Team A
Perception System Using Stereo Vision and Radar

Test Plan

Amit Agarwal
Harry Golash
Yihao Qian
Menghan Zhang
Zihao (Theo) Zhang

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INTRODUCTION

This document contains the detailed spring semester test plan for Team A: Aware. The goal is that by Spring Validation Experiment (SVE) on April 26, 2017, we will have a fully functional perception system that can detect, classify, track the objects and can also estimate the motion of objects of interest as well as ego-motion of the testing vehicle. This test plan presents detailed information on each of the progress reviews involved in the present semester and hence leading the progress to the SVE.

LOGISTICS

Test Locations

- MRSD Lab
- Outdoor parking lot
- Streets around school

Test Personals

- Amit Agarwal
- Harry Golash
- Yihao Qian
- Menghan Zhang
- Zihao (Theo) Zhang

Test Materials

- Testing Vehicle
- Grasshopper3 Cameras
- Delphi ESR 2.5 Radar
- Step-Up power distribution PCB
- Sensor mounts and fixtures
- Electromagnets and chargers
- UINSTONE 150W Power Inverter
- Laptop
- GPS

SCHEDULE

Table 1. Schedule

Name	Capability Milestone	Associated Test	Associated System Requirements
Feb 15 (PR 8)	Radar data filtering Calibrated stereo vision	Test A	• Use multiple sensors
Mar 1 (PR 9)	Object detection and tracking. Ego-motion estimation.	Test B Test C	• Detect and identify objects (pedestrians and vehicles) • Classify objects (pedestrians and vehicles) • Estimate external vehicle motion and ego-motion
Mar 22 (PR 10)	Filtered data from all sensors	Test A	• Use multiple sensors
Apr 5 (PR 11)	Sensor fusion	Test D	• Use multiple sensors
Apr 17 (PR 12)	Integrated systems	Test E	• Conduct full-range perception • Perceive in real-time

TESTS

Table 2.Test A

Name: A
Objective
Demonstrate and verify Radar data filtering & Calibrated stereo vision
Elements
Radar, Stereo Vision subsystem
Location
Outdoor Parking Lot
Procedure
• Mount the sensors on the testing vehicle • Drive the car to the parking lot with only several cars and pedestrians. • Calculate the ground truth for the depth and position information • Visualize the radar data and stereo vision • Show the depth and position information for objects
Verification Criteria
• Stereo camera should give the depth information for objects with the accuracy above 70% • Two sensors should give the results less than 1 seconds.

Table 3.Test B

Name: B
Objective
Demonstrate and verify system's ability to conduct object detection and tracking
Elements
Radar, Stereo Vision subsystem
Location
Major streets around campus with moderate traffic condition
Procedure
● Mount the sensors on the testing vehicle ● Drive the car around school for about 15min. ● Visualize the radar data and stereo vision detection and tracking with bounding boxes ● Show the depth, velocity and position information for objects
Verification Criteria
● Radar should detect the objects with the accuracy above 50% and be able to give continuous tracking results which include velocity, distance and position ● Stereo camera should detect and classify objects with the accuracy above 60% and be able to show the bounding box and tracking number of objects continuously ● Two sensors should give the results less than 500ms

Table 4.Test C

Name: C
Objective
Demonstrate and verify system's ability to estimate ego-motion of the testing vehicle
Elements
Stereo Vision subsystem, GPS
Location
Major streets around campus with moderate traffic condition
Procedure
• Mount the sensors on testing vehicle • Drive the car around school for about 15min. • Get the velocity information from the speedometer of the testing vehicle and get position information from GPS, get the orientation of the car from wheels. • Use the stereo camera to get the optical flow information • Estimate the next position of the car.
Verification Criteria
The difference between the estimated position and ground truth position should less than 10m.

Table 5.Test D

Name: D
Objective
Sensor Fusion
Elements
Radar, Stereo Vision subsystem, GPS
Location

Major streets around campus with moderate traffic condition
Procedure
● Mount the sensors on the testing vehicle ● Drive the car around school for about 15min. ● Get calibrated position and velocity information of tracked objects after integrating data from all sensors
Verification Criteria
● Radar and stereo camera should be synchronized and give the information at the same time with the difference less than 100ms ● The final object information should achieved at least 70% accuracy.

Table 6.Test E

Name: E
Objective
System Integration
Elements
Complete setup of system on the testing vehicle (Radar, Stereo Vision subsystem, GPS, sensor mounts, power source, computing device)
Location
Major streets around campus with moderate traffic condition
Procedure
● Mount the sensors on the testing vehicle ● Drive the car around school for about 15min. ● Show the object detection, classification and tracking results on the desktop, and visualize with bounding box in the video
Verification Criteria
● The system should be integrated properly on the testing vehicle and be able to output results from object detection, classification, and tracking in a single GUI.

• The system should be able to achieve all the perception requirements.

Table 7.SVE

Name: SVE
Objective
Spring Validation Experiment
Elements
Complete setup of system on the testing vehicle (Radar, Stereo Vision subsystem, GPS, sensor mounts, power source, computing device)
Location
Major streets around campus with moderate traffic condition
Procedure
• Mount the sensors on the testing vehicle • Drive the car around school for about 15min. • Detect and classify objects of interest on road and return their sizes, relative positions, and velocities. Display the organized information on a screen • Track the objects of interest on road continuously with label. • Estimate the test vehicle's velocity, yaw rate, and orientation using tracking data from the cameras and the radar.
Verification Criteria
• Using the LIDAR data provided by Delphi as ground truth, the system will detect object size with an accuracy of >80%, distance with an accuracy of >70%, and velocity with an accuracy of >80% • The system shall be able to classify objects with an accuracy of >80% • The system shall be able to estimate the test vehicle's motion with an accuracy of >70%

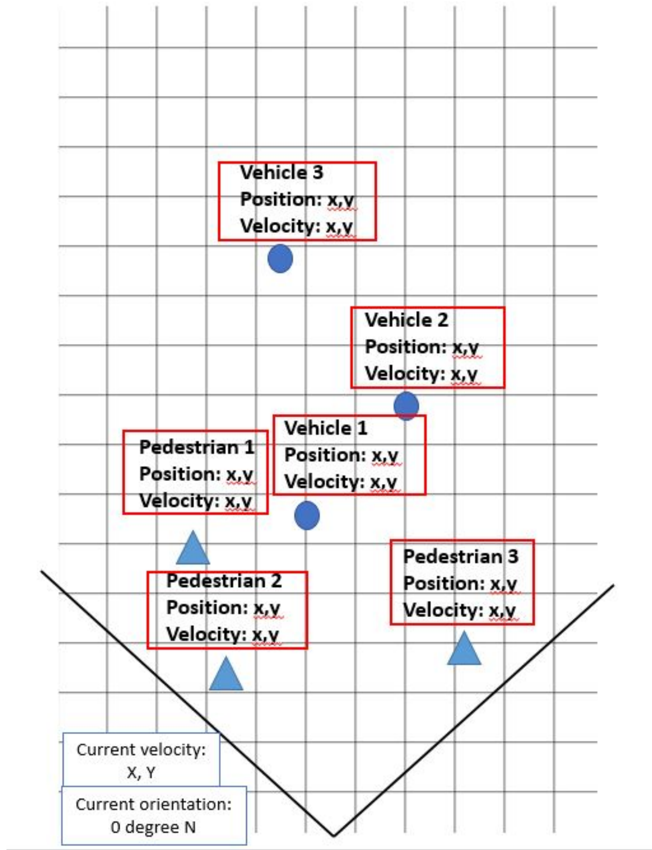

Figure 1. Example of desired output from the perception system

APPENDIX

Functional Requirements

The system shall:

- Conduct full-range perception
- Perceive in real-time
- Use multiple sensors
- Detect and identify objects (pedestrians and vehicles)
- Classify objects (pedestrians and vehicles)
- Estimate external vehicle motion and egomotion
- Be self-contained

Performance Requirements

- M.P1. Detect objects (pedestrians & vehicles) up to 150 m
- M.P2. Unify sensor data up to 50 m
- M.P3 Acquire sensor data at up to 20 Hz
- M.P4 Detect object size with an accuracy of up to 60%
- M.P5 Detect object distance with an accuracy of up to 60%
- M.P6 Detect object with an accuracy of up to 60%
- M.P7 Classify objects (pedestrians and vehicles)with an accuracy of up to 80%
- M.P8 Estimate vehicle motion with an accuracy of up to 90%