Electrical Engineering 4330/7330

Introduction to Mechatronics and Robotic Vision

Prerequisite:
ECE 3220 (Computing for Embedded Systems),
or ECE 4220 (Real Time Embedded Computing),
or C/C++ programming language,
or instructor’s consent (and Linear Algebra!!).
Background: The portmanteau "Mechatronics" (mecha for mechanisms, andtronics for electronics) was first coined by Mr. Tetsuro Mori, a senior engineer at the Japanese company Yaskawa, in 1969. The term was originally created to designate the field of study of automata (self-operating machines) from an engineering perspective. Today, this interdisciplinary degree involves courses not only in mechanics, electronics, robotics and control engineering, but also in computer engineering, software engineering, communications, digital signal processing and even nanotechnology (MEMS) and biotechnology.

Being such a broad area, many universities around the world offer today either a specific four-year degree or a multi-disciplinary degree in Mechatronics Engineering – the latter is usually obtained by taking classes from departments such as ME, ECE, and CS. Since every mechatronic system requires a mechanism and the sensors/actuators to control such mechanism, in this introductory course, we will focus on three major topics, as explained next.

Course Description: Course focuses on: 1) mechatronic systems and their components; 2) the mathematical tools used to model industrial and mobile robots; and 3) vision sensors, their underlying models and the algorithms that allow us to control and interact with robots.

Lab: In the lab, students will gain practical experience in writing programs to control real robots: industrial and mobile robots. The students will develop Matlab, C and/or C++ code to interface with sensors such as cameras, sonars, contact, etc. and use that sensory information to guide the robots to perform simulated assembly tasks and indoor navigation. The sequence of lab experiments build on the previous ones and, by the end of the semester, the students will be able to develop a complete system that will allow teams to compete on a game involving vision-guided robotics.

Many handouts will be provided and the following references were put on reserve in the CoE Library and may be used throughout the semester:


**Prerequisites:** ECE 3220 (Computing for Embedded Systems), ECE 4220 (Real Time Embedded Computing), or C/C++ programming (and Matlab) – Linear Algebra!

**Course Grading:**

**Undergrad Students:**
- Midterm 25 points
- In-class Final Exam 35 points
- Programming and Lab assignments 30 points
- Continuous Assessment 10 points

**Grad Students:**
- Midterm 15 points
- In-class Final Exam 25 points
- Programming and Lab assignments 25 points
- Projects 25 points
- Continuous Assessment 10 points

Grad Students will be assigned two Projects: a small project on camera calibration and a larger one on their choosing. For Project 2, grad students will deliver a proposal by week 8th, present their project in week 15th and turn in a report in week 16th.

**Continuous Assessment:**
1. Attendance (participation)
2. Readiness tests (preparation)
3. Tutor observation during class and group work (preparation, participation, and process)
4. Submitted group work (product)
5. Peer assessment (prep. and participation)

**Grad Scale:**
- Undergrad students: A-to-F scale with +/-.
- Grad students: A, B, C, or F with +/-.
### Topics:

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<td>Industrial Robots</td>
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<td>Joint, Links, Denavit-Hartenberg Representation</td>
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<td>Visual Servoing: Image Based and Position Based</td>
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<td>Trajectory Planning</td>
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<td>Mobile Robots</td>
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<td>Structured and Unstructured Environments, Control Architectures, Vision-guided Navigation and Localization</td>
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<td>2</td>
<td>Robot Operating System (ROS)</td>
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<td>Publisher &amp; Subscriber</td>
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<td>Concepts and Practice (Packages)</td>
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<td>LeapMotion</td>
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**Total:** 38 lectures, 2 reviews, 2 exams, 2 days of student presentations

### Lab Assignments:

- **Lab Experiment 1:** Camera Calibration
- **Lab Experiment 2:** Bin-picking: Object Detection/Recognition and 3D Pose Estimation.
- **Lab Experiment 3:** D-H Representation, Forward and Inverse Kinematics
- **Lab Experiment 4:** ROS – Publisher and Subscriber
- **Lab Experiment 5:** ROS
  - a) LeapMotion
  - b) Puma control
- **Lab Experiment 6:** Robotic Competition (Robots Playing a “Basketball/Baseball” Game).
**Academic Dishonesty:** According to University policy, instructors are required to inform students of specific guidelines regarding cheating in their courses. Instructors are required by University policy to report incidents of cheating to the Office of the Provost. In compliance with this rule, all incidents of cheating by students in this course will be reported to the Office of the Provost for determination of possible disciplinary action. Any student found to have cheated during an exam or lab will be given an “F” grade for the class and the evidence will be sent to the Provost's Office. Students submitting the same or similar solutions to a programming homework will be given a 0 for the assignment and the evidence will be sent to the Provost's Office for determination of possible disciplinary action. Second occurrences of cheating in a homework will lead to an “F” grade for the class.

Unless an assignment is specifically structured as a group project, duplicate homework written in collaboration with others is not acceptable. Although it is permissible to discuss the homework with others, these discussions should be of a general nature. All work at a detailed level must be done on your own. *Students submitting the same or similar solutions to the homework will be considered as having cheated.* No statements or actions made by anyone can alter this policy.

**Statement on ADA:**

*Students with Disabilities:*
If you anticipate barriers related to the format or requirements of this course, if you have emergency medical information to share with me, or if you need to make arrangements in case the building must be evacuated, please let me know as soon as possible.

If disability related accommodations are necessary (for example, a note taker, extended time on exams, captioning), please establish an accommodation plan with the Disability Center ([disabilitycenter.missouri.edu](http://disabilitycenter.missouri.edu), SS Memorial Union, 573- 882-4696), and then notify me of your eligibility for reasonable accommodations. For other MU resources for persons with disabilities, visit [ada.missouri.edu](http://ada.missouri.edu).

**Written Laboratory Report Format:** A formal project report from each laboratory team is to be submitted to your lab instructor. Each lab team is required to submit one team report per lab project. The lab report flow should be logical in that each step in the lab should be documented in the order conducted. The format for written reports will be determined by the lab instructor.
LAB ORGANIZATION:

1. Each student will perform the following tasks:
   a) Prelab report
   b) Programming
   c) Postlab report.

2. Each student should work independently and should NOT give their programs to others. Students are responsible for possible “proliferation” of their programs. Any violation will lead to penalty.

LAB TASKS:

1. Prelab Report:
   a) Write pseudo code or a flow chart for the program. Pseudo code should be structured and descriptive rather than technical.
   b) Other specific works assigned in the lab handout.
   c) The pseudo code or the flow chart must be turned in at the beginning of the lab period.
   d) The report must be typed.

2. Lab Work:
   a) Your T.A. will check your program during the lab period.
   b) If the program works completely following the program requirements, you will earn 50 points.
   c) Partial credits will be earned upon the work progress.

3. Postlab Report:
   a) Due by next lab period.
   b) Lab report format:
      i. Abstract
      ii. Objective
      iii. Background/Theory
      iv. Procedures
      v. Results
      vi. Conclusions
      vii. Appendices (e.g. programs).
   c) Report must be clear and neat. Programs must be structured and commented adequately. The conclusions should contain what the overall experiment taught you, specific concepts learned from the lab and, if the lab did not work, why.
   d) The report must be submitted directly to the TA. The .c and .cpp files must be included separately from the report, which may be in MS Word, or PDF format. No late reports will be accepted.
LAB GRADING:

1. Each experiment is worth 100 points including LAB 1.

2. Experiments are graded as follows:
   a) Prelab 10 points
   b) Program 50 points
   c) Postlab 40 points (No credit for late report)

i. For the lab work (Program):
   50 points, if completed during the lab period
   30 points, if completed before the next lab period
   No credit for labs which work after the next lab period.

ii. Postlab report grading guide lines:
    Objective 5 points
    Program 20 points
    Conclusion 15 points.

iii. There may be lab quizzes during the semester to check team participation.

COMPUTER FACILITY:

The lab sessions will be held in Lafarree C1246. The combination to the door will be given in class.

LAB REGULATIONS:

1. No food or drink in the lab.
2. Do not give lab combination to others.
3. Do not leave your own software or programs on the computers in the lab.
4. Do not put backpacks etc. on the computer keyboards or mice.
## Fall 2017

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**Mid-Term – Oct 11th**

| Week 8 |      | Session |      |      |      |      |
| Week 9 |      | Report | Session (Pre) |      |      |      |
| Week10 |      |      | Session |      |      |      |
| Week11 |      | Report | Session (Pre) |      |      |      |
| Week12 |      |      | Session |      |      |      |
| Week13 |      | Report | Session (Pre) |      |      |      |

**Thanksgiving Break (Nov.20 - Nov.24)**

| Week15 |      | Student Project Pre-Report |      | Session |
| Week16 |      | Student Project Presentations |      | Report |

**FINAL EXAM:** TBA (Final Project Report)