AUTOMATED DRIVING WITH ROS AT BMW.

MICHAEL AEBERHARD, THOMAS KÜHBECK, BERNHARD SEIDL, MARTIN FRIEDL, JULIAN THOMAS, OLIVER SCHEICKL.
HISTORY OF AUTOMATED DRIVING AT BMW.

BMW Track Trainer (2006).

Emergency stop assistant (2009).

Highly automated driving on the motorway (2011 / 2015).

Automated driving on the vehicle‘s limit (2014).

Fully automated remote valet parking (2015).

360° collision avoidance (2015).

ADAPTIVE – EU RESEARCH PROJECT.

– BMW is partner in the EU research project AdaptIVe.


– Goal is the widespread application of automated driving to improve traffic safety, efficiency and comfort.

– BMW prototype will demonstrate urban (partial automation) and highway (conditional automation) automated driving functions.

For more information, visit https://www.adaptive-ip.eu/.
ADAS VEHICLE FUNCTIONAL ARCHITECTURE.

**SENSORS**
- Radar
- Cameras
- Laser scanner

**ENVIRONMENT MODEL**
- Representations and Fusion
- Road Model and Localization
- Situation Interpretation

**ADAS FUNCTIONS**
- Maneuver Planning
- Trajectory Planning
- State Machine

**VEH CONTROL**

**HMI**

Michael Aeberhard, BMW Group Research and Technology
GEN2 RESEARCH PROTOTYPE.
BMW 335i GT.
SENSOR SETUP IN GEN2 RESEARCH PROTOTYPE.
CHOOSING A FRAMEWORK.

1. **MicroFramework**
   - BMW internally developed Framework for prototyping ADAS.
   - Shared memory transport mechanism.
   - Synchronized execution of software modules.
   - Internal development limited/complex.

2. **EB Assist ADTF**
   - Commercial product popular within the automotive industry (OEMs/Suppliers).
   - Readily available toolboxes to hardware used in the automotive industry.
   - Easy to use GUI for manipulating various features and configuration a system.


3. **ROS**
   - Popular open source robotics framework.
   - Reliable distributed architecture.
   - Wide use in the robotics research community.
   - Huge selection of “off-the-shelf” software packages for hardware/algorithms/etc.
CHOOSING A FRAMEWORK.

1. BMW Group Research and Technology
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Why we ended up choosing ROS for the BMW research department:

- Autonomous driving benefits from robotics research and ROS has become very popular in the robotics community.
- Stability and reliability from a very large user-base.
- Quick tests and integration of already-available algorithms and software packages → saves development time.
- Open source.
- Easier cooperation with universities and other research institutes.
- Gain experience at BMW with using ROS and learn about its advantages/disadvantages with respect to other solutions → research department should try something new!
ROS ARCHITECTURE.

ADAS Algorithms

- Environment Model and Sensor Fusion
- Situation Interpretation
- Planning

Ethernet Data

ethernet2ros

/ros/trajectory
/ros/hmi_data

ros2ethernet

Ethernet Data
ROS ARCHITECTURE.

With the simulator:
ROS ARCHITECTURE.

In the research vehicle:

Gateway or sensor hardware

Gateway2ros

Hardware2ros

/sensor_data

/vehicle_data

/trajectory

/hmi_data

Environment Model and Sensor Fusion

Situation Interpretation

Planning

ros2autobox

dSPACE

MicroAutobox II

Ethernet Data
USING MATLAB/SIMULINK WITH ROS.

- MathWorks released the Robotics System Toolbox this year for ROS integration with Matlab/Simulink.
- Easily read and analyze data from ROS Bags → useful for evaluating the system.
- Some of our software is implemented as a Simulink model.
  - Use the Toolbox to easily integrate this software into the ROS eco-system:

http://www.mathworks.com/products/robotics/
VIDEO – LASERSCANNER.
VIDEO – GRIDS.
VIDEO – OBJECTS AND LANE MARKINGS.
VIDEO – LOCALIZATION.
VIDEO – ENVIRONMENT MODEL.
VIDEO – TRAJECTORY PLANNING.
VIDEO – AUTOMATED DRIVING FUNCTION.
DEVELOPED TOOLS.

- Several RQT Plug-Ins for various purposes:
  - Plug-Ins with specific functionality, for example simulating input and/or output for testing.
  - Improved Bag Record/Play Plug-In (rosparam dump/load, extra meta-data, map view, etc.).

- Lots of RViz Plug-Ins for visualizing our interfaces.
  - Avoid using markers to reduce traffic.
  - More flexibility with Ogre API.
  - Integration of selection mechanism for displaying object-specific data.
WHAT WE LIKE ABOUT ROS.

- Reliability and stability.
- Minimalism of a basic ROS node.
- Distributed architecture.
- ROS Message concept.
- “Off-the-shelf” tools such as RViz, RQT, Bag, diagnostics, etc.
- Future potential (ROS 2, ROS Industrial, new tools, etc.).
- Lots of software packages to try out!
THERE IS STILL A LOT OF POTENTIAL.

- More options in the message transport mechanisms.
  - ROS 2 with DDS could be a huge improvement.
  - GPU transport in order to minimize GPU → CPU data transfers.
- Easier ROS Message migration / compatibility (MD5 Checksum on .msg file maybe not the best solution?).
- Continue to improve the already very useful tools.
  - RViz – plug-ins, labeling framework.
  - RQT – Topic Monitor, Plot, Bag, etc.
- Node Manager GUI (something similar to node_manager_fkie).
- Easy configuration management for different robots (currently a hodge-podge of launch files for different vehicles).
- Compliance to industry standards for software (ISO, AUTOSAR, etc.).
THANK YOU FOR YOUR ATTENTION.

Contact: michael.aeberhard@bmw.de