Quantifying the Impact of Driving Behavior on Fuel Consumption in Urban Environments

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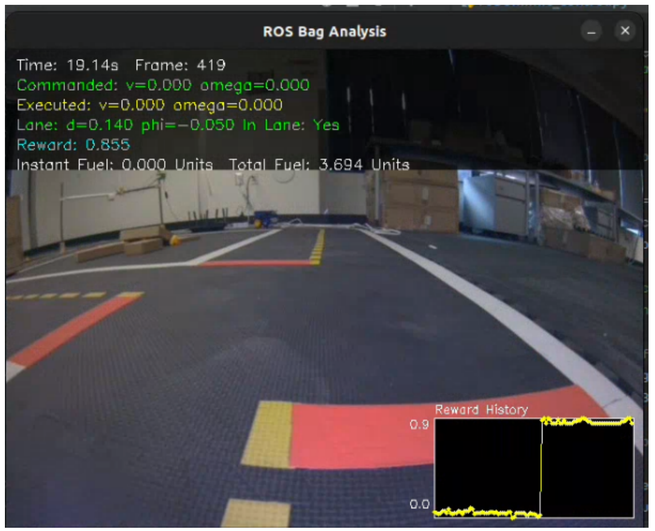
Research Question

How can we quantify the relationship between vehicle driving behaviors—such as acceleration, deceleration, and braking—and fuel consumption, in order to inform strategies for reducing carbon emissions in urban driving conditions?

Motivation

Transportation is a major contributor to urban carbon emissions. Traditional eco-driving methods are often static and fail to adapt to real-time conditions. Reinforcement learning (RL) offers a dynamic framework for optimizing driving behaviors based on continuous feedback, with the potential to significantly reduce fuel consumption.

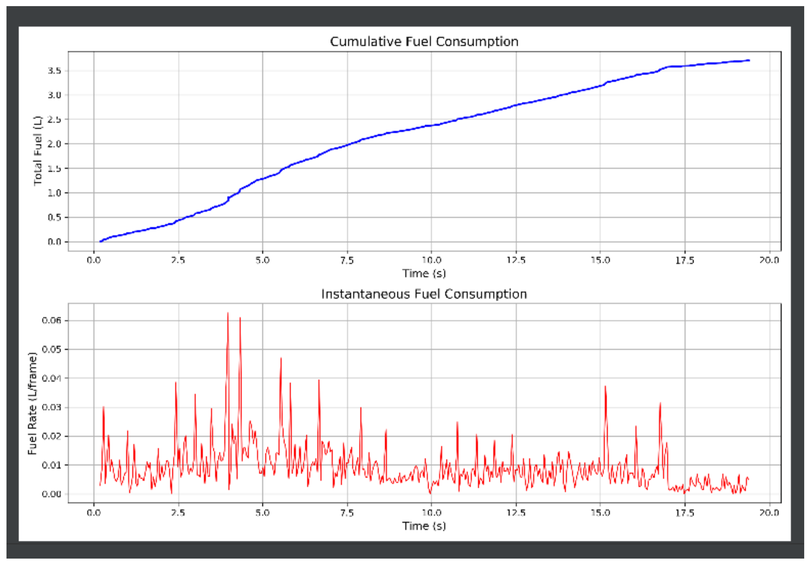


Recording fuel consumption metrics

Methodology

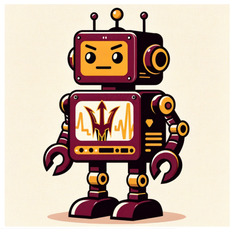
Our proposed pipeline includes the following steps:

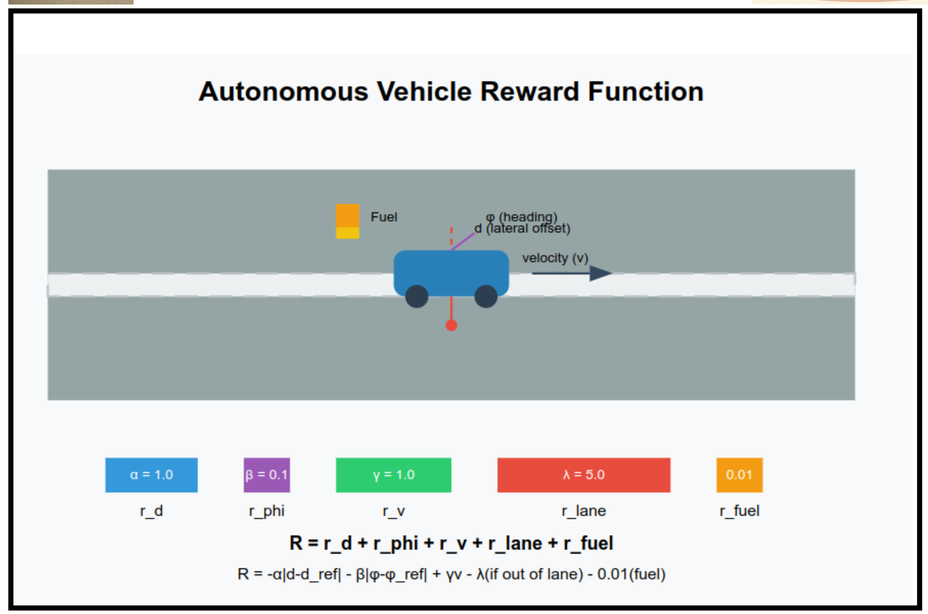
1. **Data Collection**: We used a car simulator to run a base driving model and recorded driving footage along with telemetry data—velocity, acceleration, turning angle (omega), and braking parameters.
2. **Fuel Consumption Estimation**: Since energy usage data from electric batteries was difficult to extract, we created a **custom fuel consumption estimation function** based on driving metrics. This function hypothetically calculates fuel usage for each timestep of the simulation.
3. **Data Pipeline Construction**:
   - Extract simulation data from the base model.
   - Calculate estimated fuel consumption using our function.
   - Store the processed data in a CSV format.
   - Plan to train a neural network model on this data to predict fuel-efficient actions.
4. **Model Training (Planned)**: Use reinforcement learning to train an agent that learns fuel-efficient acceleration-deceleration strategies. The model would ideally be deployed in the simulator for iterative testing.



Fuel consumption relation: Increased fuel consumption noted during braking and higher velocities

Built my own duckiebot known as "Beefboss"





Custom made reward function with fuel consumption parameter

Results and Future Prospects

- Developed a hypothetical fuel consumption function using key driving metrics
- Built a data pipeline to extract and process simulation data
- Outlined a framework for reinforcement learning-based optimization
- Next: Train and evaluate the model within the simulator
- Extend to real-world vehicle systems in future phases
- Fuel function can support future eco-driving research
- Future work: Add more driving variables and real-time adaptability

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