Creation and Deployment of HD Map Data

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Backend HD Map on the Safety Server
Backend HD Map on the Safety Server
HD Map Data on the Safety Server

Observations

Maps

Events
HD Map Data on the Safety Server

PostgreSQL 9.x
PostGIS
Importing the HD Base Map

Start with 3D Mapping's ground truth data:
- Parse the standard OpenDrive format
- Convert data to the Ko-HAF map DB schema
Aggregating Vehicle Observations

Observations → Aggregation → Import → Open Drive
Exporting HD Map Data

Observations → Aggregation → Export → Import → Open Drive
Exporting HD Map Data

- Web service provides map data to vehicles
- Encrypted communications via LTE
- Compact binary encoding
- Download of map data is possible on demand, can factor in...
  - current vehicle position
  - planned route
  - mobile radio network coverage
  - ...
Exporting HD Map Data: Tiles
Exporting HD Map Data: Updates

Request

GetMapTiles

A1:8 A2:9
B1:5 C1:0
Exporting HD Map Data: Updates

Response

A1:9
B1:8
C1:5
A2:9 OK
Exporting HD Map Data: PBF

- Encoding map tiles as Protocol Buffers
- Goal: Low bandwidth use on LTE connections

- Some optimizations:
  - Relative coordinates using variable-length integers
  - Indexed storage of strings
  - Format allows encoding updates as diffs
Exporting HD Map Data: SMAP

- Arc splines to represent linear features
Exporting HD Map Data: SMAP

- Approximation using SMAP (Smooth Minimum Arc Paths)
- Smooth arc splines
- Maximum error can be freely chosen
- Provably minimal number of segments → memory usage
- Efficient representation in storage
- Efficient calculations, including:
  - curvature
  - distance
  - offset curves
Exporting HD Map Data: Evaluation

- On average: 70 kB per tile
- Largest tile: 381 kB

Tile 11316/8403
Frankfurter Kreuz
Exporting HD Map Data: Evaluation

- On average: 70 kB per tile
- Largest tile: 381 kB

- 14–33 kB/km (dual-carriageway motorways)
- 260 MB (± 80 MB) for Germany’s motorways

- Planned re-use of the format for the @CITY research project
HD Map: Interactive Demonstration
Frontend Sensor Data Upload
Frontend Sensor Data Upload

Safety Server → Initial HD Map → Learning HD Map → Dynamic Events

Frontend: Virtual Sensors → Sensors → Processing → Fusion
- Virtual Sensors: HD Map, Dynamic Events
- Sensors: Camera, Radar, Laser, GNSS
- Processing: Dyn.-Object Detection, Static-Object Detection, HD Map Localization
- Fusion: 360° Static and Dynamic Environment Model
Communication Infrastructure

- In Ko-HAF a mobile network based vehicle to server communication is used.
- The sensors data is uploaded from the vehicles via this mobile network communication to the server.
- The HD-Map parts are sent from the server, hosted at the infrastructure provider, via LTE to the vehicle.
From Sensor Data to Upload Data

- The amount of data recorded by sensors like LIDAR, RADAR or even cameras is very high.
- The communication capacity of the mobile network is very limited compared to this data amount.
- Data needs to be reduced.
From Sensor Data to Upload Data

- Data reduction by pre-aggregation
  - Recoding data in the ego-perspective with multiple frames per second
  - Transformation of the frame to a virtual top view
  - Pre-aggregation of multiple frames to road parts of a few hundred meters
Format of the Uploaded Data

- Relative coordinates with a segment
  - Global coordinate to refer a segment
- A segment contains all types of objects like lines, signs, ...

(0,0) (1,1) (4,1) (0,0)
Communication Overview

Vehicle

AP2

- sensor data
- map data

Ethernet

AP1-Box

- enrichment
- map cache

Safety Server

- input buffer
- aggregation
- stratified map

- sensor data
- static map (tiles)
- dynamic events

Ethernet

LTE
Uploaded Data

- Borderlines
  - Type
  - Color
  - Borderline samples
  - Covariances ...

- Street signs
  - Type
  - Attributes
  - Covariances ...
Line Aggregation
Uploaded Data

- Mobile Network
  - Cell Id
  - Network Type
  - RSSI
  - Throughput
  - Round Trip Time
  - …
Demo: LTE Throughput Prediction
Demo: HD Map as a Virtual Sensor
Thank you for your attention!

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