ECE 592-Special Topics

Wireless Operation of Implantable/Wearable Devices

Instructor: Yaoyao Jia

Description: This course studies the latest research, design, and development of wireless power transmission and data communication in implantable/wearable electronics. We will start with a review of the main components in a wireless biomedical system and the challenges of enabling wireless operation in practical biomedical applications. Then, we will study the operation criteria of various wireless power transmission and data communication techniques, and the comparison and selection of one technique over another. We will also explore the relevant circuit designs of wireless power/data receiver (Rx) and transmission (Tx). We will have case studies of wireless power transmission and data communication used in practical applications to conclude this course.

Course Objective:
This course aims to provide students with both knowledge and critical thinking of enabling wireless operation of implantable/wearable devices in practical biomedical applications.

Prerequisites:
ECE 403, ECE 404, ECE 418, ECE 426, or equivalent.

Textbook:
Not required. In this course, we will mostly use journal papers, handouts, articles on the web, patents, and excerpts from various books and other references.

Topics:
1. Basics of the main components in a wireless biomedical system
2. Challenges of implementing wireless power transmission and data communication in practical biomedical applications
3. Wireless power transmission techniques
    a) Basics of electromagnetic, ultrasonic, optical, and power transmission approaches
    b) Basics of energy harvesting from the bodies of living subjects for self-powered electronics
    c) Comparison and selection of one technique over another
    d) Circuit designs of power Rx and Tx
4. Wireless data communication techniques
    a) Basics of backscattering, RF data transmission, UWB, etc
    b) Data modulation
    c) Data acquisition and processing
    d) Circuit designs of data Rx and Tx
5. Case studies
    a) Optogenetic neuromodulation applications
    b) High-density, large-scale neural recording systems
    c) The distributed array of miniaturized, high-density, and free-floating implants,
    d) Assistive technology applications

Grading:

Active participation in class	10%
Quizzes and Reading assignment summaries	20%
Presentations (I, II, and Final)	10%, 10%, 20%
Final project	30%

A- / A+: 90.0 – 100.0
B- / B+: 80.0 – 89.9
C- / C+: 70.0 – 79.9
D- / D+: 60.0 – 69.9
F: 0.0 – 59.9

Lectures:
The course meets two times per week. The first of the meetings will be a formal lecture. The second meeting will have two parts—the first will be a completion of the preceding lecture; the second portion will be a student presentation, review, and discussion of the reading assignments.

Reading Assignments:
Reading assignments, including sections of reference books, supplementary notes, online articles, patens, and several conference and journal papers that are relevant to the course topics, will be announced in class and posted on the class website. Students are responsible for lecture materials and reading assignments for active class discussions, presentations, and the final project.

Homework assignments:
These will be in the form of reading one or more papers/articles and writing a summary, an abstract, or a critical review, or deriving a conclusion.

Presentations:
Following the main lectures that are given in class by the instructor, a subset of the reading assignments related to the course topic will be presented and critically evaluated by one graduate. The discussion is then expanded to the entire class.

Course Final Project/Presentation Topics:
A principal component of the final grade will be an NIH style exploratory proposal writing. The chosen topic should be discussed with the instructor before a designated deadline in teams of two or three students and approved. Detailed project guidelines, minimum requirements, the format of the deliverables, and a list of suggested topics will be provided and updated at the beginning of each semester. The final project will also involve a presentation that will be given by the entire team in a conference-style on the day of the final exam, followed by questions and answer by the audience.

Final Exam/Presentation:
The final exam will be in the form of an IEEE conference-style oral presentation on the selected project topic along with a set of slides deliverable, given by all students in each group. Each presentation takes 15 minutes, followed by a 5-min question and answer from the audience, the instructor, and the referees.