Course: ENPM808J – Rehabilitation Robotics
Semester: Summer 2016 (May 31 – August 19)
Day(s): Wednesday
Time: 5:30-8:45 pm
Location: TBD
Instructor: Dr. Anindo Roy
Phone: (410) 200-0894
Email: aroy1975@umd.edu

Course Description
This course provides an introduction to a field of robotics dedicated to improving the lives of people with disabilities. The course is designed for graduate students wishing to learn more about the rehabilitation robotics, an emerging and one of the fastest growing field of robotics. Rehabilitation robotics is the application of robots to overcome disabilities resulting from neurologic injuries and physical trauma, and improve quality of life. In contrast with other sub-specialties and/or courses in robotics, this course considers not only engineering design and development, but also the human factors that make some innovative technologies successful and others commercial failures. Engineering innovation by itself - without considering other factors such as evidence-based R&D and product acceptance – may mean that some technologies don't become or remain available, or are efficacious to aid their intended beneficiaries. This course differs from biomedical engineering in its focus on improving the quality of life, rather than improving their medical treatment.

Course Objectives: The course provides the students with a fundamental understanding of rehabilitation robotics. In particular, it provides the theoretical knowledge of automatic control systems deployed in rehabilitation robots and insight into selection of appropriate control systems based on different robots targeting different disability conditions. The course provides information about the design and development considerations underlying different rehabilitation robots taking into account clinical and biomechanical needs of the targeted disabilities. It introduces students to experimental techniques used in human movement science to enable understanding of how bioinstrumentation is used to evaluate human performance, a key aspect of characterizing the efficacy of rehabilitation robots. Through selected state-of-art literature, both research and commercial grade rehabilitation e robots are introduced to provide students with a thorough knowledge of the field to enable students anability to professionally work in this field. The course will take students through a “virtual” design and development process of example robots to study the engineering principles of robot subsystems (sensors, actuators, motors, and controller) to understand how the design decisions are made to achieve the subsystem and overall robot performance toward alleviating specific disabilities. This will include conceiving possible changes to the hardware design and/or controller to either improve human performance or motivate the next-generation of the device/s. The course will introduce students to ethical and regulatory guidelines in the field of rehabilitation robotics. At appropriate times during the course, the instructor will bring one or more robots into the classroom for viewing and/or demonstration/s.

ELMS Site or Course Webpage: ENPM808J will be using the CANVAS course environment this semester. Students can login to their course(s) by going to http://elms.umd.edu/page/student-support. A University online identity and password are required to access CANVAS. Information on your University password is available at http://www.it.umd.edu/password/. CANVAS offers many choices for notification about course activities. It is each student’s responsibility to set their communication preferences for their Canvas accounts. Information posted on CANVAS will govern course operation. Lectures, readings, videos, announcements, etc. will be put on CANVAS.

Required Technology: This is a lecture-based course with no lab, no clickers or software is needed.

Prerequisites: Basic understanding of classical feedback control system. No background or previous experience in robotics, human biomechanics, and neuroscience is required.

Method for Communication with Students Outside the Classroom: Students may communicate with the Instructor on CANVAS, or by email regarding class cancellation, room change, or other timely announcements.

Statement of Course Goals and List of Student Learning Outcomes
• Identify the parts of the human rehabilitation system.
• Develop understanding of common neurologic injuries such as stroke and their effects on physical function.
• Have a basic understanding of brain neuro-plasticity, motor learning models, and how rehabilitation robots take utilize neuro-plasticity driven learning to restore function.
• Develop a basic understanding of human biomechanics with an emphasis on walking.
• Understand bio-instrumentation techniques to quantify human movement to diagnose movement disorders and assess rehabilitation outcomes.
• Discuss types of rehabilitation robots, their classifications, and their applications.
• Understand different types of control systems (position, force, impedance), their pros vs. cons, and their suitability for different rehabilitation robotic applications requiring physical human-machine interaction control.
• Be able to use engineering principles to identify and address a specific rehabilitation need (disability), design and develop a virtual rehabilitation robot including its control system, and defend the solution.
• Develop skills to interpret clinical findings resulting from application of rehabilitation robots in the lab and clinic.
• Develop an appreciation of ethical and regulatory guidelines pertaining for testing with human subjects.

Course Schedule: The course will be conducted per the following basic schedule that is subject to minor changes if certain topics need higher emphasis and detail as the course progresses.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Week</th>
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<tbody>
<tr>
<td>Rehabilitation</td>
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<tr>
<td>1. Definition and perspectives; human rehabilitation system; types of functional impairments; concept of neuro-plasticity; principles and models of motor learning.</td>
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<tr>
<td>2. Gait biomechanics; types of walking disorders: bio-instrumentation and techniques of gait and balance functions.</td>
<td>2</td>
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<tr>
<td>Robotics</td>
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<tr>
<td>1. Terminology; taxonomy; challenges of blending and interaction control of robotic (precise system) with frail populations (uncertain system); examples of different rehabilitation robots.</td>
<td>3-4</td>
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<tr>
<td>2. Different controllers (position, force, impedance); pros and cons; considerations for choice of appropriate control system.</td>
<td>5-7</td>
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<tr>
<td>3. Concept and benefits of under-actuation; different engineering subsystems in rehabilitation robotics (sensors, controllers, actuators); pros and cons of different designs and operating principles in various rehabilitation research and commercial grade robots.</td>
<td>8</td>
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<tr>
<td>4. Solutions for stabilizing interaction during complex tasks such as robot-assisted walking; latest clinical findings and their interpretations regarding rehabilitation efficacy of robots commonly deployed in the clinic and research labs (clinical trials)</td>
<td>9-10</td>
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<td>5. Ethical guidelines for human subjects testing including clinical trials with rehabilitation robotics</td>
<td>11</td>
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Due Dates: Homeworks will be assigned as per the following schedule with solutions due one (1) week.

<table>
<thead>
<tr>
<th>Grading Event</th>
<th>Assigned</th>
<th>Due</th>
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<tbody>
<tr>
<td>Homework 1</td>
<td>End of week 2</td>
<td>End of week 3</td>
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<tr>
<td>Homework 2</td>
<td>End of week 4</td>
<td>End of week 5</td>
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<td>Homework 3</td>
<td>End of week 7</td>
<td>End of week 8</td>
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<tr>
<td>Homework 4</td>
<td>End of week 9</td>
<td>End of week 11</td>
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<tr>
<td>Final Exam</td>
<td>Week of Aug 1-19</td>
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Expectation for Students: Students are expected to fully participate in the course by attending all lectures (unless excused by the instructor in writing – see Attendance/Participation Policy), turn in their homeworks on time (see Grading Procedures), and be as interactive as possible in the lectures in terms of Q&A. These are toward supporting a successful student experience in the context of the course.

Grading Procedures: 4 homework assignments (15% each, total 60%), Final exam (40%).

Note on Late Assignments: Assignments that are submitted between 1 minute and 24 hours late will receive 75% of the credit. Assignments that are more than 24 hours late will receive 0% of the credit. Exceptions will be made in accordance with University policy regarding these major grading events.

Course Attendance/Participation Policy: Regular attendance at lectures is expected. Students are responsible for inquiring about and obtaining course material delivered in their absence (from course colleagues). University policy excuses the absences of students for illness (self or dependent), religious observances (see Policy Here), participation in University activities at the request of University authorities, and compelling circumstances beyond the student's control. Students must submit the request in writing and supply appropriate documentation, e.g.
medical documentation. Students with written, excused absences are entitled to a makeup exam (or assignments if applicable) at a time mutually convenient for the instructor and student. For more information, see UMD’s policy on medically necessitated absences from class.

**Written Absence Policy:** Students must submit the request in writing and supply appropriate documentation, e.g. medical documentation. Students with written, excused absences are entitled to a makeup exam (or assignments if applicable) at a time mutually convenient for the instructor and student. For more information, see UMD’s policy on medically necessitated absences from class.

**Arrangements for Students with Disabilities:** UMD is legally obligated to provide appropriate accommodations for students with disabilities. The campus’s [Disability Support Service Office](mailto:dissup@umd.edu) (DSS) works with students and faculty to address a variety of issues ranging from test anxiety to physical and psychological disabilities. If an instructor believes that a student may have a disability, DSS should be consulted (4-7682 or dissup@umd.edu). Note that to receive accommodations, students must first have their disabilities documented by DSS. The office then prepares an Accommodation Letter for course instructors regarding needed accommodations. Students are responsible for presenting this letter to their instructors by the end of the drop/add period.

**Copyright Notice:** Course materials that exist in a tangible medium, such as written or recorded lectures, Power Point presentations, handouts and tests, are copyright protected. Students may not copy and distribute such materials except for personal use and with the instructor's permission. Course materials may also be marked copyrighted (e.g. © 2016 Roy).

**Textbook(s)**


**Required:** No

There is no required textbook for this course. Teaching materials include instructor's own lecture slides and notes, and reading materials (selected journal and scientific conference proceeding articles). These will be posted on CANVAS at appropriate times.

**Course Outline**

The course content will be delivered sequentially in two parts: first, concepts on human rehabilitation and performance; and second, detailed knowledge on rehabilitation robotics. As rehabilitation is fairly broad, robotics for restoration of lower-limb function including gait and balance will be used as an example model throughout; however, both students will be exposed to knowledge of both upper- and lower-limb rehabilitation robotics.

- **Rehabilitation:** Definition and different perspectives; parts of the human rehabilitation system; types of functional impairments due to neurologic injuries; concept of neuro-plasticity; principles and models underlying motor learning (massed-practice, feedback, goal setting); gait biomechanics; types of walking disorders; and types of bio-instrumentation and techniques (measurement-analysis) of gait and balance functions.

- **Robotics:** Terminology and taxonomy (operating principle, population targeted etc.); interesting and unique challenges of blending and interaction control of robotic (precise system) with frail populations (uncertain system); concept and benefits of under-actuation; different engineering subsystems in rehabilitation robotics (sensors, controllers, actuators); pros and cons of different designs and operating principles in various rehabilitation research and commercial grade robots; different controllers (position, force, impedance) and their pros and cons; considerations for choice of appropriate control system; solutions for stabilizing interaction during complex tasks such as robot-assisted walking; latest clinical findings and their interpretations regarding rehabilitation efficacy of robots commonly deployed in the clinic and research labs (clinical trials); and ethical guidelines for human subjects testing including clinical trials with rehabilitation robotics.

**Code of Academic Integrity**

The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating on exams, cheating on clicker quizzes in lecture, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity of the Student Honor Council, please visit [http://shc.umd.edu/SHC/PledgeInformation.aspx](http://shc.umd.edu/SHC/PledgeInformation.aspx).