Final Project Guidelines

A summary and timeline of project due dates is as follows:

Project Element	Percentage	Due Date
1) Project Proposal	10 %	TBD
2) Initial Paper Submission for "Review"	70 %	TBD
3) Revised Paper Submission	10 %	TBD
4a) Submit Talk Slides	5 %	TBD
4b) In-person Lightning Talk	15 %	TBD

1) Project Proposal.

Submit a 1-2 page project proposal (via Canvas) that includes the following information:

- **Name/Date**
- **Title of Project:** A (draft) descriptive title
- **Type of Project:** Indicate either Research/Application-Based or Tutorial-Based Project (see last page of this document)
- **Project Description:** A short paragraph to introduce your problem and any relevant background. Explain what the goals of your project are. Be specific.
- **Anticipated results:** Explain what type of results you expect to obtain and how these results achieve the goals mentioned in the project description. You are required to include several figures/results in your final report—discuss what these will be and what you expect them to show.

2) Paper Submission for Review (Out of 100 points)

Prepare your paper using LaTeX and *IEEE Transactions* format provided as a zip file. You may upload this zip file to Overleaf or edit using a standalone Latex editor. The report should adhere to the following requirements below which will also serve as a grading rubric:

- (2 pts) Paper is no longer than 6 pages
- (3 pts) IEEE Transactions style is used with title, name, affiliation, etc. updated
- (3 pts) A comprehensive abstract clearly describes what was done and the main results
- (1 pts) Appropriate keywords are selected
- (10 pts) The introduction section explains the problem area and why it is important, relates/compares to other literature and ongoing research, explains the essentials of the proposed technical approach, summarizes the main contribution, and outlines the remainder of the paper.
- (4 pts) A minimum of 8 high-quality and relevant references are cited throughout the paper and appear in the References section.

- (2 pts) References have no missing information and are formatted appropriately in IEEE style.
- For the following three core sections of the paper points are assigned based on the writing style/content and overall effort/quality of the work completed.
  - (20 pts) Problem Formulation: Begin by explaining any necessary mathematical background/notations/preliminaries. Do not assume the reader is an expert on your topic already. Use subsections as needed. Formulate the problem by introducing your dynamic model, objective, etc. culminating with a precise (mathematical) problem statement. For example, your problem statement might define a cost function to be minimized while satisfying constraints, etc.
  - (20 pts) Method: Describe your approach to solving the problem statement (your approach for designing a state estimator, system identification algorithm, etc.). Mention any specifics of the implementation.
  - (20 pts) Results: Describe your process for evaluating your method and the results that were obtained. Include figures that demonstrate your approach or quantify the performance.
  - (10 pts): Each of the above three sections contains at least one figure.
- (5 pts) Conclusion: Summarize your paper along with ideas for possible follow-on work.
- (-10 pts) per day if submitted late

3) Revised Paper

Revise your paper in response to comments from the reviewers and resubmit.

4) Lightning Talk

Based on your final report create a concise and well-crafted presentation. All the presentations will be held in-class on a selected date. We have 75 minutes for 11 presentations so each talk will be no more than 5 minutes (hard cutoff) followed by a 1-2 minutes of questions/transition to next speaker. For some tips on preparing a Lightning Talk, scroll down to the "Tips" section of this website: `https://www.nature.com/articles/d41586-021-01674-9`. Although the presentation is short it does not mean it will be easier to prepare: you are expected to distill your project into an easy to understand overview in the time provided. The presentations will be presented alphabetically by the presenter's last name. Grades will be assigned based on the following criteria:

- The talk includes a title slide with an interesting title for the project, name of the speaker, date, and name of the course
- The remaining content should be no more than 4-7 slides, including:
  - 1-2 slides: what is the basic problem (at a high level) and why should we care / what makes it interesting or useful? what have other people done related to this problem and how does your work fit in?

  - 3-5 slides: Background, problem formulation, method, and results

- Each slide has an informative title
- Presentation made good use of figures and visual elements (at least one per slide), text was easy to read, and at most 2-4 bullets of text were included on each slide
- Talk was timed to be close to 5 minutes (e.g., was not rushed near the end)

Project Types

You may choose from one of the two types:

- *Research or Application-Based Project.* Use the state estimation and/or system identification techniques we learned in class for your own research or a problem of interest. Example projects:
  - Work with your advisor to identify a project that involves some element of uncertainty in a dynamic system or system learning/identification.
  - Comparative study: apply two techniques we learned to the same problem and compare their performance (accuracy, computation time, etc.)
    * Example state estimation problems: inertial navigation, GNSS, orbit determination, target tracking (bearing-only, range-only), mobile robot SLAM, traffic systems, or battery state estimation
  - Generate your own data of a dynamic system, obtain data from an available simulator (e.g., ROS, Marine Systems Simulator), or use an existing data set (e.g., from MATLAB system ID toolbox) then attempt to identify/learn the system dynamics from input/output data
  - Robotic path planning/control under uncertainty (design a chance-constrained path planner, implement a LQG optimal controller, etc.)
  - Implement one of the techniques from class on a real system (pendulum on a cart, servo-controlled tracking camera, mobile robot etc.). You can construct your system using a simple microcontroller (e.g., Arduino) or use an existing system you have access to.

- *Tutorial-Based Project.* Prepare a tutorial style paper that comprehensively reviews one or more state estimation and/or system identification techniques that we did not discuss in class. The project must clearly explain the technique in an accessible lecture style. The paper should be self-contained and include any necessary mathematical background. The tutorial should include derivation of the technique, and one substantial example that is worked out both on paper and implemented in code. Example tutorial topics:
  - Nonlinear observers
  - Square root Kalman filtering
  - Multiple-model estimation
  - Multi-target tracking (e.g., JPDAF)
  - Random finite sets and PHD filtering
  - Rauch-Tung-Striebel (RTS) smoothing
  - Kalman filtering special cases: delayed measurements, colored noise

- Distributed Kalman filters
- H_∞ filtering; robust Kalman filtering
- Auotregressive modeling (ARMA, ARMAX, NARMAX, etc.)
- Matlab System ID Toolbox Tutorial
- Design of excitation signals for system ID; Optimal experimental design
- Frequency response / transfer function estimation
- Koopman operator theory