Range improvement in hybrid vehicles with DeepSim designed controller

DeepSim Value proposition

- Faster R&D
- Superior performance
- Easy RL insights

Hybrid Vehicle Range Optimization

Objectives for a given speed profile:

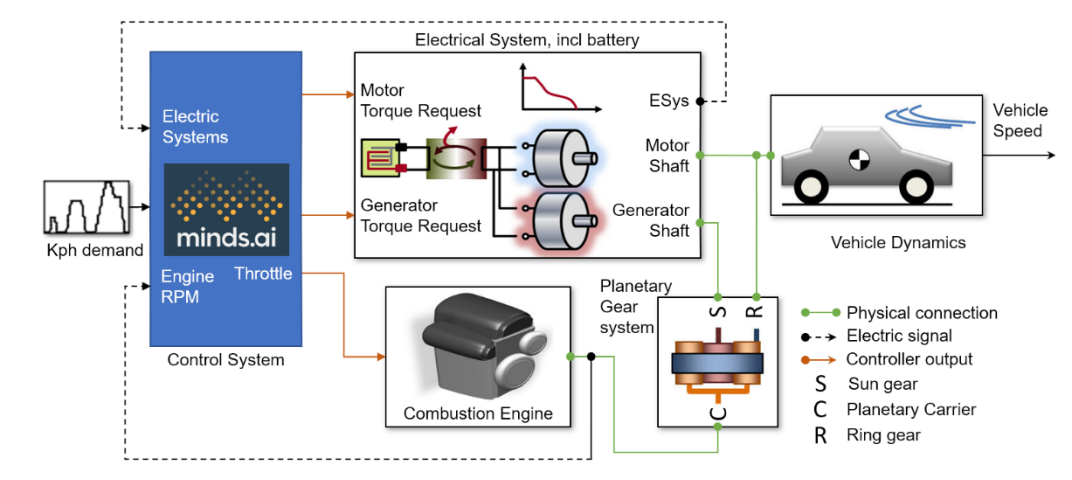
- Increase the battery state of charge.
- Reduce the fuel consumption.
- Match the required driver velocity profile.

DeepSim Solution

Using an existing hybrid vehicle model, designed in Simulink (see Fig. 1), minds.ai trained a neural network-based controller. This smart controller increases the vehicle's range while also reducing the fuel usage.
The controller improves the range by intelligently varying the usage of the IC engine and electric motor while sticking to the original speed profile with no perceivable difference to the driver.

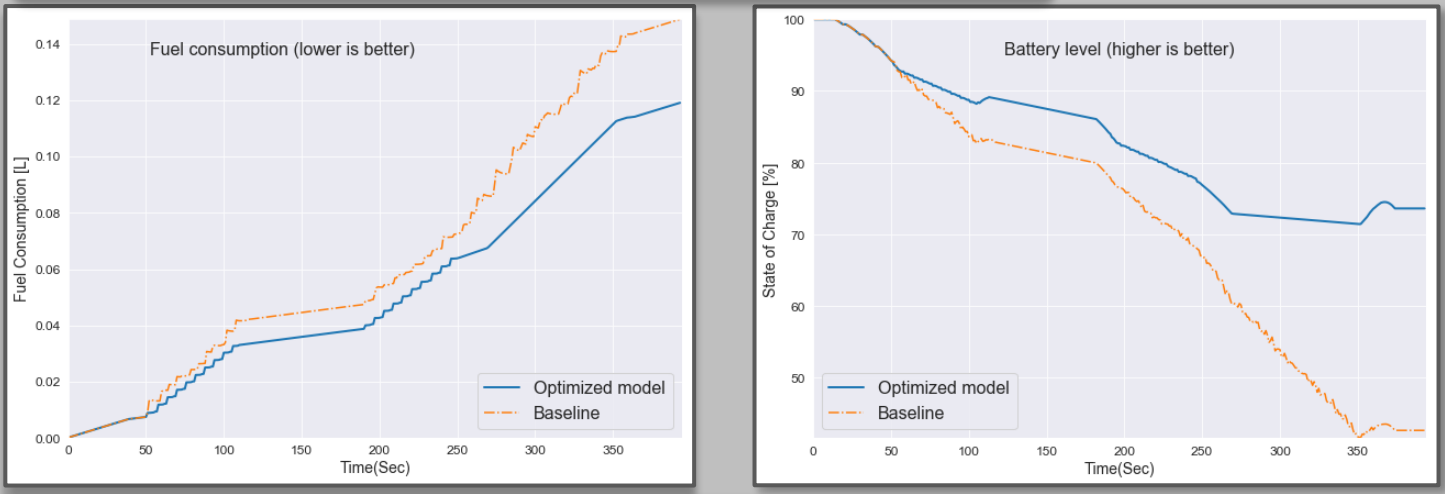
The controller can be configured for different usage scenarios (eco, sport, etc.) by setting the fuel vs. battery usage optimization ratio (called lambda). Results of this optimization process can be seen in Figures 2 and 3.

Figure 1: Simulink model



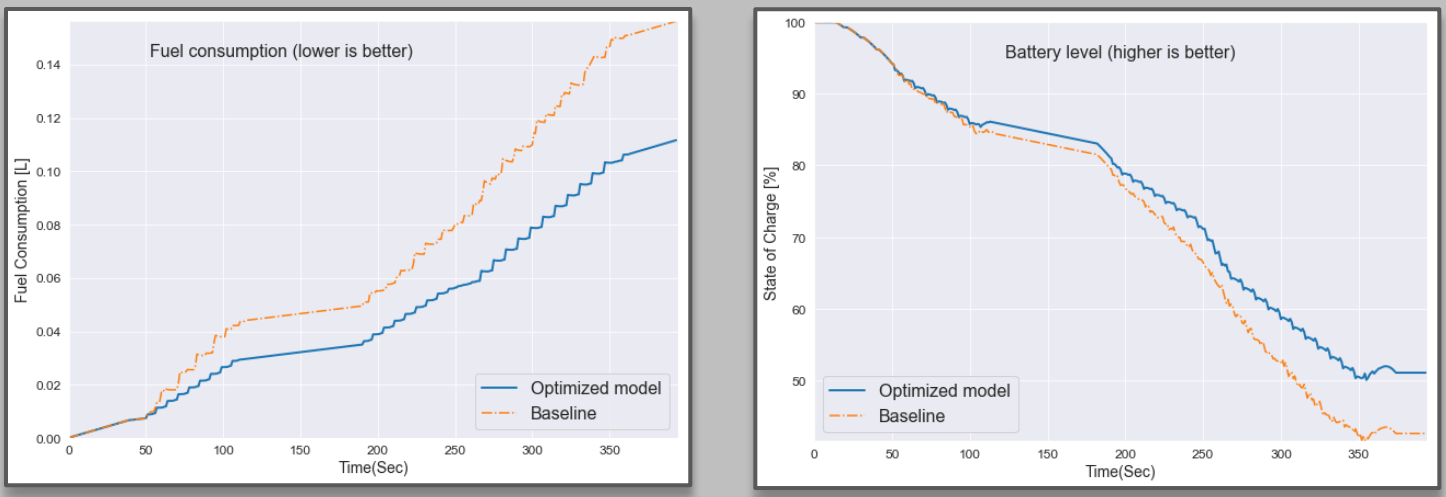
Hybrid electric vehicle drive line schematic, based on the design of [1]

Figure 2: Fuel consumption and battery state of charge with lambda = 0.25.



The fuel consumption (left panel) and the battery state of charge (right panel). The optimized, trained, model (blue solid line) is presented alongside the baseline (orange dash-dotted line). Visible is that after the training is completed, the optimized controller gives better performance both in terms of fuel consumption and state of charge. Particularly the fuel usage drops by 20% while the battery charge is increased by 72%.

Figure 3: Fuel consumption and battery state of charge with lambda = 0.1.



As Figure 2, but now with a different fuel vs battery preference ratio. In this example the fuel usage drops by 29% while the battery charge improves by 20%.
This shows it is possible to use DeepSim to tune the controller to meet different objectives.

Conclusion

DeepSim can be used to train a neural network-based controller for hybrid vehicles. The controller in this example tunes the fuel and battery consumption ratios. The difference between the results of Figure 2 and 3 shows that DeepSim can be used to tune controllers to meet different objectives for different usage scenarios. This flexibility allows developers to increase vehicle range, reduce fuel usage (and thus emissions) with a simple software update.

[1] Steve Miller (2020). Hybrid-Electric Vehicle Model in Simulink (https://www.github.com/mathworks/Simscape-HEV-Series-Parallel), GitHub. March 28, 2020.