Team Pythagoras

2/23/2022

Systems and Control

Model Predictive Control (MPC) is a powerful method of system control that sets itself apart from other control systems by relying on *prediction* rather than *reaction.* Based off a set of initial conditions, an MPC based feedback system will optimize a small set of next state inputs to attempt to bring the system to the desired value.

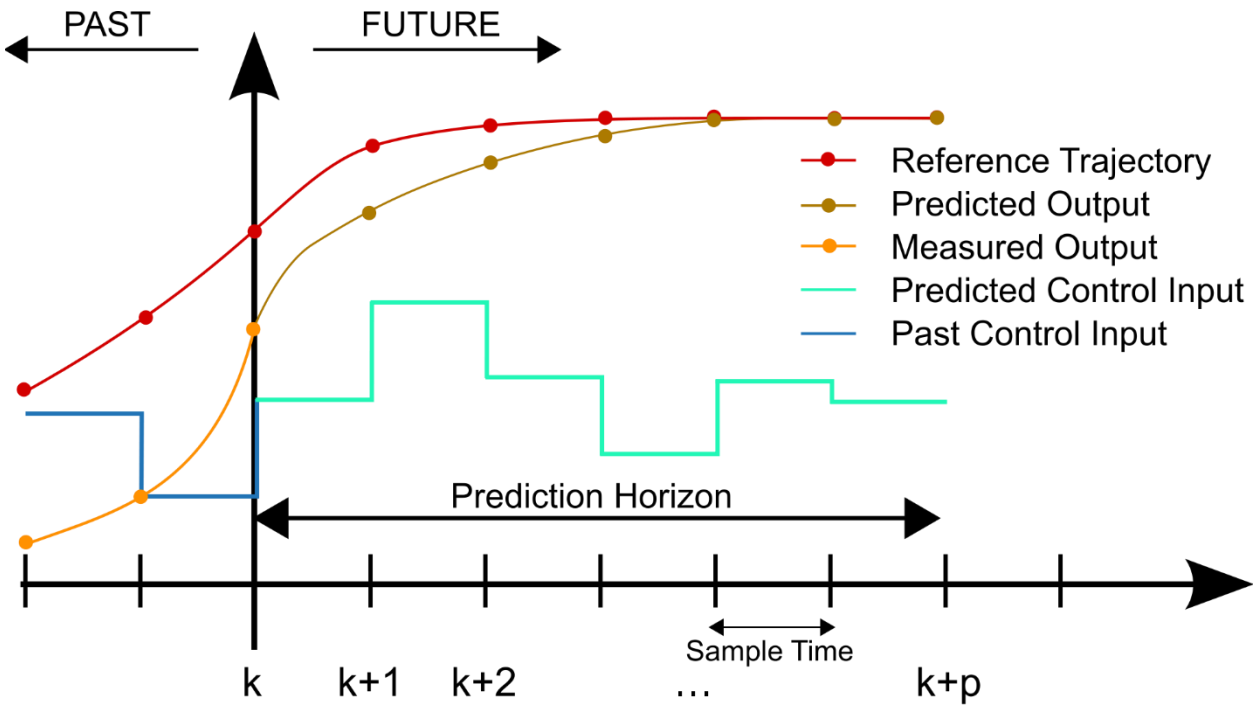

Figure 1: Basic Graph of MPC

As seen in Figure 1, the set of 'optimized' step input values is called the *horizon*. The horizon shifts by 1 t every time the response of the system is measured. When the horizon shifts, the MPC controller adjusts the original set of optimizations to either be more or less aggressive depending on if the system responded too much or too little compared to the expected output.

The equation used to determine the net input state is quite simple to understand. There are 3 components: the actual control signal $K(x_k)$, the next optimized input u_{k+1}, and the initial condition at a specified time x_k. From these, the following equation is received:

$$K(x_k) = u_{k+1}(x_k)$$

Figure 2: MPC equation

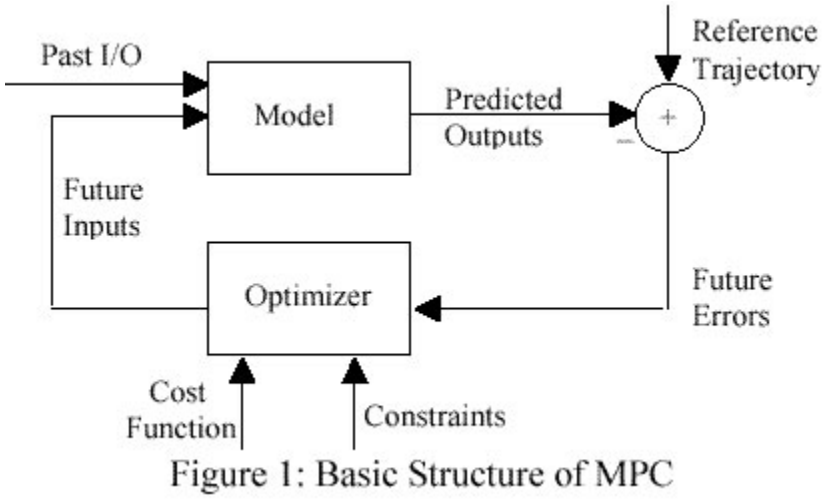

Figure 3: Block diagram of an MPC controller feedback

Since the controller makes its decision ahead of the system response instead of reacting to it, the controller can end with a much closer and more stable output. In addition, the option for constraint inputs can help keep the system response within the means of reality, without having to account for it separately, like in some other systems.

One drawback for our purposes is that MPC require state-space representations of systems. Due to our only using differential equations and transfer functions, the requirement of state-space might prove to be difficult. However, MATLAB comes equipped with an MPC toolbox to generate models, as well as a way to easily convert transfer functions to state-space models, making an MPC easy to implement through MATLAB.

MPC have access to many other benefits that are unnecessary for our needs, such as being able to handle multiple inputs, and non-linear systems. However, in industry, MPC suffers from being much more expensive and complicated compared to other simple controllers like PID.