Guidelines for MAE 598 Multi-Robot Systems Final Project Report

Fall 2020

Total possible score: **150 points (+3 extra credit points)**

Total possible score with minimum requirements: **135 points**

- This corresponds to a grade of (135/150)*100 = **90%**
- Recall from the syllabus that an **A** grade is in the range **[85%, 95%)**

General guidelines:

- The report may be written in LaTeX, Word, or whatever format you are comfortable with.
- Any references that you cite can be (but do not have to be) references that you cited in your literature review (Assignment 1).
- **The template for the report is on the next 2 pages.**

Guidelines for team projects:

- **Submission:** Only one of the team members should submit the report, and any associated files, to the **Final Course Project Assignment Page** on Canvas.
- **Division of labor:** Each of the team members should contribute approximately equal amounts of the report material. Sections II-IV can be scaled up accordingly; for example, each team member can define one of several models in Section II and analyze two properties of their model in Section III. Each team member must *at least* contribute to Section III (Analysis) *or* Section IV (Validation). In the report, identify the team member who completed each part in Sections II-IV.
- **Grading:** The report will be assigned a single score out of 150 points. All team members will receive this score if they each contributed approximately equal amounts of the report material, and the report meets (and does not exceed) the minimum requirements. Only team members who contributed material *beyond* the minimum requirements (developing a new model, designing a controller, using a multi-robot simulator or real robots for validation) will receive the extra points associated with those parts. Team members who contributed less than an approximately equal amount of the report material will receive a point deduction that corresponds to the deficiency in their contribution.

Project Title

Name(s) of student or team members

I. Abstract

- Up to **3 points**

Guidelines:

- Similar to an abstract of a conference or journal paper
- 200 – 300 words long (closer to 200 words for individual projects, closer to 300 words for team projects)
- You may use text from your literature review (Assignment 1) and/or project proposal

Describe the type of multi-robot behavior that you investigate in the project and potential applications of this behavior for multi-robot systems in practice. State the type of model(s) that you use to describe the behavior, the particular properties of the behavior that you analyze (and control, if you choose to do so), and the analysis (and control) techniques that you apply. Briefly describe and summarize the results of the simulations or experiments that you conducted to validate your analysis.

II. Mathematical Model

- Up to **32 points** if you use an existing model of the behavior. Up to **3 additional points** if you expand upon an existing model or develop your own model using the techniques covered in class.

Describe the multi-robot behavior that you are investigating and a hypothetical scenario in which you are applying it so solve a particular problem. State all assumptions and constraints; for instance, the robots' sensing and communication capabilities, the information that the robots have access to and how they acquire it, and the properties of the environment (e.g., bounded or unbounded, whether it contains obstacles, the geometric properties of any obstacles if known). Define all variables and parameters of your model, both in text and in figures (e.g., a diagram with coordinate systems and the definitions of inter-robot distances and sensing ranges). Explain why the assumptions, constraints, variables, and parameters are realistic for your hypothetical scenario. Finally, define the mathematical model of the collective behavior, and cite at least 2 references that introduced the model that you are using, or a model on which your model is based.

III. Theoretical Analysis

- Up to **50 points** if you prove 2 properties of the model. Up to **6 additional points** if you design a controller for the model to achieve a desired collective behavior.

Examples of properties that you can prove: the model's equilibrium state, largest invariance set, stability characteristics (e.g., asymptotically stable/marginally stable), and convergence rate to equilibrium. Show your calculations in detail. Cite at least 3 references that describe the analytical techniques that you use.

IV. Validation in Simulations or Experiments

- Up to **50 points** if you develop simulations in MATLAB. Up to **6 additional points** if you develop simulations in one of the multi-robot simulators listed on the page **Simulators for multi-robot systems** in Canvas. Up to **9 additional points (3 extra credit points)** if you run experiments with actual robotic hardware.

Validate the model properties that you proved in Section III using either simulations or experiments of the multi-robot behavior. Present plots of your results and describe your conclusions from the plots. Create videos of your simulations or experiments, and either include the video files with your submission, or include a link to the videos in your report. Include the code that you used to run your simulations or experiments with your submission, either as an Appendix or as separate files.