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Improving Simulink Torque Response with Model Predictive Control

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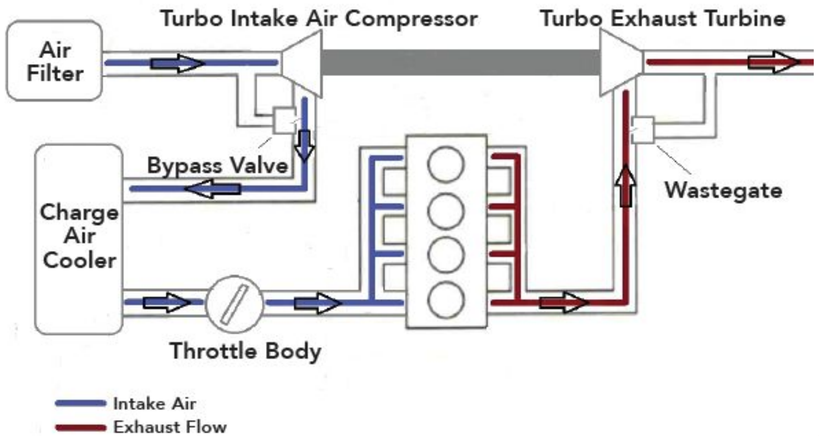
MathWorks®

Key Concepts:

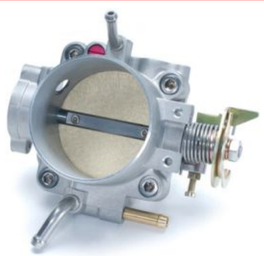
- Torque: The engine force that drives vehicle motion
- Throttle: Regulates air entering engine
- Wastegate: Regulates air flowing back into the turbine (turbocharged system) → turbine compresses more air into engine cylinders
- Model Predictive Control (MPC): Predicts future plant output and solves an optimization problem to select the optimal control
  - Quadratic Program: A type of non-linear control that optimizes a several-variable function subject to linear constraints



Physical System:

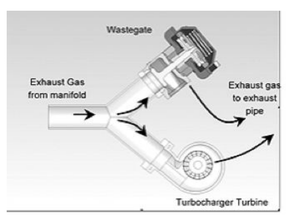
Controlled Components:

- Throttle (air into engine)
- Wastegate (air to turbine)



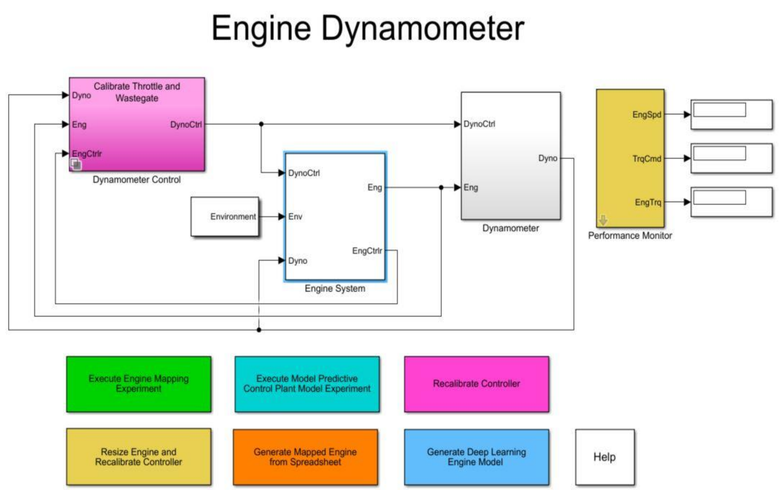
Virtual System:

- Dynamometer Control
- Engine System
  - Contains our controller
- Dynamometer



Project Background:

- In 2018 General motors created a Model Predictive Control (MPC) System to control several key parts of the engine in order to optimize torque output.
- Mathworks has a virtual dynamometer to run predictions on how engines run, and wants to create an MPC to replicate the method and apply it to the virtual dynamometer.



Motivation:

- Internal combustion engines will be prevalent for the foreseeable future.
- Modernize Mathworks' engine control unit for Powertrain Blockset engine simulation with multi-input/multi-output controller.
- Improve torque-tracking in engine dynamometer simulation.

Deliverables:

- An MPC addendum to the SI dynamometer blockset
- A arduino system to visualize the outputs of the controller

Objective:

Create and implement a Multi-Input Multi-Output control system that works with the current system to improve the throttle and wastegate control in the MathWorks Powertrain Blockset.

Approach:

- Control Throttle and wastegate position
- Use Model Predictive Control
  - Quadratic Program → Combination of speed and accuracy
  - Advantages of MPC
    - Constraints
    - Can control MIMO systems
  - Angle of throttle and wastegate (amount of air/exhaust that can go through)
- Simulink

Model Validation:

- For the virtual model, our primary method of validation will be measurements taken by Matlab. The following graph shows the output, along with some error associated that the MPC aims to improve
- Hardware in loop testing