CS 4610/5335: Robotic Science and Systems (Spring 2020)

1 General Information

Time: Monday, Wednesday 2:50–4:30 Location: 109 Robinson Hall

2 Teaching Staff

- **The preferred platform for asking questions and contacting staff is Piazza.**
- If e-mail contact is necessary (e.g., sending attachments),
  the preferred e-mail address that reaches all staff is `cs46105335-staff@ccs.neu.edu`.
- Only e-mail individual staff if absolutely necessary (e.g., confidential issue), and note that response will typically be slower than contacting all staff via Piazza or the staff mailing list.

Role	Name and E-mail	Office Hours	Location
Instructor	Lawson L.S. Wong `lsw@ccs.neu.edu`	Fri 3:30-5:30 and by appointment	513 ISEC
TA	Akshay Patil `patil.aks@husky.neu.edu`	Tue 5-7	3rd Floor, WVH
TA	Ziyi Yang `yang.ziyi2@husky.neu.edu`	Thu 12-2	3rd Floor, WVH
TA	Saumya Shah `shah.saumy@husky.neu.edu`	Sat 12-2	1st Floor, WVH

3 Course Overview

This course will introduce students to the theory and practice of robotics, including the broad areas of kinematics, motion planning, estimation, control, perception, and learning.

The above topics only cover a small portion of the entirety of robotics, and do not even cover all of the fundamentals (prominent topics that will not be covered include dynamics). However, by the end of the course, students will have developed a sufficiently broad set of technical tools, that will enable them to solve many real-world problems, self-learn additional techniques, and pursue further specialized courses in robotics.

The course material will focus on problem formulation, models, and algorithms. Applications will be discussed when relevant, but will not be the focus of the content. However, in the spirit of experiential learning, there will be significant opportunities for implementation and application, through the programming assignments and the project.

4 Textbook and Reference Materials

The main textbook is *Robotics, Vision and Control* (RVC; 2nd edition), by Peter Corke. This textbook gives a broad introductory overview of most topics that are covered in this class. Additionally, the programming assignments in this class make use of the Robotics Toolbox (to be used with MATLAB), which was also created by Peter Corke. The textbook contains many examples using this toolbox which can be easily explored outside lectures.

Northeastern students have free access to the PDF of the textbook:
`https://link-springer-com.ezproxy.neu.edu/book/10.1007%2F978-3-319-54413-7`
Take note to obtain the *second* edition of the textbook; it should say so on the right-hand side of the cover.

Although the textbook gives a broad overview of many topics, we will occasionally cover topics more deeply than contained in the textbook. The following optional references provide much greater depth into various topics.

- *Planning Algorithms*, by Steven M. LaValle. (Free PDF available)
  `http://planning.cs.uiuc.edu`
- *Probabilistic Robotics*, by Sebastian Thrun, Wolfram Burgard, and Dieter Fox.
  `http://www.probabilistic-robotics.org`
- *Reinforcement Learning* (2nd edition), by Richard S. Sutton and Andrew G. Barto. (Free PDF available)
  `http://www.incompleteideas.net/book/the-book-2nd.html`
- *Springer Handbook of Robotics* (2nd edition), edited by Bruno Siciliano and Oussama Khatib. (Free PDF available)
  `https://link-springer-com.ezproxy.neu.edu/book/10.1007%2F978-3-319-32552-1`

5 Prerequisites

- All programming assignments must be completed in MATLAB, using the Robotics Toolbox (version 10). MATLAB 2019b is recommended. You do not need to know MATLAB already, but we expect you to have sufficient familiarity with programming that you can learn to use MATLAB yourself via online resources and MATLAB's helpful and extensive documentation.
- Familiarity with mathematical concepts, including linear algebra, calculus, probability, and optimization.
- Previous experience with robotics is helpful but absolutely not required.

6 Announcements and Discussion

Course material and announcements will be posted on Piazza. The site also offers an excellent discussion forum, where both instructors and fellow students can answer questions. Everyone is encouraged to participate. Questions/notes can be posted anonymously or with identity, and may also be posted privately only to instructors. Note that posting questions/notes via Piazza will most likely result in faster responses compared to e-mailing individual instructors. Piazza sign-up link:
`http://piazza.com/northeastern/spring2020/cs46105335`

Grades will be posted on Blackboard.

7 Coursework

Exercises and projects will each constitute 50% of the final grade.

- Exercises will be assigned biweekly ($\sim$ 4–5 total) are based on the previous unit's material (roughly two weeks of lectures). Students may discuss the problems with other students, but must write up their own solutions. On each assignment, please also indicate who you discussed with (if any).
  Lateness: Up to two days late (24-hour period), penalized by 10% per day.
- The project offers an opportunity to apply learned techniques on a substantial problem that interests the student. Students will form teams of 2–4 (3 is strongly recommended), and will be working on actual robot hardware. Projects will be designed and shaped in consultation with course staff throughout the semester, depending on the choice of hardware, the interests of the team, and the team members' expertise. Approximately once every two weeks one lecture will be designated as a "lab" session, where class time will be spent working on projects, and course staff will consult with individual teams to monitor progress and tackle challenges; participation in these sessions is important and expected. The project will culminate in both a final presentation and a team report. Additional presentations and reports may be assigned during the semester with advance notice.

8 Academic Integrity

Cheating and other acts of academic dishonesty will be referred to OSCCR (office of student conduct and conflict resolution) and the Khoury College of Computer Sciences.

9 Schedule (subject to change; version 20200218)

Date	#	Topic	Reference (RVC)	Assignments due
1/6	1	Course overview	Ch. 1	
		Kinematics and Motion Planning	*RVC Part I and III*	
1/8	2	Transformations	Ch. 2	
1/13	3	Kinematics	Ch. 2, 7.1	
1/15	4	Inverse kinematics	Ch. 7.2	
		Lab: Form teams		
1/20		MLK Day (no class)		
1/22	5	Motion planning	Ch. 5	
1/27	6	Sampling-based motion planning	Ch. 5.2.4, 5.2.6	
1/29	7	Rapidly-exploring random trees	Ch. 5.2.6	Ex 1
		Lab: Start Piazza project thread		
		Estimation, SLAM, and Control		
2/3	8	Localization	Ch. 6.7	
2/5	9	Kalman filtering	Ch. 6.2, Appendix H	
2/10	10	Kalman filtering (1-D)	Ch. 6.2, Appendix H	
2/12	11	Kalman filtering (n-D)	Ch. 6.3–6.6	
2/17		Presidents' Day (no class)		
2/19	12	Mapping and SLAM	Ch. 6.3–6.6	
2/24	13	*Lab: Robot building*		
2/26	14	*Lab: Robot motion*		
3/2		Spring break (no class)		
3/4		Spring break (no class)		
		Robot Vision and Learning	*RVC Part IV and V*	
3/9	15	Robot vision	Ch. 10–14	Ex 3
3/11	16	Robot vision	Ch. 10–14	
3/16	17	Robot vision	Ch. 10–14	
3/18	18	*Lab: Milestone*		Ex 4
3/23	19	Robot learning		
3/25	20	Robot learning		
3/30	21	Robotics research		Ex 5
4/1	22	*Lab: Final*		
		Project		
4/6		*Project presentations*		
4/8		*Project presentations*		
4/13		*Project presentations*		
4/15		*Project presentations?* (or no class)		