Synergy of Human and Robotic Systems

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Overview

- Course logistics
- Introduction
Course logistics
• Research website
  • http://users.wpi.edu/~zli11/index.html

• Office hour
  • 85 Prescott 223C
  • Thursday, 3:00-4:00pm

• Interested in lab research
  • Come to talk to me during office hour
Course website

- Course website
  - Course syllabus and schedule
  - Textbook & Reference resources

- Canvas
  - Course information and materials
  - Q&A, Discussion Forum
  - Course work submission, Grades
• Sihui Li
  • sli16@wpi.edu
  • 2nd year PhD

• Research focus
  • Shared autonomous tele-nursing robots
  • Teleoperation interfaces,
  • Learning from demonstration

• Office hour
  • Monday 3-4 pm, 224 at 85 Prescott
Pre-requisites

- Linear algebra

- Linux OS, bash commands, Git

- Matlab
  - Coding assignments
  - Data analysis, algorithm prototyping
What you expect to get from this course

- On both human and robot
  - Modeling, control and learning of human and robot motions
  - Applications on various human-robot system

- Theoretical topics
  - Robot Kinematics, robot learning algorithms

- Practical topics
  - Exoskeleton for stroke rehabilitation
  - EMG-controlled prosthetic arm
  - Intelligent tele-nursing robots
Pre-requisites

• Linear algebra
  • Matrix operations, dot products, cross products, etc.

• Linux OS, bash commands, Git

• Python Coding
  • Assignments – can be done in Matlab
  • Project coding – all in python!

• You may struggle if you don’t know it well
Recommended skills

• Big plus if you know it well
  • Robot kinematics
  • ROS, and ROS-based software
  • Computer vision (OpenCV)
  • Experience with real robots (Baxter, ReFlex SF hand, Mobile base)
  • Experience with RGDB cameras (Kinect, Realsense) and LIDAR
Reference books
Further readings

- The Computational Neurobiology of Reaching and Pointing
  A Foundation for Motor Learning
  Reza Shadmehr and Steven P. Wise

- HUMAN ROBOTICS
  NEUROMECHANICS AND MOTOR CONTROL
  ETIENNE BURDET, DAVID W. FRANKLIN, AND THEODORE E. MILNER

- MOTOR LEARNING AND CONTROL
  Concepts and Applications
  Richard Magill, David Anderson, Eleventh Edition
Your grade

- In-Class Participation and Preparation 10%
  - Attendance to lecture 3% + Active participation 7%.

- Quizzes 20%

- Assignments 25%

- Course project 35%
  - Project proposal 10% + Project proposal presentation 5%
  - Project report 10% + Final presentation 10%

- Literature review (report + presentation) 10%

- Extra credit
Quiz

• Quiz every lecture!
  • Given at the very beginning of the class
  • Be sure you are not late

• Make sure you prepare
  • Review slides and recorded lecture (Echo 360)
  • Do assignments

• Make sure your hand-writing is readable
In-class Participation

• Participation matters!

• Attending lectures
  • Count your attendance by quiz submission

• Ask and answer valuable questions in class and on Canvas
  • TA will take notes in class and count Q&A

• Help each other in projects
  • Teammates will evaluate each other
In-class participation

• To avoid miscalculation:
  • Check with TA for your participation records
  • Keep a log for your work

• Submit a note by the end of the course
  • A one-page description of how you have helped teams/classmates
  • Include a paragraph in project report to describe your contribution
Assignments

• Weekly Assignment
  • Math problems
  • Algorithm implementation
  • Individual paper review

• Assignments must be done individually!
Individual Paper Review

• Individual paper review assignment will be given every week
  • Assigned reading can be a paper or book chapter
  • Prepare a 6-8 pages presentation slides
    • Express your in-depth understanding either in slide notes, or submit an additional paper review report
    • No more than 2 pages, may include figures
    • Guideline for paper review – see course website: https://docs.google.com/document/d/1AipcpudCY48TmTwt2iOrt77LMgOnsHNmmNmMHOC2Nxg/pub
  • Good paper review will be selected for student talk
Student talk for individual paper review

- Select four best paper reviews from the class
  - Receive 100% for that paper review assignment

- Choose one to give a 5 min talk in every class
  - Extra credit as reward
  - Can be used to replace one quiz grade with 100% (any one you choose)
  - Consideration for grade boosting if you are on the edge
Each project team should conduct a literature survey

- **Assigned topic**, relevant to your project
- Read 10+ papers in depth on this topic
  - Divide the task among teammates
  - Start early and continue weekly discussion
- Compose a 10-page literature survey report
- Deliver a 20-min presentation
  - See course schedule for the dates of student talk on special topic.
Presentation for group paper review

• In-depth understanding of the paper you reviewed
  • Tentatively 20 minutes long + 5 minutes of questions
  • Similar to a conference talk

• Evaluated on
  • Depth of understanding
  • Clarity of presentation
  • Presentation skill (don’t run out of time!)
Course project

• This course is research-focused and project-orientated.

• Prepare you for doing independent research
  • Propose methodology (e.g. experimental protocol, algorithms)
  • Show your results
    • User study – data collection and analysis
    • Algorithm – simulation and implementation
    • Hardware development – demonstration
Choose your course project

- Select among the projects offered by the course
  - Introduction to course project – Lecture on Sept 5
  - Work in team

- Propose your own individual project
  - Pros: Project relevant to your thesis, or on-going research
  - Cons: You will be on your own
  - Need approval of the instructor
Choose course project

• Submit through google form – link will be published

• First and second choices

• Justification for your choices
  • Previous course work, project experience

• Preferred teammates
  • List three, with student’s name, major, contact email
Project Team

• Instructor will assign project team based on
  • Student’s choice & skills
  • Whether there are enough students to form a team

• Team size is proportional to project workload
  • 3-5 members per team
  • Led by TA and senior students in my lab
As a team you should ...

- Meet with instructor weekly for project discussion
- Meet weekly for literature review reading group

Your project will be evaluated by ...

- Mandatory – Project proposal, report, presentation, demonstration (if applicable)
- Optional, but highly recommended: research log, project website
  - Show the project website to your future employer/graduate advisor
Project leader – Kenechukwu C. Mbanisi

- Kenechukwu C. Mbanisi
  - kcmbanisi@wpi.edu
  - 3rd year PhD

- Research focus
  - Human motion modeling and learning
  - Human performance assessment
  - Human-vehicle interaction
Project leader – Alexandra Valiton

- Alexandra Valiton
  - arvaliton@wpi.edu
  - 2nd year PhD

- Research focus
  - Shared autonomous tele-nursing robot
  - Interactive perception
Project leader – Heramb Nemlekar

- Heramb Nemlekar
  - hsnemlekar@wpi.edu
  - 2nd year Master

- Research focus
  - Human-robot handover
  - High-level motion planning
Important!!!

- Submitted before **noon** of the due date.
  - Do not count late submission

- Check **Course Schedule** *frequently* for most up-to-date submission date

- Check **your grade** *frequently*. Before the end of the course, you can
  - Attend **office hour** if you need help
  - Ask for **extra work** if you want to make up for your low grade

- Keep in touch with instructor, TA, project team
  - Make sure you teammates know what you are working, because **they will evaluate you in the end**.
Academic integrity

- WPI policy
  - https://www.wpi.edu/about/policies/academic-integrity
  - Same penalty for all members involved.

- Do not risk your future
Introduction
Synergy = work better together!
Synergy – When redundancy exists
Synergy – When redundancy exists
Synergy in human and robotic systems
Theory and applications

• Theory
  • Motion modeling, control and learning of/between human and robots

• Applications
  • Of human – Exoskeletons and humanoid
  • By human – Teleoperated robots
  • For human – assistive robots
Synergy of human and robotic systems
Exoskeleton for Power Augmentation
Teleoperation – control and teaching robots
From physical world to virtual reality
Novel teleoperation interfaces
Humanoid
How to achieve human-robot synergy?
Course topics

• Bio-inspired mechanical design and motion control

• From teleoperation to shared-autonomous control

• Learning from human
Assignment 01
Assignment 01 – Due Aug 29 (Wed) by noon

• Introduce yourself to this course:
  • https://goo.gl/forms/IHIloJOFkYdRcQbh2

• Make sure you can access this course on Canvas

• Check the course syllabus and schedule
Assignment 01 – Due Sep 5 (Wed) by noon

• Review course topics
  • Chapters in the Handbook of Robotics, 2\textsuperscript{nd} Edition, 2016
    • CH 43 – Tele-robotics
    • CH 70 – Human-robot augmentation
    • CH 74 – Learning from humans
  • Fill the form: https://goo.gl/forms/E1PbfWzHvfH8Xnk53
Course work submission and format
Submission on Canvas

- Go to Canvas and click on Assignments.

- Choose respective assignment and submit zip (if coding is part of the assignment) or pdf (paper review)

- You can update your post until the time of the deadline!
Submission Format

• Applied to all the submission for this course
  • Assignments, project proposal, paper preview, reports, etc.

• Submit to Canvas
  • Post Title = use [LastName]_[FirstName]_[submission content]
  • Post Content = student’s name, student number, teammates
  • Attachment
    • Multi-file submission: include all document in a Single zip file
    • Single-file submission: attach to post directly

8/27/2018
Submission Format

- Simulation model and coding files
  - In one sub-folder
  - Necessary documentation

- Documents in pdf formats
  - Math problem, paper review, report
  - 11pt, single-spaced, with 1-inch margins
Submission Format

- Submission in an incorrect format
  - First time – warning
  - Second time – deduct 20% from the grade
  - Third time and more – Rejected without grading
Naming protocol

• Assignments
  • [LastName]_[FirstName]_HW_[Assignment number]

• Reports
  • [LastName]_[FirstName]_Report_[Report_title]

• Paper Reviews
  • [LastName]_[FirstName]_Review_[Report_title]
  • In the post, include title and author of the reviewed paper, with a link to the paper file.
Welcome, and enjoy!