# ECE 8040 Networked Dynamical Systems

# (3 credit hrs)

Fall 2023

## General Information:

Instructor: Dr. Yongqiang Wang (yongqiw@clemson.edu), (805) 4532818

Meeting time: 9:30 pm - 10:45 pm Tuesdays and Thursdays at SIRINE 306 (08/23/2023 - 12/15/2023)

Office hours: Online (https://clemson.zoom.us/j/9209214331) by appointment

Course webpage: http://www.clemson.edu/canvas

Text: Readings from the literature

## Course Description & Objectives:

The theory of networked dynamical systems is having increased applications in disciplines as diverse as robotics, biology, wireless communications, distributed computing, and automatic control. This course deals with tools, methods, and algorithms for understanding and designing networked dynamical systems. Topics include decentralized control (swarm robotics, intelligent transportation), distributed computing (e.g., learning, consensus, gossip, optimization, load balancing), and decentralized coordination (e.g., clock synchronization) in communication/robotic/computer networks.

The objectives of the courses are to equip students with the following abilities:

1) Rigorously describe and analyze networked dynamical systems in various application areas;
2) Develop new algorithms for networked dynamical systems;
3) Perform basic research in networked dynamical systems, including writing a research paper as final project report.

## Optional Reference Texts (Recommended Reading for More Information):

1) *Graph Theoretic Methods in Multiagent Networks*, by M. Mesbahi & M. Egerstedt, Princeton University Press, 2010
2) *Distributed Control of Robotic Networks*, by F. Bullo and J. Cortés and S. Martínez, Series in Applied Mathematics, Princeton, 2009
3) *Distributed Consensus in Multi-vehicle Cooperative Control*, W. Ren and R. W. Beard, Communications and Control Engineering Series, Springer-Verlag, London, 2008
4) *Nonlinear Dynamics and Chaos: with Applications to Physics, Biology, Chemistry, and Engineering*, by S. Strogatz, Westview Press, 2001.
5) More materials (papers) to be announced

## Course Topics (Subject to change):

1) Fundamentals of matrix and graph theory
2) Wireless sensor networks
3) Distributed machine learning
4) Synchronization of dynamical systems

5) Clock synchronization
6) Cooperative robotics
7) Distributed computing

## Grading:

1) Class Participation and Presentations: 50%
2) Paper-format Reports (6 pages): 50%

## Schedule (Subject to change):

The course schedule is divided into three parts:
1. Seminars (recorded videos of seminars given by world-renowned researchers) (about 9 weeks)
2. Students will discuss selected papers (about 3 weeks)
3. Students research project discussions (about 2 weeks)

## Requirements on Paper Presentation:

Students are required to present one research paper selected from a given list of "Candidate Papers for Presentation" (under "Files" directory on Canvas). Each student records his/her presentation and upload to Box. The papers in the list represent the state-of-art of corresponding research topics and have substantial theoretical depths. Through thorough studying and presenting a paper, a student is expected to gain substantial knowledge about the forefront of a topic and be able to conduct research on the topic. Students are encouraged to select a paper that is relevant to his/her final project or thesis.

For paper presentations, the requirements are:

1) Select a paper from the list "Candidate Papers for Presentation" (under "Files" directory on Canvas) by Sep. 08, 2023 and email me your choice (preferably sooner);
2) Thoroughly and completely understand the selected paper (including the contents in "appendix" and "supplemental materials");
3) Present the paper and record the presentation. Both the idea and technical details of the papers are required to be presented.
4) Record presentation and upload it to Box by Sep. 27, 2023;

## Requirements on Project and Presentation:

A large part of the course grade is based on a research project. Students may work on projects alone or with a partner. Groups of three may also be allowed if approved by me. Projects must be research projects contributing new theory and/or applications to the networked dynamical systems community. The results should be a research publication suitable for a high-quality conference or workshop. You are encouraged to come up with a project that relates to your research.

The project topics can be:

1) Decentralized learning theory
2) Learning based robotic networks based on iRobot-Create 2 Robots
3) Other projects that are proposed by students and approved by the instructor

For all projects, the requirements are:

1) An online meeting with me to discuss and approve your project proposal by Oct. 5, 2023 (preferably sooner);
2) A short project status report (1–2 single-column pages) with 5 to 10 references due Oct. 26, 2023 in class;
3) A recorded project presentation should be uploaded to Box before Dec. 7, 2023;
4) A project report in IEEE conference paper style. Due Dec. 07, 2023, via email (confirmations will be given if successfully submitted).

## Policies:

Students may leave after 10 minutes if the professor or guest lecturer does not arrive in that time. Attendance while not required is highly recommended. Students who regularly attend class and participate will receive special consideration if course average is borderline. Students are responsible for getting lecture notes, and handouts for missed classes from fellow students or from the class website when applicable. Any exam that was scheduled at the time of a class cancellation due to inclement weather will be given at the next class meeting unless contacted by the instructor.

Any assignments due at the time of a class cancellation due to inclement weather will be due at the next class meeting unless contacted by the instructor. Any extension or postponement of assignments or exams must be granted by the instructor via email within 24 hours of the weather related cancellation.

It is recommended that students check their email daily for important announcements, assignments, and other class related information. It is preferred that you use your clemson.edu account and not forward to another account (e.g. hotmail, yahoo, etc.) as there is the potential for lost information with these systems.

Scantron is available through the department but will not be used in the class.

## Academic Integrity:

If someone else's work (code, slides, research publications, etc.) is used to produce any work you do for this course, you must (1) indicate how this work was used, and (2) acknowledge this work in a bibliography section. For presentations, you must create your own slides.

This course follows Clemson University procedures. Students suspected of violating academic integrity will be reported. The official statement of Clemson University on Academic Integrity:

"*As members of the Clemson University community, we have inherited Thomas Green Clemson's vision of this institution as a 'high seminary of learning.' Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we shall not tolerate lying, cheating, or stealing in any form. In instances where academic standards may have been compromised, Clemson University has a responsibility to respond appropriately to charges of violations of academic integrity.*"

More details of the graduate academic integrity policy are available at:

http://gradspace.editme.com/AcademicGrievancePolicyandProcedures#intergritypolicy

## Disability Services:

Students with disabilities who need accommodations should make an appointment with me to discuss specific needs within the first month of classes. Students should present a Faculty Accommodation Letter

from Student Disabilities Services when we meet. Student Disability Services is located in G-20 Redfern (phone number: 656-6848, email: sds-l@clemson.edu). Please be aware that accommodations are not retroactive and new FAL must be presented each semester.

## Title IX Statement:

The Clemson University Title IX (Sexual Harassment) statement: Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity (e.g., opposition to prohibited discrimination or participation in any complaint process, etc.) in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. The policy is located at http://www.clemson.edu/campus-life/campus-services/access/non-discrimination-policy.html. Jerry Knighton serves as Clemson's Title IX coordinator and he may be reached at knightl@clemson.edu or 656-3181.

## Modification Statement:

The instructor reserves the right to modify any aspect of the syllabus at any time during the semester for reasons including but not limited to COVID related situations.

## Copyright Statement:

Materials in this course are copyrighted. They are intended for use only by students registered and enrolled in this course and only for instructional activities associated with and for the duration of the course. They may not be retained in another medium or disseminated further. They are provided in compliance with the provisions of the Teach Act. Students should be reminded to refer to the Use of Copyrighted Materials and "Fair Use Guidelines" policy in on the Clemson University website for additional information: https://clemson.libguides.com/copyright.