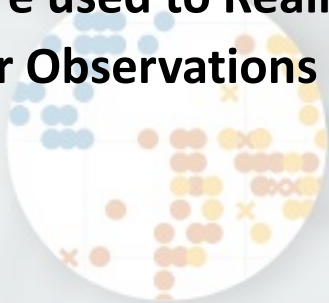# Development of Machine learning model using Simulink

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?

Problem Statement

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
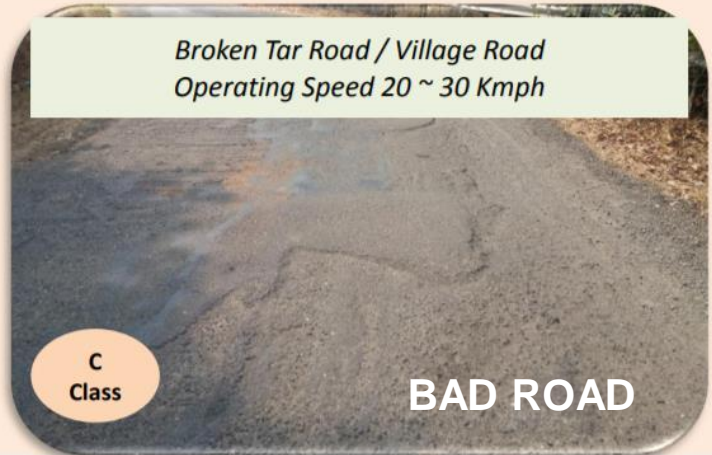- Fuel Economy Impact

How can I know the road condition?

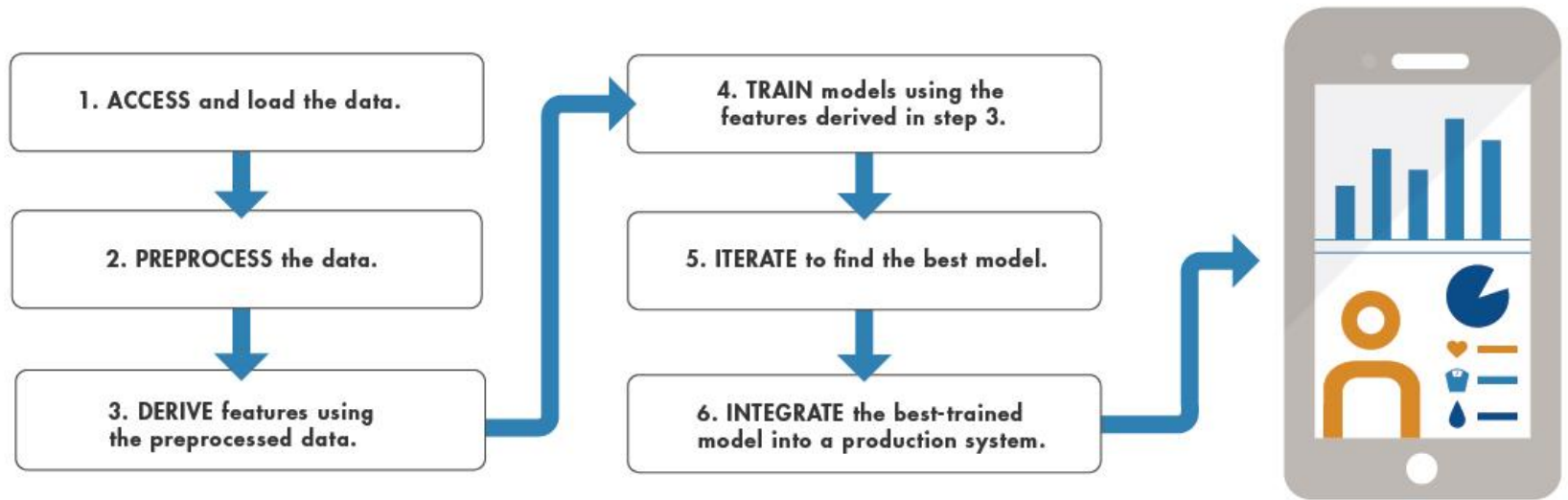Use Machine Learning to Classify Road Condition

Mahindra Trucks and Buses

Mahindra
Rise.

Step 01: What are the Road Conditions

National Highway / Expressway (Four / Six Lane)
Operating Speed 60 ~ Max. Speed (Kmph)

A
Class

GOOD ROAD

Single Lane State Highway / City Route
Operating Speed 20 ~ 50 Kmph

B
Class

GOOD ROAD

Broken Tar Road / Village Road
Operating Speed 20 ~ 30 Kmph

C
Class

BAD ROAD

No Road Condition / Damaged Road
Operating Speed < 20 Kmph

D
Class

BAD ROAD
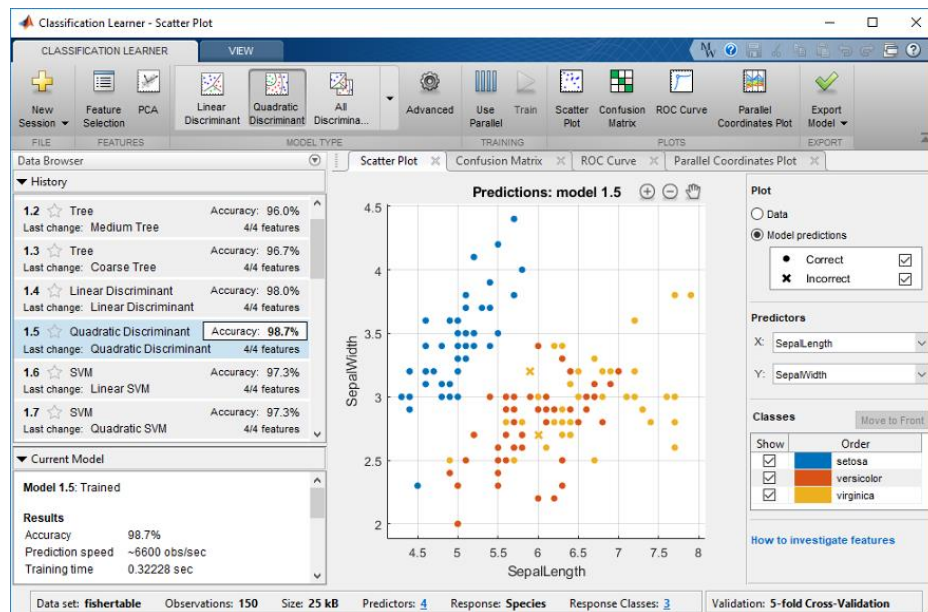
Mahindra Trucks and Buses

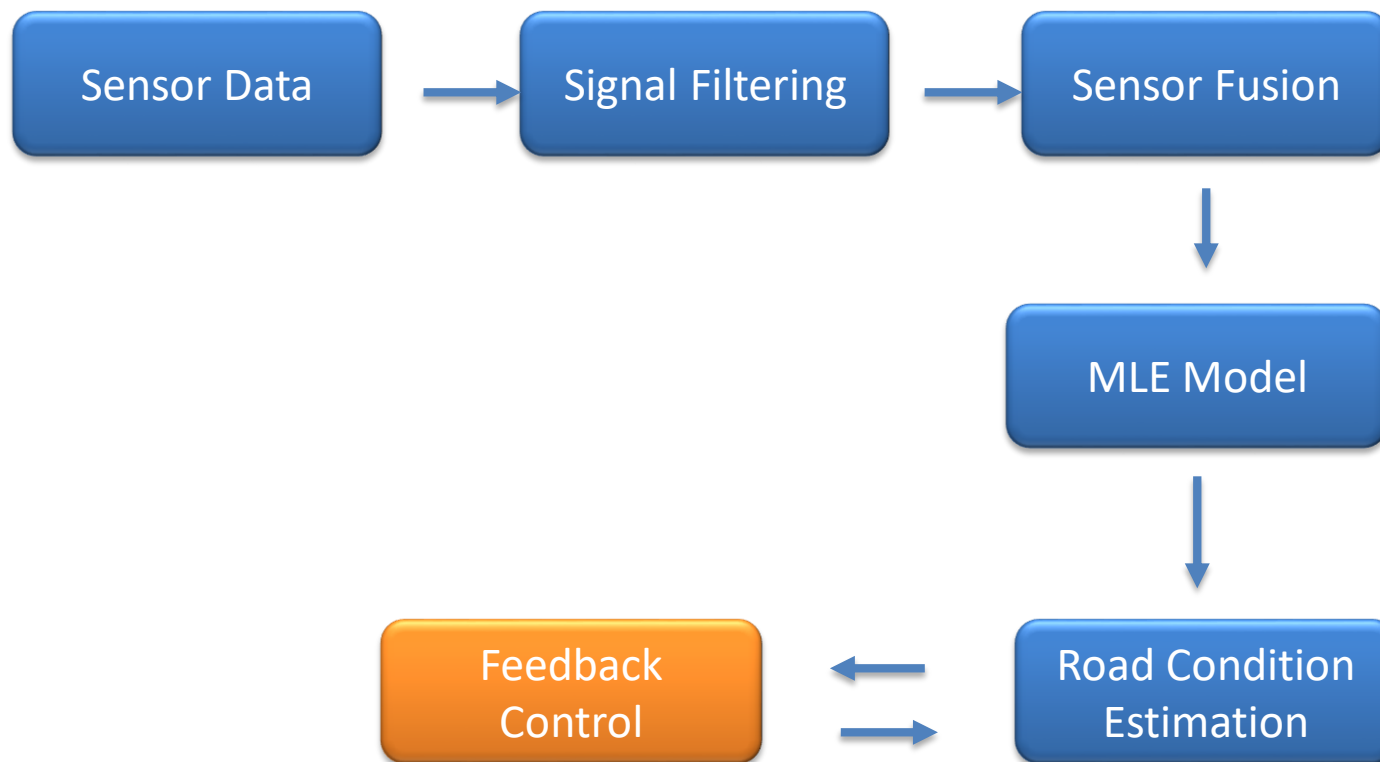Mahindra
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The Machine Learning Way?

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
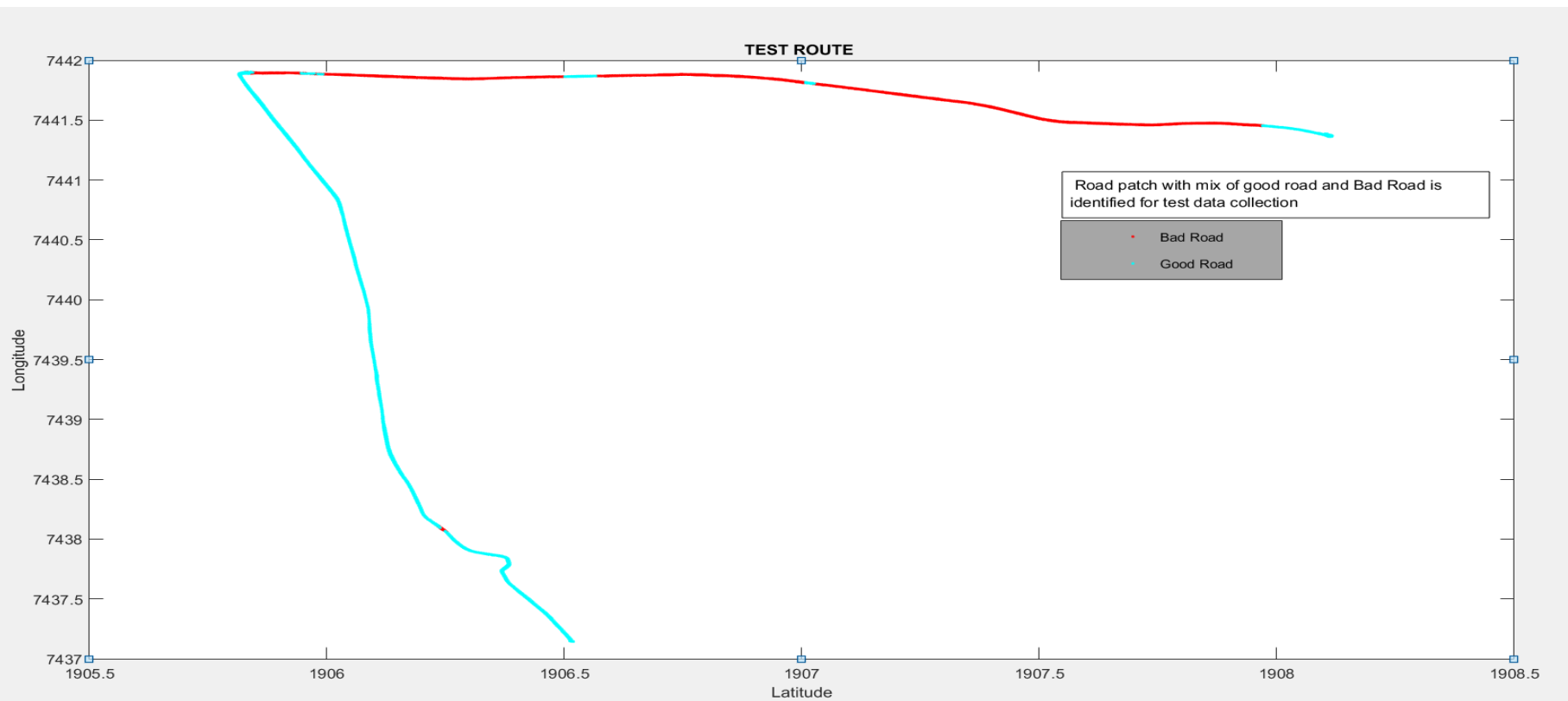
Block Diagram of the Simulink Model

```
Sensor Data ──→ Signal Filtering ──→ Sensor Fusion
                                           │
                                           ▼
                                       MLE Model
                                           │
                                           ▼
Feedback        ←──────────        Road Condition
Control         ──────────→           Estimation
```

Can serve as input to other algorithms

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Ground Truth Labelling

Ground Truth Labelling is done by manually mapping the route as per road condition during vehicle data collection trails .
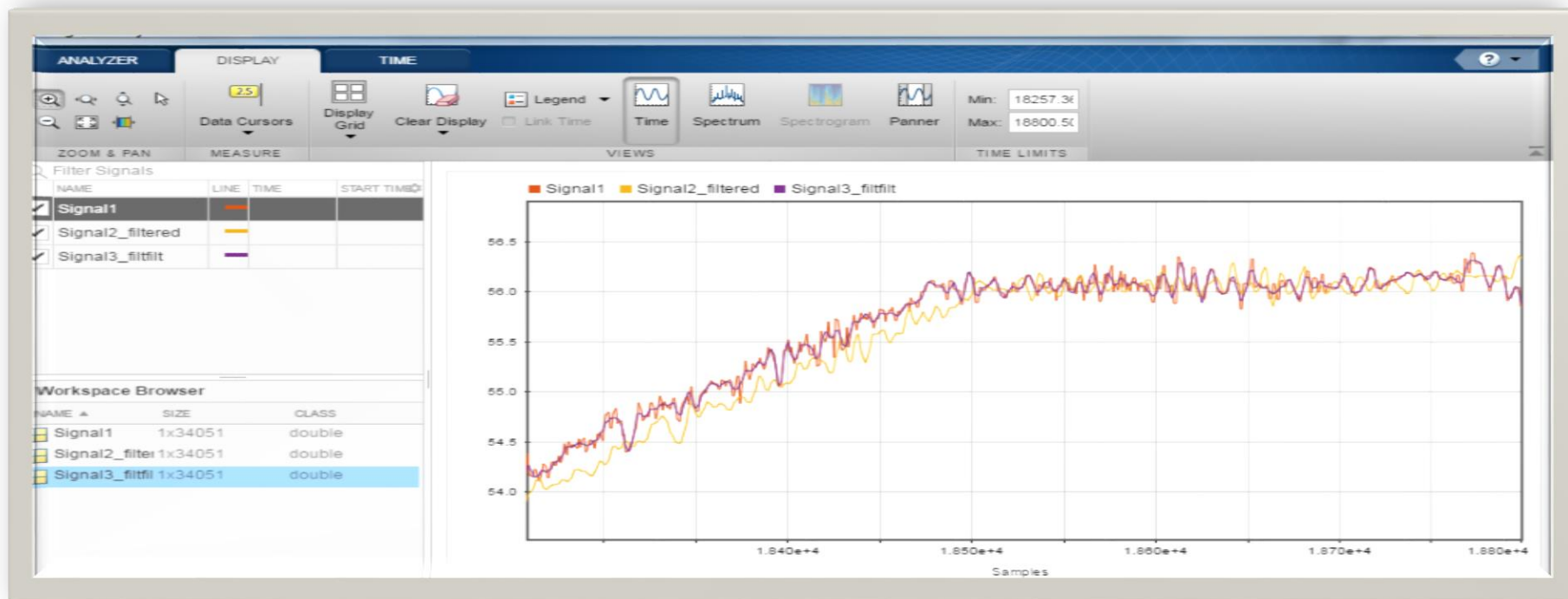
Data Analysis and Feature Extraction

- Identify Key Variables
- Data Analysis
- Analyze and Extract Features

Mahindra *Rise.*
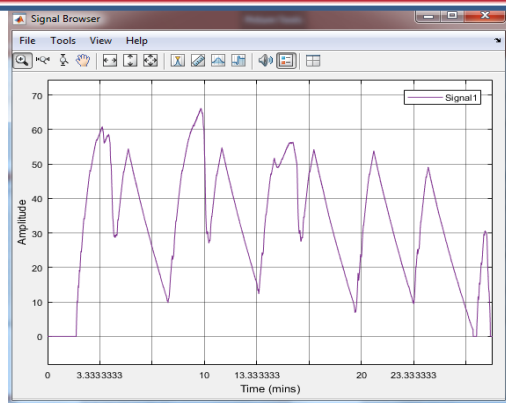
Approach & Methodology (Digital Signal Analysis)

- **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.
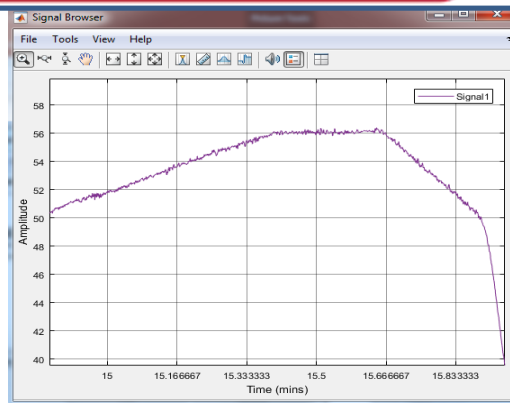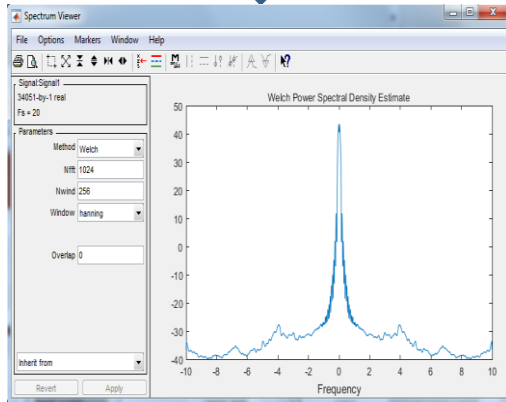
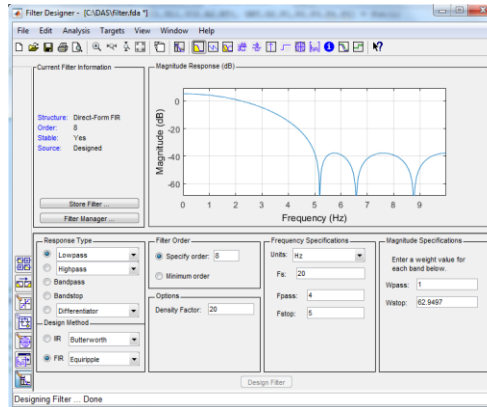Mahindra Trucks and Buses

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Digital Signal Processing

Raw Signal

True signal + Noise

Realizing filter in simulink

Power spectra of signal

Setting type and Frequency specifications of filter
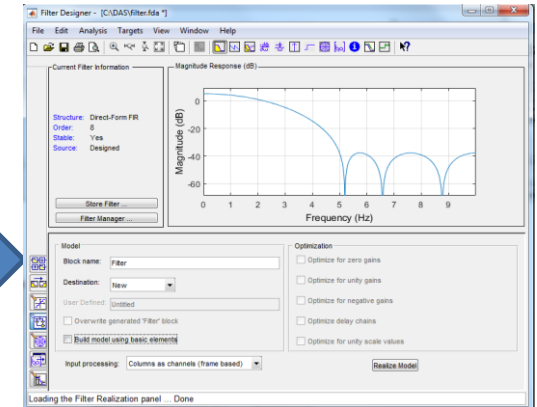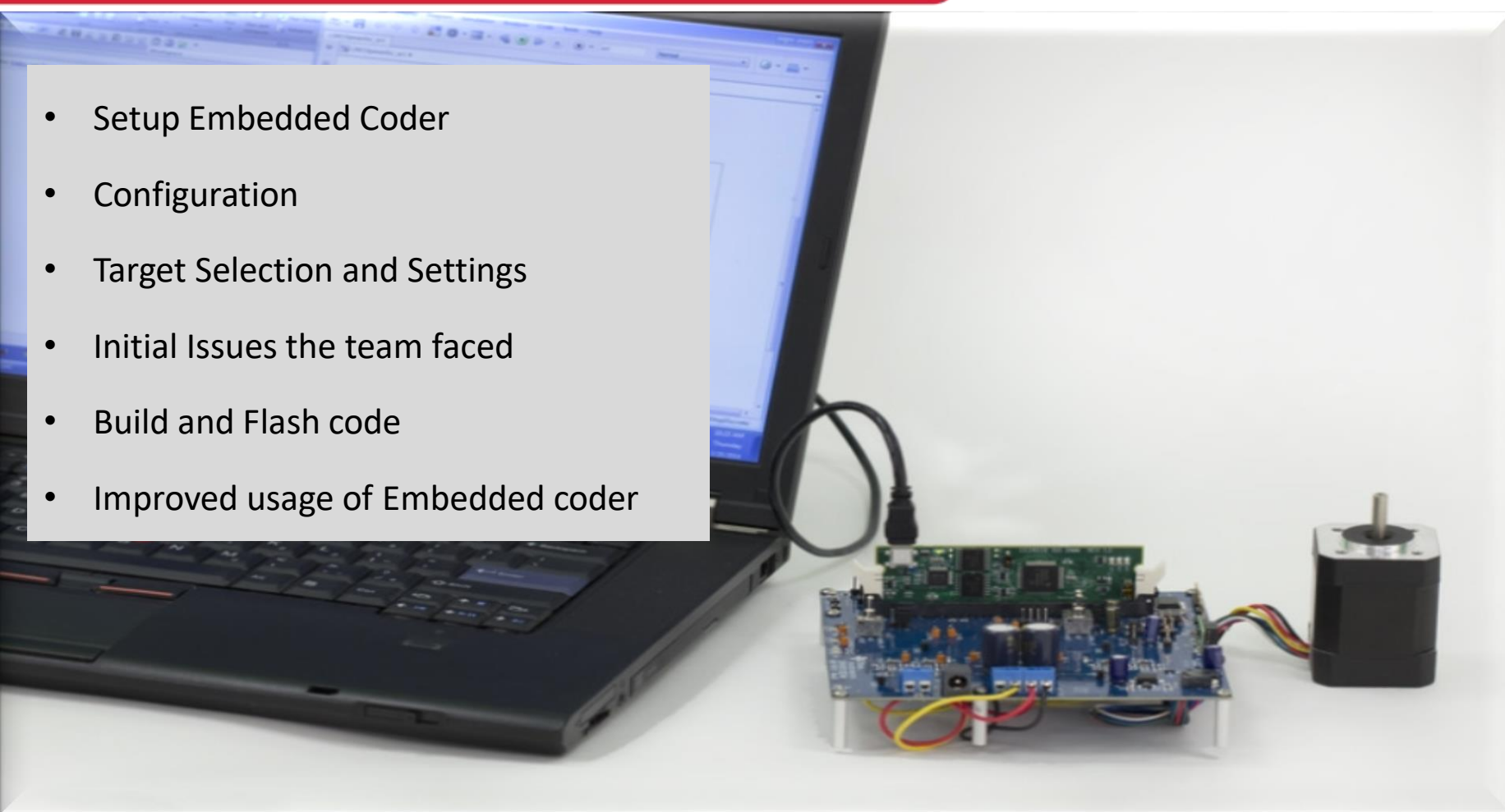

Filter settings

Embedded Coder

- Setup Embedded Coder

- Configuration

- Target Selection and Settings

- Initial Issues the team faced

- Build and Flash code
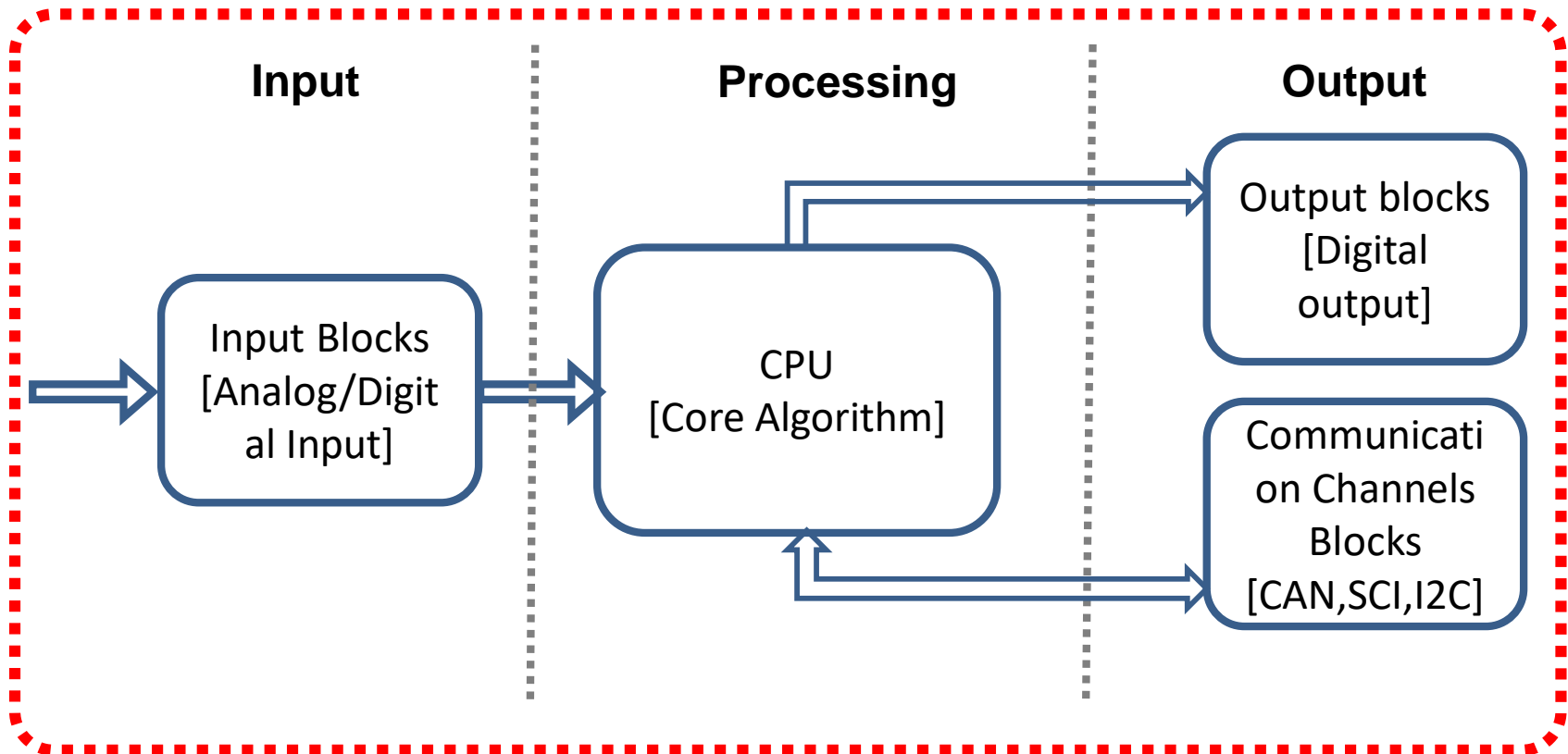
- Improved usage of Embedded coder

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Rapid Prototype Controller

Simulink Model

Results & Observations

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**

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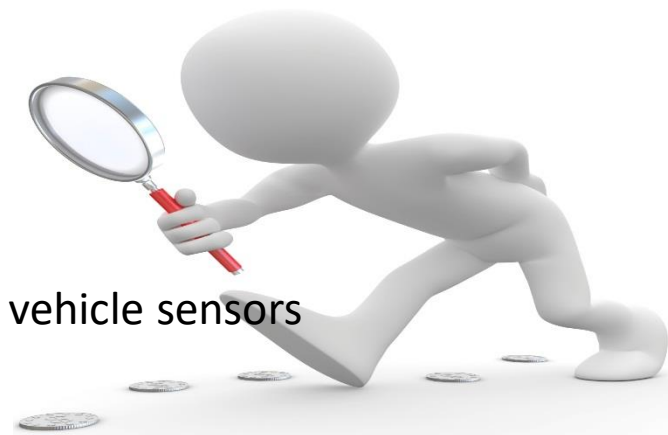
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THANK   YOU

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