroscope
Magnetometer
Accelerometer
9DOF


gyro (rad/s)
time (s)
Pitch estimation (blue: ref pitch from IMU filter)
From gyro (rad)
From acc (rad)
From KF (rad)
iteration

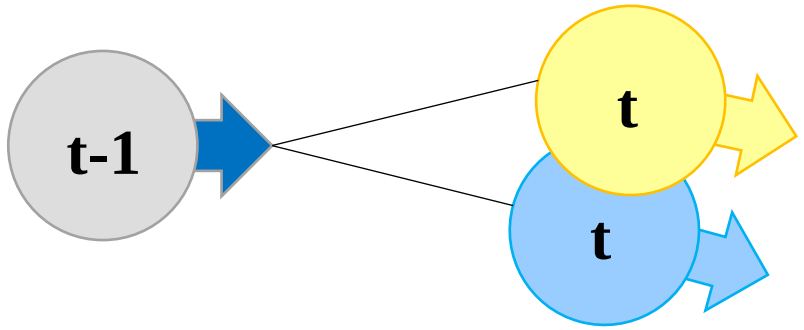

ICR


ground truth
wheel odometry
visual odometry
Z–coordinate (mm)
X–coordinate (mm)


Velodyne LiDAR

Odometry

EKF and robot trajectory

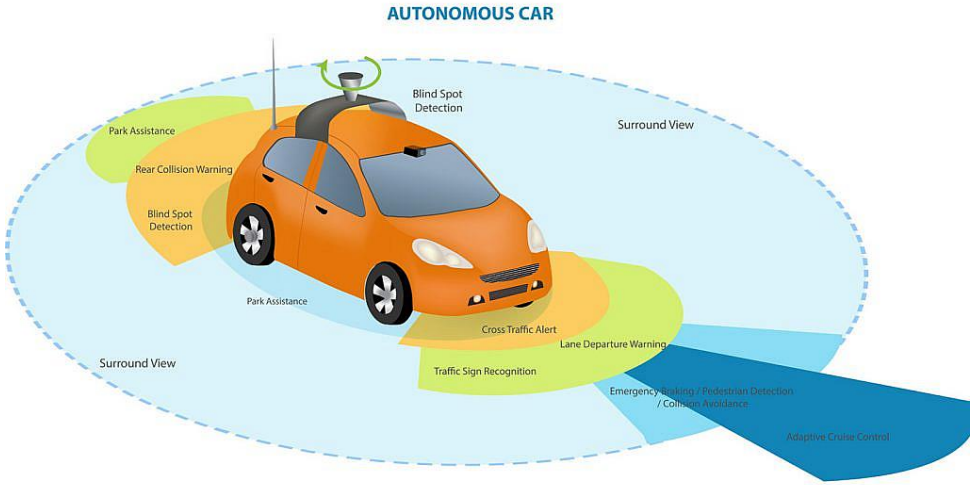


$$x_t = g(u_t, x_{t-1}) + \epsilon_t \quad \text{(odometry)}$$

$$z_t = h(x_t) + \delta_t \quad \text{(measurement)}$$

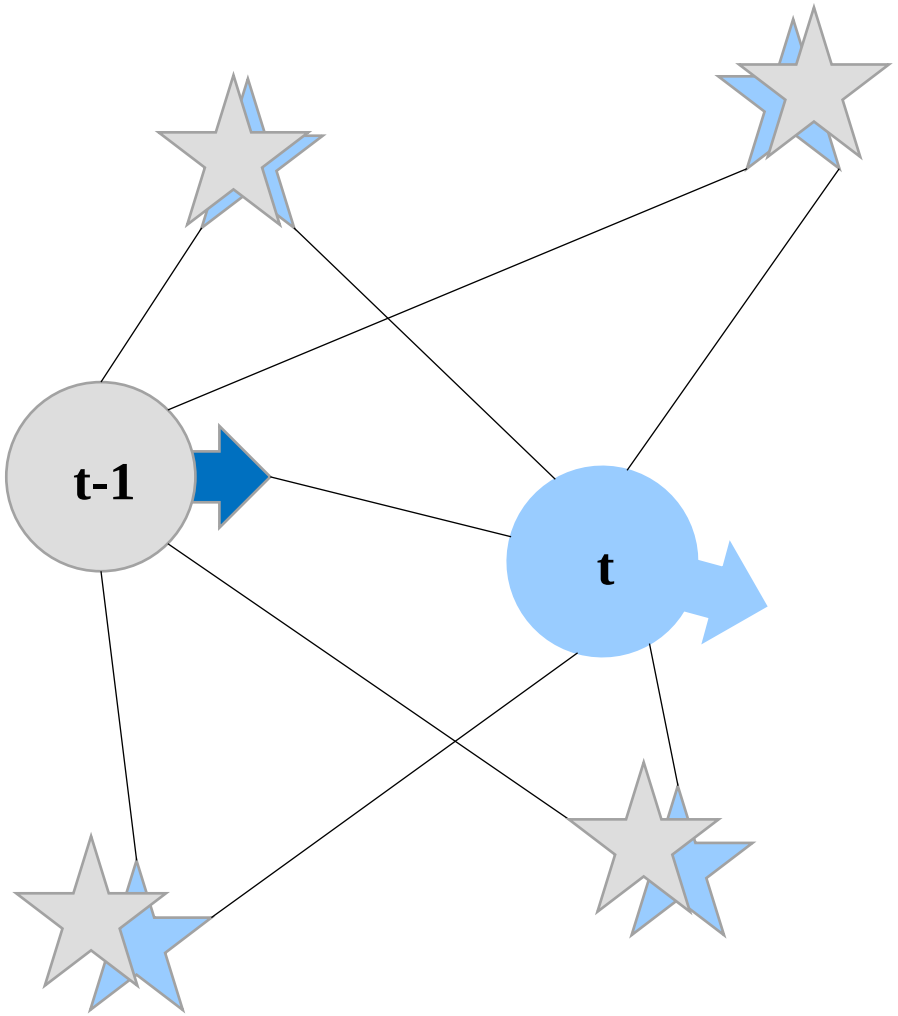
Odometry
(motion model *g*)

Robot controller
(control input *u*)



(measurement model *h*)

SLAM: Measurement model and Odometry



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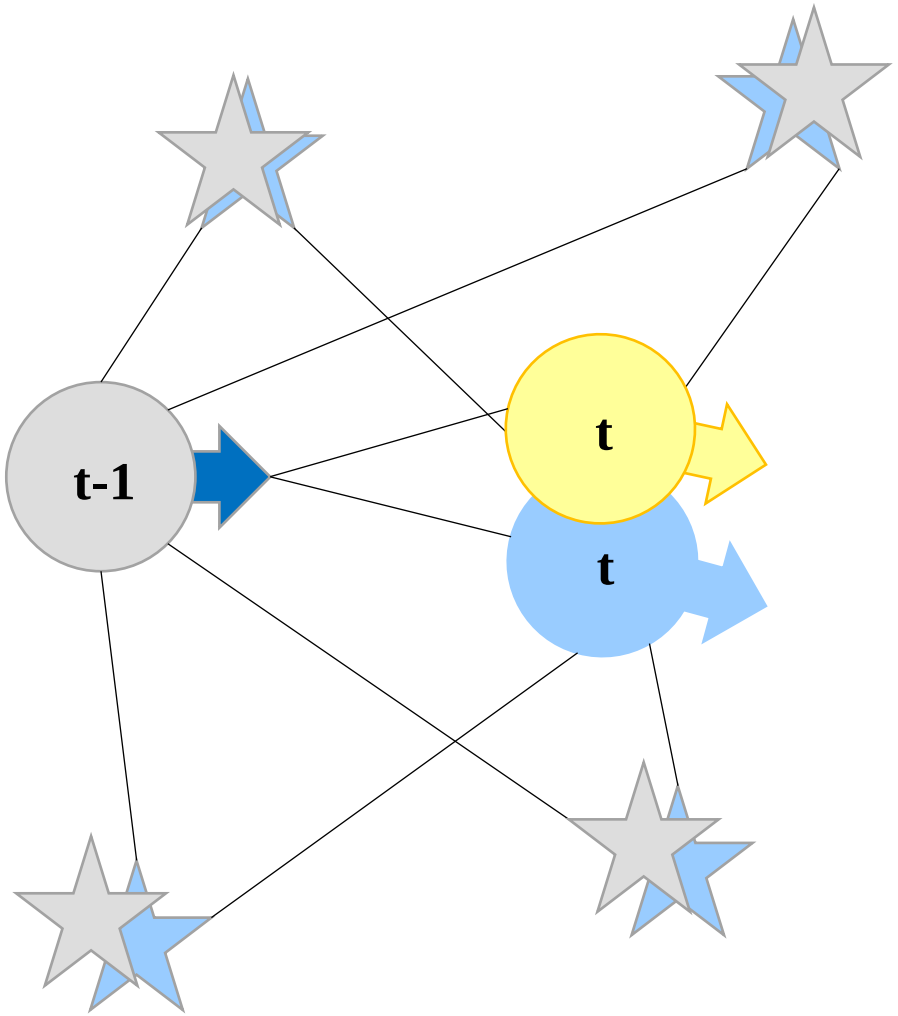
→Measuring robot pose by measuring poses of nearby landmarks

SLAM: Measurement model and Odometry



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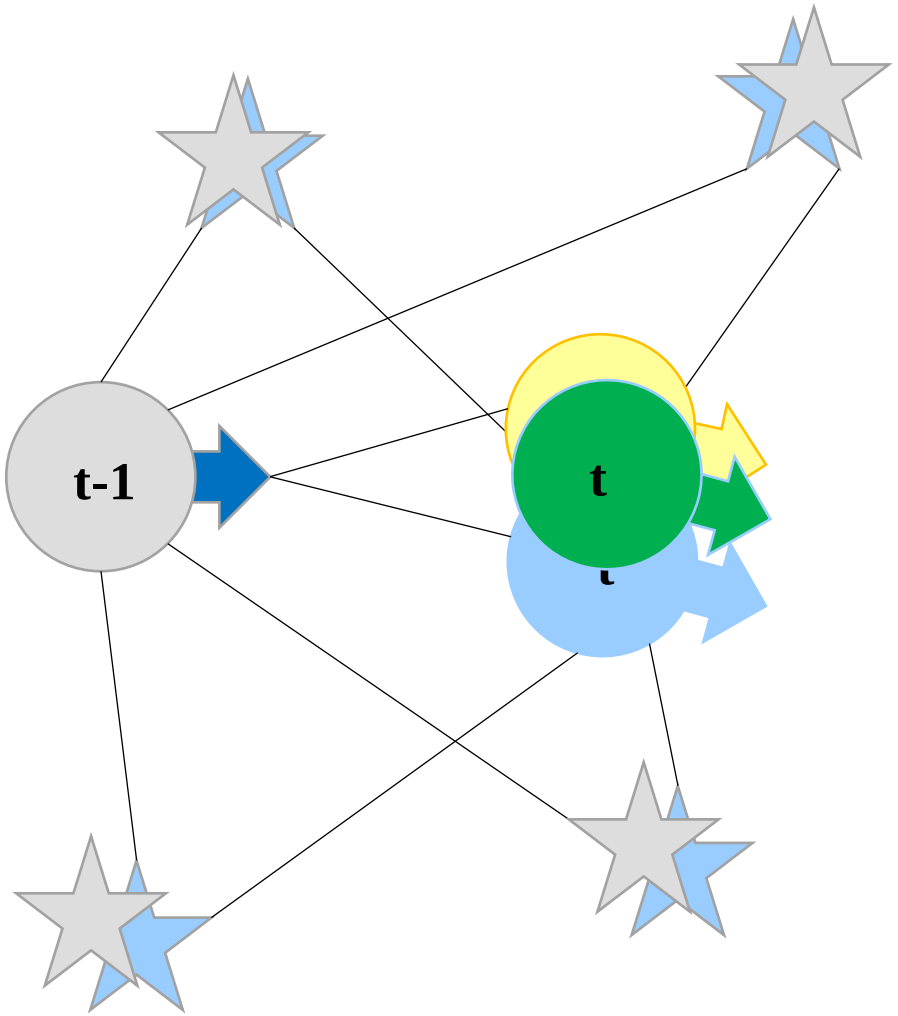
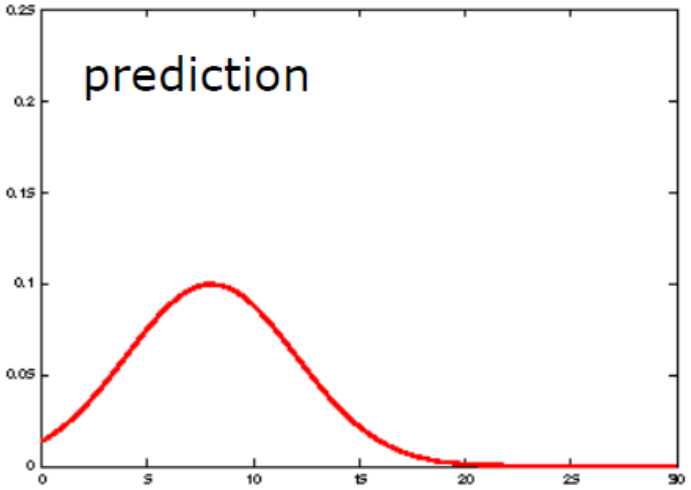
SLAM: Measurement model and Odometry

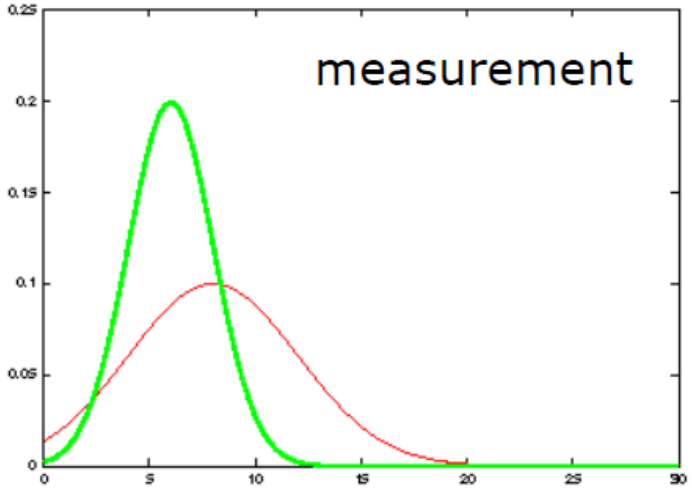


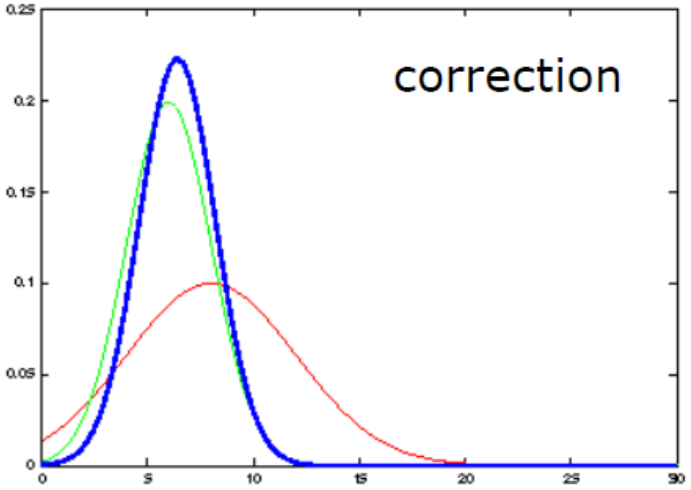
☆: Measuring robot pose from the ground truth poses of nearby landmarks
→Measuring robot pose by measuring poses of nearby landmarks

SLAM: Measurement model and Odometry

How do we take average of Measurement and Odometry?







$$x_t = g(u_t, x_{t-1}) + \epsilon_t$$ (prediction)

$$z_t = h(x_t) + \delta_t$$ (measurement)