Integration of Autonomous and Human-Driven Cars

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OpenSource AI Workshop
Outline

1. Introduction
2. Research Approach
3. Summary
Introduction

- Driver-less cars are emerging
  - Solve many challenging traffic problems
  - Opened a research area

- A mix of vehicles types coexist
  - AVs - Autonomous Vehicles
  - HVs - Human -Driven vehicles
  - Deployments of AVs is a gradual process

- How can we deal with the vehicle mix?

**Figure:** Cross road intersection with double lanes.
Social Behavior of HVS and AVS

Figure: Social Behaviour of HVs and AVs
The realization of commercial AVs is made feasible by AI technologies:

- Environmental perception
- Map building
- Path planning
- Deep neural networks
Ethical issues associated with AV

- **Privacy Issues**: Its communication standards are open for hacking
- **Morality issues**: Dilemma of taking decision - Self trolley problem
- **Safety standards**: ISO 26262 is safety standard for HVs, what of AVs? google car test 1m-km, is this ok?
- **Reliability**: What if there is network of sensor(s) failure?
- **Responsibility and Accountability**: in case of accident or incident?
- **Quality Assurance Process**: Overall quality and life time of components?
State-of-the-art in Traffic Intersection Management

Classification
- Centralized vs. decentralized approach
- Traffic lights vs. alternative flow control

Methods
- Ramp metering for merging roads
- Fuzzy Logic
- Vehicle Platooning
- Agent based system
Open Source and Interface for AVs

- Apollo - simulator engine
- Autoware - open city driving in 3D maps
- EB robinos Predictor Elektrobit - combine software’s together
- NVIDIA® DriveWorks - Software kIT - goes from detection to localization to planning to visualization.
- OpenPilot - controls break and steering system
Motivation of this Research

- Cost of AVs is higher and not affordable by everyone
- Full enabling environment for AVS are not in place yet
- Constructing roads for AVs might not be feasible
  - Cost of redesign
  - Existing city plan (changes are gradual)
- Intersections are crucial points and complex interactions
  - They need to be accounted for
Pricing of Road-Spacetime slot reservations is proposed: Airplanes use landing slots pricing to avoid conflict, what if AVs and HVs did the same thing in addition to platooning?

Figure: Intersection layout
Approach Considerations

- We model HVs with traffic light, while the AVs is controlled by an MPC.
- The car dynamics is based on Newton law of Physics
- The main measure for safety is the cross-collision point (fig)
- Full behavioural freedom assigned to HVs
- Position, trajectory, speed, time etc are parameters of cars.
Differences between HVs and AVs parameters

These differences are summarized under the following four heading:

- **Communication**: AVs operates two ways communication loop while HVs is one way.

- **Control Efficiency**: AVs observe a set of predefined rules, while human driven vehicles have freedom.

- **Response Time**: AVs response at real-time while HVs response is 2.3 seconds, this delay can be dangerous in emergency.

- **Complexity in the set of rules**: AVs are protocol-based design(movement), while human nature control in HVs.
Two different algorithms for HVs and AVs were developed.

**Algorithm for HVs**

We modelled human driven vehicle using the convention driving system thus:
- Signal Operation policy
- Simple rule
- Arriving vehicles from an active lane gets automatic reservation slot.

**Algorithm for the AVS**

This uses:
- Uses Motion protocol
- Communication and sensors
- Permission assignment rule
Coordination Algorithm for AVs and HVS

Vehicle parameters

- Vehicle Identification Number (VIN)
- Vehicle length
- Maximum and minimum acceleration
- Maximum velocity
- Maximum steering angle
- Axle distance

State variables

- Position
- Heading/direction
- Acceleration and velocity

Figure: Intersection Communication platform.
Early Results

Simulations for intersection efficiency was conducted with random numbers of cars at intersection verses its equivalent crashes as shown.

![Early results on Intersection Safety](image)

**Figure:** Graph of no of cars verses no of crashes
What we want to achieve:

- A novel intersection management scheme for safe mixed traffic
- HVs and AVs are represented by different physical/driving models
- Formal proof for the safety of the proposed management
- Performance evaluation based on mix ratio of HVs to AVs
Car Model

This model describes the forces acting on a car based on the principal of Newton’s laws of Physics.
Therefore, we model the frictional force as:

\[ F_r = \mu \cdot m \cdot g \]  \hspace{1cm} (1)

Vehicle Acceleration

The acceleration \( a \) of the vehicle is determined by the net force on the car and the car’s mass \( m \):

\[ F = m \cdot a \quad [F] = \left( \frac{m}{s^2} \right) \]  \hspace{1cm} (2)
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- Pricing of road-spacetime slot reservations could help in a hybrid environment to promote safety
- Vehicle platooning system reduce travel time, breaking and fuel consumption

Ongoing/Future work

- Implementation of a simulator with agents (will be open source)
- Investigation of various performance metrics
- Study of how this system react to failure and mitigation strategies
- Model responding to all road users (e.g., pedestrians, emergency vehicles)

Thank you for listening

Questions