ENABLING DATA DRIVEN DEVELOPMENT OF AUTONOMOUS DRIVING AT BMW

Miha Pelko
@mpelko

BMW at AD meetup Munich
19.09.2019
AGENDA

- Why Autonomous Driving Development (ADD) requires lots of data?
- How can the data platform support ADD?
- Deep dives: Validation of AD software
## Autonomous Driving Levels

<table>
<thead>
<tr>
<th>AUTONOMOUS DRIVING LEVELS</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hands On</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver has full control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle controls forward</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>motion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Support</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No support</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assistance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partly automated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fully automated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autonomous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hands Off</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hands off eyes temp. off</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hands off eyes off</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hands off mind off</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle requests driver</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>to take over control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>based on situations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No driver required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Source: SAE (Society of Automotive Engineers) International Level of Automation*
Estimated ~1MB/s of information transfer over optic nerve

Over 18 years awake time the brain would have processed ~0.75 PB of visual information stream.

Koch et al. 2005, Current Biology 16, 1428–1434
ADAS* SYSTEM SETUP

(* AUTONOMOUS DRIVING ASSISTANCE SYSTEMS)

- Full Range Radar
- Night Vision
- Side View Camera
- Side Range Radar
- Surround View Camera
- Ultra-sonic
- Stereo Front Camera
- Rear View Camera
- Surround View
- speed limit assist
- steering and lane control assistant incl. lane change assistant
- emergency steering assist
- wrong way assist
- active cruise control
- speed limit assist
- side view camera
- night vision
- active cruise control
- crossroad assist

23 SENSORS
BMW SERIES 5
DATA COLLECTION FLEET

SEVERAL TB PER HOUR
DEVELOPMENT AND VALIDATION PROCESS

Several TB/h

Data Ingest to Data Center

Up to 500 PB/a

Software in a loop, Simulation

Automatic generation
Reference sensors
Manual labeling

Deployment of trained algorithms

Ground Truth
creation

Test drives

Organize Structure Evaluate

Scenario extraction

ML Training / AD development

Target data sets

Combinatorial boost of scenarios

Deployment of trained algorithms

Synthetic data

Deployment of trained algorithms

Scenario extraction

Automatic generation
Reference sensors
Manual labeling

Ground Truth
creation

Organize Structure Evaluate

Test drives

Software in a loop, Simulation

Up to 500 PB/a

Data Ingest to Data Center

Deployment of trained algorithms

Synthetic data
I want to develop a function of driving on a roundabout with pedestrians, …

Search for existing relevant scenarios

Export part of the data for labeling and/or local development

Train the ML models

Order the drive to collect relevant scenarios

Run the new algorithms on the data

Calculate KPIs for the new versions of algorithms
YIN AND YANG OF BIG DATA ASSISTED AD DEVELOPMENT
BMW GROUP HIGH PERFORMANCE D³ PLATFORM.

MUNICH AREA
BMW Group AD Campus

GLOBAL DATA LOGISTICS
Remote Locations

Ingest

Copy Station

3rd Party Gateway
Multi-tenancy interfaces
BMW Group developer, repositories

Gateway Zone

Function Reprocessing (SIL)
Simulation
Model Training

Containerized Computing Platform
Self Service container orchestration

Backbone Network

Data Platform
Data preparation
Search
Test space analysis

Applications Development Teams
Expert Service Desk
HiL Stations
BMW Group AD Campus

On-Premise Managed Infrastructure
VALIDATION OF AD SOFTWARE – OPEN LOOP

• Manual labeling
  + Precision
  - Small scope

• Reference sensors
  + Fully independent setup
  - Limited scope

• Automatic generation (alternative offline algorithms)
  + Large scope
  - Correlation with the sensors
EXTRACTING THE SCENARIOS FROM THE DATA

Number of pedestrians vs. Vehicle Speed

Observed Scenario
EXCITING TIMES AHEAD – THANK YOU FOR YOUR INTEREST.