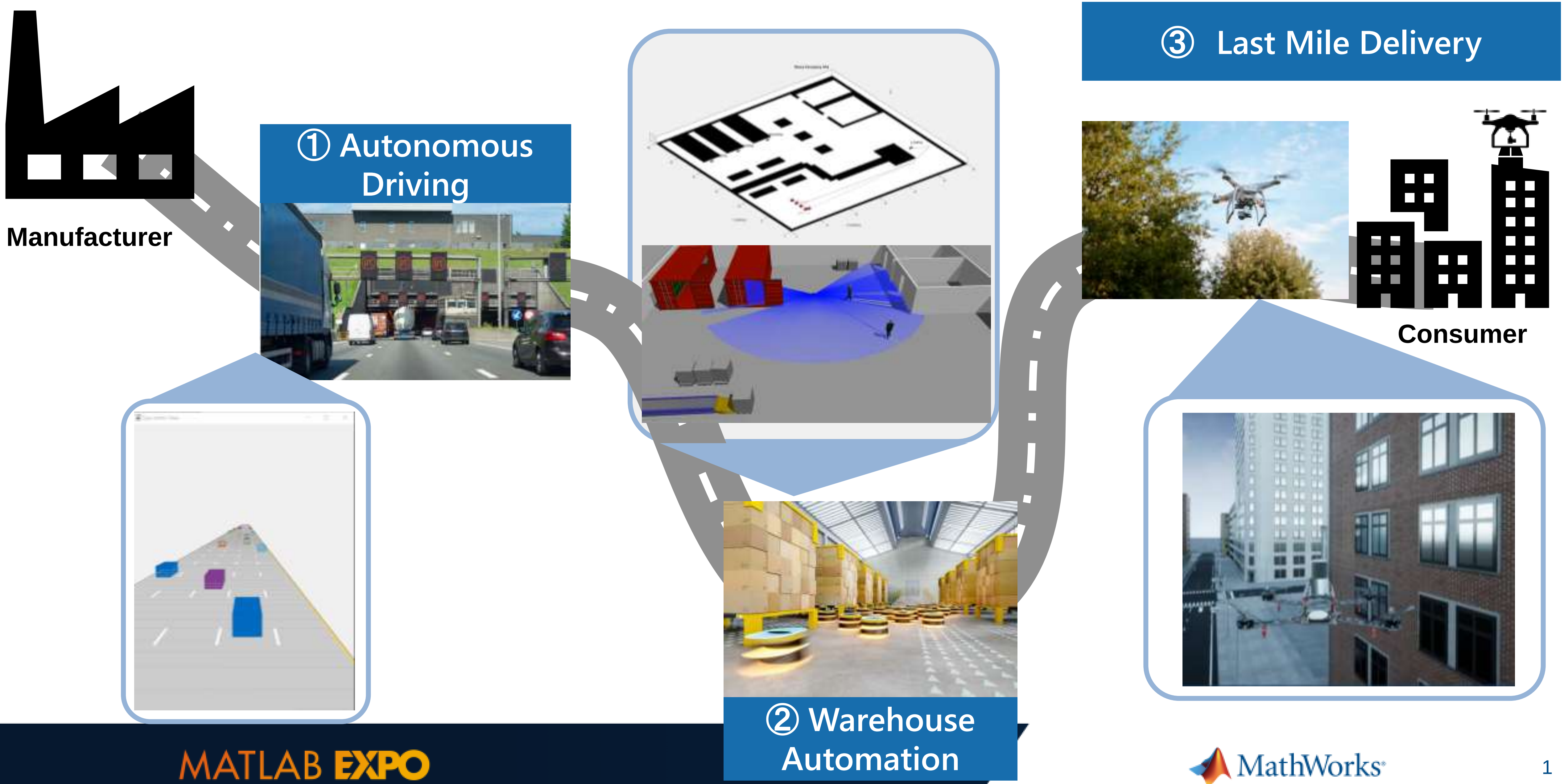
MATLAB EXPO

자율 이동로봇을 위한 센서퓨젼 및 네비게이션 알고리즘 개발

김종현, MathWorks

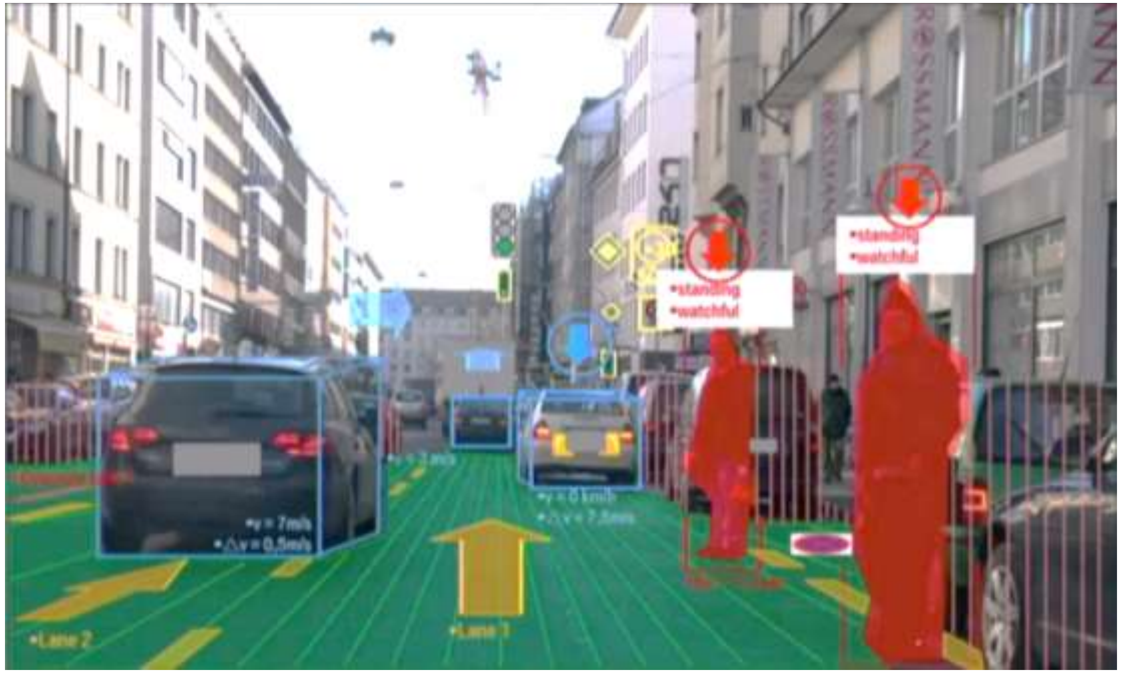
MathWorks

Smart Autonomous Package Delivery



Capabilities of an Autonomous System

Perception



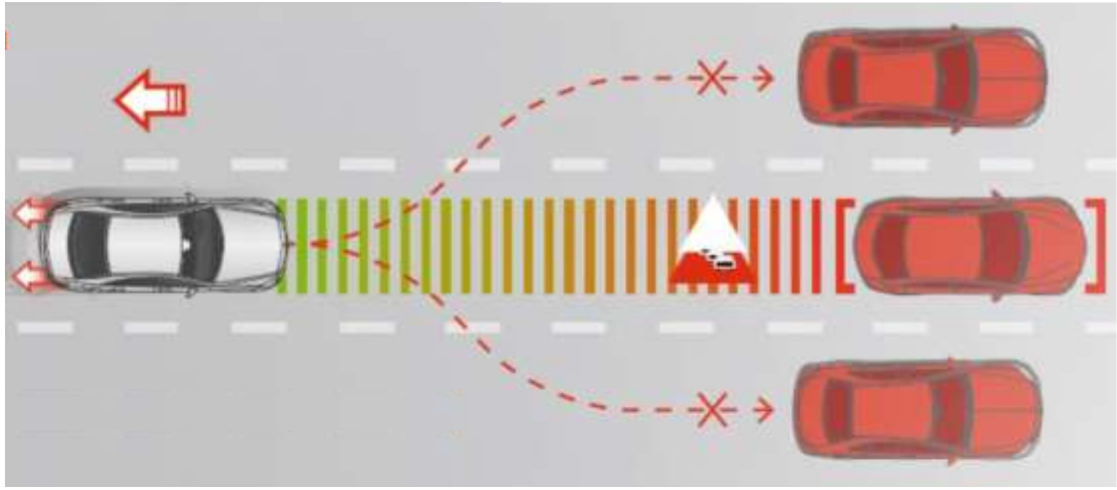
Some common Perception tasks

- Design localization algorithms
- Design environment mapping algorithms
- Design SLAM algorithms
- Design fusion and tracking algorithms
- Label sensor data
- Design deep learning networks
- Design radar algorithms
- Design vision algorithms
- Design lidar algorithms
- Generate C/C++ code

Capabilities of an Autonomous System

Perception

Planning



Some common Planning **tasks**

- Visualize street maps
- Connect to HERE HD Live Map
- Design local and global path planners
- Design vehicle motion behavior planners
- Design trajectory generation algorithms
- Generate C/C++ code

Capabilities of an Autonomous System

Perception

↓

Planning

↓

Control

Some common Control **tasks**

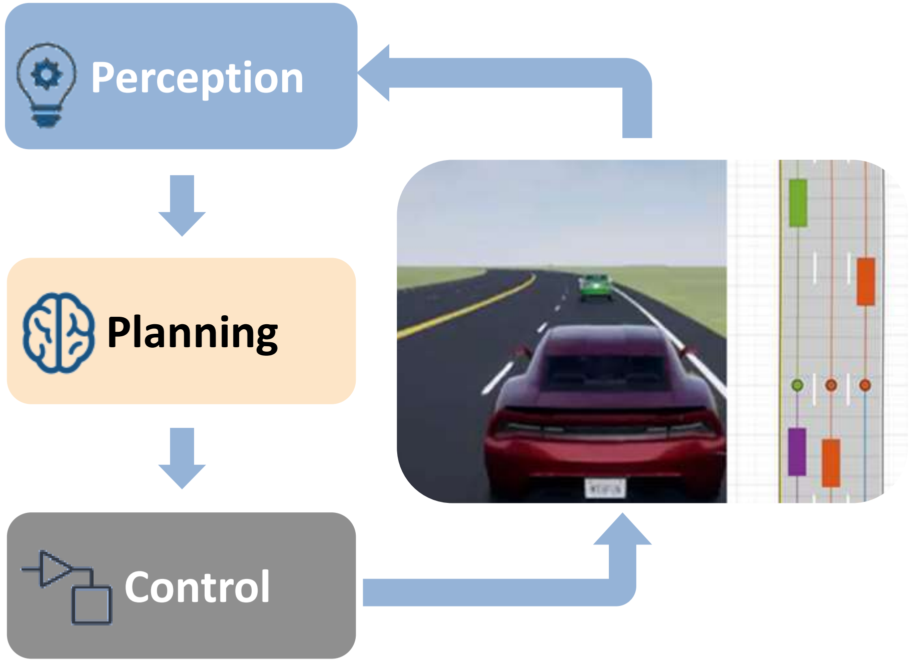
- Connect to recorded and live CAN data
- Design reinforcement learning networks
- Model vehicle dynamics
- Automate regression testing
- Prototype on real-time hardware
- Design path tracking controllers
- Design model-predictive controllers
- Generate production C/C++ code
- Generate AUTOSAR code
- Certify for ISO26262

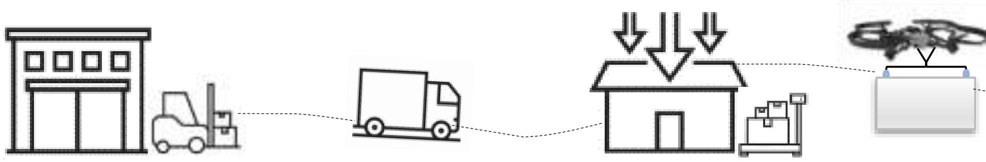
In This Talk, You Will Learn

Reference workflow for autonomous navigation systems development

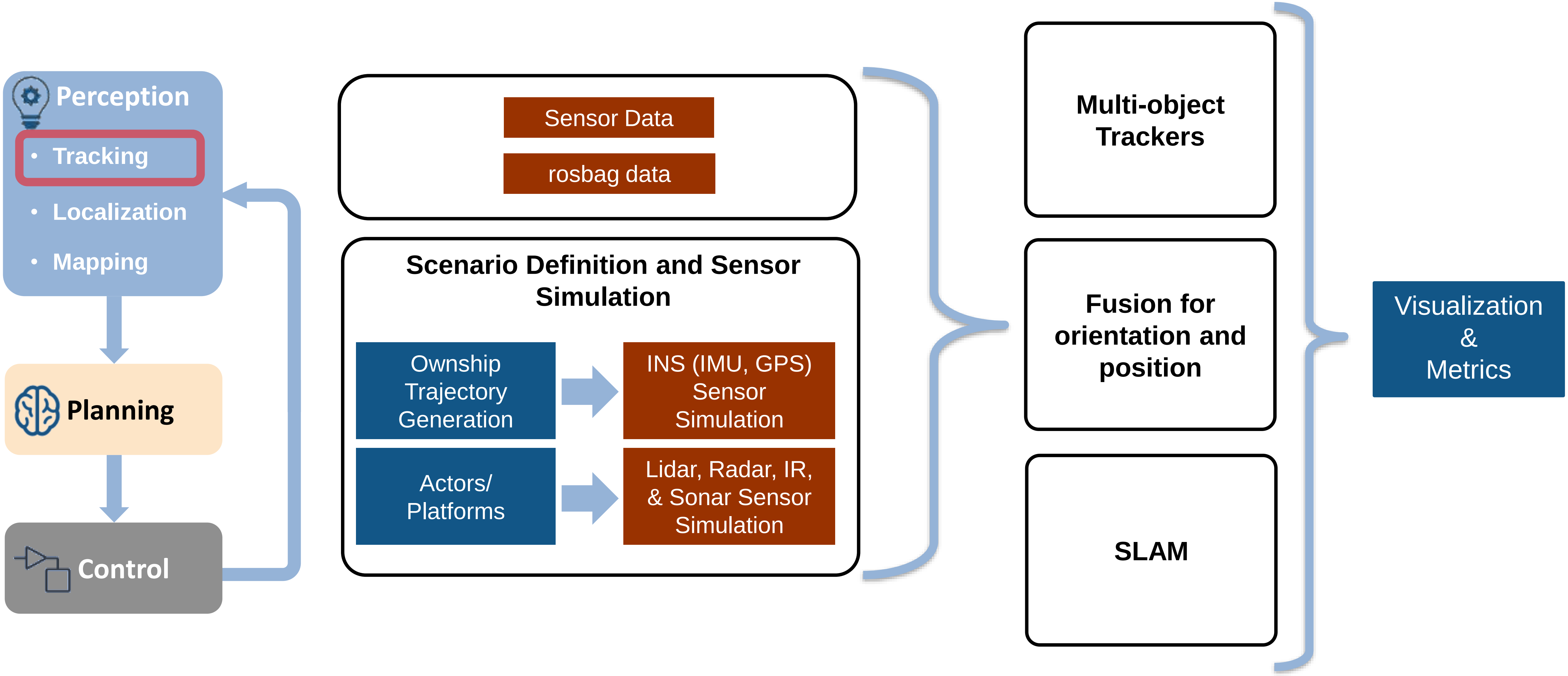
MATLAB and Simulink capabilities to design, simulate, test, deploy algorithms for sensor fusion and navigation algorithms

- Perception algorithm design
- Fusion sensor data to maintain situational awareness
- Mapping and Localization
- Path planning and path following control

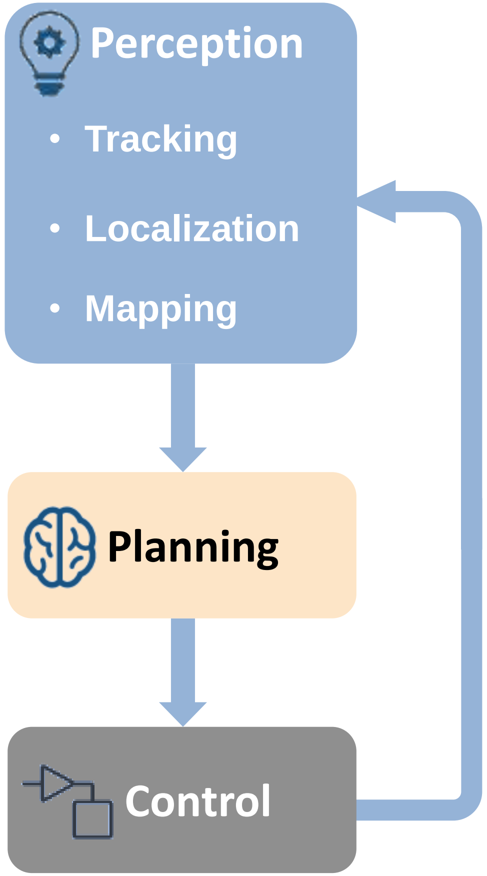




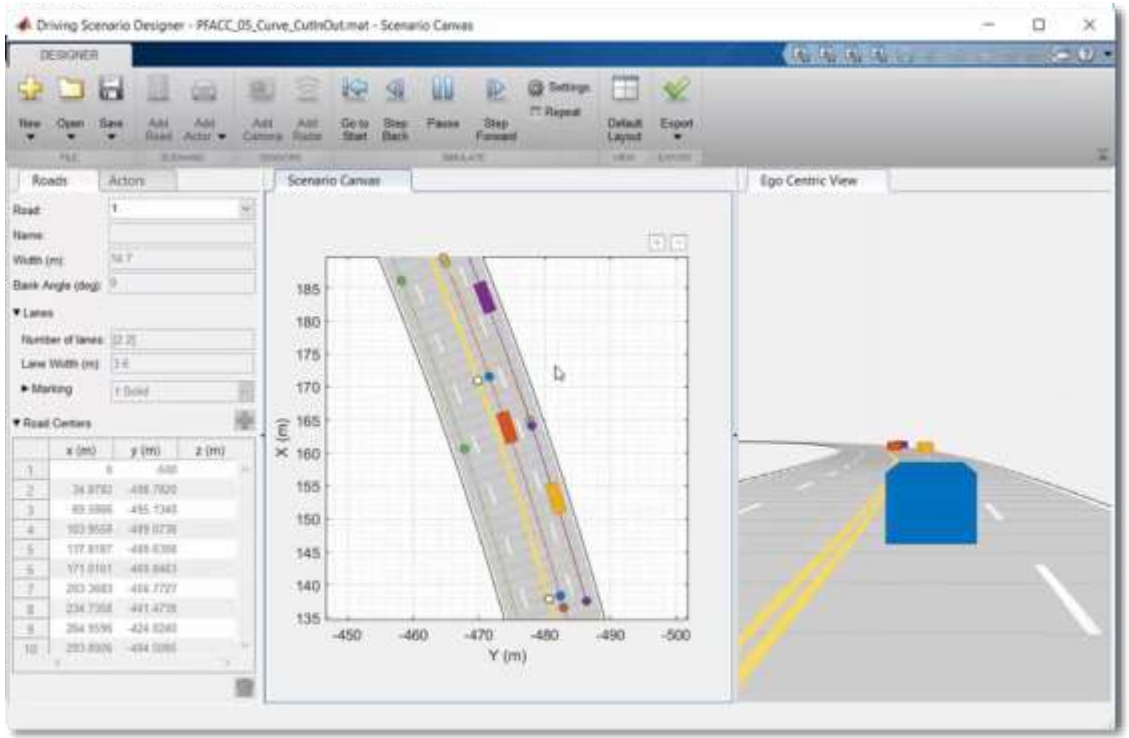
Many Options to Bring Sensor Data to Perception Algorithms



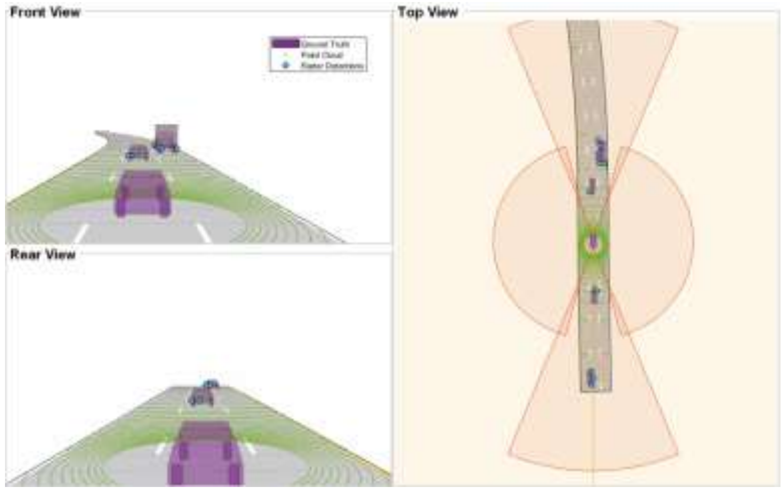
Live Data Can Be Augmented for a More Robust Testbench



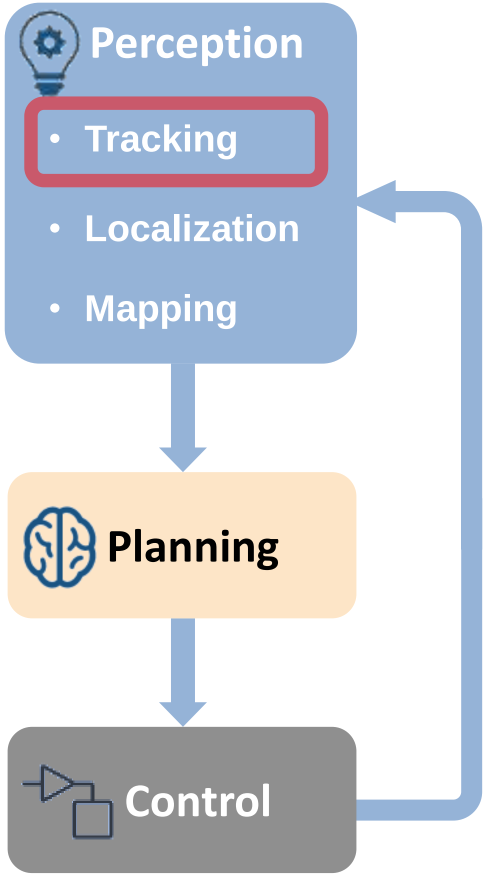
Define scenarios



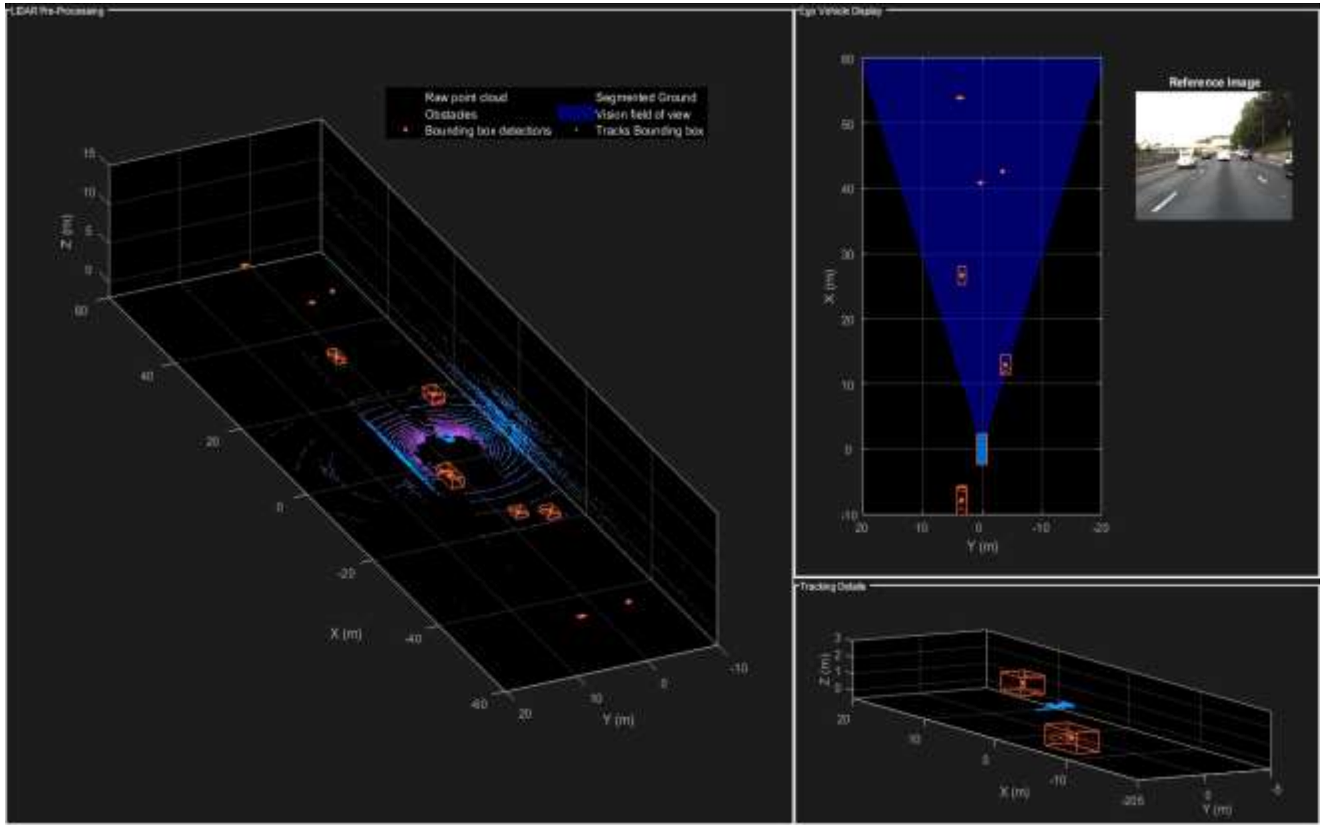
Simulate sensors



Autonomous Systems Can Track Objects from Lidar Point Clouds

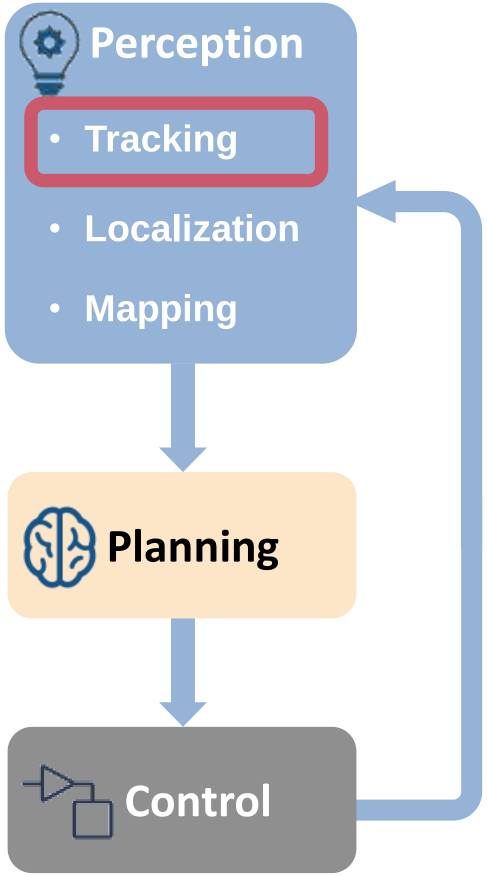


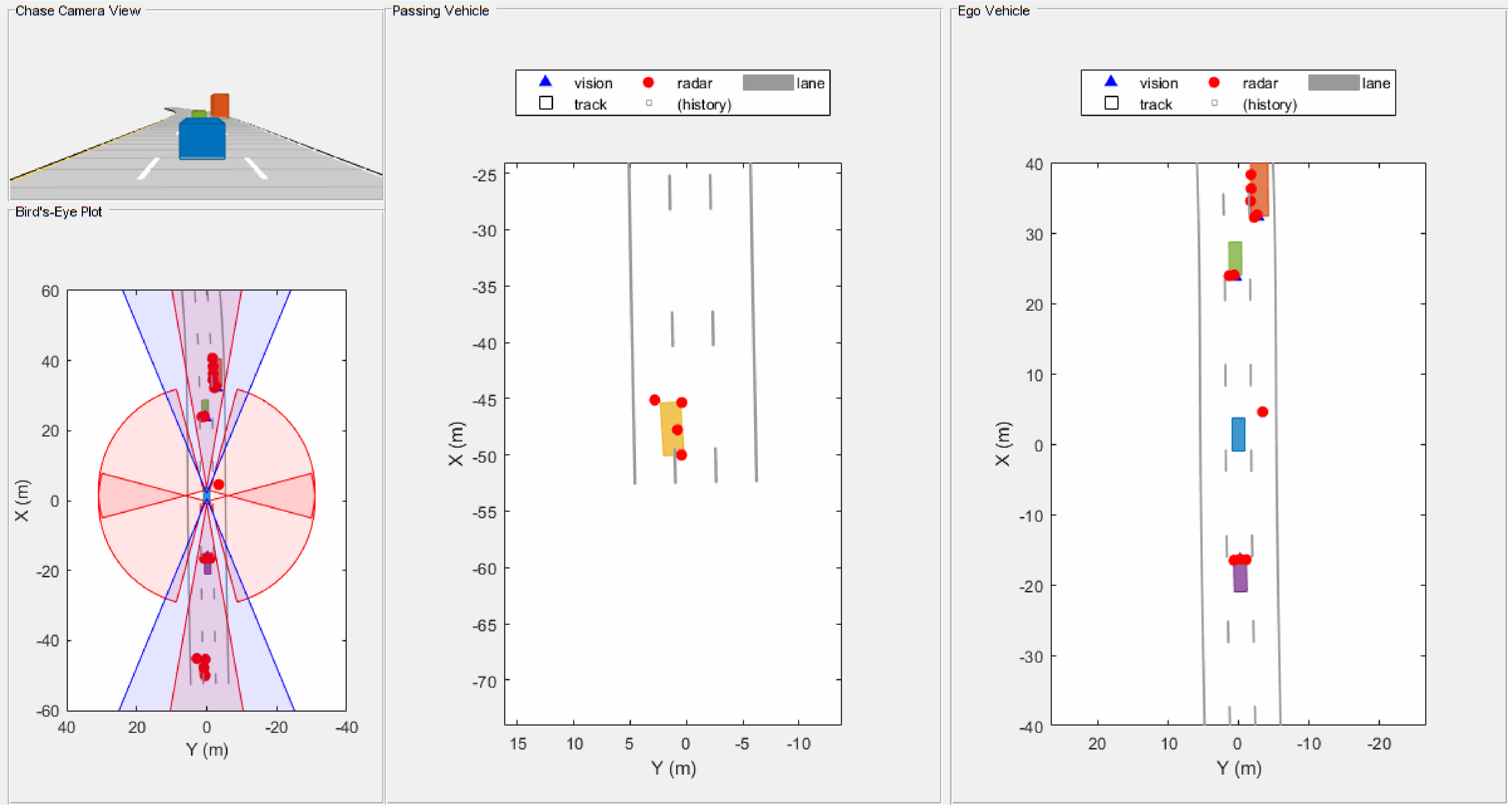
Track Objects Using Lidar: From Point Cloud to Track List



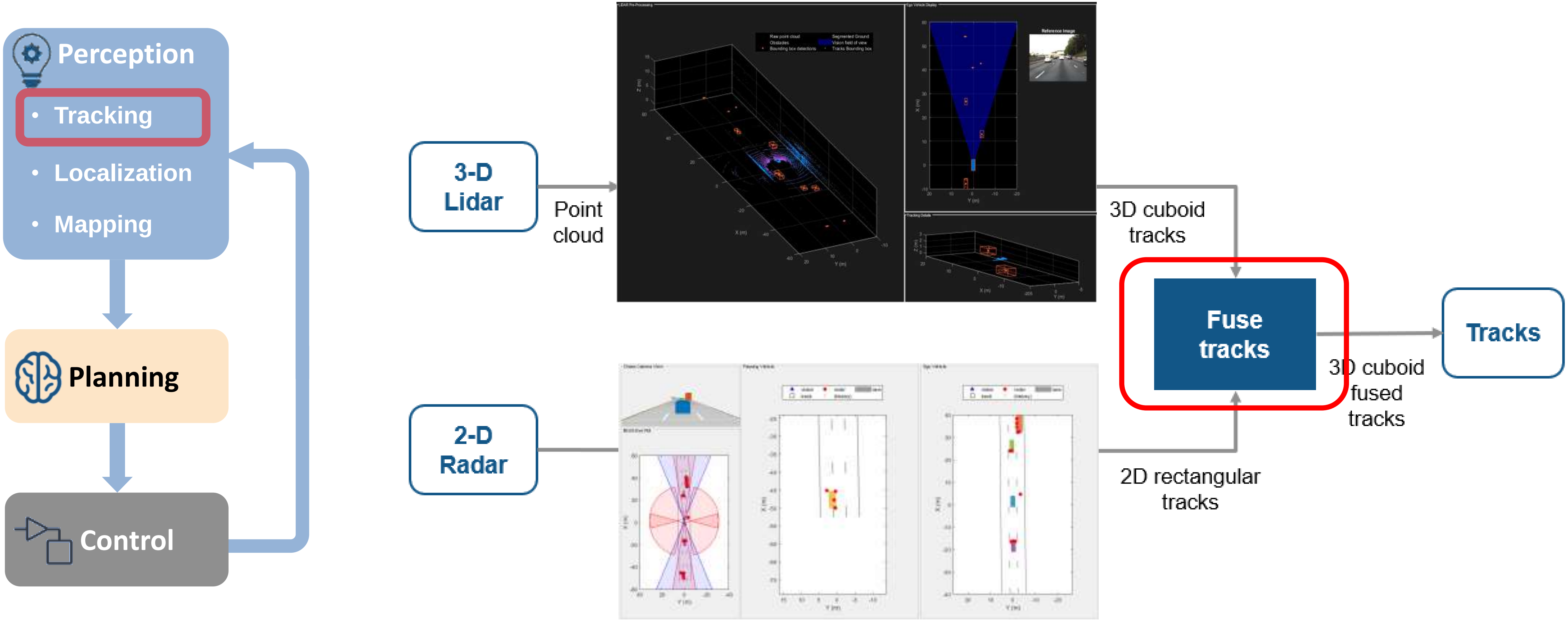
Track surrounding objects during automated lane change

2D radar Can Be Used to Track Position, Size, and Orientation

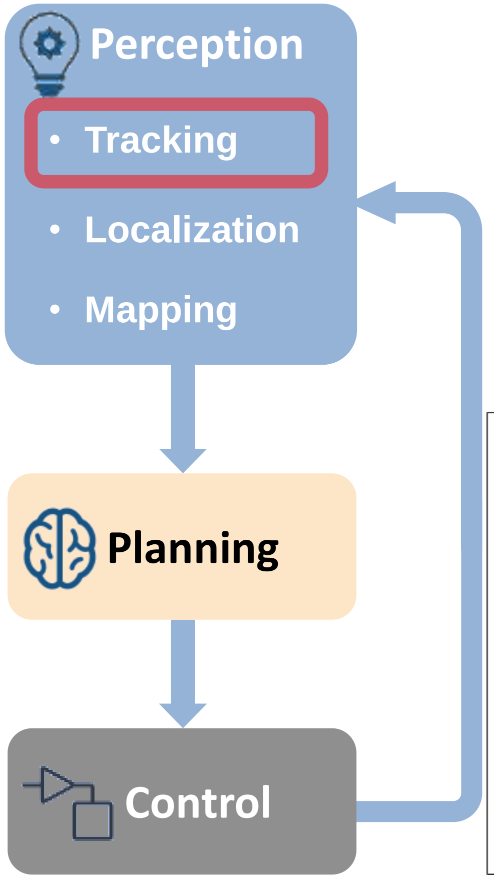


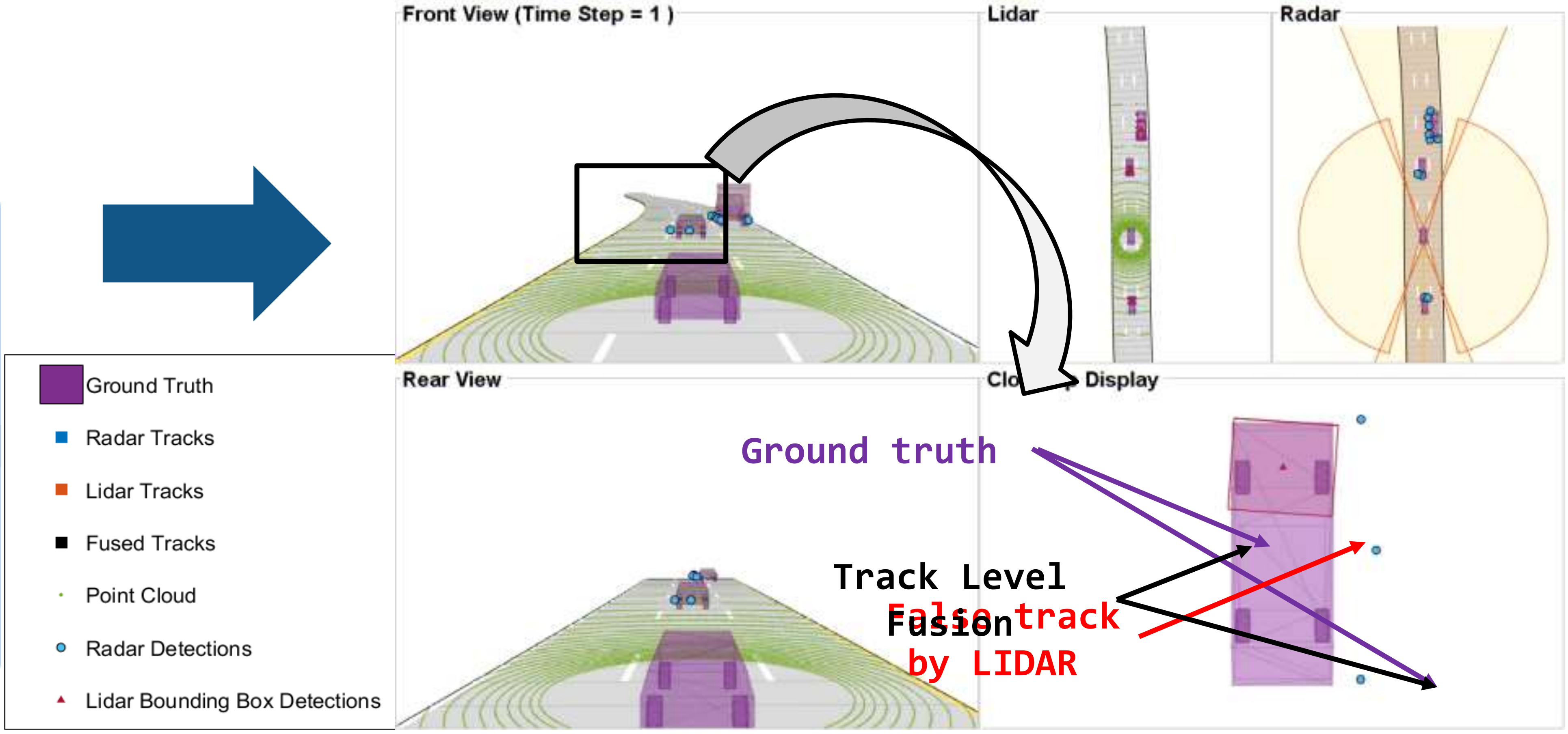


Fusing Multiple Sensor Modalities Provides a Better Result

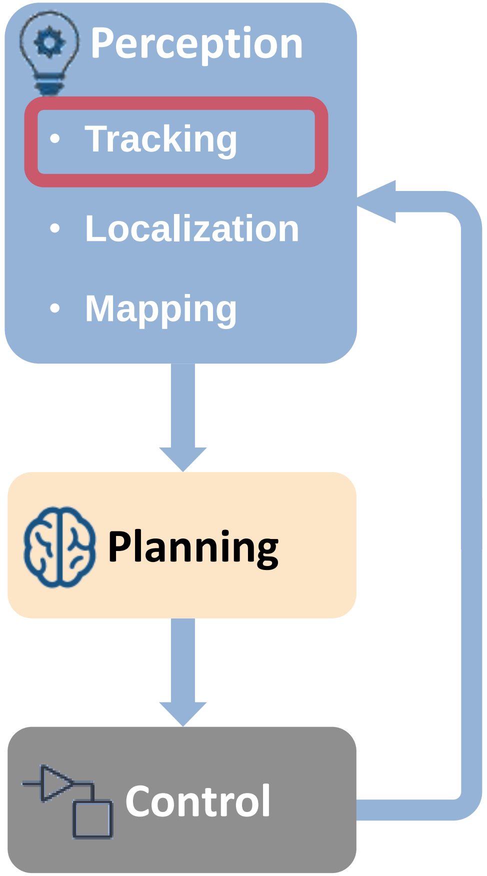


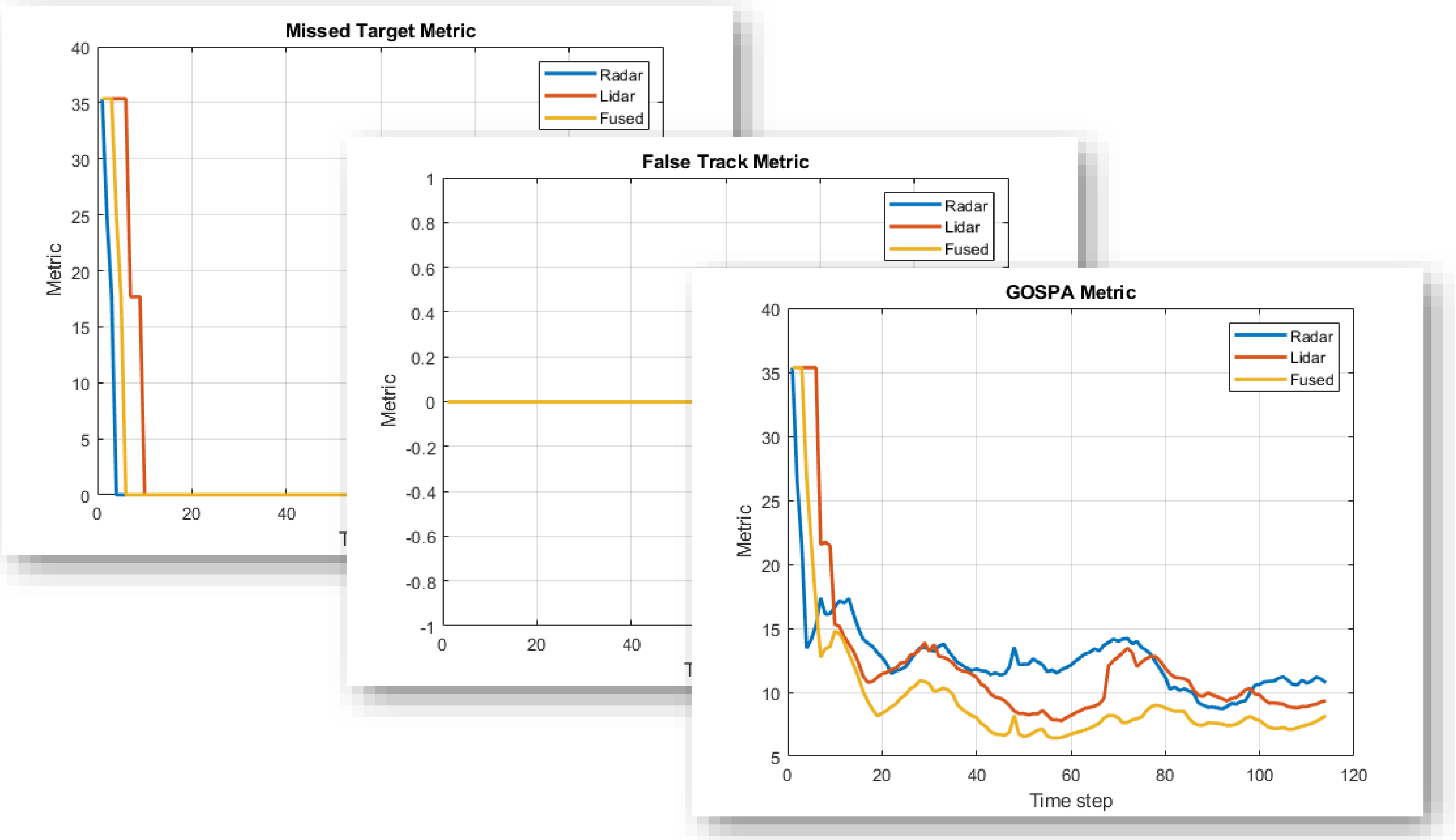
Radar and Lidar Fusion Can Increase Tracking Performance



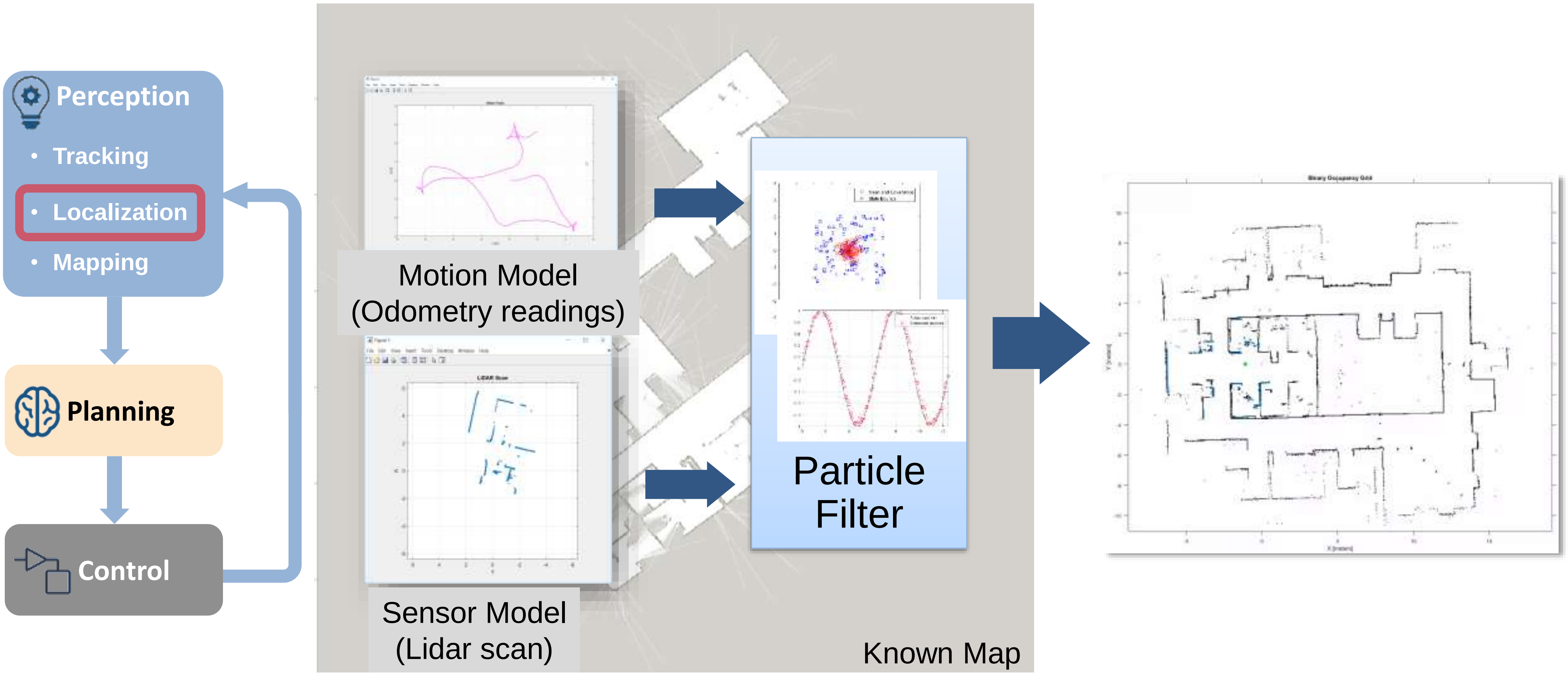


Radar and Lidar Fusion Can Increase Tracking Performance



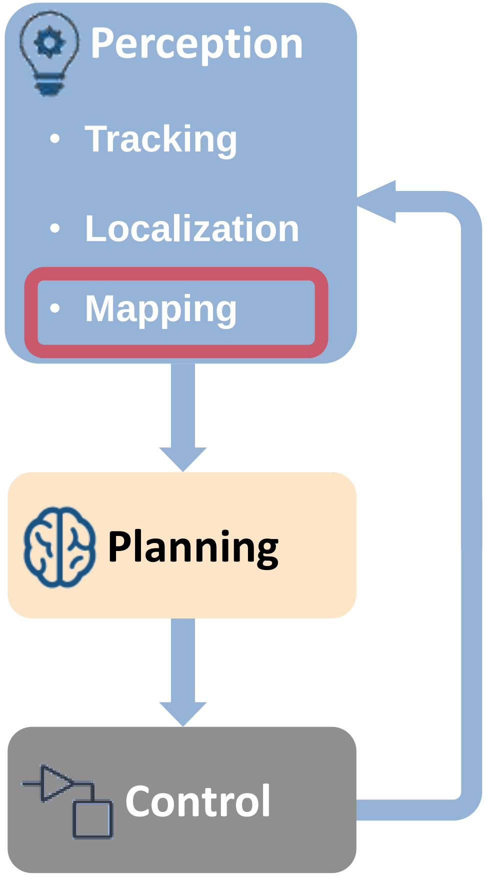


Estimate the Pose Using Monte Carlo Localization



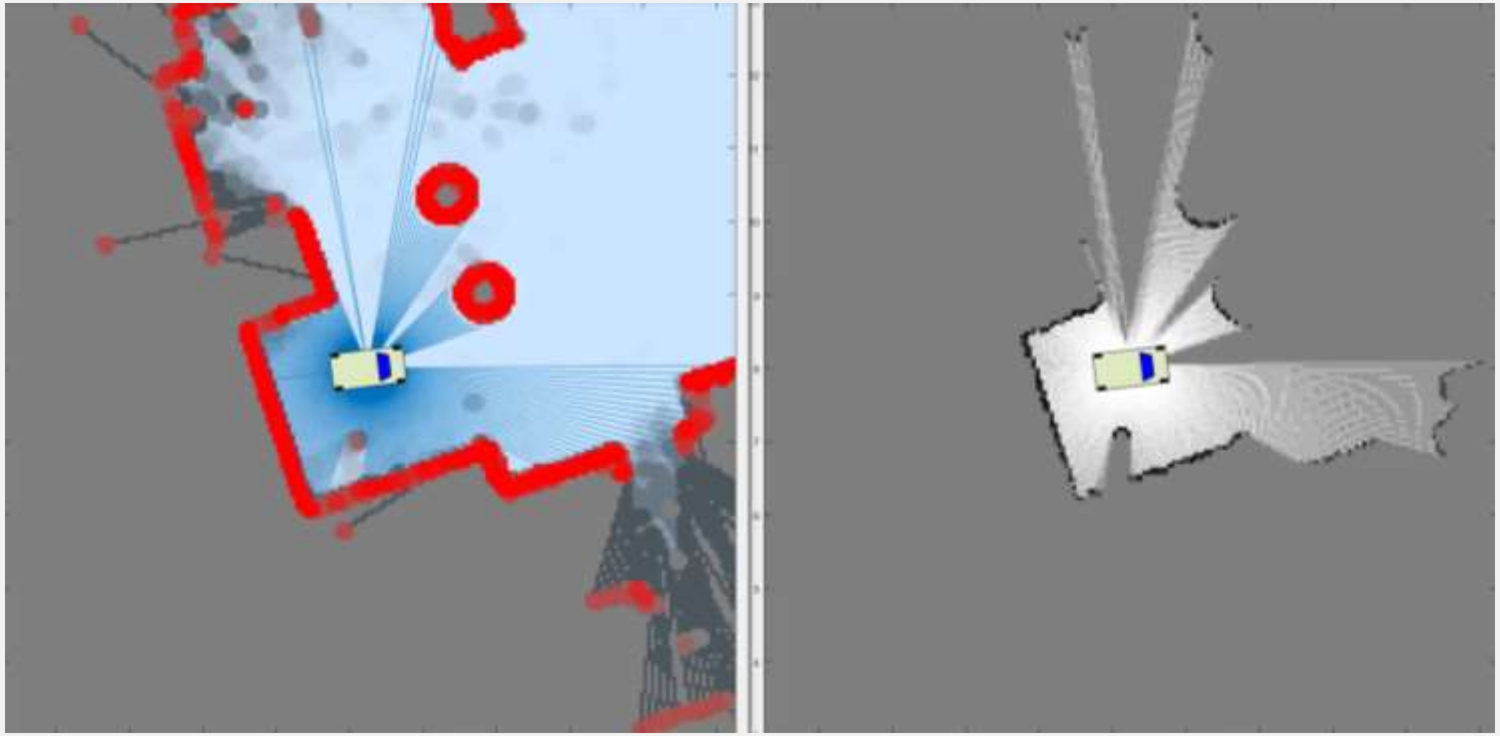
What is the World Around Me?

Egocentric occupancy maps



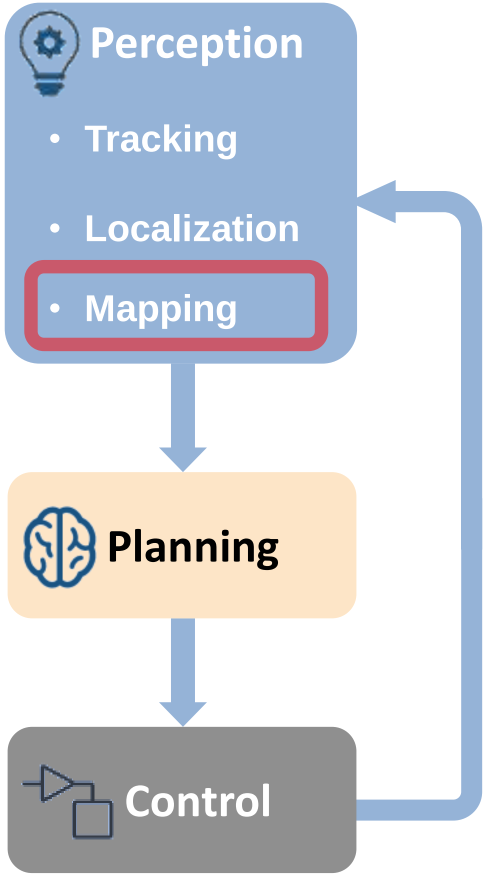
Dynamic Environment

– Support dynamic environment changes
– Synchronization between global and local maps

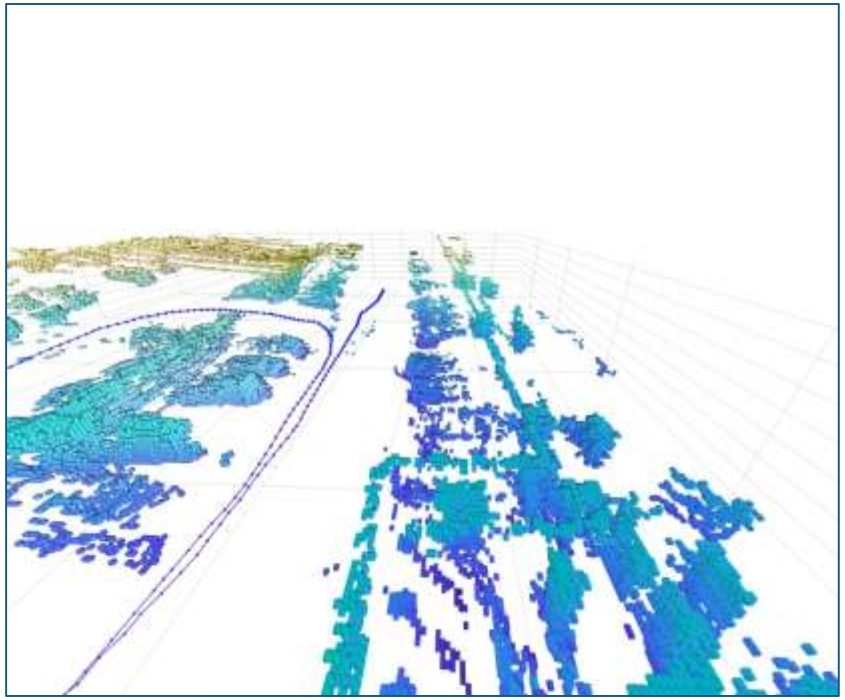


What is the World Around Me?

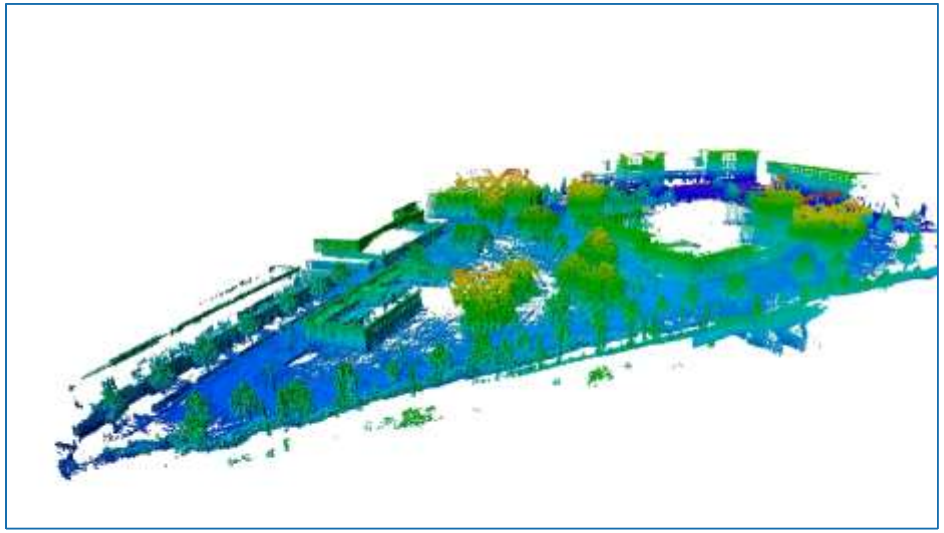
3D Occupancy Map



3D map for Autonomous Driving

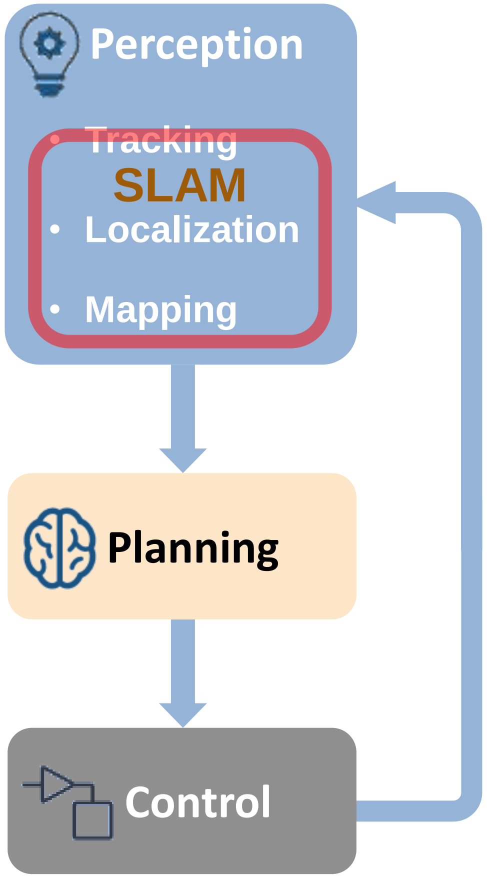


3D map for UAV motion planning

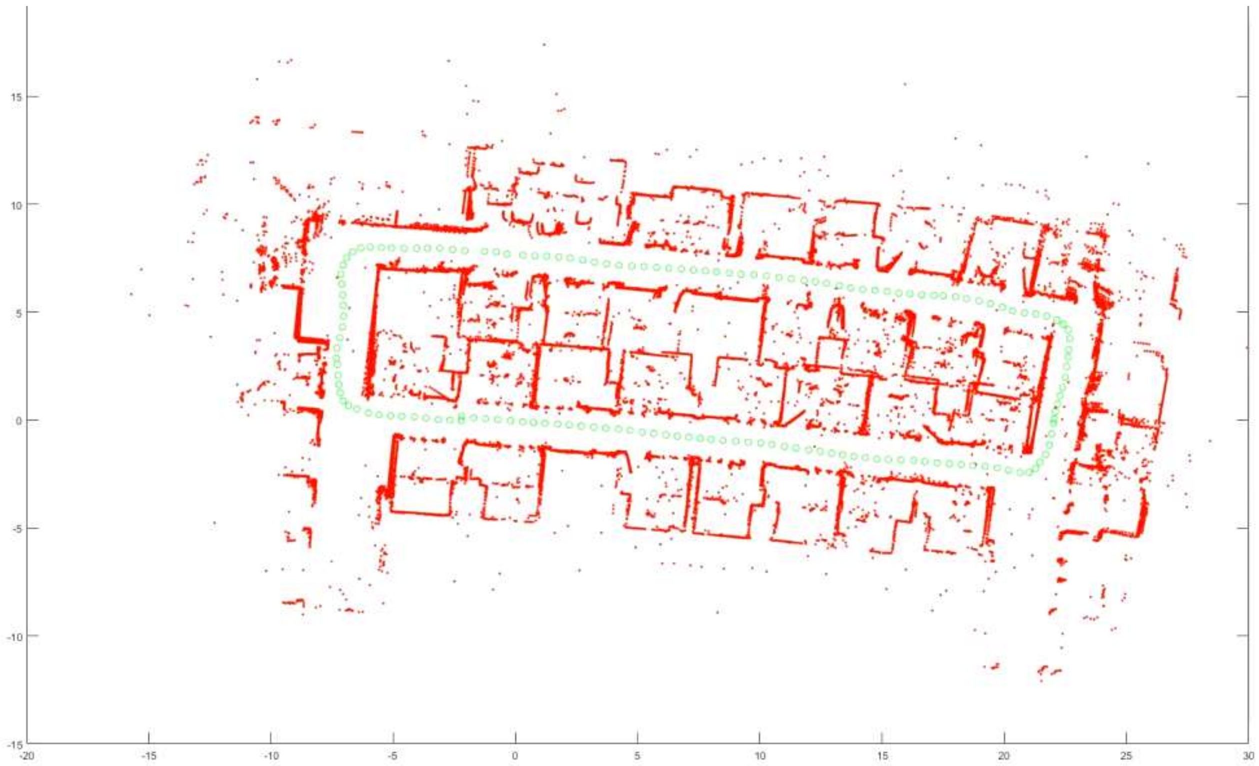


Where Am I in the Unknown Environment?

Simultaneous Localization and Mapping (SLAM)



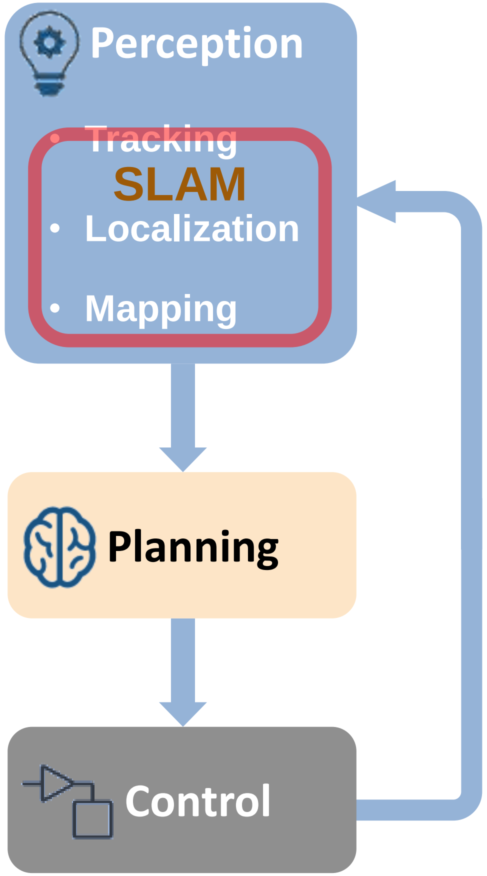
2D Lidar SLAM

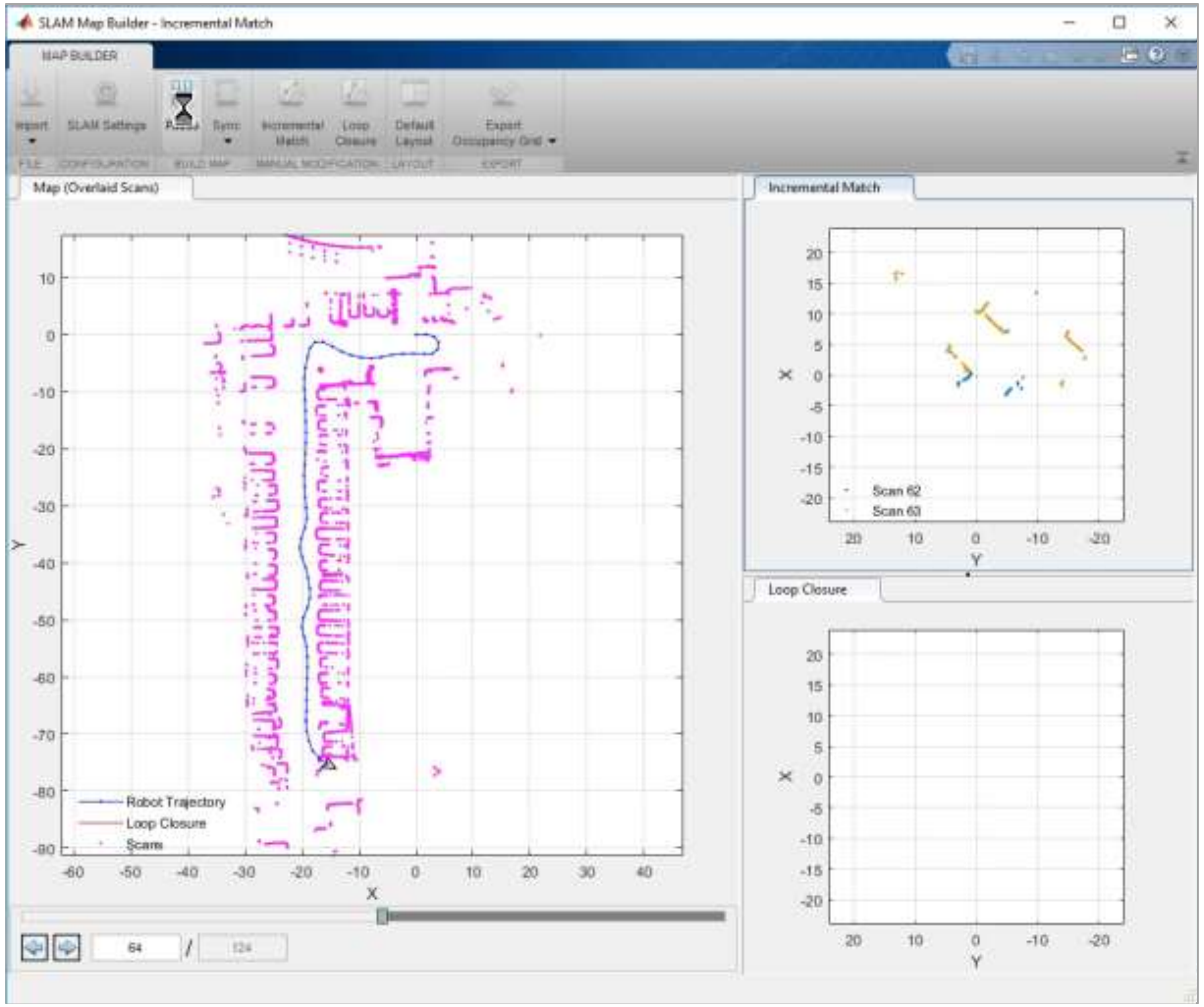


Build a map of an unknown environment while simultaneously keeping track of robot's pose.

Simultaneous Localization and Mapping

SLAM Map Builder App (2D only)

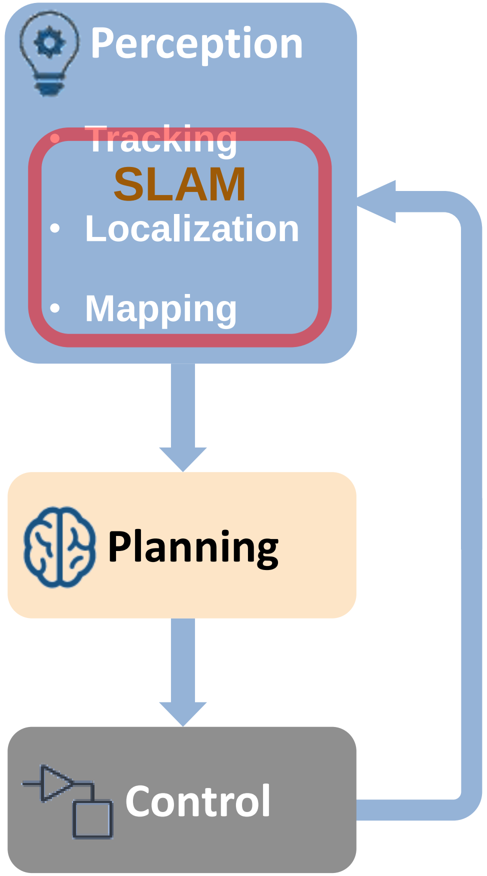




App enables more interactive and user-friendly workflow

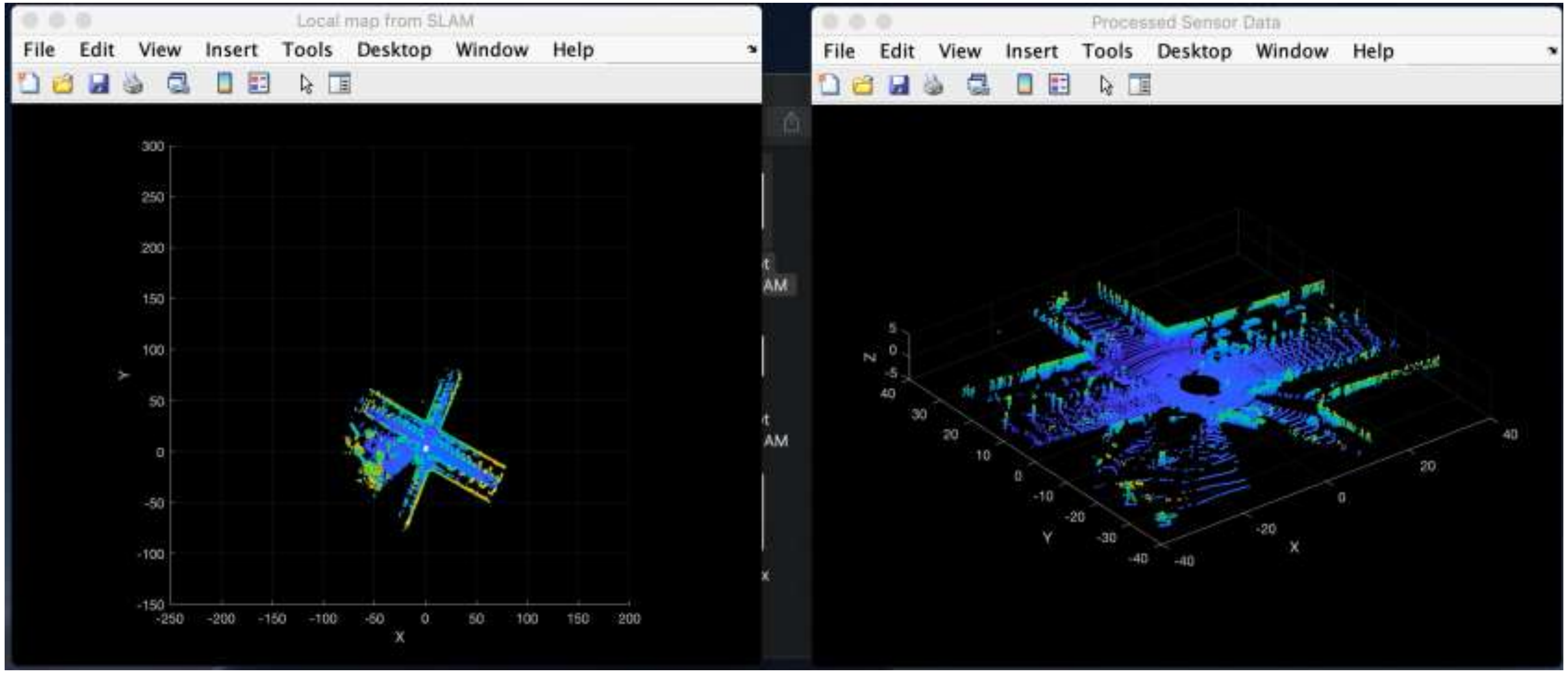
Simultaneous Localization and Mapping

3D Lidar SLAM



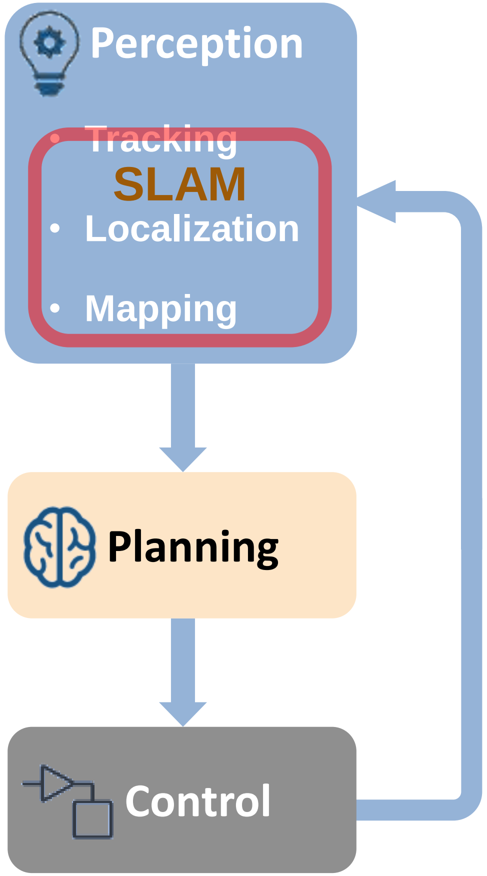
Point Cloud Processing → Local Mapping → Loop Closure Detection → Pose Graph Optimization → Map representation

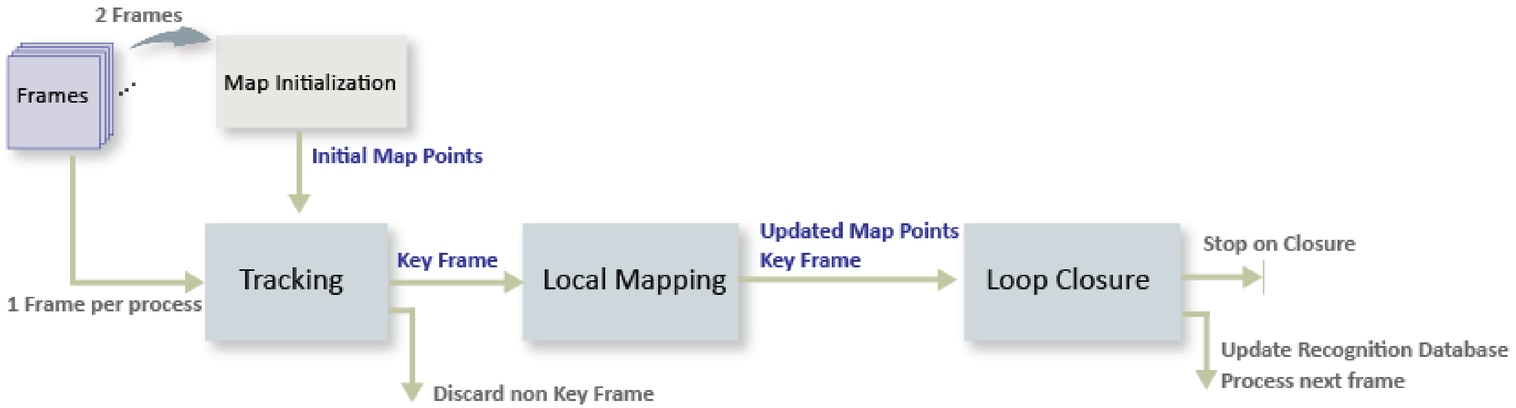
Computer Vision | **Navigation**

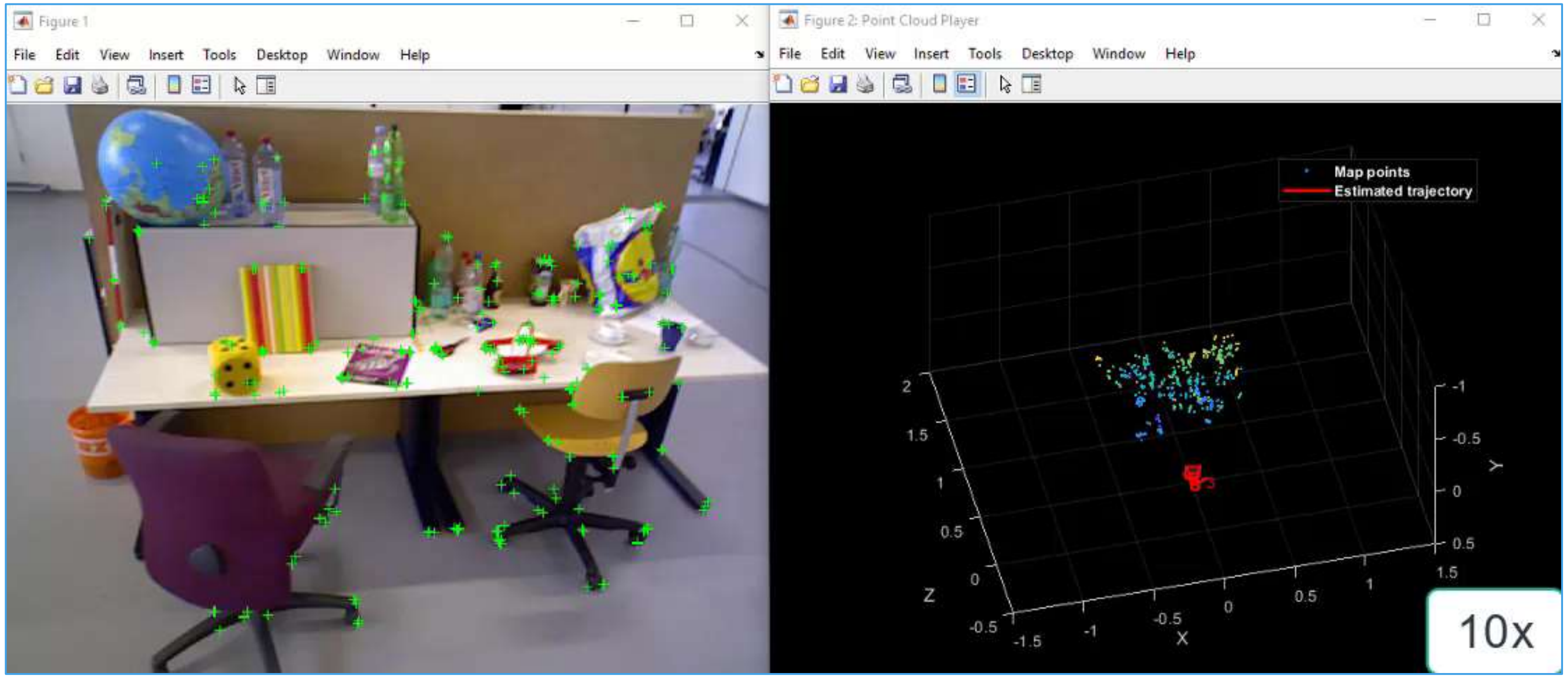


Simultaneous Localization and Mapping

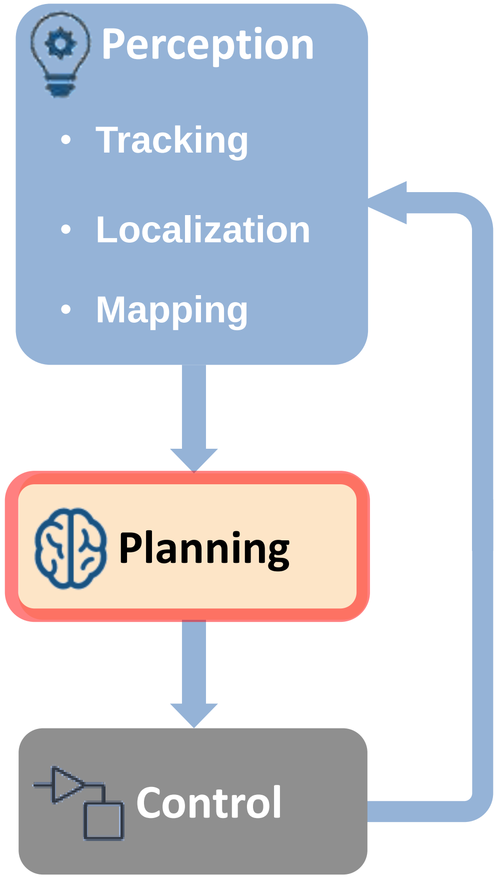
3D Monocular Visual SLAM (ORB-SLAM)



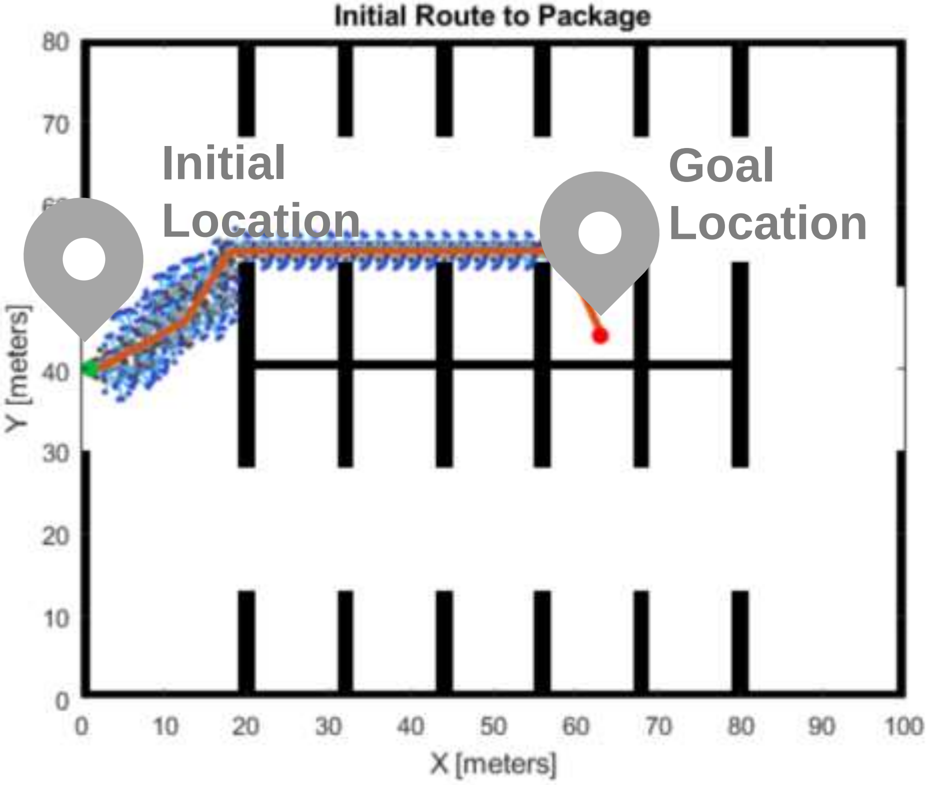




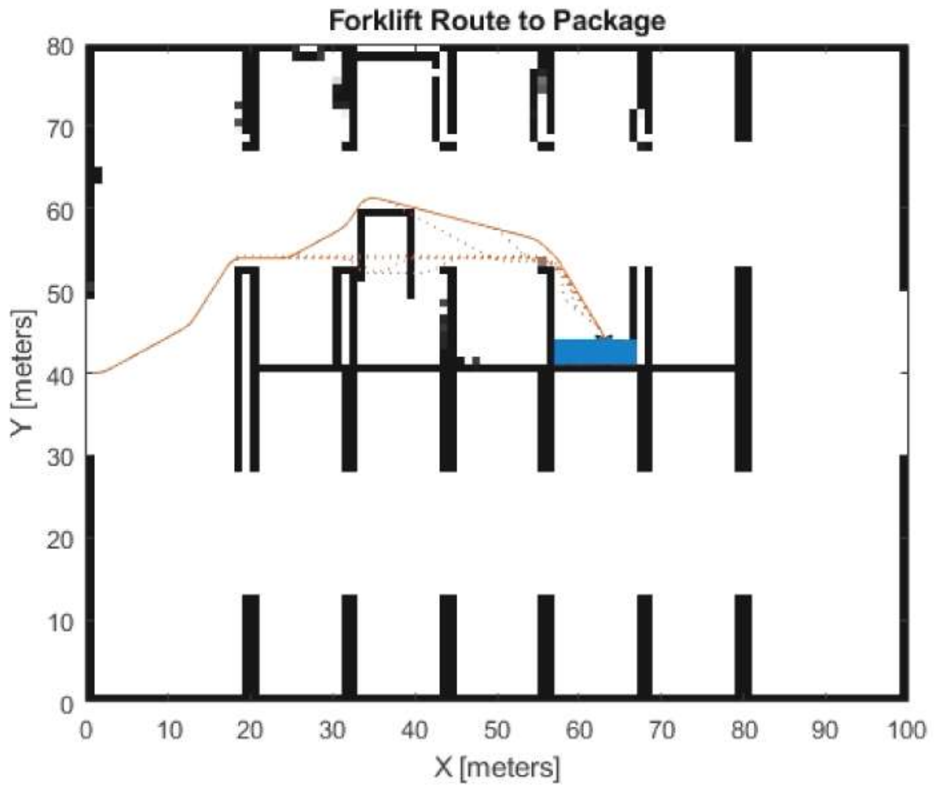
Plan a path from start to destination



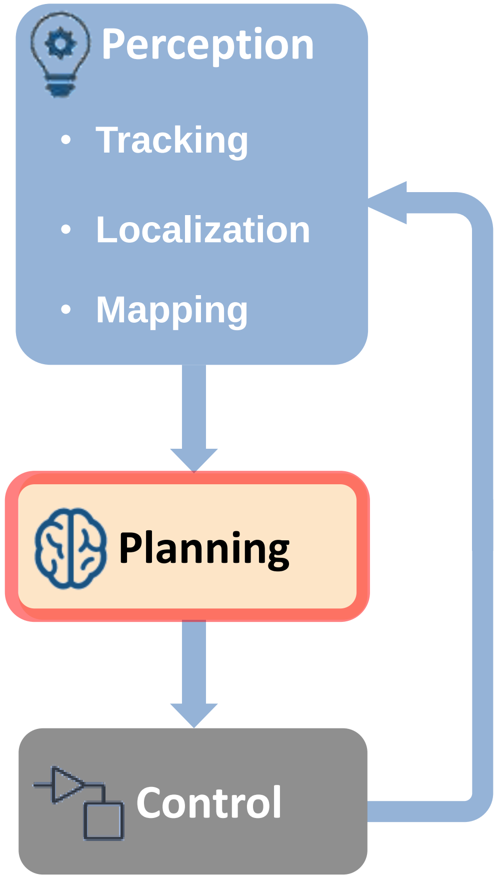
Global Planning



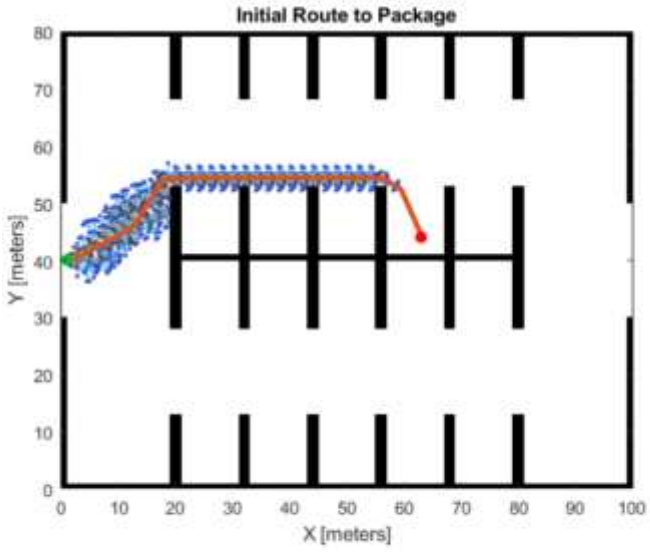
Local Re-planning

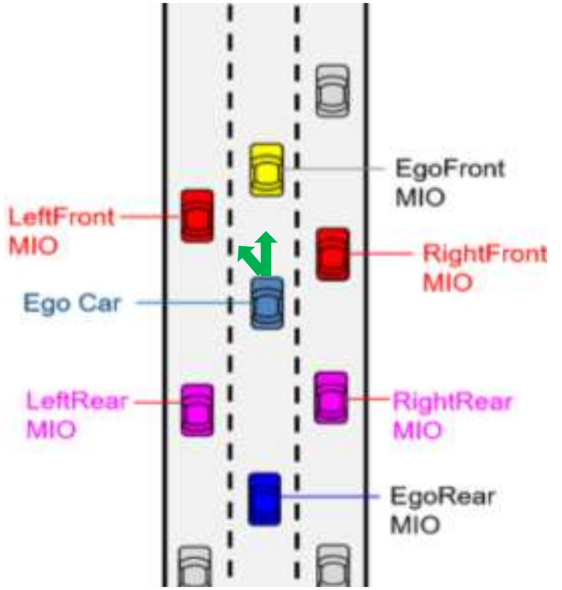


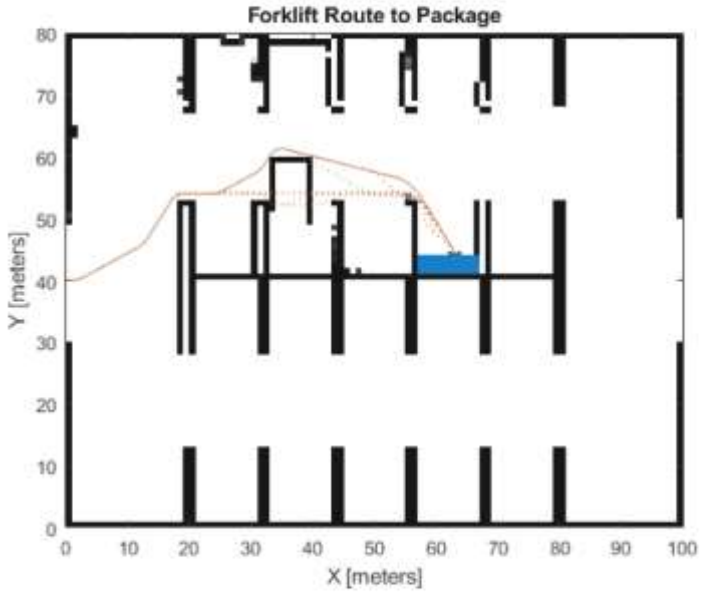
Plan a Path from Start to Destination



Global Planning	Behavior Planning	Local Re-planning
Path planning algorithms	High-level decision making	Trajectory generation



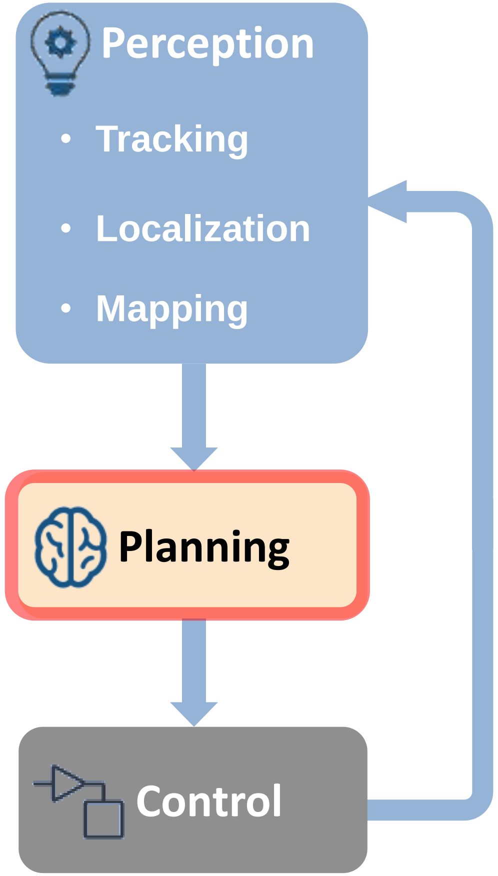


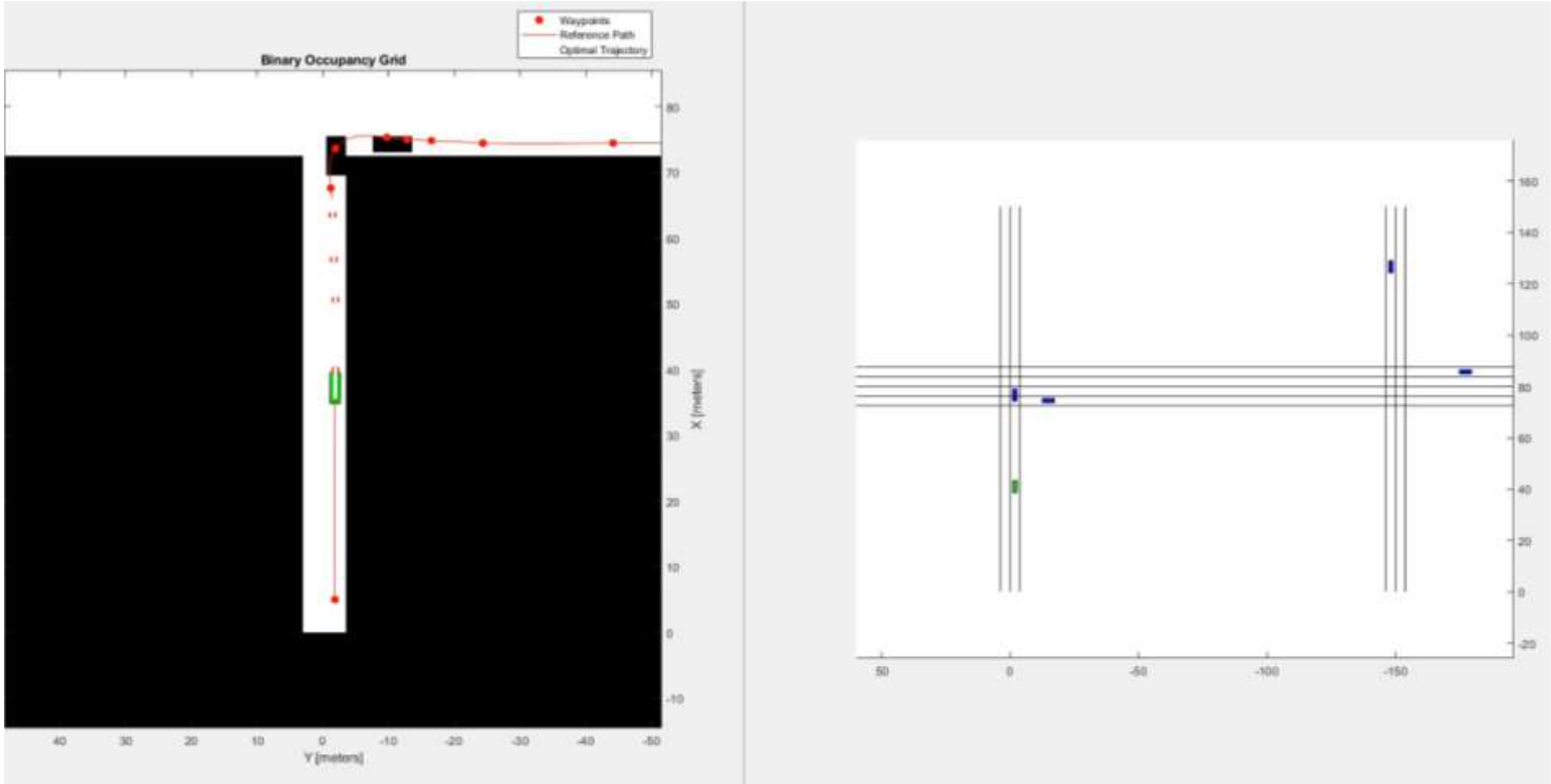


Urban Driving Needs Planning on Multiple Levels

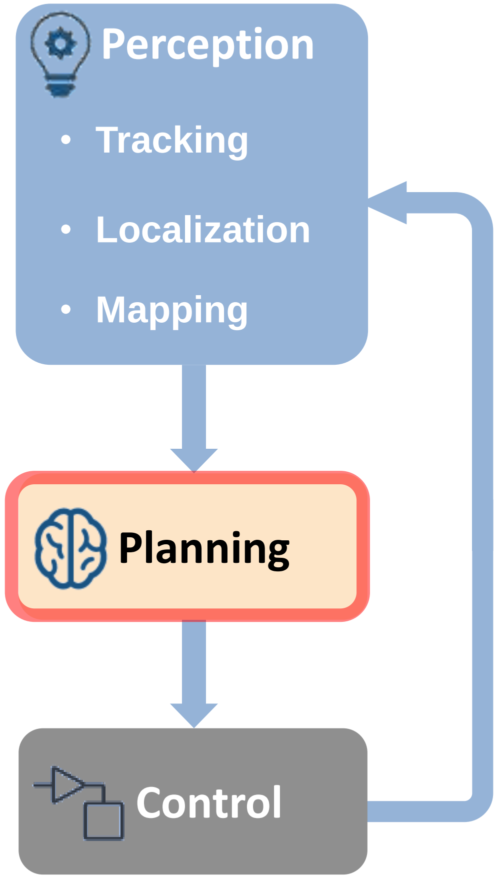
Global, behavior, and local planners

Generate optimal trajectories for local re-planning and merge back with the global plan

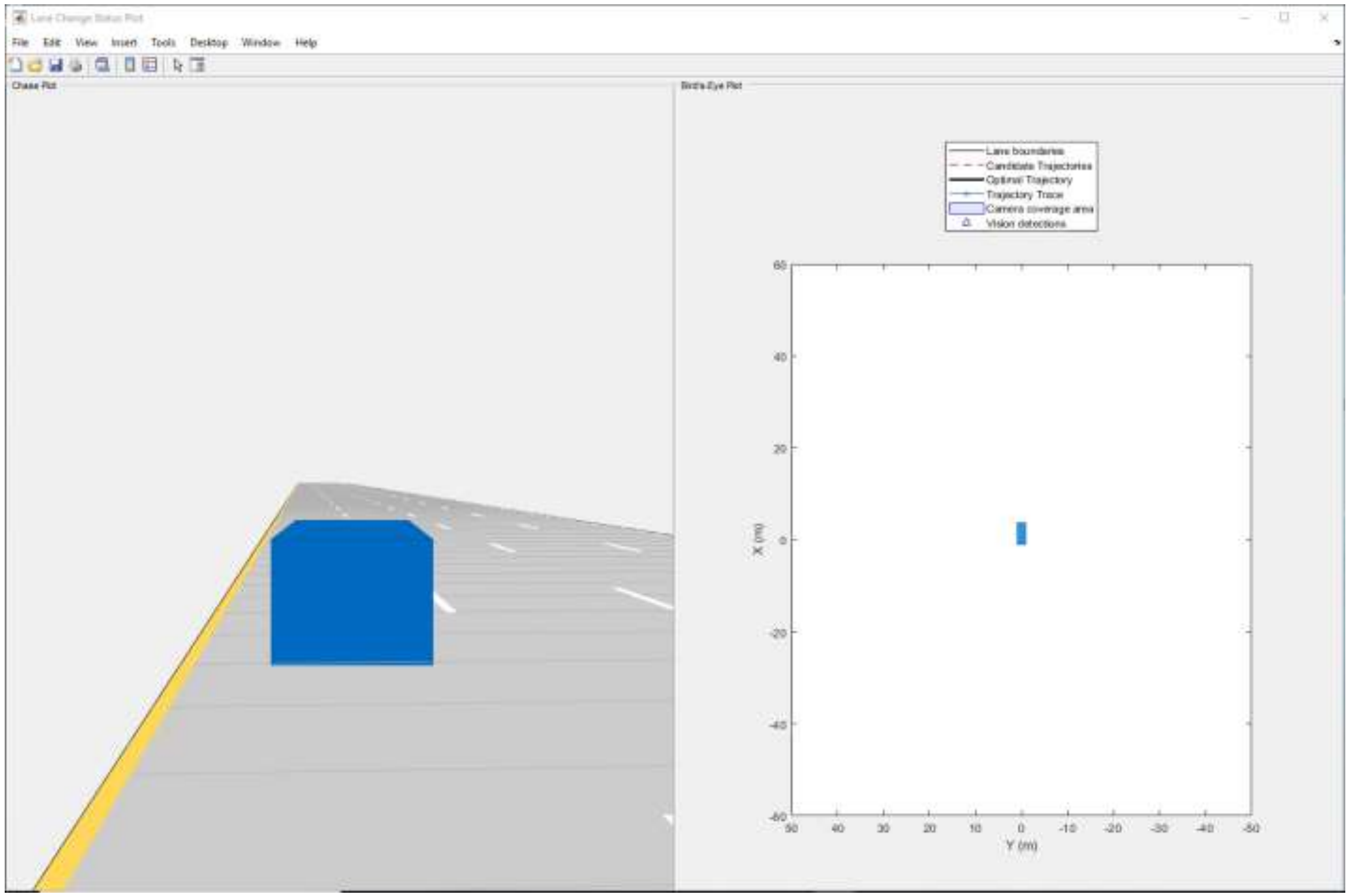




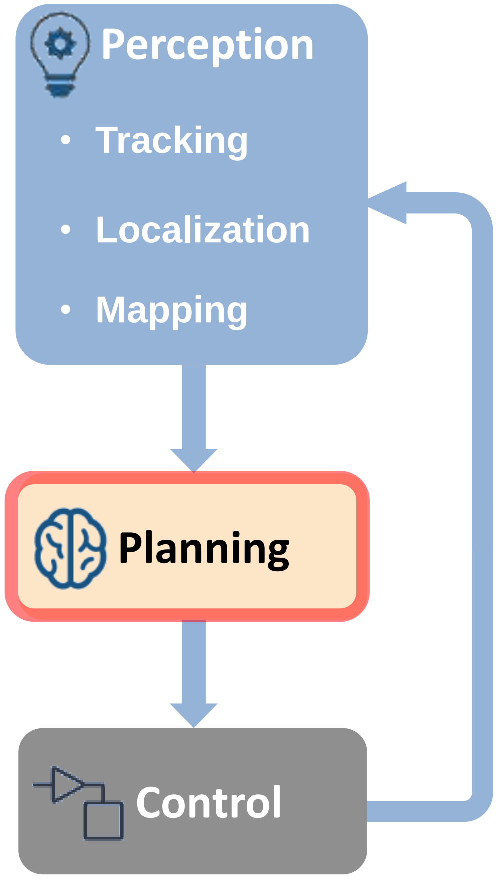
Simulate shortest path to change lanes on a highway

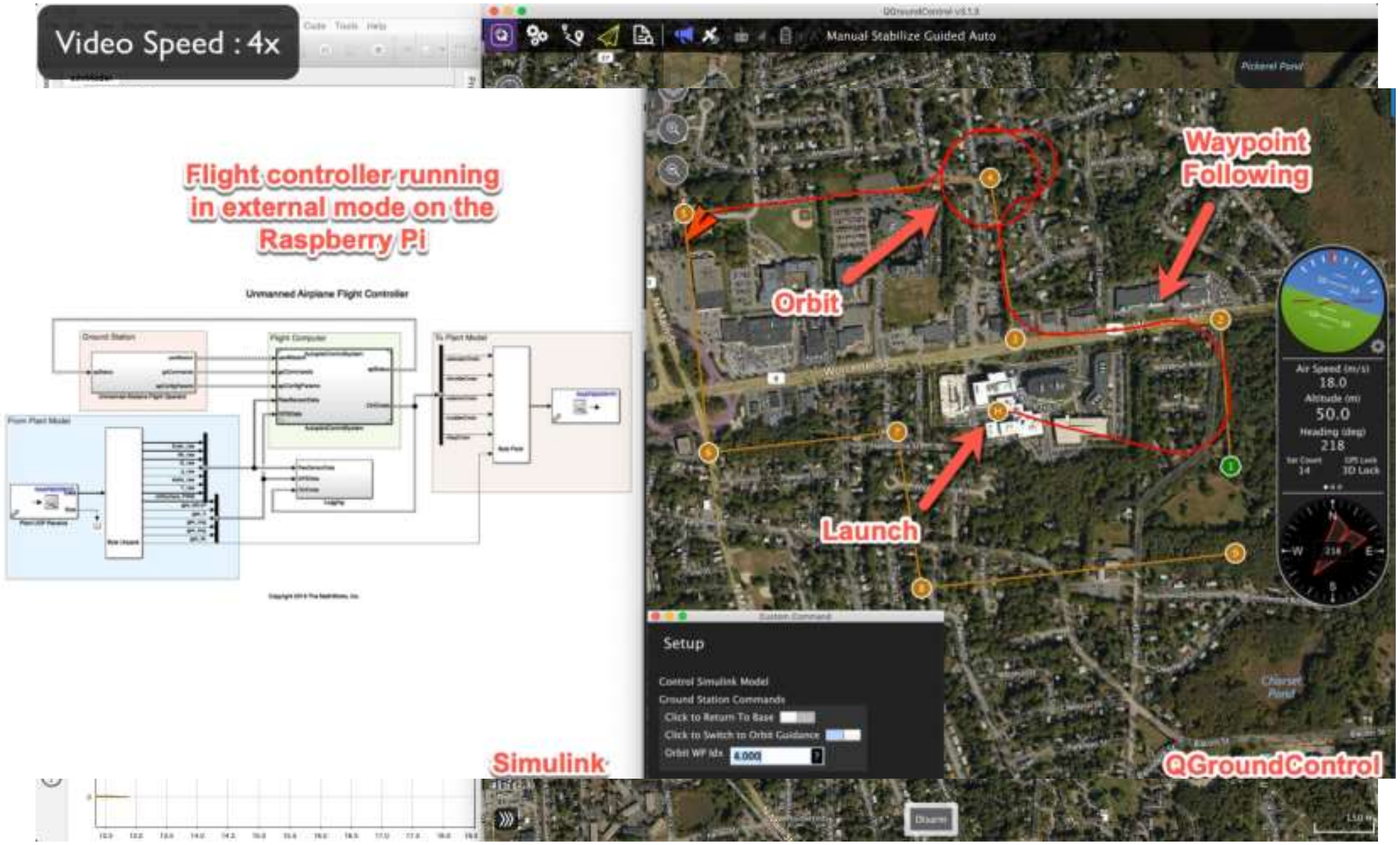


Simulate trajectory generation and the lane change maneuver

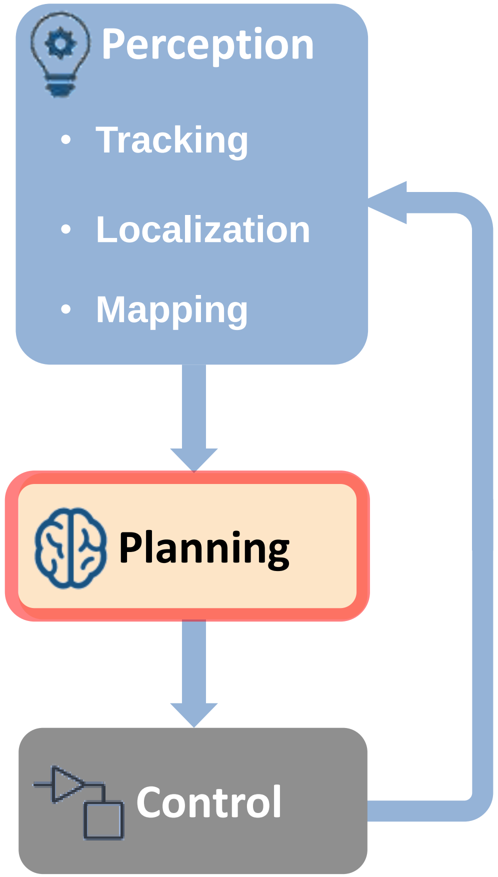


Mission planning for UAV leads to last mile delivery

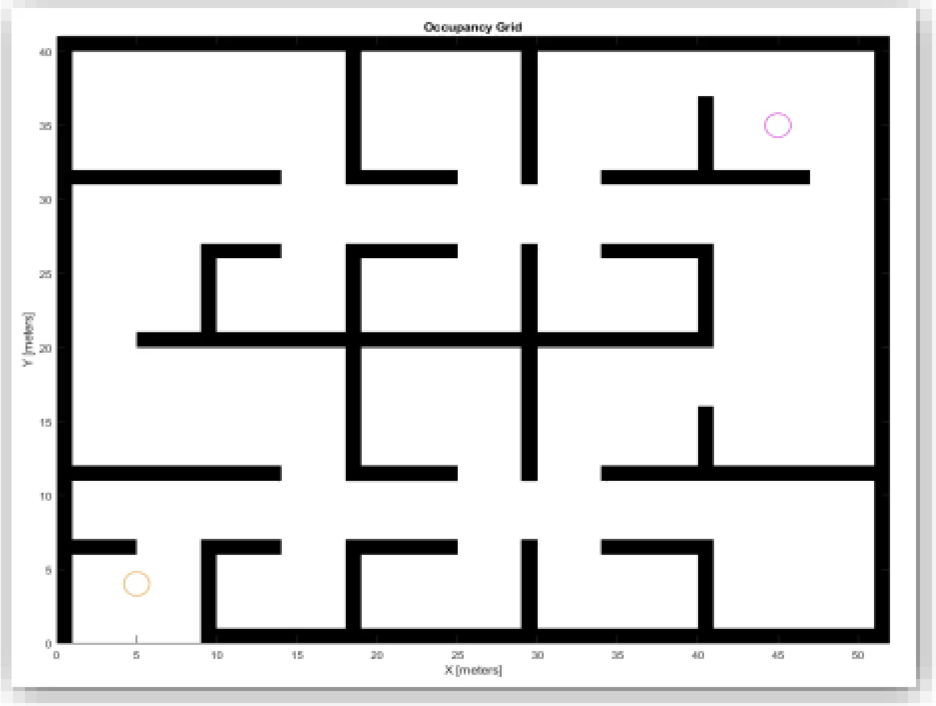




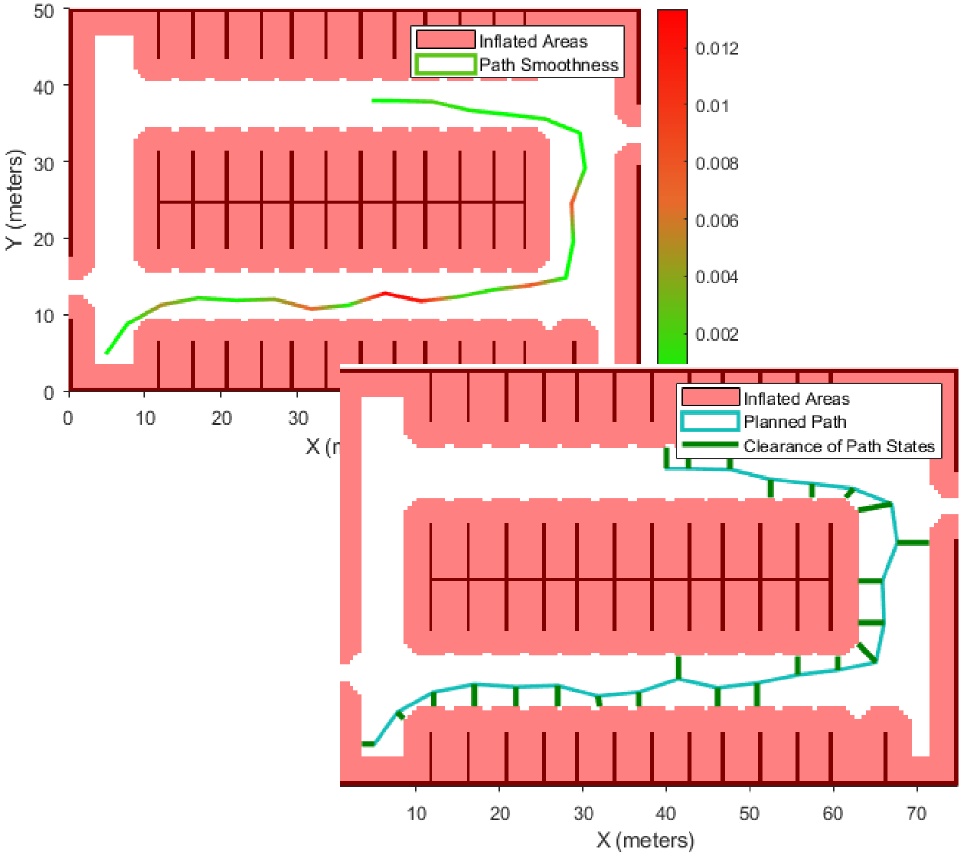
Choose a path planner based on your application



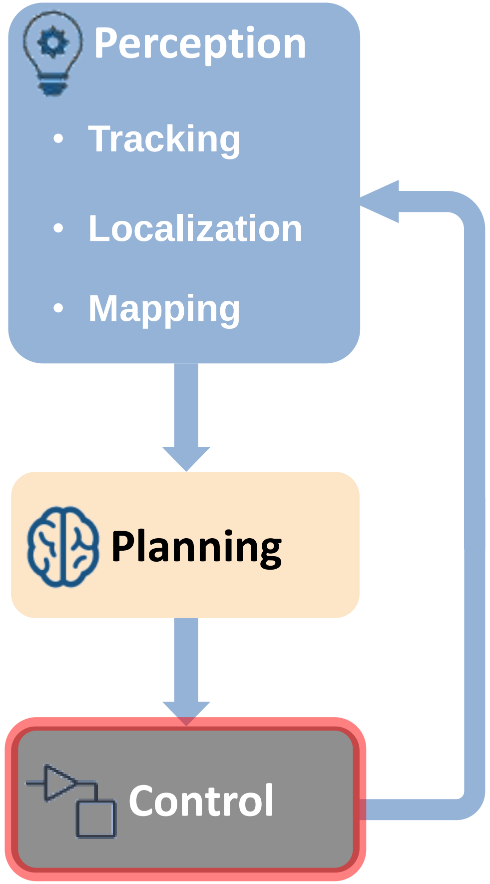
Sampling-based planners such as RRT*



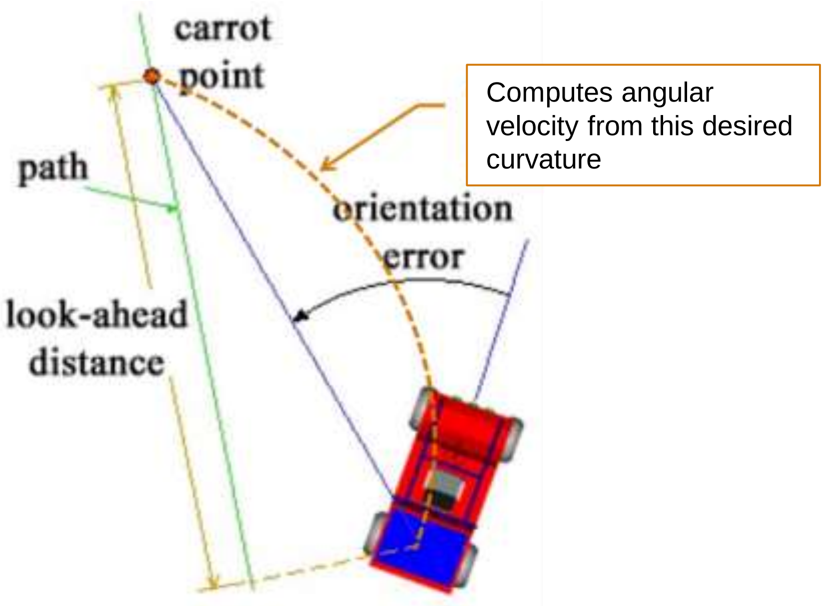
Use path metrics to compare different paths

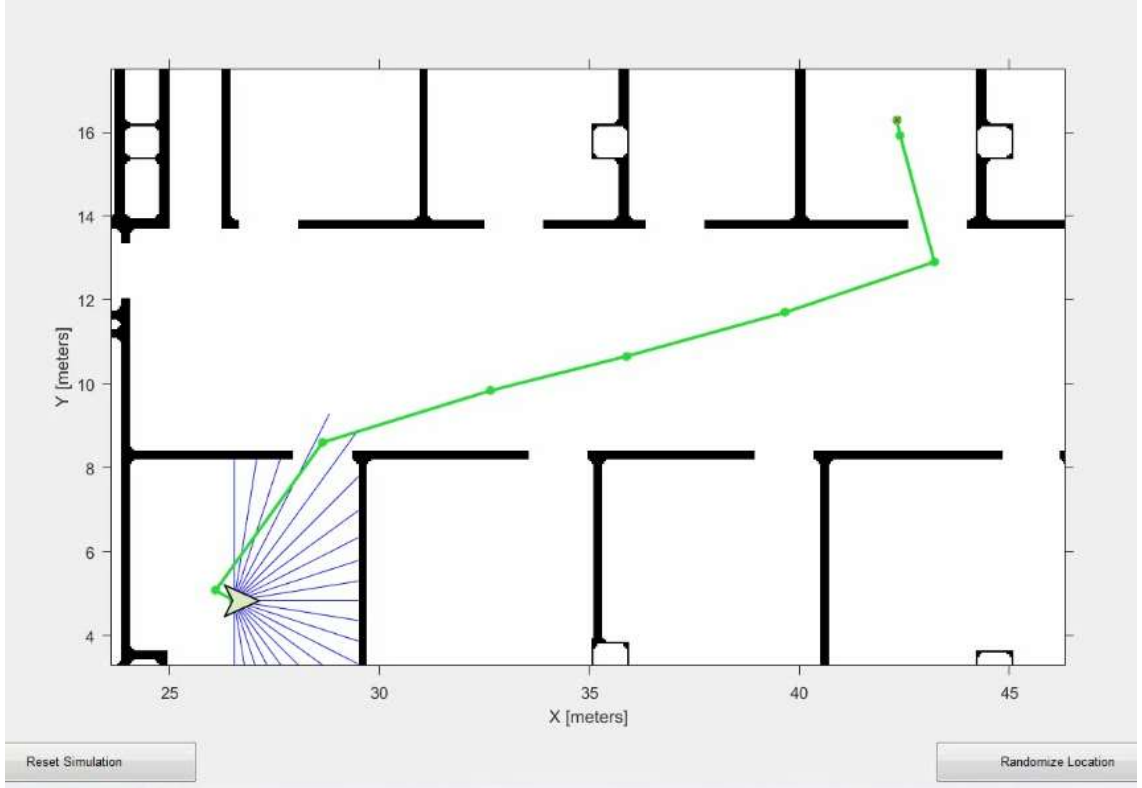


Compute Control Commands for Ground Vehicles

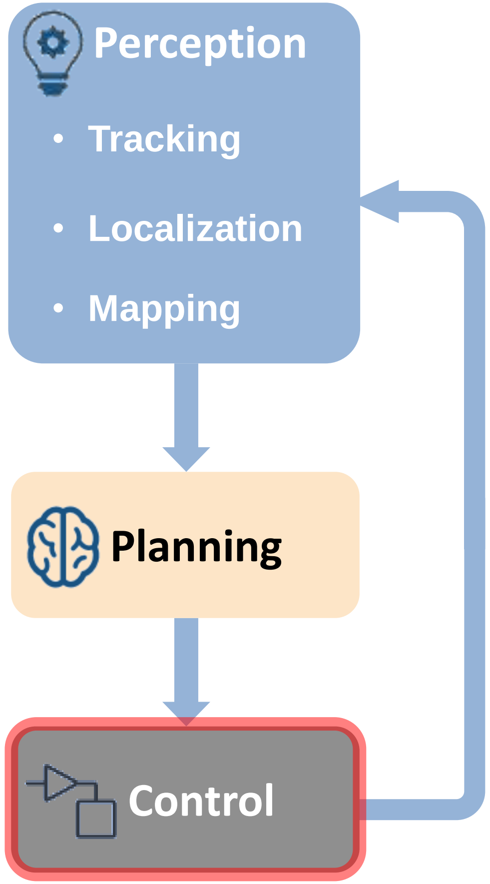


Compute linear and angular velocity commands for a mobile robot

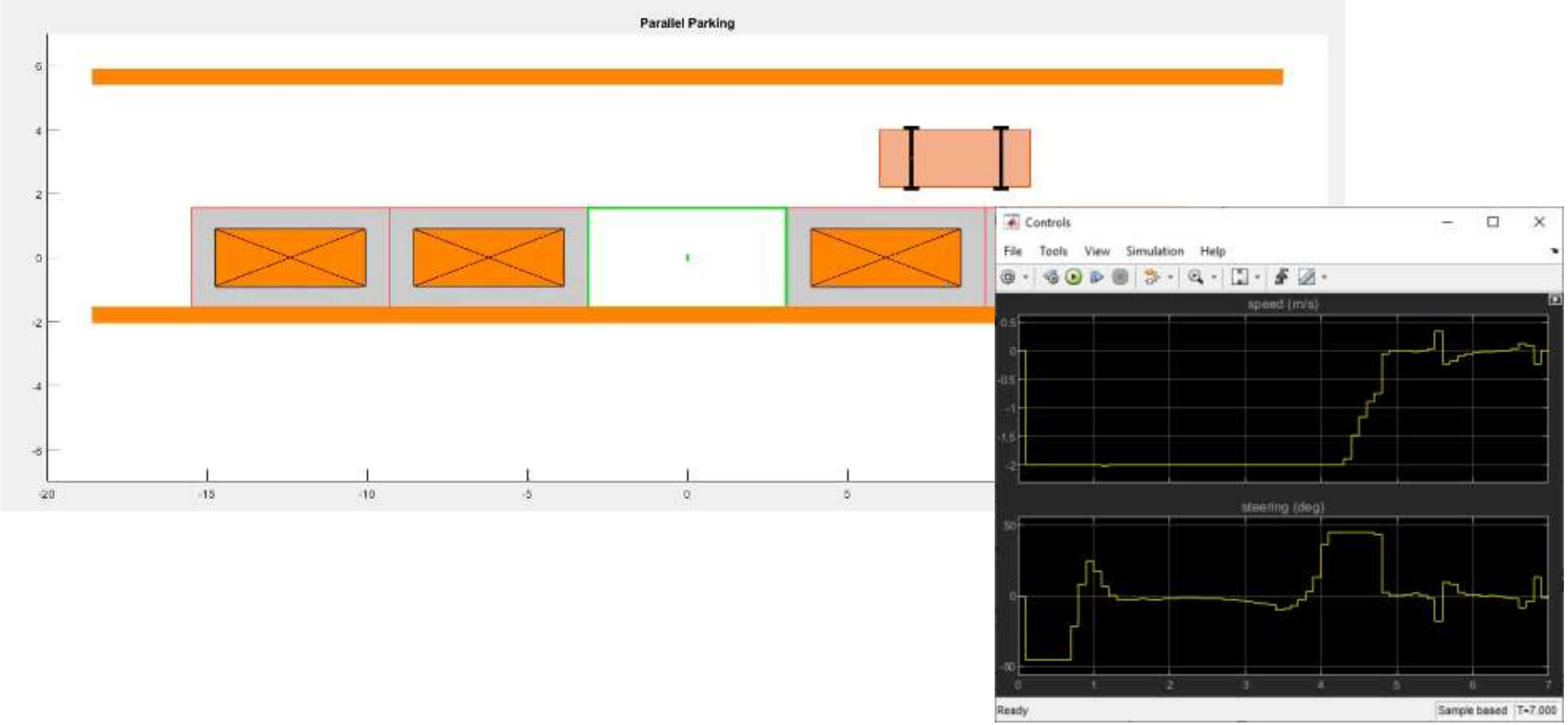




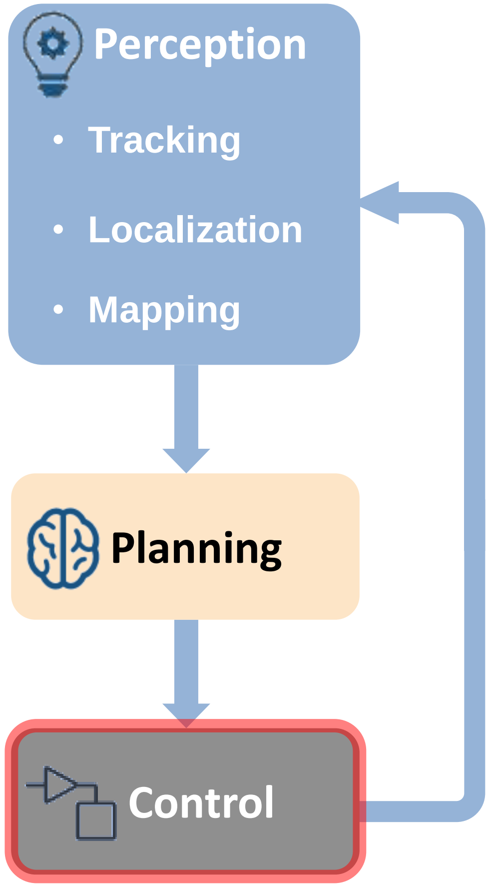
Send Control Commands to the Vehicle to Follow the Planned Path



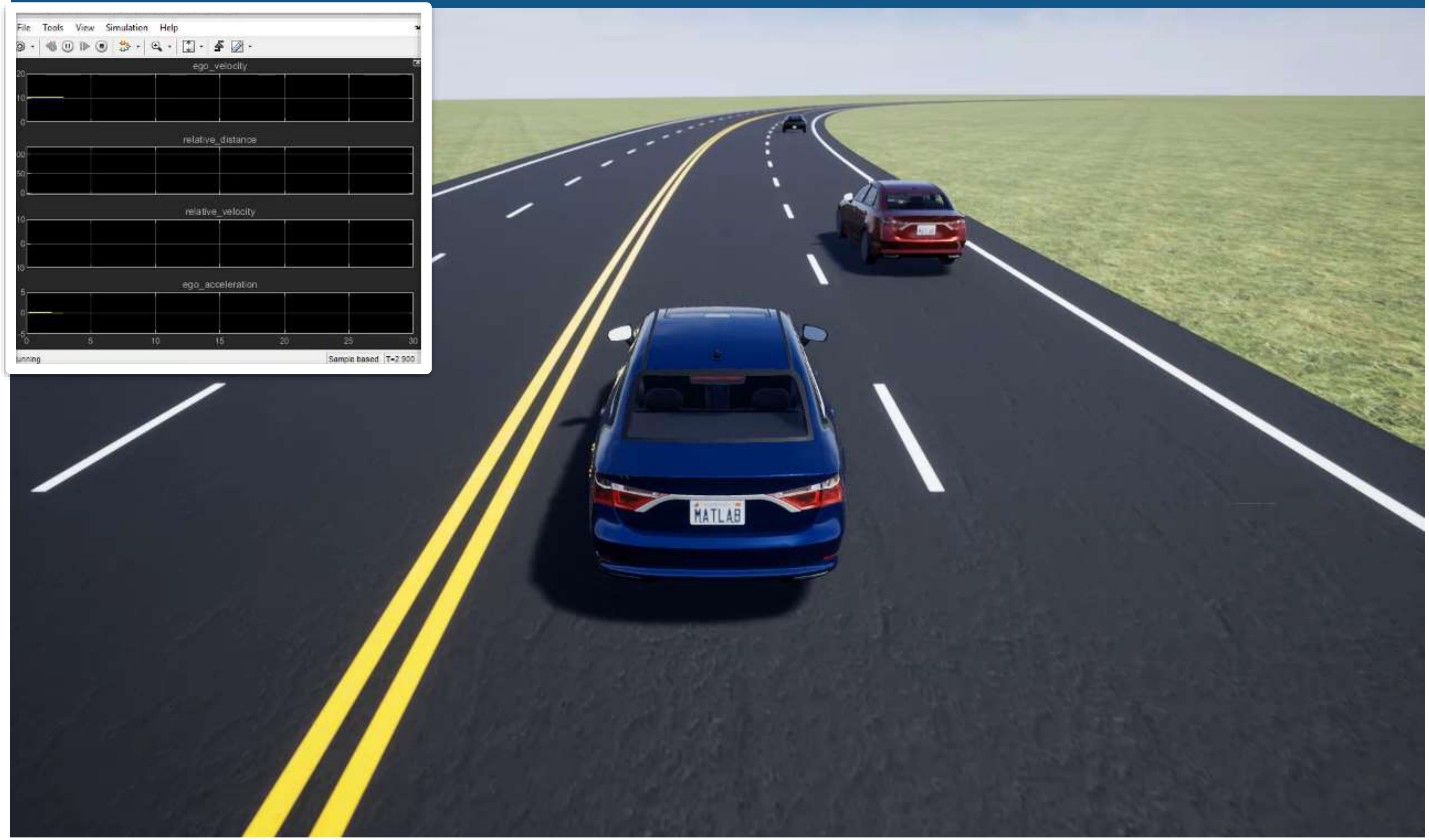
Calculate the steering angle and vehicle velocity to track the trajectories



Control Lane Change Maneuver for Highway Driving

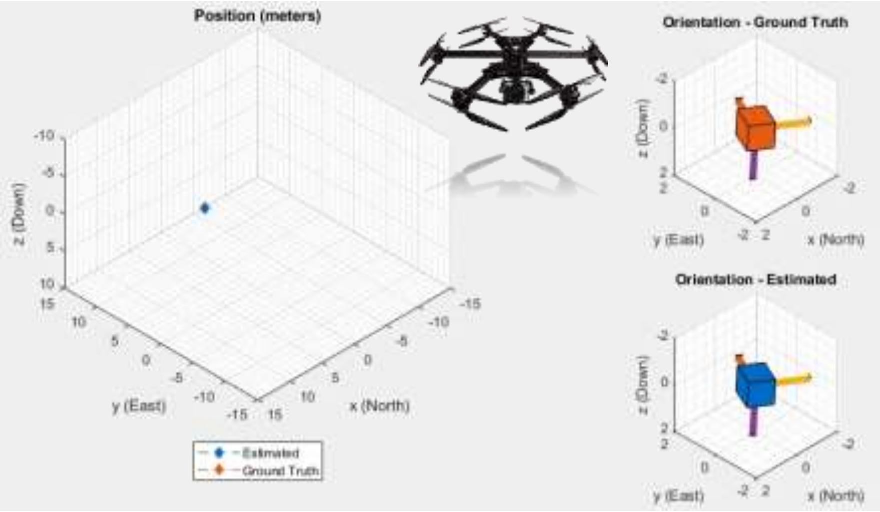


Longitudinal and Lateral Controllers to adjust the acceleration and steering

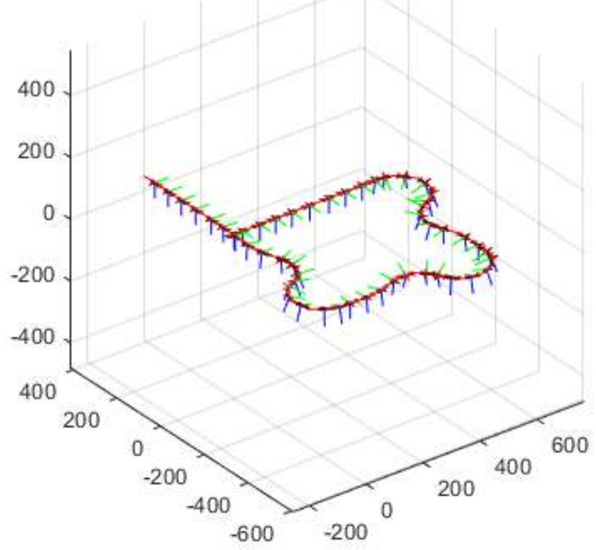


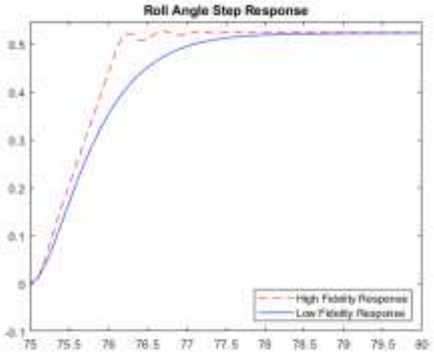
Simulate High-Fidelity UAV Model with Waypoint Following

Simulate GPS and IMU sensor models

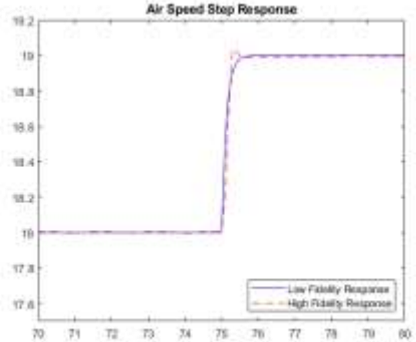


Waypoint following controller

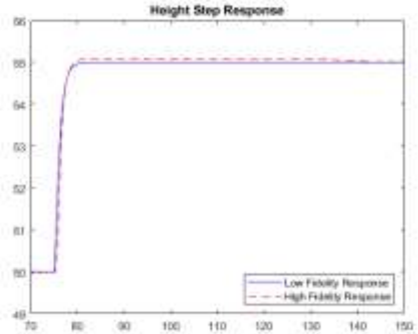




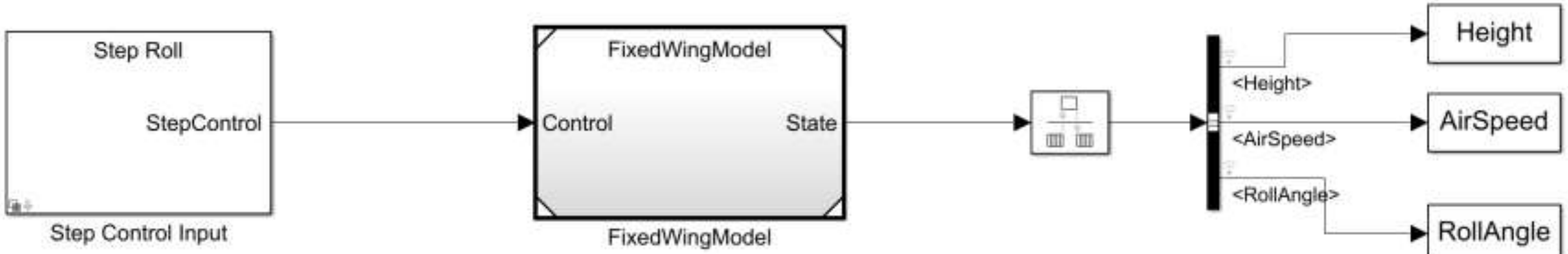
Roll Angle



Air Speed

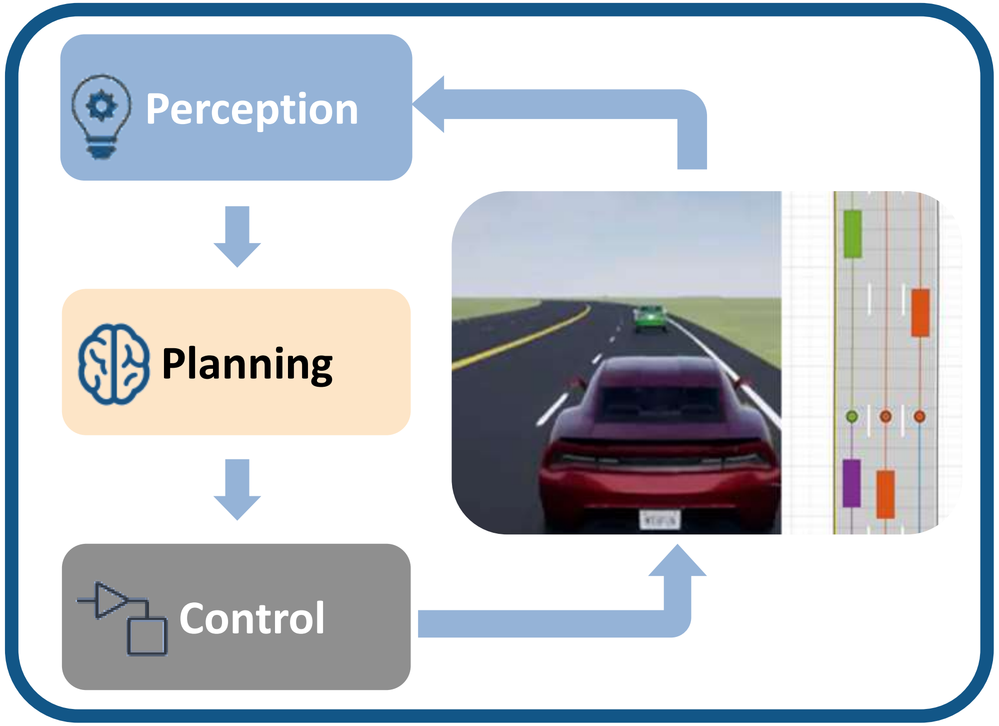


Height

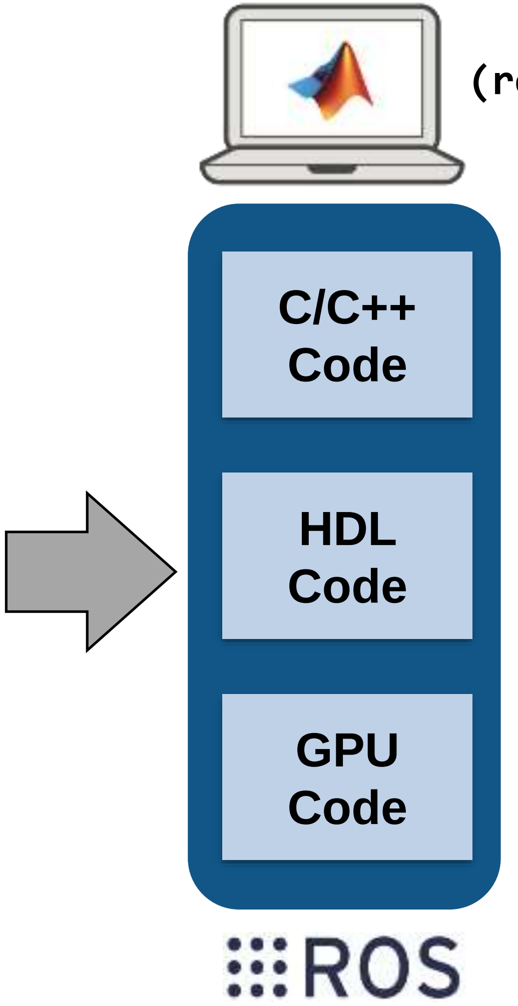


Approximate High-Fidelity Model with Low-Fidelity Model

Test Sensor Fusion and Navigation Algorithms by Deploying Them to Hardware



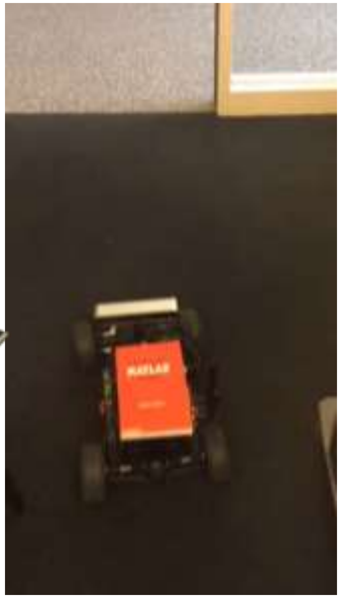
ROS Node
(roscpp code)



Processors

FPGAs

GPUs



MATLAB EXPO

MathWorks

Full Model Based Design Workflow for Autonomous Systems

Verification & Validation

Connect / Deploy

Code Generation

ROS Toolbox

AUTOSAR Blockset

Autonomous Algorithms

Sensor Fusion and Tracking Toolbox

Perceive

Plan & Decide

Navigation Toolbox

Robotics System Toolbox

Automated Driving Toolbox

Computer Vision Toolbox

Image Acquisition Toolbox

Sense

Control

Stateflow

Reinforcement Learning Toolbox

Model Predictive Control Toolbox

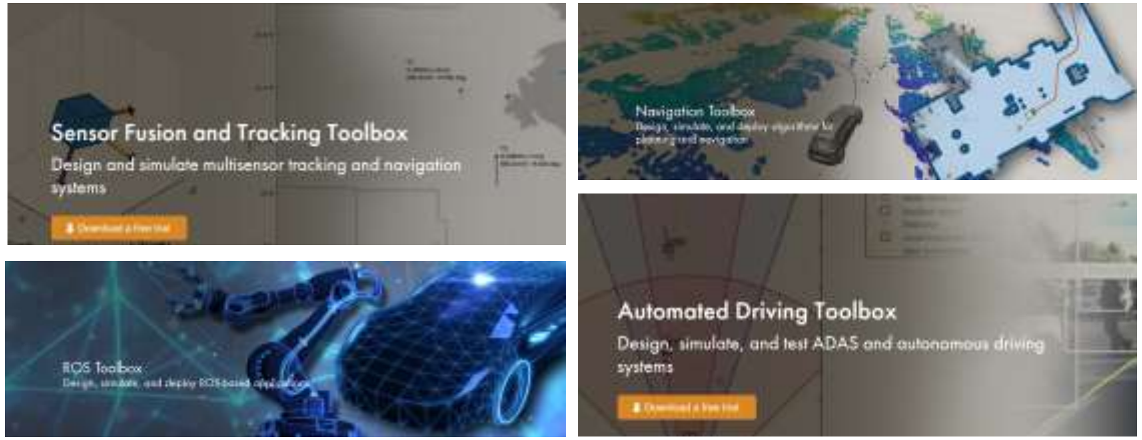
Platform

MATLAB

Simulink

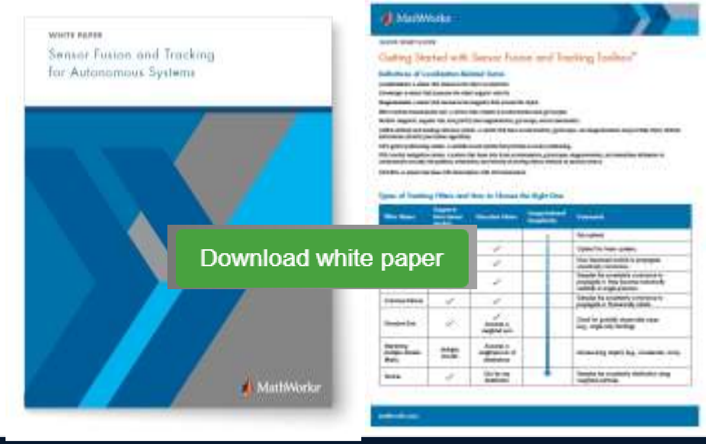
There Are Many Resources to Get Started with

Product pages



Tech Talks in Youtube

https://www.youtube.com/channel/UC6Zjgg_0PQBm96aHeiXrjXQ



White papers

Demos

In This Talk, We Learnt About..

Localization

Mapping

Tracking

Global/Mission Planning

Local Re-planning

Path Following / Tracking

Perception

Planning

Control

Thank You !!