## Model Predictive Control: Theory and Applications


Model Predictive Control (MPC) is one of the predominant advanced control techniques. MPC originated in the chemical process industry and is now applicable to a wide range of application areas. MPC is an optimization-based technique, which uses predictions from a model over a future control horizon to determine control inputs. This course will provide an overview of MPC, and will cover both theory and practical applications. The course will involve MATLAB-based hands-on learning modules for understanding and solving advanced control problems. The course will cover multiple aspects of MPC implementation, including dynamical system models, state estimation, unconstrained and constrained optimal control, and model identification. Applications of practical / industrial relevance will also be discussed.

The objectives of this course include

• Provide historical insight into MPC and its role in industry and research
• To develop linear state estimation and linear quadratic control theories
• To introduce the concept of receding horizon in MPC and its practical implementation
• To discuss tools for model building for MPC• To introduce tools for parameter identification
• To provide hands-on learning using practically relevant examples
• To discuss challenges and opportunities in research as well as industrial applications

**INTENDED AUDIENCE** : Post-Graduate students; final year UG; industry / research professionals

**PREREQUISITES** : UG Math (covering linear algebra) and Any of the following courses: Process Control; Control Engineering / Systems; Digital Control

**INDUSTRIES SUPPORT** : Automation companies, such as: ABB, Honeywell, Yokogawa, Aspen Tech, Siemens, Emerson, Rockwell, Schnieder and GE. Chemical Process Companies, such as: Shell, IOCL, HPCL, BPCL, Reliance, ONGC, Exxon Mobil, Praxair, etc.

**Prof. Niket Kaisare**

IIT Madras

Prof. Niket Kaisare is a Professor of Chemical Engineering in IIT-Madras. He works in the area of modeling, design and control for energy applications. He has over ten years of research/teaching experience in academia, and three-year experience in Industrial R&D. He uses computational software, including MATLAB, FORTRAN, Aspen and FLUENT extensively in his research and teaching.

**Faculty web-page:** http://www.che.iitm.ac.in/~nkaisare/

## COURSE TYPE

Elective

## COURSE LEVEL

Postgraduate

## COURSE LAYOUT

**Week 0: a. Introduction to Model Predictive Control**
**b. Recap of Linear Algebra**
**Week 1:Models for MPC: Step-Response Models**
Finite impulse and step response models; Model prediction; Parameter estimation
**Week 2:Models for MPC: Linear Time Invariant (LTI) models**
State-space models; Transfer function models; Model transformation
**Week 3: Model analysis and Disturbance Modeling**
Model stability; Observability and controllabilityRepresenting uncertainty; White, colored and integrating noise
**Week 4:Dynamic Matrix Control**
Step-response based MPC
**Week 5:Linear State Estimation**
State observer; Pole placement; Stability
**Week 6:Optimal Linear State Estimation**
Kalman Filter; Stochastic filtering theory
**Week 7: Linear Control Systems**
Linear control; pole placement; stability
**Week 8:Unconstrained linear quadratic control**
LQ control theory
**Week 9:Constrained LQ control**
Constrained LQ control theory
**Week 10:State-Space MPC**
State-space MPC; deterministic formulation; state feedback control
**Week 11: State-Space Output-Feedback MPC**
Separation principle; Implementation of output feedback MPC
**Week 12:Practical Implementation**
Nonlinear systems; Multi-rate system; Inferential control

## BOOKS AND REFERENCES

1. J.B. Rawlings, D.Q. Mayne and M.M. Diehl (2018) Model Predictive Control: Theory, Computation, and Design, Nobb Hill.
2. E.F. Camacho and C. Bordons (2007) Model Predictive Control, Springer.

## CERTIFICATE

The course is free to enroll and learn from. But if you want a certificate, you have to register and write the proctored exam conducted by us in person at any of the designated exam centres.
The exam is optional for a fee of Rs 1000/- (Rupees one thousand only).
Date and Time of Exams: **24 April 2021** Morning session 9am to 12 noon; Afternoon Session 2pm to 5pm.
Registration url: Announcements will be made when the registration form is open for registrations.
The online registration form has to be filled and the certification exam fee needs to be paid. More details will be made available when the exam registration form is published. If there are any changes, it will be mentioned then.
Please check the form for more details on the cities where the exams will be held, the conditions you agree to when you fill the form etc.

**CRITERIA TO GET A CERTIFICATE**

Average assignment score = 25% of average of best 8 assignments out of the total 12 assignments given in the course.
Exam score = 75% of the proctored certification exam score out of 100

Final score = Average assignment score + Exam score

**YOU WILL BE ELIGIBLE FOR A CERTIFICATE ONLY IF AVERAGE ASSIGNMENT SCORE >=10/25 AND EXAM SCORE >= 30/75. If one of the 2 criteria is not met, you will not get the certificate even if the Final score >= 40/100.**

Certificate will have your name, photograph and the score in the final exam with the breakup.It will have the logos of NPTEL and IIT Madras .It will be e-verifiable at nptel.ac.in/noc.

Only the e-certificate will be made available. Hard copies will not be dispatched.

Once again, thanks for your interest in our online courses and certification. Happy learning.

- NPTEL team