Swaayatt Robots

Autonomous Driving

Stochastic Adversarial Traffic and Unstructured Environments

Title: Role of Stochastic Traffic and Unstructured Environments in Achieving Safe and Scalable Autonomous Driving

Speaker: Sanjeev Sharma, Founder and CEO

Typical Autonomous Driving Model

Perception Algorithms

- Build 3D representation of the world
- Detect navigable and non-navigable regions

Localization Algorithms

- Compute global accurate position of the vehicle
- Use High-Fidelity Maps (HFMs) for inference
- Provide additional information layer:
  - Road delimiters
  - Lane markers and boundaries

Planning and Control Algorithms

- Compute motion and behaviour of the vehicle
- Execute motion and behaviour commands

Key Role of HFMs

Road and Lane Delimiters

- **HFMs contain two key elements**
  - Road delimiters information
  - Lane markers information
- **Projection of delimiters information from HFMs**
  - Allows fail-safe determination of delimiters
- **Reason**
  - Real-time delimiters detection is challenging
  - Environments can become unstructured - robust detection becomes even harder

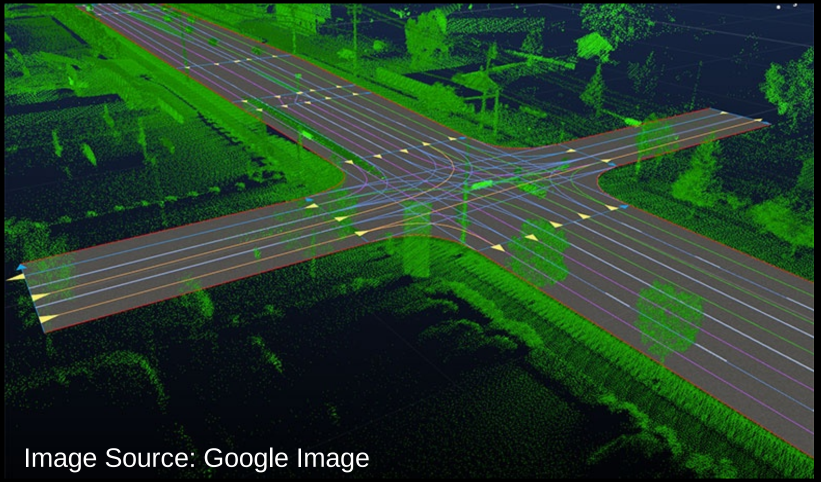
Image Source: Google Image

A sample HFM shown above

General Challenges

- **Perception**

  → Cost
  Robustness, Accuracy, Computational Efficiency

- **Planning**

  → Safety
  Unpredictable Events, Complex Traffic Dynamics, Multi-Agent Negotiation

- **Mapping and Localization**

  → Scalability
  Algorithmic Efficiency, Infrastructure

Key Abstract Questions

- **How can we guarantee safety?**
  - → Can we trust autonomous vehicles with our family and kids?
- **How do we assess the performance of algorithms?**
  - → How can we evaluate the quality of perception technology?
  - → How can we ensure that planning technology will react appropriately to unforeseeable environmental uncertainties?
- **What can be done to scale the technology rapidly?**
  - → Can we eliminate the requirement of high-definition/fidelity maps?
  - → What are the kinds of algorithms required to achieve it?

Stochastic Traffic and Unstructured Environments

Perception

→ Contextual understanding of unstructured scenes

→ Absent or unclear delimiters

Planning and Controls

→ Structured highways often have complex traffic behaviour

→ Irregularity is the only regularity

Hidden Challenges

→ Cost: Containing number of sensors and computational hardware

→ Increased amount of computations

Opportunities

Achieve Fundamental Objectives

Robustness and Reliability

→ Semantic and contextual understanding simplifies for relatively structured environments elsewhere

North America, Europe, Australia, Developed Asian and Middle East Countries

Safety Guarantees

→ Almost every driving and traffic configuration is a corner case elsewhere

Perception | Cost

Robustness, Computational Efficiency, and Cost

Our Perception Research Focus

Structured & Unstructured Environments

Real-time inference capabilities

- Loss functions
- Novel compute functions for deep neural networks
  - Lower computations - Computational Efficiency
  - Better generalization - Accuracy

Real-time delimiters prediction or generation

- Generation of Salient Delimiters
  - Faded
  - Absent
- Generation of Non-Salient Delimiters
  - Faded

Swaayatt Technology Highlights

- **Technology Enabling Perception Using Cameras**
  - One of the 2-3 companies in the world to achieve it
- **Computationally Efficient Semantic Segmentation Network**
  - Works on both structured and unstructured roads
  - Computational Efficiency: 16-30x compared to the state-of-the-art algorithms
- **Delimiters Prediction and Generation Ability**
  - Enabling autonomous vehicles to deal with unstructured environments
- **All Terrain Free Space Detector**
  - Enabling autonomous vehicles perceive both on- and off-roads
  - Significantly computationally efficient compared to similar technology developed elsewhere
- **Obstacle Detection**
  - Computational efficiency: 10x-43x compared to the state-of-the-art algorithms


हिन्दुस्तान की पहली सेल्फ ड्राइविंग कार
ZEE हिन्दुस्तान
ROBOTS
संजीव शर्मा, रोबो कार बनाने वाला
AVAILABLE ON
dishtv 660
d2h 301
TATA Sky 520
airtel digital TV 320
Swaayatt Robots Data
CBM
Swaayatt Robots Data
CBL
Swaayatt Robots Data
Swaayatt Robots Data
CBM


1999-11-30 01:01:36
1999-11-30 00:28:46
1999-11-30 00:26:31
1999-11-30 00:59:23


01-09-2019 Wed 18:15:56
CBM
CBM
1999-11-30 01:59:09

Localization | Scalability

Infrastructure, Cost, and Time

Revisiting Mapping

Road and Lane Delimiters

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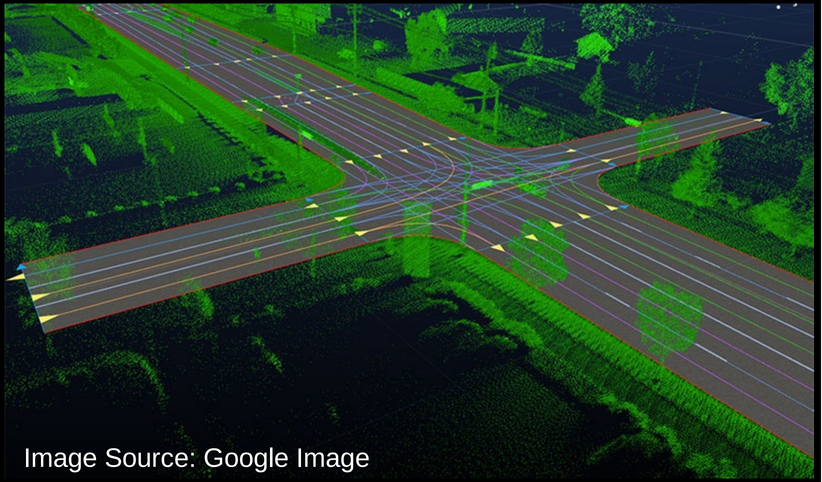


A sample HFM shown above

Problems and Solution

Problems with this autonomous driving model and challenges

- Inference against HFMs is computationally very expensive
- Remote server for computations - infrastructure challenge!
- Mapping and managing maps is costly and time consuming
- Hinders rapid scale-up of autonomous driving

Our Solution: Delimiters prediction and generation

- Robust delimiters detection, with real-time prediction and generation of delimiters
- Enabling scalable autonomous driving (without HFMs)

Our Autonomous Driving Model

Perception Algorithms

- Build 3D representation of the world
- Detect navigable and non-navigable regions

Local Delimiters Relative Localization

- Local relative accurate positioning of the vehicle
  - Enabled via delimiters prediction / generation
- Use GPS maps to determine exits and turns
  - Can use semi-dense maps for urban navigation

Planning and Control Algorithms

- Compute motion and behaviour of the vehicle
- Execute motion and behaviour commands

Delimiters Prediction Research

- **Real-time inference capabilities**
  - For both detection and prediction (or generation)
- **Real-time delimiters prediction or generation**
  - Generation of Salient Delimiters with Static or Temporal Information
    - Faded
    - Absent
  - Generation of Non-Salient Delimiters with Temporal Information
    - Faded
- **Result: Lane Detection and Generation Algorithm**
  - Enabling autonomous driving and lane keeping (ADAS feature) even in unstructured environments

Lane Detection and Generation

- **Computations: Under 12.75 GFlops**
  - Simultaneous detection and generation
- **Key Features | Advantages**
  - Detects roads boundaries and lane markers
  - Generates such delimiters in they are faded or absent on road

Sample Demo

Planning | Safety

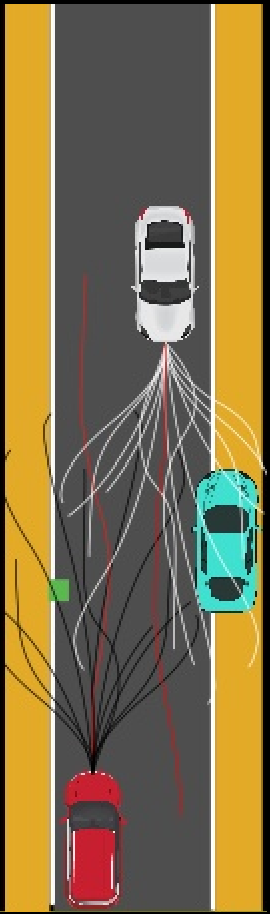
Unforeseeable Events, Complex Traffic Dynamics

Planning Research

- **Stochastic traffic negotiation**
  - Traffic dynamics as stochastic as Indian traffic Dynamics
- **Multi-Agent Intent Analysis and Negotiation**
  - Adversarial stochastic agents
  - Super-linear scale up vs exponential explosion in computations
- **Tight Space Negotiation**
  - High-speed cluttered highway negotiation; Overtaking negotiation and abortion decisions
  - Uncertain and chaotic dynamic tight space negotiation
- **Motion Planning at > 1000 Hz**
  - Ability to quickly react to adversarial situations
- **Intelligent frameworks for end-to-end navigation in unknown environments**
  - Play a key role in navigation in unmapped environments

Key Highlight

Multi-Agent Negotiation and Intent Analysis



Key Learnings

- **Safety in stochastic traffic of India ensures safe operations elsewhere**
  - Elsewhere, traffic is significantly much more structured
  - Almost every driving scenario is a corner case for the industry at large
- **Technology for unstructured environments will lead to robustness elsewhere**
  - Guarantees fail-safe operation in structured or partially-unstructured environments
  - Algorithms having enhanced ability to contextually understand the environments
- **Byproduct: Innovation in other departments of autonomous driving**
  - Delimiters prediction, as an instance - Localization & Mapping, and Perception

Thank You!