ENPM 673
Spring 2022

Perception for Autonomous Robots

Course Overview

This course offers a foundation in computer vision. The students will learn techniques and algorithms that can be used to solve an abundance of perception problems. This course is dedicated to anyone interested in giving their autonomous system (e.g. robot, autonomous driving car, or simply a smart camera) means to understand their surrounding world. Throughout the projects of this course students will gain hands-on experience in solving real-life problems such as lane detecting for autonomous driving, computing velocities of moving objects, and building a 3D model of an object using 2D images from cameras. Moreover, students will gain experience with state-of-the-art tools such as programming using OpenCV and Python.

Learning Outcomes

After successfully completing this course, you will be able to:

- Find the trend line that best fits a series of data points (curve fitting)
- Detect important features in images such as corners, edges, straight lines and others
- Segment images into background and foreground
- Estimate 3D information of objects based on their 2D images
- Estimate motion metrics of objects such as speed and direction of motion using camera feed
- Perform Simultaneous Localization And Mapping (SLAM) for mobile robot

Dr. Samer Charifa
scharifa@umd.edu

Class Meets
Tuesdays
Times and locations:
depend on the session

Office Hours
Tuesdays on 9-10 AM (Zoom)
and by appointment

Teaching Assistants
Mr. Gokul Hari
Email: hgokul@umd.edu
Office hours: Thursday (6-7 PM)
Ms. Sakshi Kakdi
Email: sakshi@umd.edu
Office hour: Monday (7-8 PM)

Mr. Jayesh Jayashankar
Email: jayeshj@umd.edu

Prerequisites
Proficiency in a programming language is required and familiarity with Python is very helpful. Programming fundamentals will have to be acquired independently.

Course Communication
Please contact by email for time sensitive matters. ELMS discussion boards will be used for discussing questions that pertain to the entire class

Required Resources

Course website: ENMP 673 course will use CANVAS course environment. Students can login to their course(s) by going to http://elms.umd.edu

Readings:

There is no textbook for this class however students should use the notes published on the class website, as well as any extra reading material that is sometimes associated with each lecture note posted on the course website.

Hardware/Software:

Hardware: Any reasonably modern computer will be good.

Software: Python 3.x with OpenCV. During the course the students will be provided will instructions on how to install these software packages.

Supplemental Resources

Readings

The following is a list of books that cover the course material:

1. **Computer Vision**
   Author: Lidar Shapiro and George Stockman
   ISBN-13: 978-0130307965
2. **Learning OpenCV**
   Author: Adrian Kaehler and Gary Bradski
   ISBN-13: 978-0596516130
3. **Computer Vision: Algorithms and Applicati**on, Richard Szeliski
   Online: http://szeliski.org/Book/
4. **Computer Vision: A Modern Approach**
   David Forsyth and Jean Ponce, 2nd Edition, 2012
   Online: http://www.csd.uwo.ca/~olga/Courses/Winter2010/CS4442_9542b/CVbook.pdf
5. **Robotics, Vision and Control: Fundamental Algorithms in MATLAB**
   Peter Corke: 2013,
   online: http://www.petercorke.com/RVC/index.php
   http://link.springer.com/book/10.1007%2F978-3-642-20144-8
6. **Multiple View Geometry in Computer Vision**
   Richard Hartley and Andrew Zisserman University Press, 2004,
   selected chapters available online: http://www.robots.ox.ac.uk/~vgg/hzbook/
7. **Computer Vision: Models, Learning, and Inference**
   Author: Simone Prince
   http://www.computervisionmodels.com/
   ISBN-13: 978-1107011793
   Publisher: Cambridge University Press

Hardware/Software:

Basic knowledge of Python programming language.

Campus Policies

It is our shared responsibility to know and abide by the University of Maryland's policies that relate to all courses. Please visit https://academiccatalog.umd.edu/graduate/policies/academic-record/ for the Office of Graduate Studies' list of campus-wide policies.

Activities, Learning Assessments, and Expectations

- The course work is organized around **four** projects and one homework. Through these projects, students will learn the theory and practical skills required in computer vision engineering.
- The programming language for this course is Python with OpenCV.
- All projects and the homework are intended to be done individually.
- Assignments can be found in the Syllabus section of the course website, as well as under Files.
- **Homework 1** is graded for 10% of the total grade
- **Projects** are graded for 60% of the total grade
- **Mid-term exam** is graded for 30% of the total grade

Course Specific Policies

- Students are encouraged to plan ahead and submit their homework and projects on time. Late submissions will be accepted within 5 days of the deadline, but with a 30% reduction in points.
- All projects and the homework are intended to be done in groups of up to three.
- The programming language for this course is Python with OpenCV.
- Please ensure that your solutions run on vanilla Ubuntu 16.04 with the built-in Python executable (i.e. no Anaconda-specific submissions please). Solution should be using Python 3.x format only.
- Please DO NOT hardcode any file paths in your submissions, ensure relative path names only or use the Python argument parser.
- If there is any built-in functionality, from any library, that directly solves a part of the assigned question for you, then you are **not** allowed to use that function. This rule applies to the homework and projects.

Accessibility and Reasonable Accommodations

The University of Maryland is committed to creating and maintaining a welcoming and inclusive educational, working, and living environment for people of all abilities. The University of Maryland is also committed to the principle that no qualified individual with a disability shall, on the basis of disability, be excluded from participation in or be denied the benefits of the services, programs, or activities of the University, or be subjected to discrimination. The University of Maryland provides reasonable accommodations to qualified individuals. Reasonable accommodations shall be made in a timely manner and on an individualized and flexible basis.

Discrimination against individuals on the grounds of disability is prohibited. The University also strictly prohibits retaliation against persons arising in connection with the assertion of rights under this Policy.

Accessibility & Disability Service (ADS) facilitates reasonable accommodations to qualified individuals. For assistance in obtaining an accommodation, contact Accessibility and Disability Service at 301.314.7682, or adsfrontdesk@umd.edu. More information is available from the Counseling Center.

Get Some Help!

You are expected to take personal responsibility for your own learning. This includes acknowledging when your performance does not match your goals and doing something about it. Everyone can benefit from some expert guidance on time management, note taking, and exam preparation, so I encourage you to consider visiting http://ter.ps/learn and schedule an appointment with an academic coach. Sharpen your communication skills (and improve your grade) by visiting http://ter.ps/writing and schedule an appointment with the campus Writing Center. Finally, if you just need someone to talk to, visit http://www.counseling.umd.edu.

Everything is free because you have already paid for it, and **everyone needs help**… all you have to do is ask for it.

Names/Pronouns and Self Identifications

The University of Maryland recognizes the importance of a diverse student body, and we are committed to fostering equitable classroom environments. I invite you, if you wish, to tell us how you want to be referred to both in terms of your name and your pronouns (he/him, she/her, they/them, etc.). The pronouns someone indicates are not necessarily indicative of their gender identity. Visit trans.umd.edu to learn more.

Additionally, how you identify in terms of your gender, race, class, sexuality, religion, and dis/ability, among all aspects of your identity, is your choice whether to disclose (e.g., should it come up in classroom conversation about our experiences and perspectives) and should be self-identified, not presumed or imposed. I will do my best to address and refer to all students accordingly, and I ask you to do the same for all of your fellow Terps.

Grades

Grades are not given, but earned. Your grade is determined by your performance on the learning assessments in the course and is assigned individually (not curved).

All assessment scores will be posted on the course ELMS page. If you would like to review any of your grades (including the exams), or have questions about how something was scored, please email your TA first, and then email me if the issue is still not handled.

Students are encouraged to plan ahead and submit their homework and projects on time. Late submissions will be accepted within 5 days only of the deadline, but with a 30% reduction in points.

Final Grade Cutoffs									
A	91.00%	B	80.00%	C	74.00%	D	60.00%	F	<60.0%

Course Schedule

This following is the outlines and timetable for the course. This is a tentative table and subject to change throughout the course:

DATE	TOPIC	ASSIGNMENT DUE DATE
Week 1: (1/25/2022)	1.a Class Overview, Sensors, Robots and Perception. 1.b Image Formation, Lenses Properties, and Essential Definitions	Software installation, OpenCV with Python 3.x. is required
Week 2: (2/1/2022)	1.a Linear Algebra, Estimation (LS, TLS, Regularization, RANSAC) 2.b Image Filters, Convolution, and Correlation	
Week 3: (2/8/2022)	3.a Edge Detection 3.b Homography Estimation	
Week 4: (2/15/2022)	4.a Features: Corners, SIFT 4.b Fourier Transform, Histograms	Homework 1 is due,
Week 5: (2/22/2022)	5.a Projective Geometry 5.b Camera Calibration	
Week 6: (3/1/2022)	6.a Rigid Body Transforms 6.b Projective Geometry	
Week 7: (3/8/2022)	7. MidTerm Exam	Project 1 is due
Week 8: (3/22/2022)	8.a Image Segmentation: Graphs, Mean Shift 8.b Image Segmentation: Probabilistic Models	
Week 9: (3/29/2022)	9.a Introduction to Deep Learning	

	9.b Segmentation Using Deep Learning	
Week 10: (4/5/2022)	10.a Epipolar Geometry 10.b Stereo	Project 2 is due
Week 11: (4/12/2022)	11.a Image Motion 11.b Tracking	
Week 12: (4/19/2022)	12.a Probabilistic Markov localization, Particle Filter 12.b SLAM, Kalman Filter	
Week 13: (4/26/2022)	13.a Object Recognition for Specific Objects 13.b Object Recognition with Machine Learning	Project 3 is due
Week 14: (5/3/2022)	14 Texture	
Week 15: (5/10/2022)	15.a Registration 15.b Range Data	
(5/17/2022)		Project 4 is due