On the way to autonomous driving:
The Story of NIO

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NIO is more than a car company

Conceived and planned since 2012 and formally founded on November 28, 2014. NIO is a global company that designs, develops, and produces smart, high-performance, premium electric vehicles. Our aspiration is to shape a better life for our users through thoughtful design, amazing services, and cutting-edge technology.
NIO’s Products

FE Racing Car → EP9 → EVE → ES8 → ES6
NIO has over 9,500 employees and world-class research and development, design, and manufacturing centers in Shanghai, Beijing, San Jose, Munich, London and other locations.
NIO USA - San Jose - Advanced Technologies Group:
HW/FW
SW & Algorithms
Perception
Systems Integration/Validation
350+ people
EP9 – Autonomous Lap Project 09/16 – 02/17
One of the Fastest Electric Cars in the World
From Track to Road
Autonomous Driving Platform: Timeline

- **Start HWY tests**
  - Parking Lot Test: Mar 17
  - HWY Testing: Apr/May 17
  - HWY NIO-Pilot: June 17
  - Lane Change: July 17
  - Stop/Go: Aug 17
  - Map + Perc. Integration: Sept 17
- **Demonstration of Map + Perception Integration**
- **Testing closed loops, paths for AD ALGO's**
- **Demonstration of Stop/Go Capability**
- **Demonstration of Autonomous Lane Change ALGO's**

**Begin development**

Testing HWY NIO-Pilot ALGO's
Autonomous Driving Platform: **Timeline @ 10/2017**
Autonomous Driving Platform: Timeline

Autonomous parking solutions

Jan-Mar 18  |  Apr/May 18  |  June 18  |  July 18  |  Aug 18  |  Sept 18  |  Oct 18  |  Nov 18  |  Dec 18

Improve Real-Time Planning for Obstacle/Collision Avoidance
Autonomous Driving Platform: L4

• GOAL:
  • Fully redundant L4 Solution
    • (SW & HW)
  • Based on our EV platform
    • Release first HWY-L4
    • Extend to Urban setting
ALGORITHMS

- Perception/Fusion
- HD Maps
- World Model
- Object Intent and Trajectory Prediction
- Routing
- Behavioral Planning
- Low-level Planning for Obstacle/Collision Avoidance
- Dynamic Control & Tracking

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Operating Frequency</th>
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<tbody>
<tr>
<td>Routing to final destination</td>
<td>1Hz</td>
</tr>
<tr>
<td>6-10 seconds</td>
<td>1-5 Hz</td>
</tr>
<tr>
<td>1-3 seconds</td>
<td>20-40Hz</td>
</tr>
<tr>
<td>(Steering/Acceleration/Deceleration)</td>
<td>100Hz</td>
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</tbody>
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- Object intent and trajectory prediction for different time horizons with different confidences
Algorithm Selection and Evaluation

- Linear Systems theory
- Nonlinear Systems theory
- Stochastic Systems theory
- Markov processes
- Statistics based learning strategies
Testing, Validation and Simulations

• Simulation environment: SIL & MIL
Testing, Validation and Simulations

• Simulation environment: SIL & MIL
L4 Autonomous Driving in HWY Environment
Problem domain and Solution

- Statistical Learning
- Deterministic Systems Theory
- Stochastic Systems Theory

L4
• Achieving robustness guarantees
  • Handling qualities for all operation domain ad conditions

• Achieving safety/collision guarantees
  • 97.8% → is it enough?
  • 98.9%. → guarantee safety?
ALGORITHMIC CHALLENGES

• Testing and validation
  • `simulation-driven-miles`
  • `real-world-miles`
    • How much is enough?!
  • 5 million miles?!
  • 10 million miles?!
  • 15 million miles?!
ALGORITHMIC CHALLENGES

• Testing and validation
  • Different conditions
    • Mumbai vs. London vs. Melbourne
      • How do you guarantee same level of safety with different level of driving cultures?
Blue Sky Coming
Thank you