Final Project for Advanced Control Systems

Switching Adaptive Control of a Torsional System

The objective of this project is to design a switching adaptive controller for the torsional system and implement it on Simulink.

The adaptive scheme is implemented using the conventional blocks of Simulink and some S-function blocks that should be written/completed by the students. The following S-functions are used in the scheme:

LPV model: Using the three identified models a Linear Parameter Varying (LPV) model is constructed. This block has two inputs: the plant input and a scheduling parameter $\alpha \in [-1, 1]$. For $\alpha = 1$ the model `G1` is used to compute the output of the plant. In the same way, for $\alpha = 0$ the model `G2` and for $\alpha = -1$ the model `G3` are used. For other values of α the model $G(\alpha)$ is computed by linear interpolation of the parameters of the fixed models. The S-function corresponding to this LPV model is named `LPV_Torsional` and is available on the Moodle of the course.

Multi controller: This block takes the reference signal and the plant output and computes the control signal based on the parameters of an RST controller. The RST controller is chosen among a set of fixed RST controllers and one adaptive controller according to a switching signal $\sigma \in 1, 2, 3, 4$. For example if $\sigma = 2$, the RST controller designed (off-line) based on the model `G2` will be used to compute the controller. The S-function corresponding to this multi controller is named `RST_Switch` and is partially available on the Moodle of the course. The students should complete the S-function.

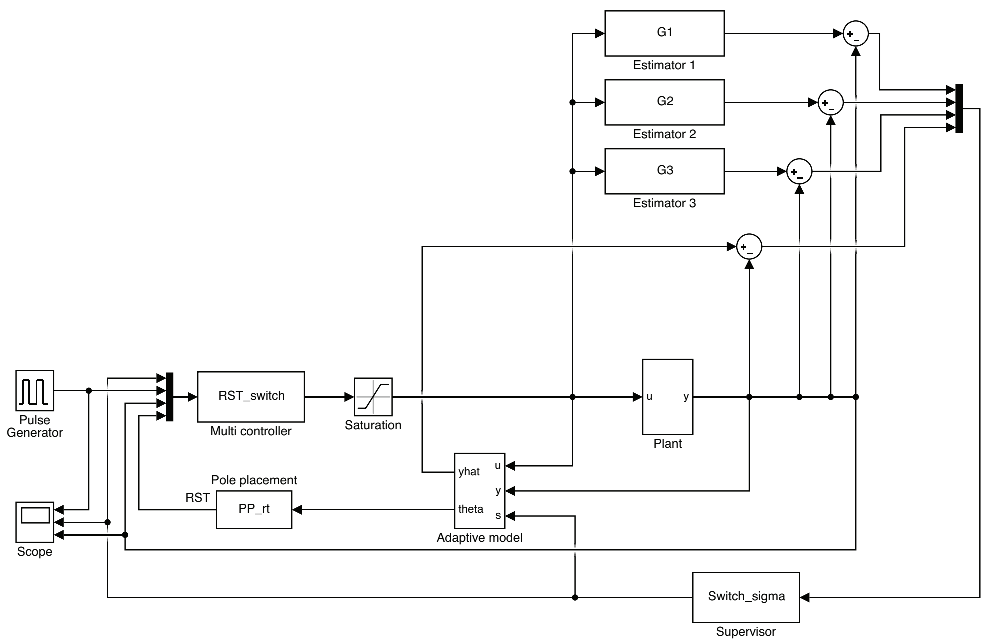
Supervisor: This block takes three estimation error signal from 3 fixed estimators and one estimation error computed by an adaptive model. Its output is the switching signal $\sigma \in 1, 2, 3, 4$ indicating the best estimator. The weighted two norm of the estimation error together with a dwell time algorithm should be used to choose the best model. The S-function corresponding to the supervisor is named `Switch_sigma` and is partially available on the Moodle of the course. The students should complete the S-function.

Adaptive model: This block represents a parametric adaptation algorithm. It takes the input and output of the plant and estimate the parameters of the model. The parameters are initialised with the parameters of the last best fixed model chosen by the supervisor. The first output of the block is the prediction error and the second output is the vector of estimated parameters $\hat{\theta}(t)$. The S-function corresponding to the adaptive model is named `aap` and is partially available on the Moodle of the course. The students should complete the S-function.

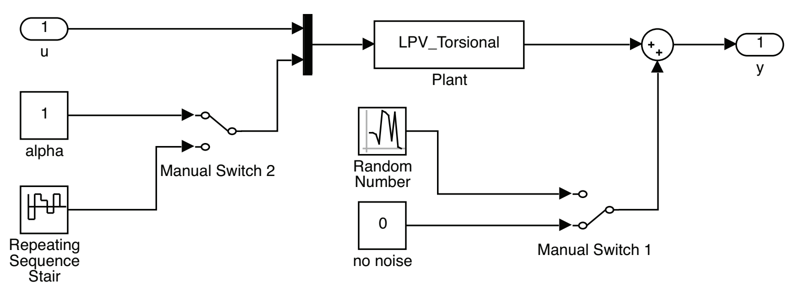
Pole placement: This block takes the real-time estimate of the parameters from the adaptive model and compute an RST controller based on the pole placement technique. The S-function corresponding to this block is named `PP_rt` and is partially available on the Moodle of the course. The students should complete the S-function.

The following steps should be carried out for the final project:

1. Three RST controllers should be designed for the three fixed models `G1, G2, G3` in `TorMod.mat`. Any design method can be used for this step (e.g. pole placement, Q-parameterization, H_∞, etc.).
2. Block diagram of a switching adaptive control for the torsional system should be drawn in Simulink (see Figure below).



   The block diagram of the "Plant" and the "Adaptive model" are given in the moodle of the course.
3. All S-functions should be completed.
4. The reference signal, the switching signal, the scheduling parameter, the plant output and input should be drawn for the following experiments:
   - The scheduling parameter is fixed to values $\alpha \in \{1, 0, -1, 0.5, -0.5\}$ for noiseless output (see figure below).



   - The scheduling parameter follows a repeating sequence stairs for noiseless output (the simulation time for this experiment should be 200 s).
   - Repeat the above items for noisy output. Increase the variance of noise gradually and find the maximum noise variance for which the algorithm works properly.

The final report should include the design of RST controllers, all requested plots and the codes of all S-functions.