AuE-8930 Deep Learning Final Project Proposal

Team Members (Group 4)

- Tanmay Samak
- Chinmay Samak
- Vasanth Seethapathi

Tentative Project Title

Data-Driven Discovery of Vehicle Motion Model using Bayesian Deep Learning

Problem Statement

Motion models are crucial for simulation and state estimation purposes and can be either developed using traditional or learning-based methods. On one hand, formal methods such as first-principles modeling are interpretable and explainable but require extensive system identification for parameter tuning and may result in computationally complex models. On the other hand, simple data-driven methods such as end-to-end learning can capture the dynamics to certain extent with low-latency inference, but their interpretability and explainability may be questionable. This work will investigate whether Bayesian deep learning can help bridge the gap between formal and data-driven approaches to develop computationally light-weight surrogate models that are generalizable, interpretable, and explainable. Particularly, we will be using the proposed approach to "learn" a reduced-order (i.e., surrogate) motion model of an Ackerman-steered vehicle given its low-level control inputs such as throttle, brake and steering.

Work Breakdown Structure

Following are the three phases planned for the project:

1. **Phase 1: Data Collection**
    - Shortlist control inputs and states to be measured/estimated
    - Collect dynamical dataset of an Ackerman-steered vehicle
    - Post-process the dataset to get required features and labels
2. **Phase 2: Model Training**
    - Define architecture of Bayesian neural network
    - Define/tune hyperparameters
    - Train and save the model
3. **Phase 3: Model Inference**
    - Forward-simulate the trained model by providing control inputs to it
    - Benchmark the model against ground-truth and comment on its validity

Detailed Schedule

Week	Day	Task	Deliverables
10	3/13	Draw up the schedule	
	3/17	Draw up the schedule	
11	Spring break	Write project proposal	
	Spring break	Write project proposal	
12	3/27	Submit proposal	Detailed proposal (2~3 pages)
	3/31	Review of the project proposal	
13	4/3	Data acquisition	
	4/7	Data acquisition	
14	4/10	Data acquisition and processing	
	4/14	Data acquisition and processing	Interim project report (1~2 pages)
15	4/17	Model building and training	
	Midterm	Model building and training	
16	4/25	Model test and validation	Final codebase
	4/28	Documentation	Final project report (5~10 pages)
17	5/2	Final project presentations	Final project slides (5~10 slides)
	5/4	Final project presentations	

Dataset

- **Data Collection Platform:** We plan to use AutoDRIVE Ecosystem for collecting the vehicle dynamics dataset. Particularly, we plan to collect the data of AutoDRIVE's scaled vehicle (called Nigel) using the high-fidelity AutoDRIVE Simulator (from our initial exploration, this task seems to demand a lot of data collection/filtering across various operating conditions that the vehicle can undergo. Consequently, we plan to exploit this physically accurate and graphically realistic simulation tool to collect data in controlled conditions.)
- **Dataset Structure:** The proposed dataset will need to have vehicle states (at least posX, posY, yaw) and the control inputs (throttle, brake and steering). We plan to record realistically plausible sensor data from the simulator (i.e. data that can be sensed/estimated in real world as well; no unfair advantage of using simulation) to ensure the sim2real capability of our approach going forward. Following is a header describing the dataset structure:

time	throttle	steering	leftTicks	rightTicks	posX	posY	posZ	roll	pitch	yaw	speed	angX	angY	angZ	accX	accY	accZ	cam0	cam1	lidar
yyyy_MM_dd_ HH_mm_ss_fff	%	rad	int	int	m	m	m	rad	rad	rad	m/s	rad/s	rad/s	rad/s	m/s^2	m/s^2	m/s^2	img_path	img_path	ranges (m)

Submission Deliverables

- Dataset
- Source code
- Project report
- Presentation slides