CHME 6961 B.W. Bequette
Fall 2007 27 Aug., 2007

Model Predictive Control

Days and Room

Tu/F 10:00-11:50 Low 4040 Office Hours: TBA

Instructor

B.W. Bequette (bequette@rpi.edu)

Course Objective

The primary objective of the course is to provide an introduction to the theory and application of model predictive control (MPC). Model predictive control is the class of advanced control techniques most widely applied in the process industries. A primary advantage to the approach is the explicit handling of constraints. In addition, the formulation for multivariable systems with time-delays is straightforward.

MPC was developed in the process industries in the 1960's and 70's, based primarily on heuristic ideas and input-output step and impulse response models. The basic principle is to solve an open-loop optimal control problem at each time step. The decision variables are a set of future manipulated variable moves and the objective function is to minimize deviations from a desired trajectory; constraints on manipulated, state and output variables are naturally handled in this formulation. Feedback is handled by providing a model update at each time step (often the "additive disturbance correction"), and performing the optimization again.

Since students with a variety of backgrounds will be taking this course, we first provide a review of continuous and discrete models. A historical perspective of various MPC approaches follows, then we derive the analytical solution for the unconstrained problem. The quadratic programming solution for linear models and constraints and a quadratic objective function is presented.

Recent results on stability, robustness and state estimation will be covered. Also, extensions to nonlinear systems using different types of nonlinear models will be studied. MATLAB and SIMULINK will be used for the simulation of MPC applied to different problems. In addition to homework assignments students will complete a major research/design MPC project.

The course is taught in a *studio format*, combining lectures and simulations in a single classroom. It is assumed that all students have taken an undergraduate control course, with content similar to that of Bequette (2003). This text will be used for a review of basic modeling concepts and an introduction to MPC. Copies of relevant literature sources and teaching materials will be provided throughout the course.

Text

B.W. Bequette. *Process Control: Modeling, Design and Simulation*. Prentice Hall (2003).

Homework Assignments

The majority of the computer homework assignments will be performed individually.

Students may discuss the problems with other students, but are not allowed to share solutions (MATLAB m-files, etc.).

Exams

Unless demanded by the students, there will be no in-class examinations in this course.

Course Grade

The course grade will be determined using the following:

Homework	50%
Final Project	50%
Total	100%

Class participation will be considered for borderline grades. Students may be called upon for discussion questions.

Final Project

During the last 1/2 of this course you will work on a special project of your choice. This will give you a chance to "tie it all together" and apply model predictive control to an area of interest to you. You will provide a detailed written report and make an oral presentation to the entire class.

Lecture Schedule

Lectures will be on Tuesdays and Fridays, with the following known exceptions:

18 Sept (Tuesday)
9 Oct (Tuesday) - a Monday for class scheduling purposes
16 Oct (Tuesday) and 19 Oct (Friday)
26 Oct (Friday)
6 Nov (Tuesday)
20 Nov (Tuesday)
4 Dec (Tuesday)

Topics

Concise review of lumped parameter models

Review of classical analysis and control techniques

Using MATLAB to discretize continuous-time systems

Implementing discrete-time controllers in MATLAB and SIMULINK

Discrete internal model control

Dynamic matrix control (DMC)

State space model-based predictive control

State estimation techniques

State estimation-based MPC

Multiple model predictive control

Nonlinear model predictive control