Plant Modeling for an Autonomous Vehicle

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Objective and Contributions

Objective

- Provide accurate plant models of each autonomous vehicle subsystem to be used for designing controllers

Contribution

- Determine if System Identification or Neural Network modeling produces better models
- Non-linearity modeling

Applications

- Use in testing to help develop more accurate vehicle controllers
- Create a guide for modeling future vehicle subsystems

Problem Setup

- Conducted a literature review to look for existing solutions
- System Architecture

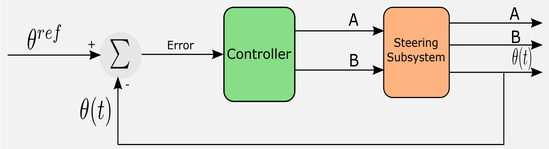

Figure 1:Steering subsystem block diagram

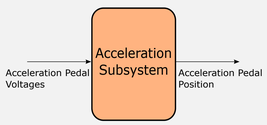

Figure 2:Acceleration subsystem block diagram

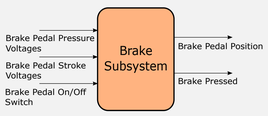

Figure 3:Brake subsystem block diagram

- Collected data using a Lexus RX450H vehicle platform

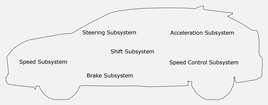

Figure 4:Lexus vehicle with subsystems

Figure 5:AutonomouStuff Lexus RX450H vehicle

Transfer Function Modeling

- MATLAB's System Identification Toolbox used to create models
- Models needed to meet best fit and error requirements

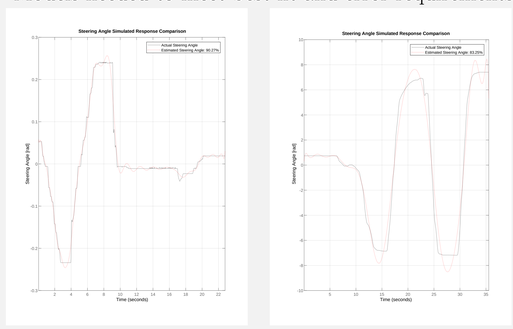

Figure 6:Steering System Estimated Steering Angle Comparison

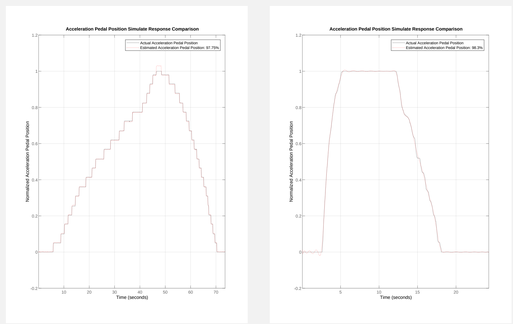

Figure 7:Acceleration System Estimated Pedal Position Comparison

Neural Network Modeling

- Used MATLAB's Neural Network Time Series App
- Generated models using the Bayesian Regularization Algorithm
- Models trained using collected log data

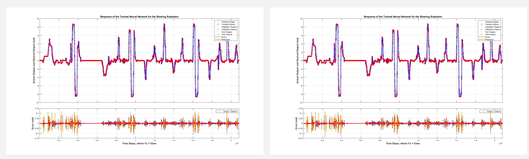

Figure 8:Steering System Training Plots

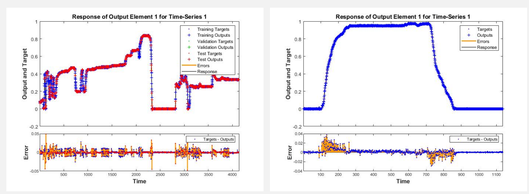

Figure 9:Brake System Training Plots

Neural Network Algorithm

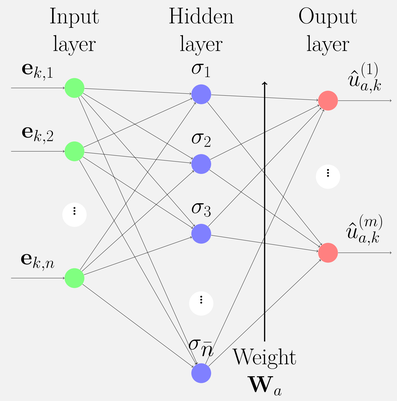

Figure 10:Actor neural network structure for approximating control input.

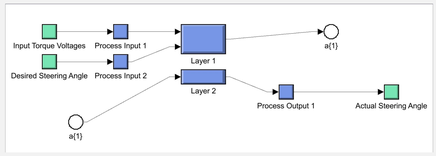

Figure 11:Steering Neural Network Simulink Model

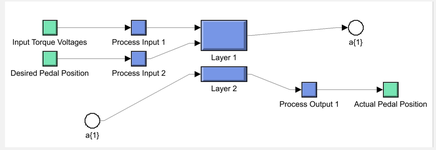

Figure 12:Acceleration Neural Network Simulink Model

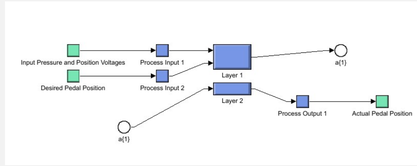

Figure 13:Brake Neural Network Simulink Model

Neural Network Modeling (Cont.)

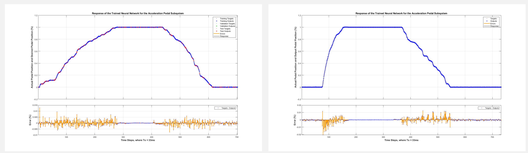

Figure 14:Acceleration System Training Plots

Experimental Results

- Preliminary model testing conducted before sending models to AutonomouStuff
- Official testing conducted using dSPACE software and HIL Bench

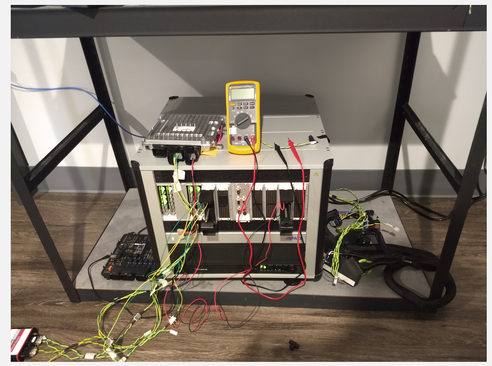

Figure 15:Experimental Setup

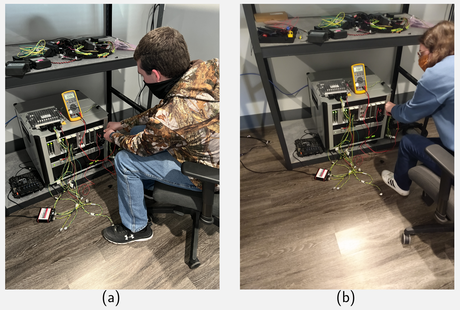

Figure 16:Verifying voltage measurements on the HIL Bench

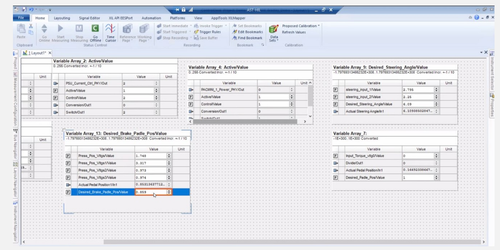

Figure 17:Model validation setup

Conclusion and Future Work

- Using Neural Networks produced more accurate models than System Identification
- Test models using Hardware-in-the-Loop
- Create new vehicle controllers