Odin: Team VictorTango’s Entry in the DARPA Urban Challenge

ICRA 2008
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Presentation Outline

Overview

Perception

Planning

Results
Team VictorTango

Partnership between Virginia Tech and TORC Technologies, LLC

4 Faculty members
4 TORC engineers
10 Graduate students
50 Undergraduate students
Mostly Mechanical Engineers

Premier Sponsors:
Caterpillar, Inc.
Ford Motor Company
Base Platform

2005 Ford Escape Hybrid

Highly integrated drive-by-wire system

Electrical power provided by hybrid drive system

Compact computing and electronics packaging
Sensor Suite

2 IBEO Alasca XT
2 Cameras
4 SICK LMS
1 IBEO Alasca A0

70m

NovAtel GPS/INS
SICK LMS
Cameras
IBEO Alasca XT
IBEO Alasca A0
Object Classification

Clustering performed by built-in IBEO software

Object size, shape, and velocity used to classify as static or dynamic

SICKs detect small objects

SICK objects added to IBEO list
Vision Classification

IBEO detected objects transformed into regions of interest in image

Regions examined for vehicle characteristics (tail lights, tires, etc)

Not used for final competition due to insufficient testing time
Road Detection

RNDF processed and fitted with cubic splines at load

SICK road detection profiles road for probabilistic fit

Vision road detection searches for road lines

Active road detection not used in Urban Challenge
Route Planner focuses on mission level goals.

Driving Behaviors is responsible for following the rules of the road.

Motion Planning controls the vehicle path and avoids obstacles.

Vehicle Interface executes the motion commands.
Driving Behaviors

Optimal Route
Route Builder
Assemble waypoints based on Exits, pre-assign each point a Situation

On-Demand
Periodic

Determine Situation
Point in Road, Stop, Approaching Stop...

Drivers activated based on Situation

Drivers produce outputs with an Urgency Factor

Behavior Integator
Depending on situation, choose winning driver from each driver category

Request Replan

Horn/Signals

Behavior Profile

Route Driver
Assumes no other traffic

Passing Driver
Pass other vehicles

Blockage Driver
React to blocked roads

Precedence Driver
Stop sign precedence

Merge Driver
Enter/cross moving traffic

Left Turn Driver
Yield when exiting roads

Zone Driver
Re-route when stuck

Victor Tango
Virginia Tech
TORC Technologies, LLC
Ford
Caterpillar
Motion Planning

**INPUTS**
- Behavior Profile
- Vehicle Localization
- Road Detection
- Dynamic Obstacles
- Static Obstacles

**OUTPUTS**
- Target Achievability
- Motion Profile

**Motion Profile**
- Dynamic Obstacles
- Static Obstacles
- Speed Limit
- Obstacle ID
- Zone?

**Trajectory Search**
Determines fastest path based on:
- Drivable area (Zones)
- Lane (Segments)
- Static/Dynamic obstacles
- Vehicle dynamics
- Speed Limits
Completed multiple laps on NQE A

Cut-off vehicles due to IBEO bug

Detected phantom obstacle
NQE B & C Performance

Completed NQE B on 2nd attempt

Difficulties with Gauntlet

Large GPS “pop”

Completed NQE C

Sensors had difficulty detecting stop sign barrier
Final Event Performance

Successfully completed Final Event
Third Place overall by time
No major mistakes

Minor Issues:
Minor GPS pops
IBEO Reset
Phantom Obstacle
Successes

Base Vehicle Design

Software Architecture

Simulation Environment

JAUS Communications
Contact Information

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