HydraOne: An Indoor Experimental Research and Education Platform for CAVs

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Research and Education Platforms

IoT · Drones · Smart Home · INDUSTRY 4.0

Edge · CAVs · Cellular Tower · Edge Server

Cloud · Microsoft Azure · Google Cloud

For Edge Computing?

openstack · kubernetes · MESOS
Edge Computing on CAVs

THE COMING FLOOD OF DATA IN AUTONOMOUS VEHICLES

RADAR
~10-100 KB PER SECOND

SONAR
~10-100 KB PER SECOND

GPS
~50 KB PER SECOND

CAMERAS
~20-40 MB PER SECOND

LIDAR
~10-70 MB PER SECOND

AUTONOMOUS VEHICLES
4,000 GB PER DAY... EACH DAY

Tesla Autopilot

Google Waymo

Baidu Apollo
HydraOne Overview

- 3D LiDAR
- HD Cameras
- DC Motors w/Encoder
- Mecanum Wheels
- Wi-Fi & Bluetooth Antenna
- Computing Platform

ROS Kinetic Kame
Hardware Design

**Sensors**
- Camera \(\times 2\)
- LiDAR
  - Velodyne VLP16

**Computing Platform**
- Computing Node
  - NVIDIA Jetson TX2
- Control Board
  - Arduino Mega 2560
- Edge Server

**Actuators**
- Encoder Motor \(\times 4\)
- Mecanum Wheel \(\times 4\)
- Motor Driver \(\times 2\)
- 3S LiPo Battery \(\times 2\)

**Connections**
- USB 3.0
- Ethernet
- UART
- I2C
- PWM
- 12V
- 5V

**Power Sources**
- 12V
- 5V

**Additional Components**
- Leopard Imaging AR023Z
- Motion
- Vision
- Remote
- Power
Software Framework

ROS Framework on HydraOne

- camera_node1 → /camera1/image → object_detection_node → /chassis/control
- camera_node2 → /camera2/image → path_planning_node → /chassis/control
- LiDAR_node → /lidar/point_cloud → SLAM_node → /slam/map
- sensor_node n → /lidar/laser_scan → processing_node n

Edge Server

- remote_control_node

HydraOne

- chassis_node
- actuator_node n

Chassis

ROS Framework on HydraOne

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- LiDAR_node
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Chassis
Experimental Enablers

• Design Modularization
  • Test, replace, and upgrade each module on HydraOne

• Resource Extensibility and Openness
  • Mount and develop new resources on HydraOne
  • Access, analyze, and customize any resources on HydraOne

• Function Isolation
  • Prevent exclusive access to hardware resources
  • Isolate the ROS function with other libraries
Remote Control

HydraOne

/camera1/image

camera 1

Edge Server

remote_control_node

camera_node1

/chassis/control

chassis_node

Chassis

For Holonomic mode (strafing), hold down the shift key:

U: up (+z)
I: down (-z)
J: left (-x)
K: right (+x)
L: increase/decrease max speeds by 10%
M: increase/decrease only linear speed by 10%
N: increase/decrease only angular speed by 10%
CTRL-C to quit

currently: speed 2.29748649318 turn 0.000000000000

currently: speed 2.5272351425 turn 0.000000000000

currently: speed 2.77095860675 turn 0.000000000000

Connected and Autonomous dRiving Laboratory
End-to-end Autonomous Driving

Connected and Autonomous Driving Laboratory
Map Generation

[Diagram showing LiDAR node and connections to 3D_mapping_node and 2D_mapping_node]

/Lidar/point_cloud

/Lidar/laser_scan

3D_mapping_node -> /3d_slam/map

2D_mapping_node -> /2d_slam/map
Energy Efficiency

- **Chassis**
- **Computing Platform**
- **Sensors**

<table>
<thead>
<tr>
<th>State</th>
<th>Running Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idle</td>
<td>15.7</td>
</tr>
<tr>
<td>Remote Control</td>
<td>40.7</td>
</tr>
<tr>
<td>End-to-end AD</td>
<td>41.7</td>
</tr>
<tr>
<td>Map Generation</td>
<td>41.2</td>
</tr>
</tbody>
</table>

- Chassis: 0-15.7 W
- Computing Platform: 15.7-40.7 W
- Sensors: 40.7-45 W
Conclusion

• HydraOne, research and education platform for CAVs
• Supported research problems for CAVs
  ➢ Autonomous driving algorithms
  ➢ Vehicle-to-everything (V2X) applications
  ➢ Computing system and architecture on CAVs
  ➢ Operating system designed for CAVs
  ➢ Trusted execution environments on CAVs
  ➢ ...
• Be valuable to researchers, developers, and students
Thank You

Q & A

http://thecarlab.org/

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Discussion

• What kind of feedback you are looking to receive
  ➢ We would like to know what kind of CAVs research platform do the researchers want, and what kind of CAVs applications they cannot deploy and evaluate in the real-world environment due to the research platform missing.

• The controversial points of the paper
  ➢ The most controversial point is the HydraOne is an indoor platform, so the environment of HydraOne might not be as complicated as outdoor vehicles. Some CAVs applications need further modifications when evaluating in outdoor scenarios, for example, the lane detection application.

• The open issues the paper does not address
  ➢ This paper did not discuss how other researchers use the platform remotely. At this point, we need to think about how to replicate the same design for other people.

• Under what circumstances the whole idea might fall apart.
  ➢ The whole idea of HydraOne will be challenged if other researchers found it is very difficult to use the proposed platform.