Development of Machine learning model using Simulink
How is the talk paced?

- Introduction
- What is the Problem
- What is the approach & solution
- What tools are used to Realize it
- What are our Observations
- Results
Introduction

- INTRODUCTION OF BS4 REGULATIONS
- ECU + SENSORS
- ECU CAN RUN A HOST OF PROGRAMS
- BETTER INFORMATION PROCESSING
- ECU + SENSORS + ALGORITHMS
- CAN MACHINE LEARNING BE USED?
What is the problem?

- Road Surface and its condition is a critical parameter for vehicle operation
- Diversified categories of road with different terrain combinations
- Terrain change needs a change in driving style

What can I predict if I somehow know the road condition?

- Tire life and wear
- Vehicle Durability and aging impact
- Fuel Economy Impact

How can I know the road condition?

Use Machine Learning to Classify Road Condition
Step 01: What are the Road Conditions

- **A Class**: National Highway / Expressway (Four/Six Lane)
  - Operating Speed 60 ~ Max. Speed (Kmph)
  - GOOD ROAD

- **B Class**: Single Lane State Highway / City Route
  - Operating Speed 20 ~ 50 Kmph
  - GOOD ROAD

- **C Class**: Broken Tar Road / Village Road
  - Operating Speed 20 ~ 30 Kmph
  - BAD ROAD

- **D Class**: No Road Condition / Damaged Road
  - Operating Speed < 20 Kmph
  - BAD ROAD
The Machine Learning Way?
Our Workflow

- Internet Study
- Collect and Label Data
- Process Data
- Extract Features
- ML Model is generated using Classification Learner Application
- Then, ML Model is Optimized
- Build Model in Simulink
- Generate code and flash it on to a target hardware
Block Diagram of the Simulink Model

- Sensor Data
- Signal Filtering
- Sensor Fusion
- MLE Model
- Road Condition Estimation
- Feedback Control

Can serve as input to other algorithms
**Ground Truth Labelling** is done by manually mapping the route as per road condition during vehicle data collection trails.
Data Analysis and Feature Extraction

- Identify Key Variables
- Data Analysis
- Analyze and Extract Features
- **Filter Designer tool** is used to design a low pass filter of required order and transition band.
- To analyze original as well as the filtered signals in time and frequency domain, **Signal Analyzer Tool** is used.
Digital Signal Processing

Raw Signal

Power spectra of signal

True signal + Noise

Setting type and Frequency specifications of filter

Realizing filter in simulink

Filter settings
Embedded Coder

- Setup Embedded Coder
- Configuration
- Target Selection and Settings
- Initial Issues the team faced
- Build and Flash code
- Improved usage of Embedded coder
Hardware Implementation

Rapid Prototype Controller

Input

- Input Blocks [Analog/Digital Input]

Processing

- CPU [Core Algorithm]

Output

- Output blocks [Digital output]
- Communication Channels Blocks [CAN,SCI,I2C]

Simulink Model
Observations

- Road Condition Estimation is possible with in-built vehicle sensors
- There is a scope to define more road categories

Results

- Good prediction capabilities seen with use of ML model

Conclusion

- ML Models might provide good initial model to predict inputs without an empirical model
- Simple ML model deployment is possible on controllers with limited memory footprint and there is scope to further optimize
THANK YOU