Project Overview

Mapping Technology Assessment for Connected Vehicle Highway Network Applications

CGSIC – Seattle Washington
August 2012
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- Connected Vehicle Program Goals
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- Field Test
FHWA’s Connected Vehicle Program was established to facilitate the implementation of applications related to vehicles and/or infrastructure for helping to enhance safety, mobility, and the environment.

These applications will utilize mapping, positioning, and communication technology for their operations to provide information on the location of vehicles in relation to the roadway, other vehicles, and pedestrians.

Connected Vehicle is a large, multi-faceted program managed by the ITS Joint Program Office of the Research and Innovative Technology Administration (RITA).
Communications Technologies

Traffic Signal Controller

Wide Area Duplex Link

Wide Area Broadcast Link

DSRC
Positioning Technologies

Earth Frame
- Geographic North Pole
- Prime Meridian
- North
- Latitude
- Longitude
- Equatorial Plane

IMU Body Frame
- x
- y
- z
- North
- Latitude
- Equatorial Plane

Navigation Frame
- x
- y
- z
- Wandering Angle

Reference Station at known point

Differential baseline

IMU
- b, d
- Navigation Processor

GPS Receiver
- Kalman Filter

Error Estimates
- p_NS, v_NS
- p^e, v^e

Position Estimates
- Position
- Velocity
- Attitude

Kalman Filter
- error

yaw(\phi)

pitch(\theta)

roll(\psi)
Relative Position of Targets Referenced to Absolute Position Provided by GPS

Absolute Position: Area in which the Vehicle Position Lies, within the Specified Confidence Level (Typically 95%)

Note: Also may have Elevation Error; however generally not used.
Signal Phase and Timing System Setup

- Roadside equipment (DSRC)
- Traffic signal controller
- DSRC-enabled vehicle
Mapping Technologies

- As one of the main supporting technologies of the Connected Vehicle Program, **Mapping Technologies** provide critical support across safety, mobility, and environment applications through the provision and update of roadway data.

- The mapping of roadways involves developing an accurate geometric representation of the roadway and attribution of those geometries with application relevant data.

- Roadways are usually represented in GIS databases as linear features. Lane configuration and connectivity may also be represented in the form of additional geometries in the database or through attribution.

- The development of maps supporting Connected Vehicle applications requires the initial creation of the maps as well as ongoing, timely update of these maps.
Mapping Technology Assessment Project

- The *Mapping Technology Assessment for Connected Vehicle Highway Network Applications* project aimed to analyze and determine the best current and anticipated geospatial technologies and mapping approaches to support intelligent transportation systems (ITS).

- This assessment is fundamental to providing solutions that allow connected vehicle network applications to bring about transformational improvements in the safety, mobility, and environmental performance of our nation’s transportation systems.

- Mapping Technologies are a key enabler for the Program and its applications:
  - Vehicles need to know where they are in relation to other vehicles (relative position).
  - Vehicles need to know where they are in relation to the roadway (absolute position).

- The focus of the project is across 3 major areas:
  - Assess what mapping technologies meet the requirements of Connected Vehicle applications.
  - Test relevant technologies in lab and in the Connected Vehicle Highway Testbed (CVHT).
  - Develop a data management framework for compilation, storage, and update of collected data.

- The goal of the connected vehicle vision is high, but the potential benefits are significant as implementation of connected vehicle network applications can have far reaching impacts on transportation.
Overview of Field Test Data Flow Process

Map Data Accumulation

Vision
GPS/INS
Lidar

Raw Data

Offline Processing

Smoothing/Feature Extraction

Feature Data

Database

Database Management Tool

Mapping Database Development

Application Demonstration Development

Vision
GPS/INS

Application Software: Navigation + Feature Detection

Export

Database
GPS/IMU

LIDAR

sensor platform

Panoramic camera
Equipment Configuration for Field Test

Vehicle Mounting of Equipment
Mapping Sensors and Data Rates

- LIDAR
- Camera set
- IMU
- GNSS Receiver
- High capacity HD
- Roof Platform
- Power supply
- CPU

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Hrs. of collection per TB: ≈1 Hr.
Miles of coverage per TB (assuming a speed of 30 mph): ≈30 miles
LIDAR Data Collection
Bing Map, TFHRC Aerial Image, LIDAR-based intensity image overlay – combined in ArcMap
Applications

Mapping Data Accumulation

Vision
GPS/INS
Lidar

Raw Data

Offline Processing

Smoothing/Feature Extraction

Feature Data

Database

Database Management Tool

Mapping Database Development

Database

Export

Application Software: Navigation + Feature Detection

Database

Vision
GPS/INS

Application Development
Sensor platform for positioning

- Inexpensive GPS/IMU
- No LIDAR
- Inexpensive rectilinear camera
- No panoramic camera

Sensor platform
Application Graphical User Interface…
Lane Departure Warning...
Curve Overspeed Warning...
Field Study Summary

- Automated sensor-based mapping is necessary for nationwide lane-level map production
  - This project task developed software and demonstrated that automated sensor-based mapping is feasible with centimeter-level accuracy

- Two lane-level applications built on the foundation of lane-level maps were demonstrated using decimeter-level positioning techniques
  - Lane departure warning
  - Curve overspeed warning

- Future lane-level application
  - Signal Phase and Timing, at lane-level
Potential Areas of Future Research/Development

- Thorough process evaluation in less-structured, more-dynamic environments
- Transition from semi-automated to fully automated mapping process
- Maintenance of the precision map
  - Crowd sourcing
  - Targeted updates
- Large scale computer or cloud implementation for mapping larger environments
Questions?

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