Enhancing Model-Based Control for Automotive Cold Start Emissions

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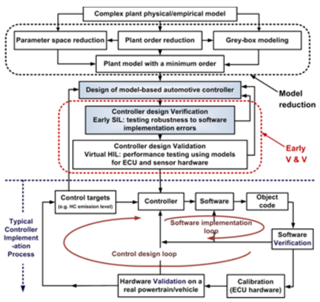
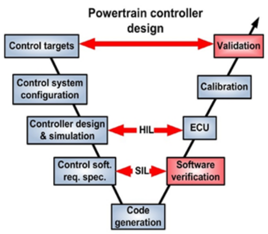
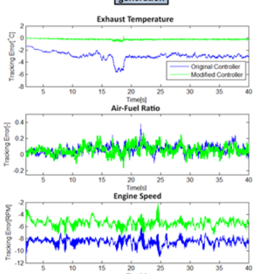
Early V & V

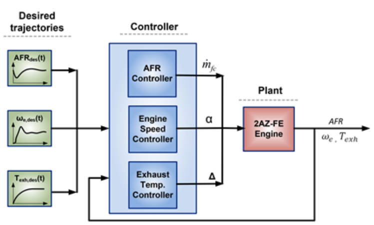
V & V. Increasing complexity of automotive powertrain systems requires the use of a Verification & Validation procedure for system design. Within controller design, early V & V mitigates potential issues before costly hardware implementation.



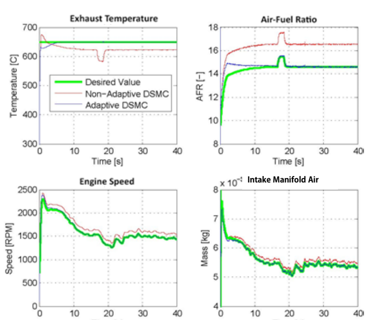




Model. We use three parallel sliding mode controllers. The tracked states are Air-to-Fuel Ratio (AFR), engine speed, and exhaust temperature. The control inputs are fuel injection rate, air mass flow rate, and spark timing.

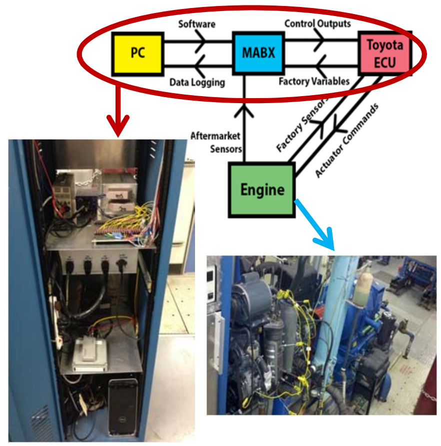


Robustness to uncertainty. Worst case uncertainty bounds due to quantization and fixed point errors are incorporated into the control inputs. Adaptation on uncertainty in the model is incorporated for lower actuation effort.

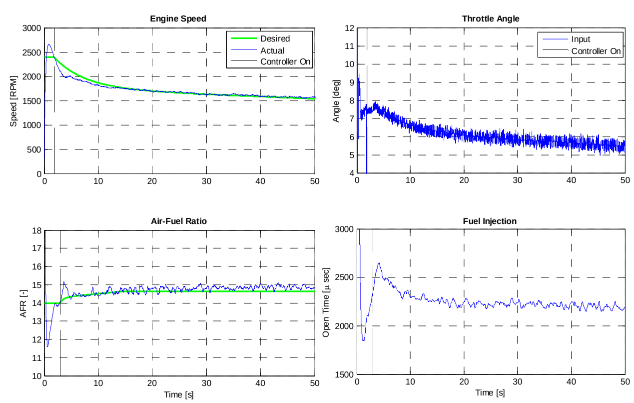


Engine Test Cell

Engine. The engine test cell contains a 4-cylinder, 2.4 liter, dual overhead camshaft Toyota 2AZ-FE engine with a three-way catalytic converter.

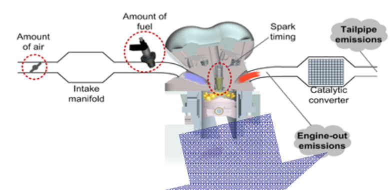


Control Setup. The engine test cell allows for running default control commands from the ECU as well as testing new algorithms for reducing cold start emissions. Several experiments have been run on the engine to test our controller designs, most recently the performance of a discrete-time sliding mode controller was evaluated.

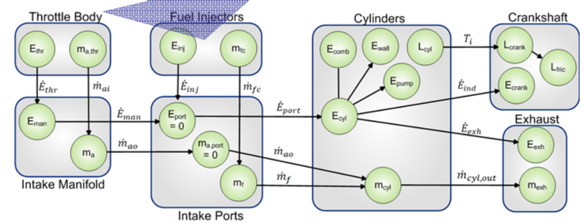


HLMT

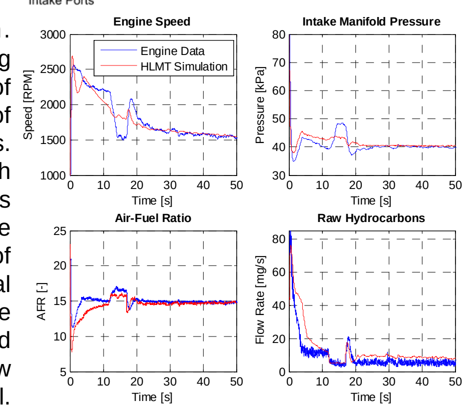
High Level Modeling Tool. HLMT facilitates the derivation of a model that is reusable, easily verifiable and allows for simultaneous design of engine and control system yielding an optimized overall design.

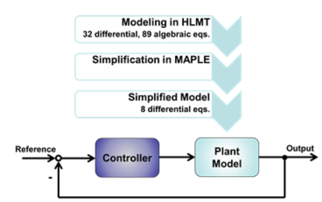


Conservation Laws. Laws of conservation are employed to eliminate empirical relations with physics based equations if possible.



Evaluation. The resulting model consists of a complex set of DAE's. Comparison with measurements implies that the core dynamics of the actual physical engine could be reflected by the new model.





Model Simplification. Using Maple, model simplification is performed to obtain a simplified model description in terms of ordinary differential equations suitable for control design.

Acknowledgement. The authors gratefully acknowledge the support received from Toyota Motor Corporation.