ECE 780-T09: Network Systems and Control

Spring 2018

Department of Electrical and Computer Engineering
University of Waterloo

Many large-scale natural and engineering systems can be modelled as collections of independent agents or subsystems which interact with one another through physical coupling, communication, or both. Examples include flocking birds, schooling fish, electric power systems, mobile robot teams, and sensor networks. The dynamic behaviour of these network systems depends on the nature of the agents, the nature of the inter-agent physical or communication-based coupling, and most interestingly on the global pattern of interaction between all agents.

This course is concerned with analyzing and designing the dynamics of multi-agent network systems, and is intended primarily for graduate students in engineering and applied math interested in dynamics over networks, cooperative and distributed control, and distributed algorithms. Topics include:

 (i) theory of nonnegative matrices (Perron–Frobenius theory);

 (ii) graph theory, with an emphasis on algebraic graph theory;

(iii) discrete-time and continuous-time distributed averaging (consensus) algorithms;

(iv) positive and compartmental linear systems;

 (v) circuit theory: graph models, dynamic stability, effective resistance, model reduction

(vi) distributed optimization using multi-agent systems;

(vii) applications to networks of coupled oscillators, viral spread models, sensor networks, power system dynamics, resource allocation problems, and population dynamics.

Instructor

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(*Please place "ECE 780" in the subject header of all e-mail correspondence.*)

Course Website and Credit

Units: 0.5

Website: <https://ece.uwaterloo.ca/~jwsimpso/networks/>

Prerequisites

Competency in linear algebra and graduate-level LTI systems theory (ECE 682 or equivalent) is strongly recommended. Exposure to nonlinear dynamical systems theory (ECE 688 or equivalent) is recommended – particularly Lyapunov stability theory – but is not required.

Lecture and Office Hours

Lectures:
- Monday 2:30pm, EIT 3141

Office Hours:
- Drop-in or by appointment

Textbook

F. Bullo *Lectures on Network Systems*. Available online through UC Santa Barbara.

Other Reference Material:
- M. Mesbahi and M. Egerstedt *Graph Theoretic Methods in Multiagent Networks*.
- L. Farina and S. Rinaldi *Positive Linear Systems*.

Assignments

There will be three to four assignments. Students may work together on assignments, but the submitted work must be your own. Assignments will be graded for completeness, clarity of thought, and clarity of presentation.

Project

Each student will pursue an individual research project on a topic of interest in the area of multi-agent dynamics/stability/control/optimization. The purpose of this project is to learn about a topic outside the immediate scope of the course, digest it, clearly write about it, and clearly explain it to the class. There is no requirement for novelty. A list of suggested topics will be posted in Week 5. Students are free however to pursue any appropriate project with instructor approval.

Ambitious students are encouraged to attempt applying course concepts to their thesis research. There will be three deliverables associated with the project:

 (i) Week 6: a proposal outlining the project (maximum 1/2 page);

 (ii) Week 12: a final report; the report should follow a standard structure: introduction, motivation for research, literature review, main results, etc. Evaluation will be based on completeness, depth of understanding, and clarity and polish of presentation. Format is a maximum 6 pages in IEEE double-column conference format, including references;

(iii) Week 12: a 20 minute in-class presentation explaining the final report. The presentation should be targeted to class participants who will be familiar with the course material, but not necessarily familiar with the specific research topic under discussion. Evaluation will be based on appropriateness and quality of slides and on clarity of presentation.

Evaluation

$$\textbf{Grade} = 0.5 \times \textbf{Assignments} + 0.5 \times \textbf{Project}$$

Please familiarize yourself with University of Waterloo's Assignment and Exam Regulations.

Academic Integrity, Discipline, Grievances, and Appeals

In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. For an overview of academic integrity policies and sanctions, see here.

A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about rules for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline. For typical penalties check Guidelines for the Assessment of Penalties.

A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.

A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is a ground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals).

Disability Policy

AccessAbility Services, located in Needles Hall 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.