CAP 6415: Computer Vision

CRN 15066, Section 901, 3 Credit Hours

Computer Science and Engineering

COURSE SYLLABUS

Instructor:	Prof. Sudeep Sarkar	Term & Year:	Spring 2020
Phone:	813 974 2113	Class Days:	Tues, Thursday
E-Mail:	sarkar@usf.edu	Class Time:	11:00 am–12:15 pm
Website:	www.cse.usf.edu/~sarkar/	Class Location:	NES 108
Office Hours:	T/Th 9 am to 10:45 am @ ENB 345		
TA:	Daniel Sawyer; Wed TBD @ ENB TBD; Email: danielsawyer@mail.usf.edu		

I.   Welcome!

We rely on our eyes to live in this world. You are using it now as you are reading this. Your eyes are just registering the color and intensity changes on the retina and send it off to the brain for further processing and to make sense of the registered input. Despite head movements and eye blinks, your perception of this page and the world is relatively stable. Ever wonder how all this happens? If we could replicate even a fraction of this functionality in artificial systems, we could impact lives through autonomous driving, precise medical diagnosis, computational photographic art, fast and accurate response during disasters, empowerment of the visually disabled, seamless communication with the Deaf, and many more.

Can we write computer algorithms that process information to extract information from images and video? If we and many animal species can do it so effortlessly, how hard can it be? Let us find out.

II.   University Course Description

Techniques for description and recognition of objects, use of stereo, texture, and motion information for scene segmentation and description, consistent labeling and matching, use of knowledge and planning in computer vision.

III.   Course Prerequisites

CAP 5400 Digital Image Processing or equivalent experience.

IV.   Course Purpose

This is a graduate elective course in the general theme of artificial intelligence (AI) and will teach you about algorithms to extract information from images and video. We will start off by understanding the geometry of the 3D world is registered into 2D images, followed by how we can invert and estimate 3D information from 2D image(s), using stereo,

motion, and optical flow. We will also learn about object detection and recognition using traditional and deep learning methods.

V.   How to Succeed in this Course
You should be familiar with programming with images. The course will also draw heavily from your knowledge about data structures, algorithms, linear algebra, and probability theory. So, please refresh them during the first week so that you can follow the lectures. If you have not taken a prior image processing course, you should at least read Sections 3.1, 3.2, and 3.3 and do Exercises 3.11 and 3.14

There will be heavy demand on your time beyond the classroom. The nature of the topic will require you to read papers/books, write reports, understand and implement algorithms, and present to the class. You will need to be programming almost every week for this course.

VI.   Course Topics
- Segmentation – mean-shift, EM, K-means, graph cuts
- Image Features – points, Kalman tracking
- Geometric Alignment – 2D-2D, linear, affine homography,
- 3D Camera model and calibration, Tsai calibration
- Structure from Motion (SFM) – Triangulation, 2-frame SFM, Optic flow, iterative least squares.
- Stereo – correspondences, wide baseline, RANSAC, Markov Chain Monte Carlo
- Object Recognition – category recognition, neural networks and deep learning

VII.   Student Learning Outcomes

By the end of this course, students will be able to:

- Identify and apply various computer vision methods to images and videos
- Read, understand, and implements ideas in computer vision papers and books.
- Code computer vision algorithms based on algorithms at high level.
- Communicate computer vision concepts to others.

VIII.   Required Texts and/or Readings and Course Materials
- Computer Vision: Algorithms and Applications, Richard Szeliski, ISBN 978-1-84882-935-0, Springer
- The pdf of the book is available at http://szeliski.org/Book for free. You can buy a hardcopy if you want, but it is not required to do so.

IX.   Supplementary (Optional) Texts and Materials
Other reading materials will be provided as need arises in class, based on background of students.

SPRING 2020- Class Dates					
Tues	**Lecture Topic**	**Notes**	**Thurs**	**Lecture Topic**	**Notes**
1/14/20	Segmentation (mean-shift)	Sec 5.3	1/16/20	Segmentation (EM, K-means)	Sec 5.3
1/21/20	Segmentation (K-means, Graph cuts)	Sec 5.4	1/23/20	Segmentation (Graph spectral grouping)	Sec 5.4, class notes **Assignment 1 (Ex 5.5) due**
1/28/20	Image Features (Point features)	Sec 4.1	1/30/20	Image Features (Kalman)	Class notes
2/4/20	Geometric Alignment (2D-2D)	Sec 2.1, 6.1	2/6/20	Geometric Alignment (2D-2D linear, affine)	Sec 6.1 **Assignment 2 (Ex 4.5) due**
2/11/20	Geometric Alignment (homography,rotation)	Sec 6.1	2/13/20	Geometry of Image (camera models)	Sec 2.1.5
2/18/20	Geometric Alignment (camera calibration)	Sec 6.3/tsai	2/20/20	2D to 3D pose estimation (camera calibration)	Sec 6.3 **Assignment 3 (Ex 6.4) due 2/15**
2/25/20	Triangulation (3D errors)	Sec 7.1	2/27/20	Triangulation (Image Residuals)	Sec 7.1 **Project Proposal due**
3/3/20	2-frame SFM (Essential Matrix)	Sec 7.2	3/5/20	2-frame SFM (R and T from E)	Section 7.2
3/10/20	Correspondences (SIFT, RANSAC)	Sec 4.1	3/12/20	Wide Baseline (BLOGS, MCMC)	**Assignment 4 (Ex 6.7) due 3/8**
3/17/20	Spring Break 2020		3/20/20	Spring Break 2020	
3/24/20	Projective motion Flow, Optic Flow	Section 8.4 + Trucco-Verri	3/26/20	Object Recognition (feature-based)	Sec 14.4
3/31/20	Neural networks		4/2/20	Object Recognition (deep learning)	
4/7/20	Object Recognition (deep learning)		4/9/20	Object Recognition (deep learning)	
4/14/20	Object Recognition (deep learning)	**Presentation Slides due**	4/16/20	**Final Presentations**	Groups 1,2,3
4/21/20	**Final Presentations**	Groups 4,5,6	4/23/20	**Final Presentations**	Groups 7,8,9
4/28/20	**Final Presentations**	Groups 10,11,12	4/30/20	Reading Day	
5/5/20	**Final Report Due (9 am on May 5, 2020)**				

XI. Grading Scale

Final score will be curved. A grade B will be assigned to scores round the mean. Minus/plus grades may be assigned to some students whose are within 2 points of grade boundaries.

XII. Grade Categories and Weights

Paper-based assignments and in-class work: 20%
Programming Assignments (four): 40% (10% each)
Project: Proposal: 10%, Presentations: 10, Written Report: 20%

XIII. Programming Assignments and Projects

The programming assignments will be assigned from problems in the text book. You may choose your own final project, but we will also share a potential list of projects towards of the middle of the semester.

For your assignments and final project, you will have to code in C/C++, python, or Matlab.

Solutions to your **programming assignments** have to be self-sufficient and **not dependent on other computer vision code, such OpenCV or Matlab vision package**. You may use packages for display graphics or mathematics packages, such as for linear algebra (numpy, for example, matlab (but not computer vision module)) or graphs or optimization.

You may use other packages or code for your final project.

All reuse of code has to be clearly acknowledged in the source code, any README files, and also in the report. Failure to do so will be considered plagiarism.

XIV. Grade Dissemination

Graded paper-based materials in this course will be returned individually. Online submissions will be graded online. You can access your scores at any time using "Grades" in Canvas.

XV. Course Policies: Grades

Late Work Policy:
There are no make-ups for in-class writing, quizzes. Assignments and reports turned in late will be assessed a 25% penalty of the earned grade each late day.

Grades of "Incomplete":
An Incomplete grade ("I") is exceptional and granted at the instructor's discretion only when students are unable to complete course requirements due to illness or other

circumstances beyond their control. The course instructor and student must complete and sign the "I" Grade Contract Form that describes the work to be completed, the date it is due, and the grade the student would earn factoring in a zero for all incomplete assignments. The due date can be negotiated and extended by student/instructor as long as it does not exceed two semesters for undergraduate courses and one semester for graduate courses from the original date grades were due for that course. An "I" grade not cleared within the two semesters for undergraduate courses and one semester for graduate courses (including summer semester) will revert to the grade noted on the contract.

Graded Work Retention Policy:
The graded works on paper will be retained for one semester following the current one, and then they will be destroyed.

Group Work Policy:
Everyone must take part in a group project. All members of a group will receive the same score; that is, the project is assessed and everyone receives this score. However, that number is only 75% of your grade for this project. **The final 25% is individual and refers to your teamwork. The instructor will assign a grade that is informed by declaration of work division in the project report and performance during project presentations.** Once formed, groups cannot be altered or switched, except for reasons of extended absence due to medical reasons.

XVI. Course Policies: Technology and Media

Email: Use email to communicate with instructor and TA online. We will try our best to answer your email within 24 hours.

Canvas: This course will make use of USF's learning management system (LMS), Canvas. If you need help learning how to perform various tasks related to this course, please view the following videos or consult the Canvas help guides. You may also contact USF's IT department at (813) 974-1222 or help@usf.edu.

Panopto: We may use lecture-capturing. Note that student voices may be heard in the captured content.

Laptop Usage: Use of laptop during lecture is allowed only for capturing notes and looking up course/lecture related materials. Use of laptop for other purposes is prohibited.

Classroom Devices/Student Recording: Use of tape-recorders or other recording devices is NOT allowed in the class.

You do not have the right to sell notes or tapes of lectures generated from this class.

Phone Usage: Use of phone during class is not allowed, including texting or surfing the Internet. Students may not take photos/video/audio recordings of the class. Only pictures of the whiteboard notes are allowed.

XVII. Standard University Policies

Policies about disability access, religious observances, academic grievances, academic integrity and misconduct, academic continuity, food insecurity, and sexual harassment are governed by a central set of policies that apply to all classes at USF. These may be accessed at: https://www.usf.edu/provost/faculty/core-syllabus-policy-statements.aspx

XVIII. Course Policies: Student Expectations

Academic Integrity
Academic integrity is the foundation of the University of South Florida System's commitment to the academic honesty and personal integrity of its university community. Academic integrity is grounded in certain fundamental values, which include honesty, respect, and fairness. Broadly defined, academic honesty is the completion of all academic endeavors and claims of scholarly knowledge as representative of one's own efforts. The final decision on an academic integrity violation and related academic sanction at any USF System institution shall affect and be applied to the academic status of the student throughout the USF System, unless otherwise determined by the independently accredited institution. The process for faculty reporting of academic misconduct, as well as the student's options for appeal, are outlined in detail in USF System Regulation 3.027.

The USF Policy on Academic Integrity specifies that students may not use websites that enable cheating, such as by uploading or downloading material for this purpose. This does apply specifically to **CourseHero.com** – any use of this website (including uploading materials) constitutes a violation of the academic integrity policy.

Disruption to Academic Progress
Disruptive students in the academic setting hinder the educational process. Disruption of the academic process is defined as the act, words, or general conduct of a student in a classroom or other academic environment which in the reasonable estimation of the instructor: (a) directs attention away from the academic matters at hand, such as noisy distractions, persistent, disrespectful or abusive interruption of lecture, exam, academic discussion, or general University operations, or (b) presents a danger to the health, safety, or well-being of self or other persons.

Academic Grievance Procedure
The purpose of these procedures is to provide all undergraduate and graduate students taking courses within the University of South Florida System an opportunity for objective review of facts and events pertinent to the cause of the academic grievance. An "academic grievance" is a claim that a specific academic decision or action that affects

that student's academic record or status has violated published policies and procedures, or has been applied to the grievant in a manner different from that used for other students.

Disability Access

Students with disabilities are responsible for registering with Students with Disabilities Services (SDS) (SVC 1133) in order to receive academic accommodations. **SDS encourages students to notify instructors of accommodation needs at least five (5) business days prior to needing the accommodation.** A letter from SDS must accompany this request.

Sexual Misconduct / Sexual Harassment

USF is committed to providing an environment free from sex discrimination, including sexual harassment and sexual violence (USF System Policy 0-004). The USF Center for Victim is a confidential resource where you can talk about incidents of sexual harassment and gender-based crimes including sexual assault, stalking, and domestic/relationship violence. This confidential resource can help you without having to report your situation to either the Office of Student Rights and Responsibilities (OSSR) or the Office of Diversity, Inclusion, and Equal Opportunity (DIEO), unless you request that they make a report. Please be aware that in compliance with Title IX and under the USF System Policy, educators must report incidents of sexual harassment and gender-based crimes including sexual assault, stalking, and domestic/relationship violence. If you disclose any of these situations in class, in papers, or to me personally, I am required to report it to OSSR or DIEO for investigation. Contact the USF Center for Victim Advocacy and Violence Prevention: (813) 974-5757.

Religious Observances

All students have a right to expect that the University will reasonably accommodate their religious observances, practices and beliefs (USF System Policy 10-045). The USF System, through its faculty, will make every attempt to schedule required classes and examinations in view of customarily observed religious holidays of those religious groups or communities comprising the USF System's constituency. Students are expected to attend classes and take examinations as determined by the USF System. No student shall be compelled to attend class or sit for an examination at a day or time prohibited by his or her religious belief. However, students should review the course requirements and meeting days and times to avoid foreseeable conflicts, as excessive absences in a given term may prevent a student from completing the academic requirements of a specific course. **Students are expected to notify their instructors at the beginning of each academic term (by end of first week of classes)** if they intend to be absent for a class or announced examination, in accordance with this Policy.

Statement of Academic Continuity

In the event of an emergency, it may be necessary for USF to suspend normal operations. During this time, USF may opt to continue delivery of instruction through methods that include, but are not limited to: Learning Management System, online conferencing, email

messaging, and/or an alternate schedule. It is the responsibility of the student to monitor the Learning Management System for each class for course-specific communication, and the main USF, College, and Department websites, emails, and MoBull messages for important general information (USF System Policy 6-010). For additional guidance on emergency protective actions and hazards that affect the University, please visit www.usf.edu/em

Attendance Policy:
Students are expected to attend classes. There is no makeup for in-class assignments or worksheets. Documented excused absences for due assignments and presentations, maybe allowed by making arrangements ahead of time (when possible) or by providing a reasonable amount of time to make up missed work.

Professionalism Policy:
Per university policy and classroom etiquette; mobile phones, iPods, etc. **must be silenced** during all classroom and lab lectures. Those not heeding this rule will be asked to leave the classroom/lab immediately so as to not disrupt the learning environment. Please arrive on time for all class meetings. Students who habitually disturb the class by talking, arriving late, etc., and have been warned may suffer a reduction in their final class grade.

End of Semester Student Evaluations:
All classes at USF make use of an online system for students to provide feedback to the University regarding the course. These surveys will be made available at the end of the semester, and the University will notify you by email when the response window opens. Your participation is highly encouraged and valued.

Food and Drink Policy:
Please adhere to the firm policy of no beverages (other than bottled/capped water), food, tobacco products, or like items in the classroom. Your understanding of the necessity for this policy and cooperation will be greatly appreciated. This policy will be strictly enforced.

Turnitin.com:
In this course, turnitin.com will be utilized. Turnitin is an automated system which instructors may use to quickly and easily compare each student's assignment with billions of web sites, as well as an enormous database of student papers that grows with each submission. Accordingly, you will be expected to submit all assignments in both hard copy and electronic format. After the assignment is processed, as instructor I receive a report from turnitin.com that states if and how another author's work was used in the assignment. For a more detailed look at this process visit http://www.turnitin.com. Essays are due at turnitin.com the same day as in class.

We will also use MOSS code checker https://theory.stanford.edu/~aiken/moss/ to check for code plagiarism.

The Writing Studio:
The Writing Studio is a free resource for USF undergraduate and graduate students. At the Writing Studio, a trained writing consultant will work individually with you, at any point in the writing process from brainstorming to editing. Appointments are recommended, but not required. For more information or to make an appointment, visit http://www.lib.usf.edu/writing/, stop by LIB 2nd Floor, or call 813-974-8293.

XIX. Important Dates to Remember (see detailed syllabus above)
The dates and assignments in this syllabus are tentative and can be changed at the discretion of the professor.