

# 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

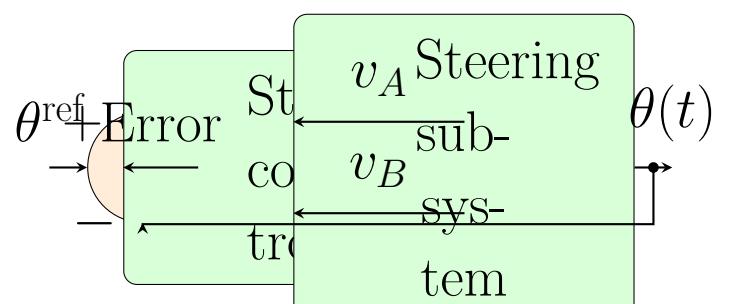


Figure 1:Steering subsystem block diagram.

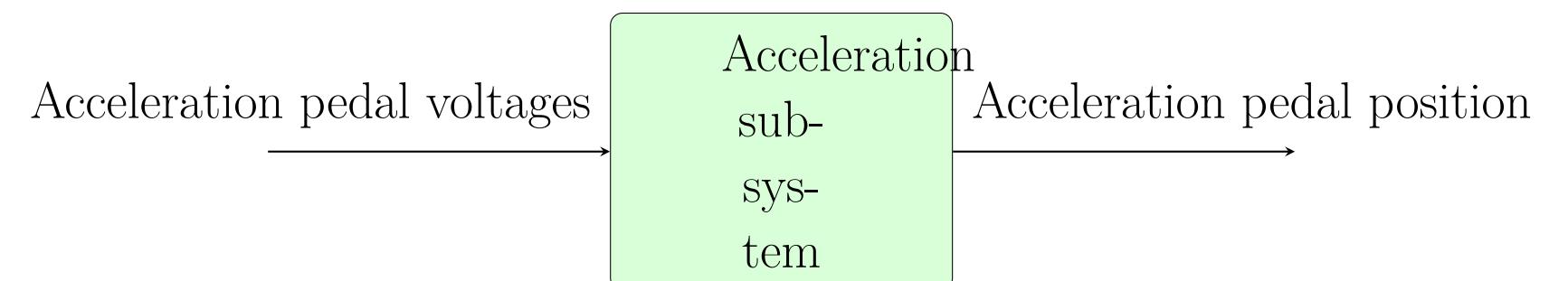


Figure 2:Acceleration subsystem block diagram

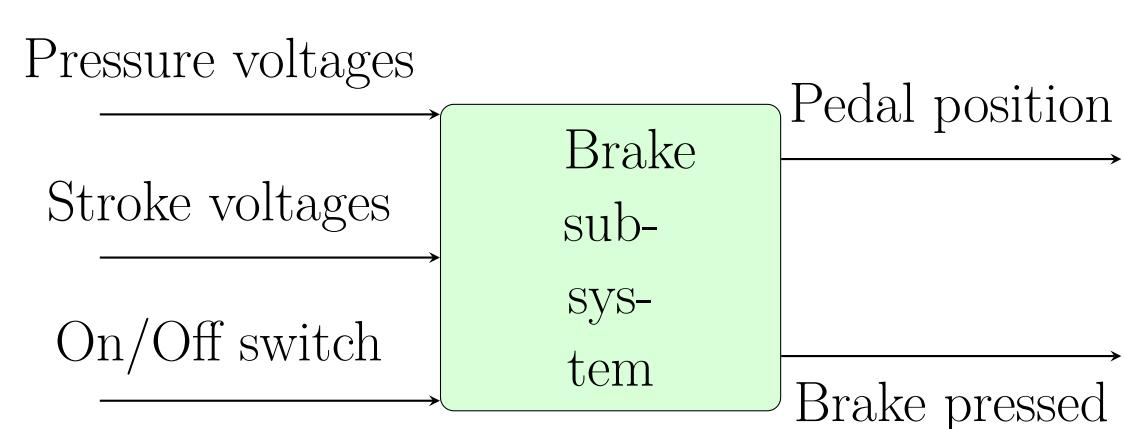


Figure 3:Brake subsystem block diagram

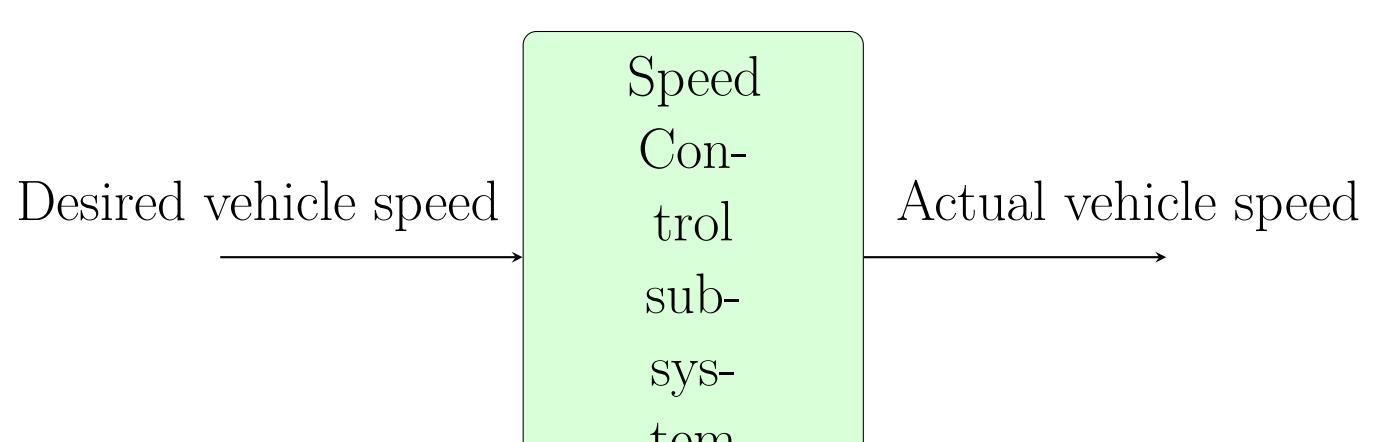


Figure 4:Speed Control subsystem block diagram

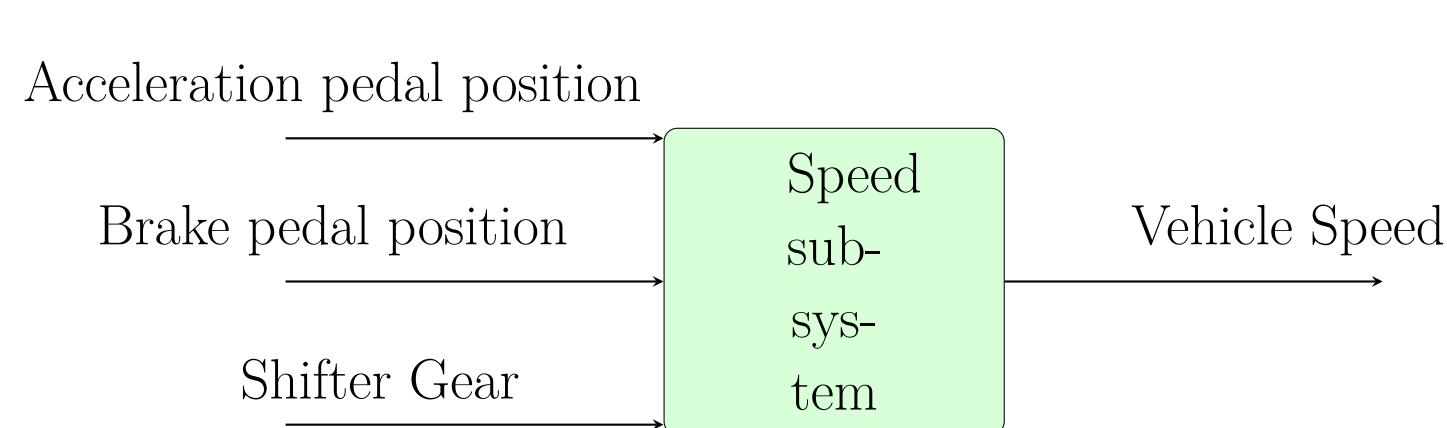


Figure 5:Speed subsystem block diagram

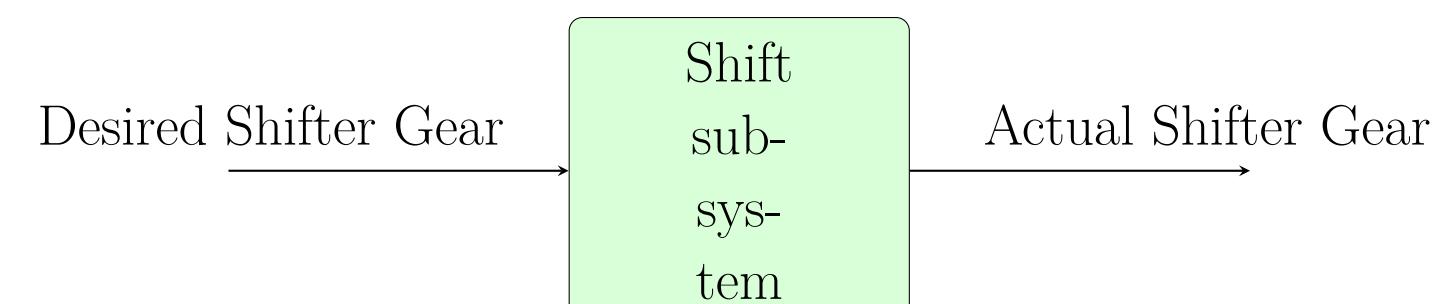


Figure 6:Shift subsystem block diagram

- Collected data using a Lexus RX450H vehicle platform

## Transfer Function Modeling

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

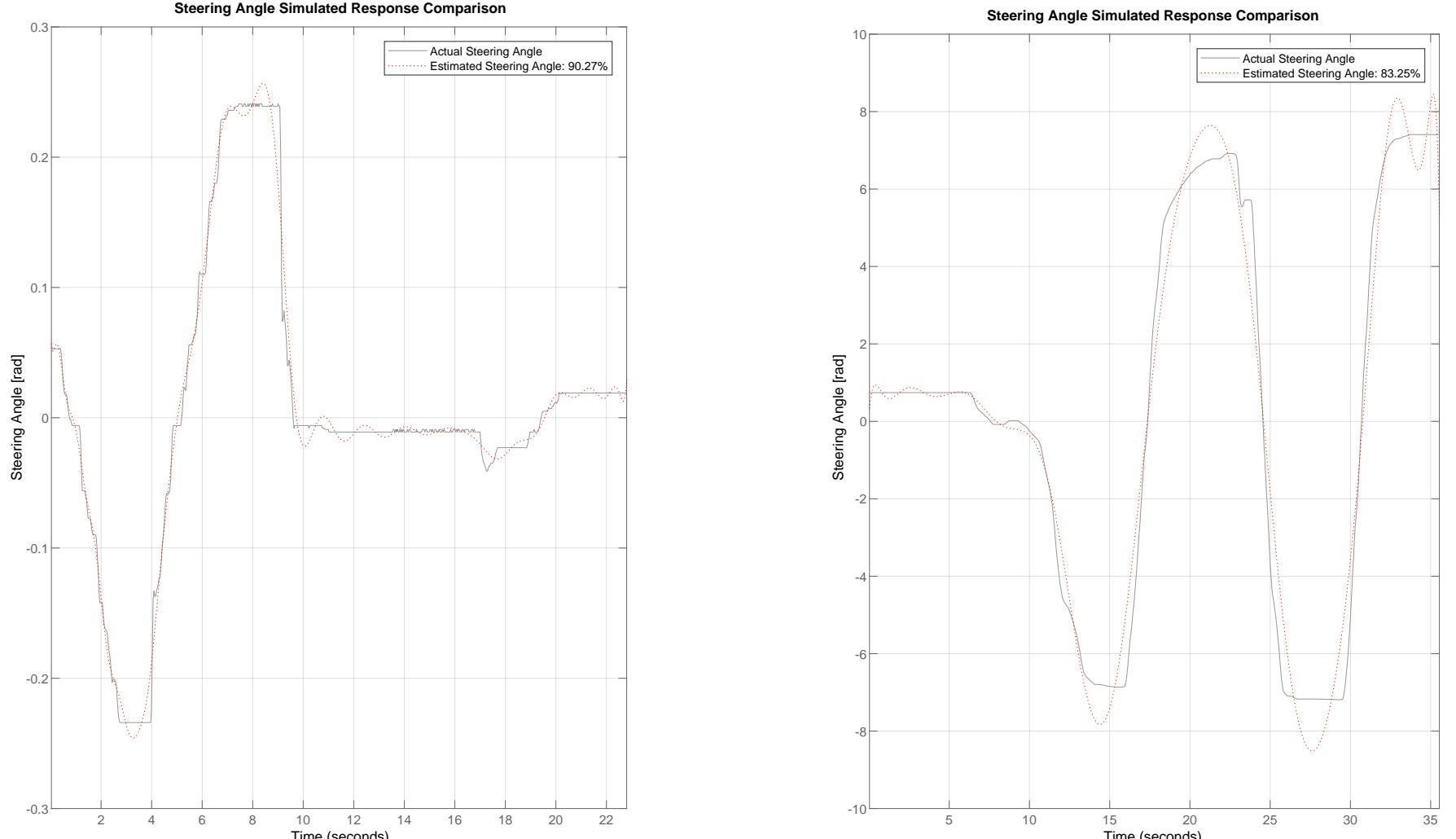


Figure 7:Steering System Estimated Steering Angle Comparison

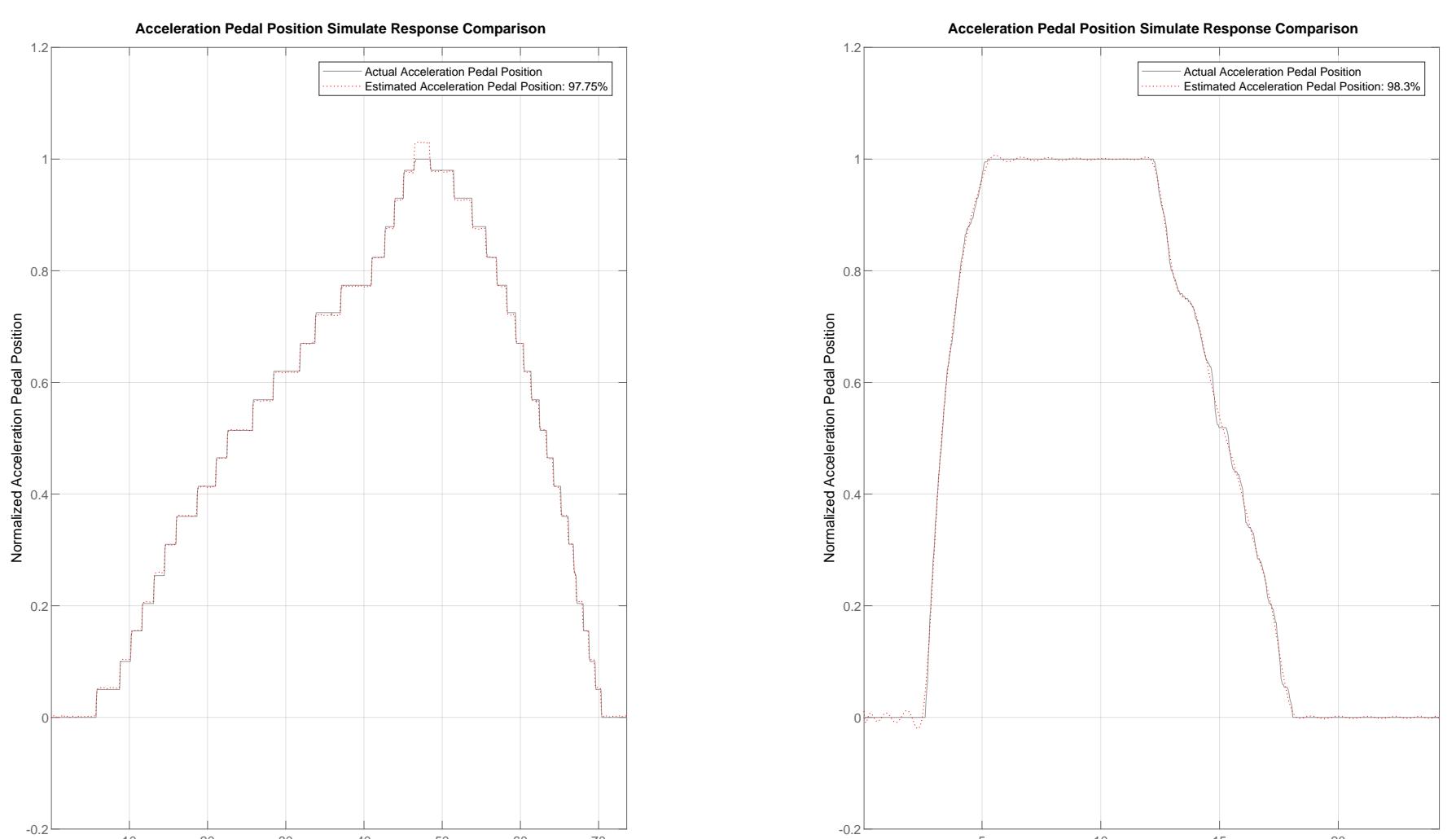


Figure 8:Acceleration System Estimated Pedal Position Comparison

## Neural Network Modeling

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

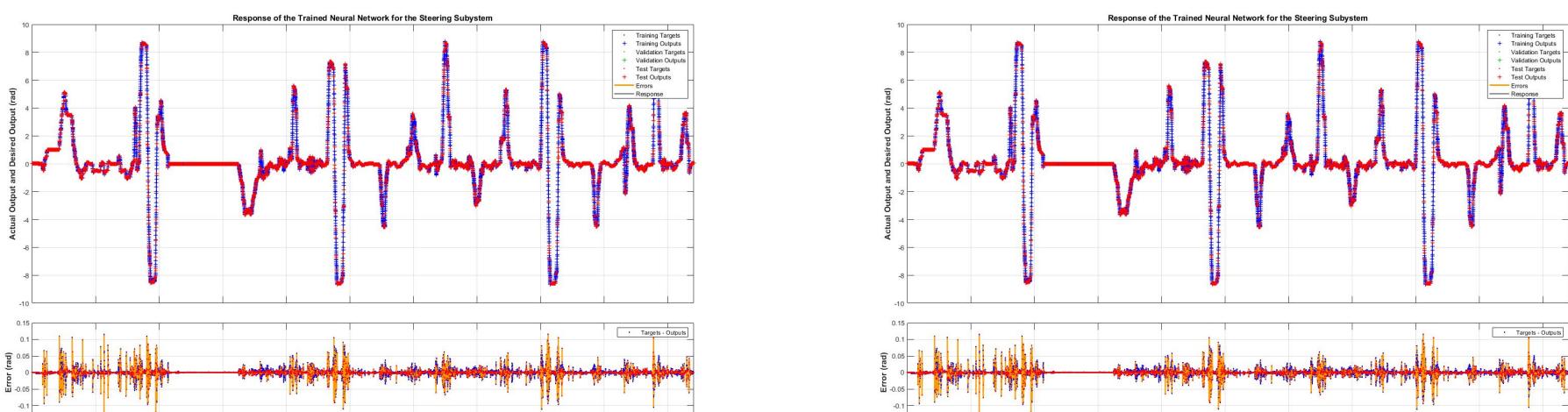


Figure 9:Steering System Training Plots

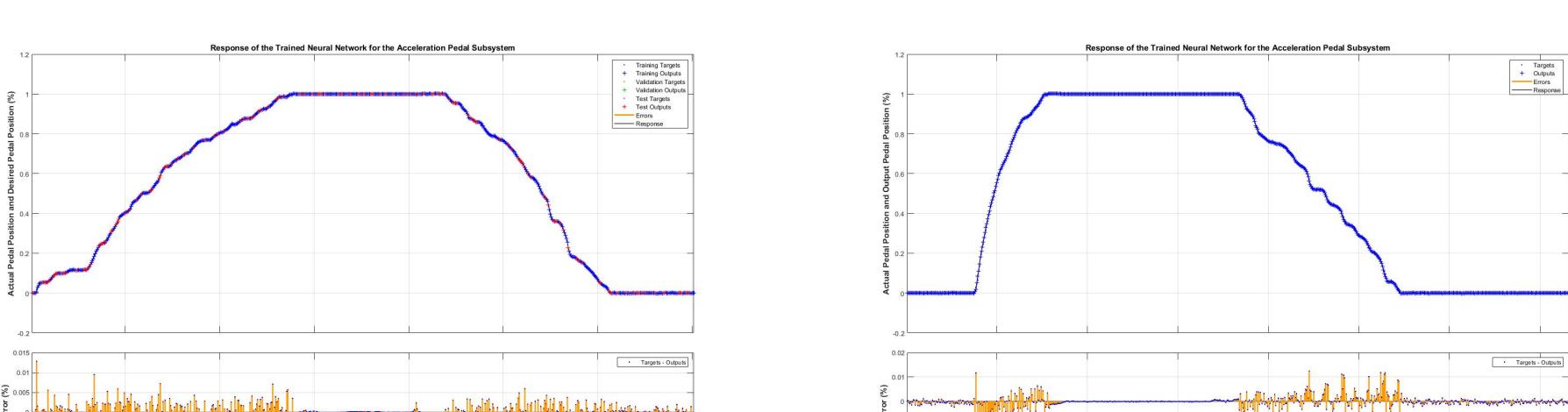


Figure 10:Acceleration System Training Plots

## Neural Network Algorithm

- Uses neural network based on difference between desired and actual orientation to determine optimal gain

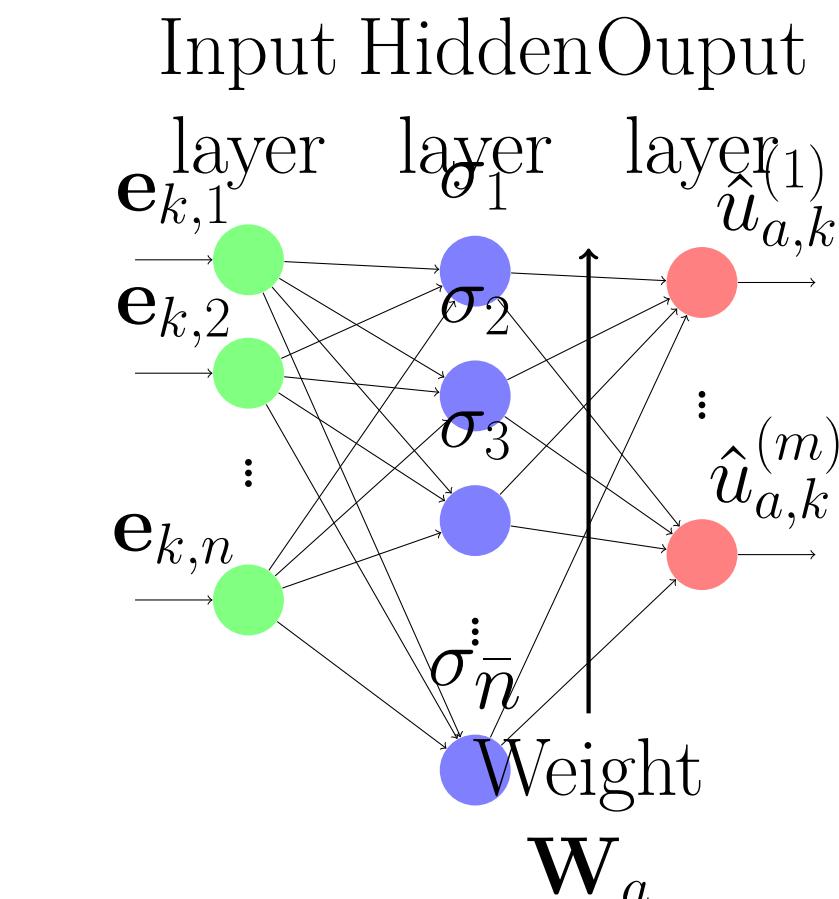


Figure 12:Actor neural network structure for approximating control input.

## Experimental Results

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



Figure 13:Experimental Setup

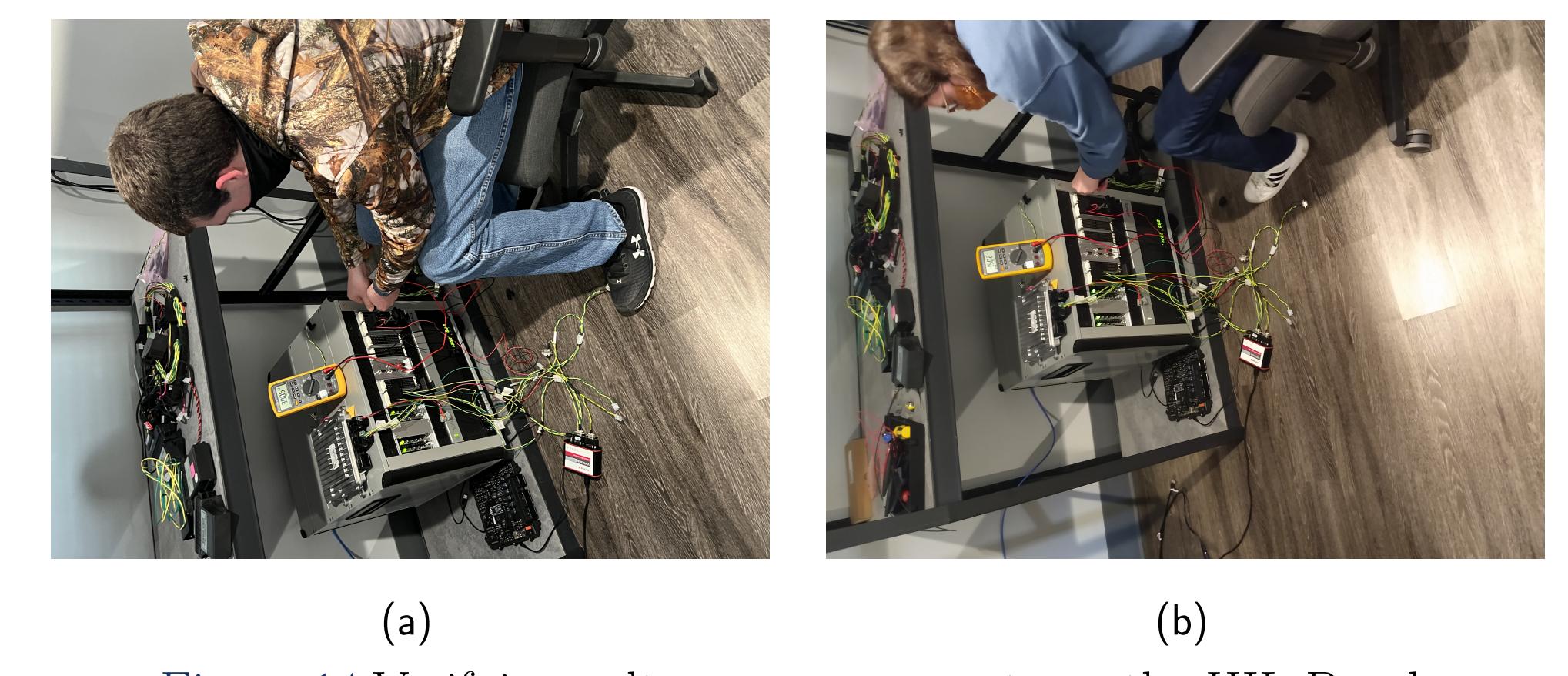


Figure 14:Verifying voltage measurements on the HIL Bench

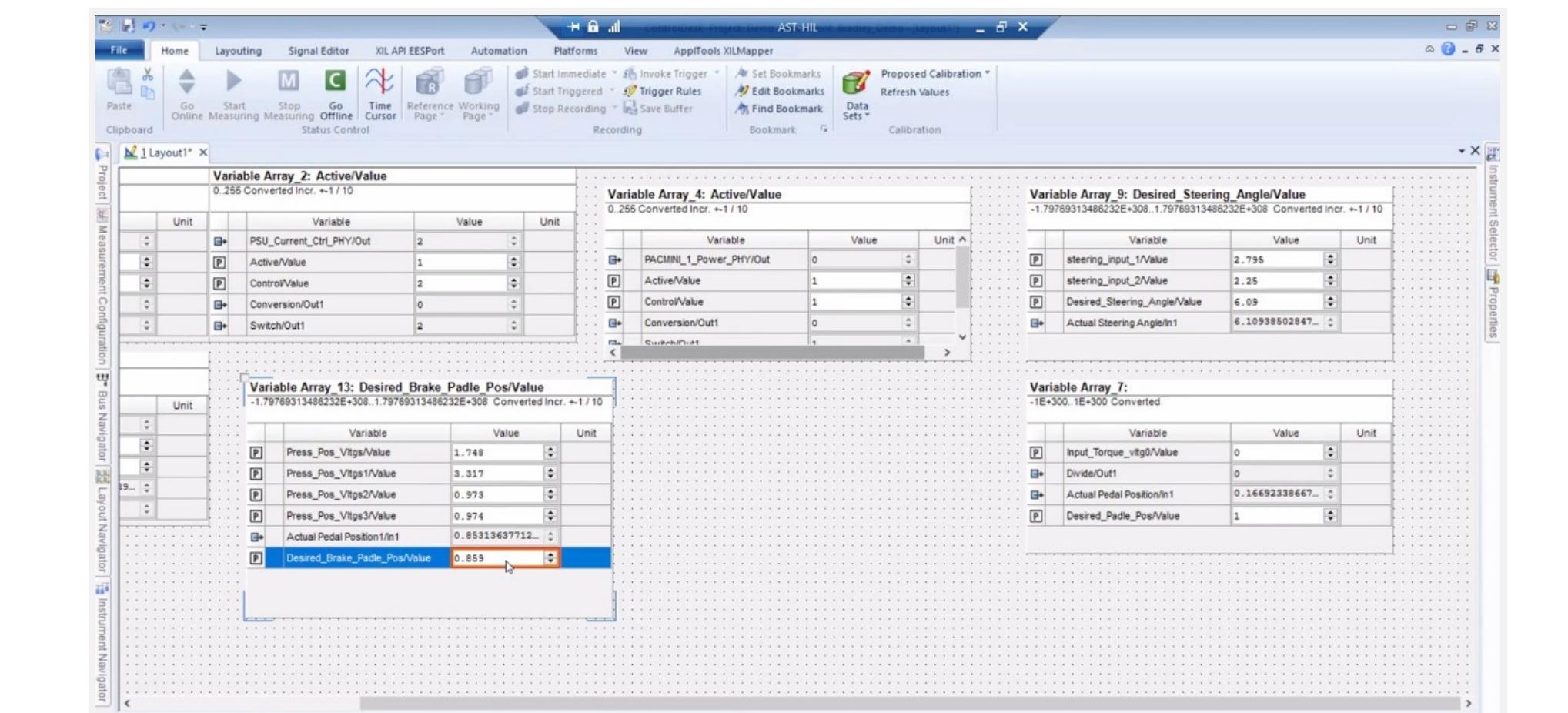


Figure 15:Model validation setup

## 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