ESE 358 COMPUTER VISION

Stony Brook University, Electrical and Computer Engg., Fall 2020, 3 credits.

Instructor: Prof. Murali Subbarao
(Subject to minor changes)

Catalog Description

Introduces fundamental concepts, algorithms, computational techniques, and applications in visual information processing. Covers image formation models and image filtering, binary image analysis, feature detection, contours, image segmentation, 3D image capture and analysis through stereo, motion, structured-light, and LIDAR, medical images, pattern classification, machine learning, and 3D object recognition.

Prerequisites: ESE 305; ESE 224 or CSE 230, 3 credits

Instructor : Prof. Murali Subbarao murali.subbarao@stonybrook.edu
Office Hours: Tue. 11.15 am to 1.15 pm
Thurs. 11.15 am to 1.15 pm

Pre-requisite topics: Basic background in Linear algebra, Calculus, Probability, and Programming. Projects will be in MATLAB. If you have prior programming experience (as in ESE 224), then you will need 12 hours to learn enough MATLAB for this course.

Text book:
Computer Vision: Algorithms and Applications, Richard Szeliski, Spinger 2010, Available free at **http://szeliski.org/Book/**
Many Online resources

References
Many online resources.
Some examples:
https://www.cc.gatech.edu/~hays/compvision/
http://www.cs.cmu.edu/~16385/
http://vision.stanford.edu/teaching/cs131_fall1920/syllabus.html

Part I Image Formation Models and Image Processing

Topic 1 :

1. *Introduction:* Introduction, Overview, and applications.
2. Digital images for representing 2D, 3D, and moving objects. Human eye and digital camera models.

Topic 2 :

3. MATLAB tutorial for computational vision, and Linear algebra overview. (vectors, points, lines, planes, surfaces, matrices). Other CV tools: Python, numpy, OpenCV, Tensor flow, etc.
4. Image recognition paradigm, Quantitative vision for robotics and industry, and qualitative vision for object recognition (e.g. face recognition).

Topic 3 :

5. *Photometric information: Color:* Physics of color, human perception of color, color models (RGB, HSI).

Topic 4 :

6. *Geometric-information:* Representation of points, lines, planes, surfaces, and shapes in 3D, nature and structure of medical images. Two-dimensional and three-dimensional geometric transformations of images and 3D scenes.

Topic 5 :

7. *Image filtering:* gray-level transformations, histograms, convolution, noise reduction, spatial and Fourier domain filtering and convolution, Gaussian filtering, and image resolution pyramids.

Part II Image Features: detection and matching

Topic 6 :

8. *Feature detection*: gradient vector, Canny's edge detection, Harris-corner detector.

Mid-term test 1.

Topic 7:

9. *Contours:* Model fitting, Total LSE, Least Median Square Error.
10. RANSAC, Hough transform.

Topic 8 :

11. SIFT vector, image stitching.
12. *Pattern classification and Image segmentation:* Image features, SIFT and related feature vectors, clustering techniques, K-mean clustering. PCA.

Topic 9 :

Part III 3D Imaging, 3D Motion, Medical imaging.

13. *Three-dimensional shape recovery:* 3D from Stereo Images; Stereo Camera model, calibration, matching, rectification.

Topic 10 :

14. structured-light, RGBD cameras, Laser and LIDAR, and related techniques.
15. 3D Motion from Video, optical flow, other shape-from-x methods (texture, shading, focus/defocus, Optical flow, etc). Machine and robot vision applications and self-driving cars.

Topic 11 :

16. *Medical Imaging:* Modes of medical imaging, X-ray Computed Tomography, image reconstruction algorithms.

Mid-term test 2.

Part IV High-level Vision: Machine Learning, Neural Nets, and Artificial Intelligence

Topic 12 :

17. Machine learning principles and techniques for object recognition. Nearest-neighbor, nearest centroid, K-NN.

Topic 13 :

18. Support Vector Machines.

Topic 14 :

19. Neural Nets, Convolution Neural Nets,
20. Deep learning, AI.

Final Quiz (10%. Final exam will be a 30 minute quiz, with questions having short answers).

There will be around 3 programming projects using MATLAB. Each project may take around 10 hours for completion.

Project 1: 2D and 3D Geometric transforms, imaging in a pin-hole camera.
Project 2: Image filtering, local image features, and model fitting.
Project 3: Convolutional Neural Networks and Machine Learning.

GRADING : Grading is based on absolute total score.

Mid-term Test 1 :	**25%**	**(1 hr 20 mins) (Tue. 10/1/2019, to be confirmed)**
Mid-term Test 2 :	**25%**	**(1 hr 20 mins) (Tue. 11/12/2019, to be confirmed)**
Final Quiz :	**10%**	**(30 mins) (Thurs. 12/19/2019, to be confirmed)**
Projects: :	**30%**	
Homeworks :	**10%**	

Late submission of assignments

Homeworks: Late submissions are not accepted as the weight for any individual homework is small, around 1% of the overall total. Homeworks help prepare for tests and be engaged in a continuous learning process.

Projects: One or two days late: graded out of 75% (at a penalty of 25%). Submissions that are more than two days late are not accepted.

See the SBU Blackboard website of the course for all the latest announcements. We will also use piazza.com for question/answers.

Grading Policy
Grades are assigned based on absolute percentage of total marks as below.
A : 93—100 , A- : 88—92 ,
B+ : 83—87, B : 78—82, B- : 73--77
C+ : 70—72, C : 65—69, C- : 61—64,
D+ : 56—60, D : 51—55, F : 0—50

LEARNING OBJECTIVES: Upon completion of the course,

Students will be able to design and implement computational algorithms to solve problems in the following areas:

i. Image formation and geometric transformations.
ii. Gray level image analysis, edge detection and local feature descriptor, and image filtering operations.
iii. Stereo image analysis, 3D object representation and recognition techniques.
iv. Convolutional Neural Networks for Object Recognition.

Interaction: Student/student and student/faculty interaction will be conducted in online class, piazza.com, email, and online zoom meetings.

Technical Requirements: **MATLAB** software will be needed along with a laptop computer (Intel i5 processor with 8GB RAM or equivalent or higher).

Academic Integrity Measures: Exams will be conducted live over zoom meeting software. Respondus software may be used for monitoring if needed.

Minimal Instructional and Student Responsibilities

Please refer to:

https://www.stonybrook.edu/sb/bulletin/current/policiesandregulations/policies_expectations/min_instructional_student_resp.php

Student Accessibility Support Center (SASC) Statement:

If you have a physical, psychological, medical or learning disability that may impact your course work, please contact the Student Accessibility Support Center (SASC), ECC (Educational Communications Center) Building, room 128, (631) 632-6748. They will determine with you what accommodations, if any, are necessary and appropriate. All information and documentation is confidential.

[*In addition, this statement on emergency evacuation is often included, but not required:*
Students who require assistance during emergency evacuation are encouraged to discuss their

needs with their professors and the staff at the Student Accessibility Support Center (SASC). For procedures and information go to the following website: http://www.stonybrook.edu/ehs/fire/disabilities]

Academic Integrity Statement:

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty are required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty, please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

Critical Incident Management Statement:

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Judicial Affairs any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures.

Minimal Instructional and Student Responsibilities

By accepting responsibility for their education, students enhance the development of their academic, social, and career goals. It is expected that students accept responsibility for their academic choices as part of their educational experience at Stony Brook. Services are available to assist students with academic advising, long-range goals, and career exploration. Students are responsible for reviewing, understanding, and abiding by the University's regulations, procedures, requirements, and deadlines as described in official publications, including, by way of example only, this Undergraduate Bulletin, the University Conduct Code, the Student Handbook, and class schedules.

Responsibilities in the Classroom

Students are expected to attend class regularly unless other arrangements are made; arrive for class on time and leave the class only at the end of class; engage in class discussions and activities when appropriate; exhibit classroom behavior that is not disruptive of the learning environment; secure and turn off all electronic communications and entertainment devices during class time unless otherwise directed by the course instructor. Any use of a cell phone or other unauthorized electronic device during an examination may lead to an accusation of academic dishonesty.

Absentee Policy

Students are expected to report for their examinations and major graded coursework as scheduled. If a student is unable to report for any examination or to complete major graded coursework on time, the student must contact the faculty member immediately. If the student cannot reach the faculty member, then s/he should contact the Director of Undergraduate Studies.

Although faculty will consider each student's request on its own merits and not attempt to define ahead of time the validity of all possible reasons a student might give for missing an examination or the date to turn in major graded coursework, instructors are expected to accept an excuse of significant illness, tragedy, or other personal emergencies and to make reasonable alternative accommodations for the student. It shall be the student's responsibility to provide sufficient documentation to support any such request. Accommodations for other reasons will be at the discretion of the faculty.

Course Responsibilities

Students are expected to observe the requirements for the course and consult with the instructor if prerequisites are lacking; obtain and understand the course syllabus; keep up with the coursework and take all scheduled examinations; address any conflicts in syllabus and exam scheduling with the instructor as soon as possible; review all graded material and seek help if necessary; notify the instructor as soon as possible of any disabilities that might interfere with completion of coursework; complete the course evaluation form fairly and thoughtfully.