JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Computer Science EN.601.461/661
Computer Vision
Fall, 2020 (3 credits, EQ)

Instructor

Professor Greg Hager, hager@cs.jhu.edu, https://www.cs.jhu.edu/~hager/
Office: Malone 341
Office hours: Tuesdays and Wednesdays 5-6 (sign up here) or by appointment – contact Tracy Marshall tmarshall@jhu.edu

Teaching Assistant

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Office: Malone 260
Office hours: Mondays and Fridays 5-6pm or by appointment

Meetings

Tuesday, Thursday, 12:00-1:15, Zoom Meeting ID: 928 2586 5189; passcode: 801061

Textbook

There is no single text that covers all of the material in this course. Here are a few that we will make reference to and which, in aggregate cover all of the relevant aspects of computer vision:

Optional: R. Szeliski, *Computer Vision*, Springer (2011).
Optional: Forsyth and Ponce, *Computer Vision: A Modern Approach, 2nd Edition,* Prentice Hall (2012).
Optional: Hartley and Zisserman, *Multiple View Geometry in Computer Vision*, Cambridge University Press (2010).
Optional: Goodfellow, Bengio, Courville, *Deep Learning*, MIT Press, 2016. Also online at https://www.deeplearningbook.org

Online Resources

This term we will be using Piazza for class discussion. All online resources will be posted there. Rather than emailing questions to the teaching staff, I encourage you to post your

questions on Piazza. If you have any problems or feedback for the developers, email team@piazza.com.

Our class signup link is: https://piazza.com/jhu/fall2020/en601461661

Course Information

This course gives an overview of fundamental methods in computer vision from a computational perspective. Methods studied include: camera systems and their modelling, computation of 3-D geometry from binocular stereo, motion, and photometric stereo, and object recognition, image segmentation, and activity analysis. Elements of machine learning and deep learning are also included.

- **Prerequisites**
  - Intro. Programming (EN.600.107 or the equivalent)
  - Linear Algebra (AS.110.201 or the equivalent)
  - Prob/Stat (AS.550.311 or the equivalent)
- **Elective**

Course Goals

This course is intended for advanced undergraduates and early stage graduate students (MS and/or Ph.D.). We require a mathematical background (e.g., calculus, linear algebra, some knowledge of probability and statistics) and the ability to program in Python. This will be a very hands-on course where we will both learn AND program the concepts we are learning. Computer Vision is as much about application as it is about theory. If you are unsure about your background, please email the instructor. We aim to give you hands-on experience in applying scientific principles to physically-grounded systems and learn to work in groups and present your work in a clear and concise fashion.

Specific Outcomes for this course are that

- Students will learn the mathematical fundamentals of computer vision
- Students will become acquainted with the modern programming tools for computer vision
- Students will learn the best practices of develop computer vision systems
- Students will experience team-based project development which will require developing a proposal, creating a project schedule, developing a solution, and presenting their solution in oral and written form.

This course will address the following Criterion 3 Student Outcomes

1. Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions.
2. Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.

3. Communicate effectively in a variety of professional contexts.
4. Recognize professional responsibilities and make informed judgments in computing practice based on legal and ethical principles.
5. Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.
6. Apply computer science theory and software development fundamentals to produce computing-based solutions.

Course Topics

- image formation
- image processing
- edge detection
- feature detection
- image alignment
- image geometry
- camera calibration
- stereo vision
- structure-from-motion
- optical flow
- visual tracking
- object recognition
- deep learning (DL)
- DL image classification
- DL semantic segmentation
- DL object detection
- DL activity recognition
- DL style transfer

Course Expectations & Grading

Course grades will be calculated based on out-of-class homework assignments, weekly lab/programming assignments, a midterm exam, a final project and in-class quizzes. There will be three homework assignments and each assignment will be assigned a point value. For the final project, there will be a brief project proposal due during the early stages of the semester. You are expected to work on the final project of your choice throughout the semester and you will give final presentations during the designated final exam period for this course. More details about the project will be provided on a final project description. There will be weekly quizzes and python notebooks with useful practical exercises. You are expected to finish the quizzes in class and the notebooks on your own time. Each quiz/notebook will be assigned a point value and the lowest three grades will be dropped.

30% Homework assignments

20% Exam

30% Final project

10% Weekly quizzes (Policy - drop the lowest three)

10% Weekly coding exercises (Policy - drop the lowest three)

Key Dates

The class schedule will be available on Piazza.

Assignments & Readings

Assignments and readings will be available on Piazza

Ethics

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Ethical violations include cheating on exams, plagiarism, reuse of assignments, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition.

In this course, you must be honest and truthful, abiding by the *Computer Science Academic Integrity Policy*:

> Cheating is wrong. Cheating hurts our community by undermining academic integrity, creating mistrust, and fostering unfair competition. The university will punish cheaters with failure on an assignment, failure in a course, permanent transcript notation, suspension, and/or expulsion. Offenses may be reported to medical, law or other professional or graduate schools when a cheater applies.
>
> Violations can include cheating on exams, plagiarism, reuse of assignments without permission, improper use of the Internet and electronic devices, unauthorized collaboration, alteration of graded assignments, forgery and falsification, lying, facilitating academic dishonesty, and unfair competition. Ignorance of these rules is not an excuse.
>
> Academic honesty is required in all work you submit to be graded. Except where the instructor specifies group work, you must solve all homework and programming assignments without the help of others. For example, you must not look at anyone else's solutions (including program code) to your homework problems. However, you may discuss assignment specifications (not solutions) with others to be sure you understand what is required by the assignment.
>
> *If* your instructor permits using fragments of source code from outside sources, such as your textbook or on-line resources, you must properly cite the source. Not citing

it constitutes plagiarism. Similarly, your group projects must list everyone who participated.

Falsifying program output or results is prohibited.

Your instructor is free to override parts of this policy for particular assignments. To protect yourself: (1) Ask the instructor if you are not sure what is permissible. (2) Seek help from the instructor, TA or CAs, as you are always encouraged to do, rather than from other students. (3) Cite any questionable sources of help you may have received.

On every exam, you will sign the following pledge: "I agree to complete this exam without unauthorized assistance from any person, materials or device. [Signed and dated]". Your course instructors will let you know where to find copies of old exams, if they are available.

This course will often involve group work for some homework and projects. It is expected that each group will perform the assigned work on their own, and each member will equitably collaborate to perform the assigned work. There should be no "free riders." Each student will be asked to document their contributions to a shared assignment or project. If there are concerns related to a student's compliance with this policy, you may contact the instructor. If you wish to remain anonymous you may contact the director of undergraduate studies (Joanne Selinski, joanne@cs.jhu.edu) who will anonymously pass along your concerns to the instructor.

Report any violations you witness to the instructor. You may consult the associate dean of student conduct (or designee) by calling the Office of the Dean of Students at 410-516-8208 or via email at integrity@jhu.edu. You can find more information about university misconduct policies on the web at these sites:

- For undergraduates: https://studentaffairs.jhu.edu/policies-guidelines/undergrad-ethics/
- For graduate students: http://e-catalog.jhu.edu/grad-students/graduate-specific-policies/

Personal Wellbeing

- If you are sick please notify me by email so that we can make appropriate accommodations should this affect your ability to attend class, complete assignments, or participate in assessments. The Student Health and Wellness Center is open and operational for primary care needs. If you would like to speak with a medical provider, please call 410-516-8270, and staff will determine an appropriate course of action based on your geographic location, presenting symptoms, and insurance needs. Telemedicine visits are available only to people currently in Maryland. See also https://studentaffairs.jhu.edu/student-life/student-outreach-support/absences-from-class/illness-note-policy/

- The Johns Hopkins COVID-19 Call Center (JHCCC), which can be reached at 833-546-7546 seven days a week from 7 a.m. to 7 p.m., supports all JHU students, faculty, and staff experiencing COVID-19 symptoms. Primarily intended for those currently within driving distance of Baltimore, the JHCCC will evaluate your symptoms, order testing if needed, and conduct contact investigation for those affiliates who test positive. More information on the JHCCC and testing is on the coronavirus information website.
- All students with disabilities who require accommodations for this course should contact me at their earliest convenience to discuss their specific needs. If you have a documented disability, you must be registered with the JHU Office for Student Disability Services (385 Garland Hall; 410-516-4720; http://web.jhu.edu/disabilities/) to receive accommodations.
- Students who are struggling with anxiety, stress, depression or other mental health related concerns, please consider connecting with resources through the JHU Counseling Center. The Counseling Center will be providing services remotely to protect the health of students, staff, and communities. Please reach out to get connected and learn about service options based on where you are living this fall at 410-516-8278 and online at http://studentaffairs.jhu.edu/counselingcenter/.
- Student Outreach & Support will be fully operational (virtually) to help support students. Students can self-refer or refer a friend who may need extra support or help getting connected to resources. To connect with SOS, please email deanofstudents@jhu.edu, call 410-516-7857, or students can schedule to meet with a Case Manager by visiting the Student Outreach & Support website and follow "Schedule an Appointment".

Classroom Climate

As your instructor, I am committed to creating a classroom environment that values the diversity of experiences and perspectives that all students bring. Everyone here has the right to be treated with dignity and respect. I believe fostering an inclusive climate is important because research and my experience show that students who interact with peers who are different from themselves learn new things and experience tangible educational outcomes. Please join me in creating a welcoming and vibrant classroom climate. Note that you should expect to be challenged intellectually by me, the TAs, and your peers, and at times this may feel uncomfortable. Indeed, it can be helpful to be pushed sometimes in order to learn and grow. But at no time in this learning process should someone be singled out or treated unequally on the basis of any seen or unseen part of their identity.

If you ever have concerns in this course about harassment, discrimination, or any unequal treatment, or if you seek accommodations or resources, I invite you to share directly with me or the TAs. I promise that we will take your communication seriously and to seek mutually acceptable resolutions and accommodations. Reporting will never impact your course grade. You may also share concerns with the Department Head (Randal Burns,

randal@cs.jhu.edu), the Director of Undergraduate Studies (Joanne Selinski, joanne@cs.jhu.edu), the Assistant Dean for Diversity and Inclusion (Darlene Saporu, dsaporu@jhu.edu), or the Office of Institutional Equity (oie@jhu.edu). In handling reports, people will protect your privacy as much as possible, but faculty and staff are required to officially report information for some cases (e.g. sexual harassment).

Family Accommodations Policy

You are welcome to bring a family member to class on occasional days when your responsibilities require it (for example, if emergency child care is unavailable, or for health needs of a relative). In fact, you may see my children in class on days when their school is closed. Please be sensitive to the classroom environment, and if your family member becomes uncomfortably disruptive, you may leave the classroom and return as needed.

University Policy on Incompletes

The university recognizes that the Fall 2020 semester is surrounded with uncertainty and many students may find themselves in unexpected situations where study is difficult if not impossible. Students who are confronted with extraordinary circumstances that interfere with their ability perform their academic work may request an incomplete grade from the instructor. While approval of such a request is not automatic, it is expected that faculty will make every effort to accommodate students dealing with illness in the family and other pandemic-related hardships. The instructor and student must establish a timetable for submitting the unfinished work with a final deadline no later than the end of the third week of the Spring 2021 semester (**February 12, 2021**). Exceptions to this deadline require a petition from the instructor to the student's academic advising office by February 12, 2021. When entering an Incomplete grade in SIS, faculty must include a reversion grade which represents the grade the student will receive if s/he does not complete the missing work by the agreed-upon deadline.

Deadlines for Adding, Dropping and Withdrawing from Courses

Students may add a course up to **September 11, 2020**. They may drop courses up to **October 12, 2020** provided they remain registered for a minimum of 12 credits. Between **October 12 and November 13, 2020**, a student may withdraw from a course with a W on their academic record. A record of the course will remain on the academic record with a W appearing in the grade column to indicate that the student registered and then withdrew from the course.

For more information on these and other academic policies, see https://e-catalogue.jhu.edu/engineering/full-time-residential-programs/undergraduate-policies/academic-policies/grading-policies/