Capabilities of an Autonomous System
Capabilities of an Autonomous System
Capabilities of an Autonomous System

Sense

Perceive

Decide & Plan
Capabilities of an Autonomous System

- Sense
- Perceive
- Decide & Plan
- Act
Agenda

- Introduction
- Technology overview of perception
- Algorithm development for sensor fusion and tracking
- Q&A
- Resources for further exploration
Sensor fusion and tracking is…

Self- awareness

Situational awareness

Accelerometer, Magnetometer, Gyro, GPS…

Radar, Camera, IR, Sonar, Lidar, …

Signal and Image Processing

Sensor Fusion and Tracking

Control
Timeline of Technology Advances

Multi-object tracking
- Air Traffic Control
- Computer Vision for Transportation
- Multi-sensor Fusion for Autonomous Systems

Localization
- Military
- Commercial
- Ubiquitous

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Fusion Combines the Strengths of Each Sensor

Vision measurement at time step k

Radar measurement at time step k

Fused estimate at time step k

Predicted estimate at time step k

Fused estimate at time step k-1

Legend

- Vision Measurement
- Radar measurement
- Track (fused estimate)
- Ellipse represents uncertainty
What is Localization?

Inertial Sensor  Attitude  Position
Fusing Sensor Data Improves Localization

Ground truth vs. Estimate

Sensors

Error Measurements
Fuse IMU & GPS for Self-Localization of a UAV

Sense

Perceive
- Locate Self
- Track Obstacles

Decide & Plan

Act

Position (meters)

Orientation - Ground Truth

Orientation - Estimated

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Flexible Workflows Ease Adoption

Scenario Definition and Sensor Simulation

- Ownship Trajectory Generation
- Actors/Platforms
- INS Sensor Simulation
- Radar, IR, & Sonar Sensor Simulation

Algorithms

- INS Filter, Tracker, etc..

Documented Interface for detections

Documented Interface for tracks

Visualization & Metrics
A Multi-object Tracker is More than a Kalman Filter

- Assigns detections to tracks
- Creates new tracks
- Updates existing tracks
- Removes old tracks

- Fuses measurements with the track state

From various sensors at various update rates
Performing What-If Analysis

Two targets seen as one by the radar

± 270m at 30km

1° Azimuth Resolution

Did the trajectories cross?
Performing What-If Analysis

tracker = trackerGNN( ... 'FilterInitializationFcn',@initCVFilter,... 'MaxNumTracks', numTracks, ... 'MaxNumSensors', 1, ... 'AssignmentThreshold', gate, ... 'TrackLogic', 'Score', ... 'DetectionProbability', pd, ... 'FalseAlarmRate', far, ... 'Volume', vol, 'Beta', beta);

tracker = trackerGNN( ... 'FilterInitializationFcn',@initIMMFilter,... 'MaxNumTracks', numTracks, ... 'MaxNumSensors', 1, ... 'AssignmentThreshold', gate, ... 'TrackLogic', 'Score', ... 'DetectionProbability', pd, ... 'FalseAlarmRate', far, ... 'Volume', vol, 'Beta', beta);
Performing What-If Analysis

```
tracker = trackerTOMHT(...
    'FilterInitializationFcn', @initIMMFilter, ...
    'MaxNumTracks', numTracks, ...
    'MaxNumSensors', 1, ...
    'AssignmentThreshold', [0.2,1,1]*gate, ...
    'TrackLogic', 'Score', ...
    'DetectionProbability', pd, ...
    'FalseAlarmRate', far, ...
    'Volume', vol, 'Beta', beta, ...
    'MaxNumHistoryScans', 10, ...
    'MaxNumTrackBranches', 5, ...
    'NScanPruning', 'Hypothesis', ...
    'OutputRepresentation', 'Tracks');
```
Comparing Trackers and Tracking Filters

False track
Dropped track

Slower
Faster
### Point object vs. Extended object

- **Point object**
  - Distant object represented as a single point
  - One detection per object per scan

- **Extended object**
  - High resolution sensors generate multiple detections per object per scan
Extended Object Tracking

- Sense
- Perceive
- Locate Self
- Track Obstacles
- Decide & Plan
- Act

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Tracking with Lidar

- Sense
- Perceive
- Locate Self
- Track Obstacles
- Decide & Plan
- Act
Connect to Decision Making / Control: ACC Demo

Sense
Perceive
Locate  Track  Self  Obstacles
Decide & Plan
Act

ACC with Sensor Fusion
ACCWithSensorFusionMdlRef
Vision
Acceleration
Radar
Prediction Time
Tracks
Longitudinal Velocity
Curvature (1/R)
ACC with Sensor Fusion
Tracks
MIO Track
MIO
MIO Index
Vehicle and Environment
Vision
Radar
Prediction Time
Longitudinal Velocity
Curvature
ego_velocity
acceleration
Connect to Decision Making / Control: ACC Demo

Sense

Perceive
Locate
Track
Self
Obstacles

Decide
& Plan

Act
Sensor Fusion and Tracking …

Is Ubiquitous  
Leverages Sensor Strengths  
Enables Autonomy

Sense  
Perceive  
Decide & Plan  
Act

Signal and Image Processing
Sensor Fusion and Tracking
Control
Summary

Improve your **development and test workflows** for localization and tracking. We provide not only algorithms but sensor models, scenario generation and metrics. **Integrate** with home grown tools and fill in gaps.

Our configurable tracking and fusion algorithms **enable re-use and sharing** across your organization and industry which will also improve overall efficiencies.

Perform quick algorithm and system trade-offs **eliminate errors early** in the development cycle.

Direct path to move from tracker and fusion models to C-code for **prototyping and initial deployment**.
Please visit our Technology Showcase for more details on the workflows.