PROJECT TITLE – **LEARNING HUMAN DRIVER BEHAVIOR WITH MACHINE LEARNING**

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ME 420 - MECHANICAL ENGINEERING INDIVIDUAL RESEARCH PROJECT

Project Proposal Report

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LIST OF ABBREVIATIONS

EV	Electric Vehicle
HEV	Hybrid Electric Vehicle
MBSD	Model Based System Design
CNN	Convolutional Neural Networks
RNN	Recurrent Neural Networks
GPS	Global Positioning System
CAE	Computer Aided Engineering

1. INTRODUCTION

1.1 State of the Art

Autonomous driving and mimic human driver behavior are rapidly evolving field with several active areas of research. Traditional model-based techniques of autonomous driving vehicles use maps to localize themselves.[1] The advancement of technology and machine learning algorithms have shown great promise in developing intelligent driver assistance systems and autonomous vehicles that can learn from human driver behavior.

Primarily, deep learning models are used in the research to identify and classify different driver behavior. The deep learning models can be trained on large datasets of real-world driving scenarios to learn patterns and behaviors that can be used to predict driver intensions and actions.[2] Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN) are very suitable for recognizing and predicting driver behavior, including turning, braking and lane changing.

The development of reinforcement learning algorithms can learn to control autonomous vehicle by observing human driver behavior. It commonly uses trial and error method to learn optimal control policies in different driving scenarios. Reinforcement learning models are very suitable for developing intelligent driver agents that can assist human drivers in real time such as automated emergency braking and departure warning systems.

Another method of learning human driver behavior is development of simulation environment. The simulations can be used to train and evaluate machine learning models for autonomous driving. These simulations can generate realistic driving scenario and allow to test or evaluate different machine learning algorithms in a safe and controlled environment. Also, simulations can be used to generate synthetic data to augment real world datasets, which can improve the performance of machine learning models.

Therefore, there is strong evidence that the advancement of machine learning algorithms lead to the development of intelligent driver assistance systems and autonomous vehicles that can learn from human drivers.

1.2 Motivation

Learning human driver behavior with machine learning leads to revolutionize the automotive industry and improve the road safety. With rise of autonomous vehicles, there is a high requirement of algorithms which can accurately predict and react to human driver behavior in real time.

Development of intelligent driver agent systems can assist drivers in real time and detect dangerous driving behavior, such as drowsiness or distracted driving. Also, these systems can provide warnings and take corrective action to prevent accidents.

There is another motivation for research in this field is the potential to develop autonomous vehicles that can learn from human driver behavior. Autonomous vehicles must be able to anticipate and react to the behavior of other drivers on the road, which is a complex and dynamic task. By analyzing large datasets of human driver behavior and using machine learning algorithms can learn to predict driver intentions and react accordingly. This will make autonomous vehicles safer and more efficient.

Reducing accidents and fatalities on the road also a crucial motivation to do this project. By developing machine learning algorithms that can accurately predict and react to human driver behavior, we can significantly reduce the number of accidents and fatalities on the road.

1.3 Summary of Outcomes

Table 1.1 Summary of Literature Survey Outcomes

Title of the Paper	Author	Outcome	Conclusions
Extracting Human-Like Driving Behaviors from Expert Driver Data Using Deep Learning	Kyle Sama, Yoichi Morales, Hailong Liu, Naoki Akai, Alexander Carballo, Eijiro Takeuchi, Kazuya Takeda	Quantitative trajectory comparison between AI Driver agent and expert driver data. Alternate route comparison by training the autoencoder.	Created an autonomous agent to correctly select the proper behavior to use depending on the environment by a deep auto encoder network which cluster the latent features into behaviors and create velocity profiles.
Detecting Human Driver Inattentive and Aggressive Driving Behavior using Deep Learning.	Monagi H Alkinani, Wazir Zada Khan, Quartulain Arshad	Comparative study of Driver Fatigue or Drowsiness Detection Techniques	HIDB and HIADB can be efficiently detected and accurately assessed by using multiple sources of information.
Driving Behavior Style Study with a Hybrid Deep Learning Framework Based on GPS Data	Jingqiu Guo, Yangzexi Liu, Lanfang Zhang, Yibing Wang	Collected large set of GPS data in the city of Shenzhen and driver behaviors are clustered with different parameter combinations.	Back propagation through the multi-layer autoencoders were effective for non-linear and multi-modal dimensionality reduction, producing low reconstruction errors on big GPS datasets.

2. AIM OF THE PROJECT

The aim of the project is to develop a realistic statistical model that can accurately predict and react to human driver behavior in real time. The goal is to improve road safety and passenger comfort. Also creating intelligent driver agent systems and autonomous vehicles that can learn from human drivers are key factors for revolution in automotive industry.

The aim can be achieved by developing machine learning algorithms that can analyze large datasets of human driver behavior and learn to recognize patterns and behaviors. Also, need to develop simulation environments that can generate realistic driving scenarios and allows to test different algorithms.

3. OBJECTIVES

There are specific objectives to achieve realistic statistical model for human driver behavior. They are,

- Develop and evaluate machine learning algorithms that can accurately predict and react to different driver behaviors.
- Identify the most important features and factors that influence human driver behavior, such as road conditions, traffic patterns, and driver characteristics, and incorporate them into machine learning models.
- Generate large datasets of human driver behavior through simulation environments, that can be used to train and evaluate machine learning models.
- Develop reinforcement learning algorithms that can learn to control autonomous vehicles by observing human driver behavior and adapt to new driving scenarios in real-time.
- Test and evaluate the performance of machine learning algorithms in different real-world scenarios, including urban and highway driving, to ensure that they are robust and reliable.
- Obtain accurate results in the design aspects, such as emissions, noise, vibration and harshness (NVH) by having realistic driver model.
- Obtain an optimized machine learning algorithm to mimic human driver behavior for automotive driving.
- Using ML techniques to improve the accuracy of CAE design of the automotive vehicle.

4. METHODOLOGY

The project is divided into four steps. The initial stage is getting familiar into the field and literature review. Then in the second step is generating data and the third one is training of the model. The last part is testing and validation.

Step 1:

Searching and learning about model-based design engineering.

Learning the fundamentals of machine learning.

Literature review on the research topic.

Getting familiar with tools & Languages: MATLAB, Simulink, Python

Designing of EV and HEV vehicles in Simulink.

Development of Virtual Vehicle for data generation and testing.

Step 2:

Assume a reward function (can be logically reason out)

Use ML methods to learn the policy of the agent. (replacement driver)

Step 3:

Assuming the existing driver (agent) as a real human.

Generate data and use it to approximate the reward function.

Step 4:

Obtain an optimized solution for realistic driver model.

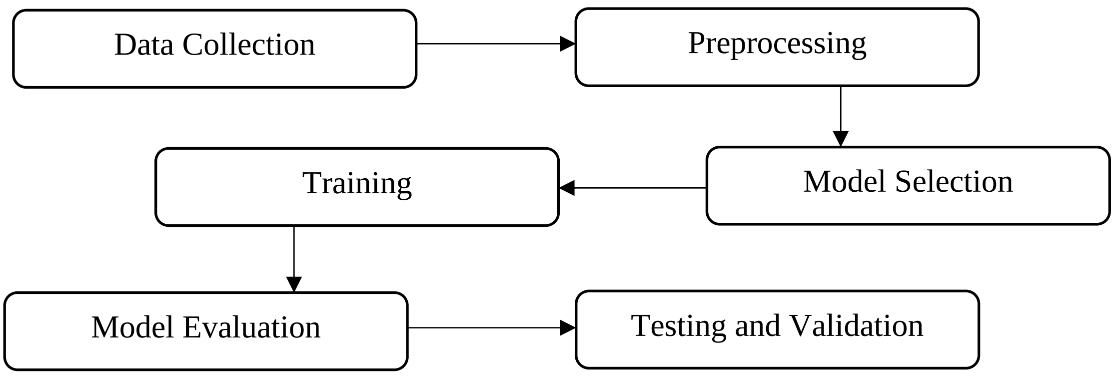

Figure 4.1 Machine Learning Project Steps

Table 4.1 Project Timeline

No.	Task Description	Week																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1	Selection of Research topic	■	■																												
2	Discussion with Supervisor		■	■																											
3	Project Title Approval				■																										
4	Literature Review			■	■	■	■	■	■	■	■	■	■																		
5	Tutorials on MATLAB and Simulink			■	■	■																									
6	Following ML courses			■	■	■	■	■	■	■	■	■	■	■	■	■															
7	Design of Virtual Vehicle					■	■	■	■	■	■	■	■	■	■	■	■	■													
8	Project Proposal Presentation							■	■																						
9	Assume reward function and generate data															■	■	■	■	■	■	■	■	■	■						
10	Progress Evaluation 1															■	■														
11	Approximate the reward function using generated data																■	■	■	■	■	■	■	■	■	■	■	■			
12	Progress Evaluation 2																						■	■							
13	Testing of the model																							■	■	■	■	■	■		
14	Project report submission 1																								■						
15	Final Oral Presentation																													■	■
16	Viva voce																													■	■
17	Project report submission 2																														■

5. REQUIREMENTS

The requirements for the research project can be categorized into several parts. The research project mainly focusing on CAE MBSD and generate data using the simulation environment. MATAB & Simulink are major tools for simulation and good performance computing resources are required to continue the project. Data Processing, Machine learning model development and performance evaluation requires tools like python programming language or MATLAB programming, PyTorch and Scikit-Learn. Also, for the effective continuation of the project human expertise on the relevant field is required. Fundamentals of machine learning, model based designing techniques, MATLAB and Simulink environments and fundamentals of automotive engineering are required for the project.

6. LEARNING OUTCOMES

- Designing of Electric Vehicle (EV) and Hybrid Electric Vehicle (HEV) using MATLAB and Simulink.
- Improved understanding of human driver behavior through the development of machine learning algorithms that can accurately predict and react to different driver behaviors.
- The development of machine learning algorithms that can effectively learn from large datasets of human driver behavior can lead to new techniques and approaches that can be applied in other domains beyond autonomous driving.
- Machine learning algorithms that can accurately predict and react to different driver behaviors can enhance the safety and efficiency of autonomous driving, reducing the number of accidents and fatalities on the road.
- Can identify new research directions and areas for improvement in autonomous driving technologies.
- Can contribute to society by reducing traffic congestion, improving accessibility, and reducing the environmental impact of transportation.

7. REFERENCES

[1] Kyle Sama, Yoichi Morales, Hailong Liu, Naoki Akai, Alexander Carballo, Eijiro Takeuchi and Kazuya Takeda, “Extracting Human-Like Driving Behaviors from Expert Driver Data Using Deep Learning” (2020). IEEE Transactions on Vehicular Technology, Vol 69.

[2] Monagi H Alkinani, Wazir Zada Khan and Quartulain Arshad, “Detecting Human Driver Inattentive and Aggressive Driving Behavior using Deep Learning” (2020). IEEE Access, DOI:10.1109

[3] Jingqiu Guo, Yangzexi Liu, Lanfang Zhang and Yibing Wang, “Driving Behavior Style Study with a Hybrid Deep Learning Framework Based on GPS Data.” (2018). Sustainability, DOI:10.3390

[4] Sentouh, Chouki & Chevrel, Philippe & Mars, Franck & Claveau, Fabien, “A Human-Centered Approach of Steering Control Modelling” (2009).