Introduction to Model Predictive Control

Model Predictive Control (MPC) is the only advanced control technique that’s seen widespread impact on industrial process control

⇒ It’s the only control technology that can deal with constraints

• Operation near constraints can bring about profitable and efficient operation

• The concepts behind predictive control are:
  – Easy to understand
  – Extensible to multivariable systems
  – More powerful than Proportional-Integral-Derivative (PID) control

• The origins of predictive control go back 50 years – but all formulations have the following common elements:
  – An explicit internal model
  – Idea of a receding horizon
  – Computation of control signal by optimizing predicted plant behavior

• Interestingly, these ideas fundamentally reflect innate human behavior!

• Predictive Control describes an approach to control design and not a specific algorithm – there are many types of predictive control laws
Main components of model predictive control are shared

- Actions depend on predictions
- Predictions are based on a model
- Current input is based on achieving a *best* output
- Limited time window (receding horizon)
- Precise control requires an accurate model
- Handles constraints in a systematic way

Principles of Predictive Control

Prediction

- Why is prediction important?
- How far ahead should we predict?
- What happens if we don’t predict accurately?
- How do we predict?

You are driving a car down a winding road in the darkness. Your headlights illuminate the roadway ahead for a fixed distance. How does the headlamp distance affect your driving performance?

Receding Horizon

- What is a receding horizon?
- Why is it essential?
  - What are the consequences of uncertainty?
- How is it embedded into model predictive control?
What advantages does it bring and what consequences does it have on prediction accuracy?

Model

- What is the model used for?
- How does the model use impact the modeling approach?
- What type of model is required? (e.g., FIR, state-space, etc.)
- How accurate must the model be?
  - Transient behavior
  - Steady-state behavior
- What is the relationship between the model and the computational environment?

Performance Index

- Why do we need a performance index?
- How should a performance index be designed?
- What kind of trade-offs should we consider?
- How does horizon length affect the performance index?

Constraints

- How are constraints addressed in most control strategies?
  - Classical control?
  - Modern control?
• Do you use a posteriori or a priori design?
• How do humans embed constraints into their behavior?
• How is MPC different from most conventional approaches?