BE 567: Nonlinear Systems in Biomedical Engineering

Fall Semester, 2009

Classes: Monday & Wednesday 12-2 pm.

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Office hours: Friday 1-2.

Textbook: Steven H. Strogatz: Nonlinear dynamics and chaos

Additional Material: Nicolis and Progigine: Exploring complexity: An introduction; and several research papers from various journals (will be distributed)

Goals: 1. To provide an introduction to the analytical tools necessary to explore nonlinear dynamic systems
2. To introduce nonlinear dynamic models from physiology and biology and apply the above tools to gain quantitative understanding

Main Topics:
1. Introduction (1 lecture)
2. One dimensional flows
    - Flows on the line (2 lecture)
    - Analysis of bifurcations (2 lecture)
        - Examples from mechanics and biology
    - Flows on the circle (1-2 lecture)
        - Oscillators, pendulum, fireflies
3. Two-dimensional flows
    - Review of linear systems (1 lecture)
    - Phase plane methods (2-3 lectures)
        - Predator-prey models, pendulum revisited
    - Limit cycles (2-3 lectures)
        - Van der Pol oscillator, application to breathing
    - Bifurcations in higher dimensions (2-3 lectures)
        - Chemical oscillators, neural networks, pendulum
4. Chaos
    - Lorentz equation (3 lecture)
        - Weather forecast, planetary motion, additional chaotic systems
    - One dimensional maps (1 lecture)
    - Fractals (1-2 lectures)
        - Examples from physiology
5. Additional examples: Origin of life (1-2 lectures)

Laboratory: Several projects involving numerical analysis and computational modeling of various nonlinear systems. Students may form groups of 2 for each assignment. Team mates are encouraged to discuss their project. However, directly copying a classmate's work or allowing a classmate to knowingly copy your work is not allowed. A good rule to follow is to never share written versions of lab reports or computer code.

Homework: Homework will be given from each topic, approximately once a week.

Grading: Laboratory project 20%, Homework 30%, Midterm exam 20%, Final exam 30%.

Incomplete & withdrawal: Incomplete will be given to students demonstrating good progress (C or better) with acceptable reason for being unable to complete the course. Students may withdraw from course prior to the University deadline. Having taken the final exam, students will not be able to receive an incomplete or withdraw.