Department of Biomedical Engineering
BME 674-101: Principles of Neuromuscular Engineering
Fall 2013

Course Syllabus

INSTRUCTOR

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CLASS HOURS

Lecture Monday 6:00pm – 9:05pm Fenster 636

OFFICE HOURS (EAST 616 OR 665)

Monday, 3:30pm - 5:30pm, other times by appointment.

READING MATERIAL:

- Printouts, PowerPoint presentations and research papers will be posted on http://moodle.njit.edu and will be distributed in the classroom and by email.
- Mark Latash. Neurophysiological Basis of Movement. Human Kinetics, 2008, ISBN-10: 0736063676.
- Excellent Matlab manuals are available online at http://www.mathworks.com/academia/student_center/tutorials/launchpad.html. Introductory Matlab textbook: Mastering MATLAB by D. Hanselman and B. Littlefield, ISBN-10: 0136013309.

COURSE OUTLINE

Recently, it has been shown for the first time that adult brain can be changed through intensive sensorimotor stimulation. In the nearest future, robotics- and virtual reality-based therapies will be designed that will be able to induce restoration of lost function in a damaged brain. Chronically-implanted electrodes will allow people with paralyzed or prosthetic limbs to control them with the force of their mind. These ongoing technological advances, as well as breakthroughs in neuroscience create unprecedented opportunities for a biomedical engineer to revolutionize neuromuscular rehabilitation. Moreover, new technologies will provide for a better understanding of how the brain controls movement and how movement diseases disrupt these control processes. This, in turn, will accelerate the progress in creating rehabilitative therapies. To be successful in this exciting emerging field, an engineer needs an in-depth knowledge of the human motor system. This course will blend muscle, spinal cord and brain neurophysiology, control theories and Matlab programming to get some understanding of the human motor system, with the emphasis on sensorimotor learning and neurorehabilitation. We will start with an introduction to the central nervous system. In the first part of the course, we will study muscle properties, spinal motor circuitry and dynamics of limb motion. This will allow us to understand some basic properties of the machinery that the brain has to control to execute movements. We will also discuss the principles of sensorimotor learning and neural plasticity. We will then focus on the experimental analysis

of arm movement kinematics and muscle electrical activity during reaching, grasping or balancing a stick. Our objective will be to learn how to relate the motor control problems with the neurophysiology of the motor system and to understand how motor disorders affect movement control. The students will be required to use Matlab and Simulink for their data analyses and simulations. This course is complementary with BME courses 671 - Biomechanics of Human Structure and Motion, 661 - Neural Engineering, and 673 – Biorobotics.

09/09 Lecture 1. Review of recent advances in neuromuscular engineering: brain-machine interfaces, deep brain and transcranial stimulation, brain imaging, muscle and brain implants. Introduction to the central nervous system.
09/16 Lecture 2. Skeletal muscle, motor unit and electromyography.
09/23 Lecture 3. Muscle receptors and spinal reflexes.
09/30 Lecture 4. Brain and spinal cord. Functional organization of perception and movement.
10/07 Lecture 5. Control of voluntary movement of a single muscle. Mathematical models.
10/14 Lecture 6. Control of voluntary movement. Primary and secondary motor areas.
10/21 Lecture 7 Sensorimotor brain maps. Brain plasticity and neurorehabilitation.
10/28 Lecture 8. Sensorimotor learning. Novel approaches in neurorehabilitation.
11/04 Lecture 9. Kinematic and electromyographic analysis of limb movement: Registration methods, data processing, hypotheses testing and statistics.
11/11 Lecture 10. Paper presentations and discussions.
11/18 Lecture 11. Paper presentations and discussions.
11/25 Lecture 12. Paper presentations and discussions.
12/02 Lecture 13 Kinematic analysis of a simple motor task.
12/9 Lecture 14 Simulink-based modeling of a single-joint neuromuscular system.

Final Report is due December 17. Students will be consulted on any modifications to the syllabus during the semester.

GRADING:
Class Participation, Lab Reports and Quizzes: 40 %, Presentation: 30%, Final Report: 30%.

NJIT HONOR CODE
The NJIT Honor Code will be upheld in this and all courses, and any violation will be brought to the immediate attention of the Dean of Students. The Honor Code can be found at http://www.njit.edu/academics/honorcode.php.

OUTCOMES:
Students will:

- Obtain basic knowledge of the neurophysiology of human movement and functional organization of the central nervous system.
- Understand the concepts of neuromuscular control from an engineering perspective.
- Learn basics of experimental data analysis in Matlab and basic modeling techniques through the use of Simulink.
- Improve their ability to read and understand scientific literature.