

Project Deliverables and Timeline:

- 10/13 - Project Proposal: Submitted electronically by 5pm.
- 10/24 and 10/26 - Project Discussions: 15 minute in-class one-on-one meetings.
- 11/28 and 11/30 - Project Presentations: 15 minute in-class presentations.
- 12/08 - Project Report: Submitted electronically by 5pm.

Project Summary:

The project in this course provides the opportunity for independent study of an advanced MPC technique of your choosing. Just like the overall course, each project is intended to have elements of MPC theory and application. Depending on your interests, the project can be *theory-driven* or *application-driven*. In a *theory-driven* project, the goal is to solve a well-defined, yet generic, control problem through the design and analysis of a specific MPC formulation. The application would then use a numerical example to demonstrate the key ideas/feature of this control formulation. In an *application-driven* project, the goal is to use MPC to solve a practical control problem for a specific application. Here, the elements of the practical control problem should be analyzed to identify the corresponding MPC theory that can guide the control design and overcome any particular challenges associated with the application. The numerical results would then focus on demonstrating and evaluating the control performance in the specific context of the application.

For either a theory-driven or application-driven project, the following steps should be used to guide your project selection and overall workflow.

1. Think of a high-level aspect of MPC or control application that you would like to become more familiar with and that you think sounds fun. (The best projects are a result of working on something you enjoy!)
2. Conduct a literature review on this idea to see what has been done already and identify the specific research area of MPC that you would like to focus on, including but not limited to those in the MPC Literature Library we created on MS Teams. The goal here is to find a paper that solves a specific control problem using a specific MPC control formulation and analysis.
3. Use this paper (or papers) to guide your project. The goal is not to simply recreate this paper, but to use this paper as a solid foundation. You can use this paper to learn more about the area of MPC that you have chosen including the system assumptions, specific controller formulation, relevant analysis techniques, and key features of the overall approach.
4. Then plan out your goal for the project. What would you like to get out of this project and what would the end result look like? Think about your final presentation and final report. What would you like to be able to show and discuss?
5. Identify the key steps you will need to do to achieve this goal and these end results. Is this achievable in the time allotted (the remainder of the semester)? Is there anything you can do to simplify your project while still achieving the same goal? Are there any major challenges or sources of uncertainty that could limit the success of your project?

Based on these steps, each of the following sections provide additional details on the deliverables listed above.

Note: projects may be done individually or in teams of at most 2 people.

Project Proposal:

The project proposal should be a typed 1-2 page document that describes your planned project with respect to the five steps listed above. Specifically, the project proposal should 1) clearly identify your chosen theoretical aspect of MPC and/or control application area, 2) provide reference(s) from the existing literature that will serve as a foundation for your project, 3) identify which aspects of your chosen reference you plan to use and how you might extend or deviate from what is in the paper, 4) state your scope or final goal for the project, and 5) identify the key steps, and potential challenges, for achieving this goal. You should submit this document via eLearning. I will review these proposals quickly after the deadline to provide immediate feedback if major modifications are needed for your proposed project to be successful.

Project Discussions:

This one-on-one project discussion will provide an opportunity for me to provide additional feedback on your project proposal and discuss your overall progress roughly 2 weeks after submitting the project proposal. At this point you should have started the project and made some tangible progress on the key steps you identified in the proposal. There is no formal deliverable for these discussions. Instead, these meetings serve as a check point to make sure that you are on-track to achieve your project goals.

In addition to this scheduled project discussion meeting, you are encouraged to reach out to me at any time during the semester to discuss ideas or receive help in overcoming any unexpected challenges.

Project Presentations:

The project presentation is an opportunity for you to share what you have done with your classmates and learn from each of your classmates about a different MPC topic. For the 15 minutes, you should plan for a 12 minute presentation with 3 minutes for questions at the end. Just like at a conference, you will be stopped if you go beyond your allocated 15 minutes. So it is very important practice ahead of time to make sure that you have prepared a presentation that you can deliver in the allotted time.

This presentation should not just be your final report in presentation slide format. As with any presentation, it is very important to know your audience. In this case, your audience is your fellow classmates and therefore you can assume that they have the same MPC background as you but may not be familiar with your chosen area of MPC. You should provide the relevant background and motivation for your work, discuss the key features, and show specific numerical results that highlight these key features. The focus of the presentation will differ depending on if you chose a theory-driven or application-driven project. However, for either option, your presentation should focus on using a strategic combination of figures and math/equations to clearly communicate the key ideas/concepts of your project.

Project Report:

Your project report should be viewed like a conference paper of roughly 6 pages. Your report should be formatted using the IEEE conference standard using the *letter* versions of the LaTeX or MS Word templates found here <https://css.paperplaza.net/conferences/support/support.php> under the headings LaTeX Support or MS-Word Support. These templates also provide some valuable information on how to write a good paper in terms of formatting, using math and equations, including figures and tables, and avoiding common mistakes. While your specific paper might vary based on your chosen focus, the following sections and ideas should be used as a rough guide.

1. **Introduction:** Motivate your work and provide the relevant background needed to put your work in context. This motivation and background should reference prior related work you found during your literature review. Specifically, you should introduce and discuss a control problem and why MPC is a good control approach for solving this control problem.
2. **Model and Problem Formulation:** Define the class of systems for which your work is applicable, derive the model of your system, state any simplifying assumptions or limitations, and formulate the control problem you wish to solve. The focus of this section is highly-dependent on if your project is theory-driven or application driven.
3. **Model/Control Properties and Problem Solution:** This is the analysis section which might contain the main theoretical contributions in a theory-driven project or system/model/control design analysis in an application-driven project.
4. **Numerical Results:** Present a specific numerical example that showcases the key ideas of your project and your chosen area of MPC. Describe your Matlab-based simulation studies in detail and include well-formatted plots and other visualizations to effectively communicate the results of these simulations. Discuss the key ideas and main takeaways from these results and the project as a whole.
5. **Conclusions:** Summarize your project and discuss potential future work if you were to continue this project.
6. **Supplemental Material:** You are expected to provide your Matlab code (and any additional functions/toolboxes required to run your code) as separate files.

Additional Comments:

- A portion of your project report grade is for overall quality and style of your report, including but not limited to grammar, clarity of writing, typesetting, and figure quality.
- Since the first word in MPC is *model*, it is expected that a (potentially significant) portion of your work might be dedicated to developing a “control-oriented” model for an application-driven project. This is okay and should be reflected in the Model and Problem Formulation section of your report. It is also acceptable to make significant simplifying assumptions to restrict the scope of your project and allow you to focus more on system analysis and MPC control design.

- For a theory-driven paper, you are not expected to develop a brand-new novel MPC theory. Instead, you could focus on an existing MPC theory and dive deeply into the technical aspects of the theory including the assumptions, problem formulation, analysis, and theoretical proofs. Your report should not just be a restatement of what is in an existing paper but should provide your specific commentary on these theoretical aspects. You should also include a numerical example that clearly demonstrates the key ideas of this theory. Developing the code to implement a specific controller formulation is a great way to reinforce your understanding of the theory.