Course Title: Computer Vision

An Institute Elective Course (UG3 / UG4)
By: Dr. Shiv Ram Dubey

Course Level: L1 L-T-P-C: 3 - 1 - 0 – 4

Course Website: https://sites.google.com/site/iiitscv/

Previous Offerings:
Spring 2018: https://sites.google.com/site/iiitscv/spring2018/
Spring 2017: https://sites.google.com/site/iiitscv/spring2017/

Pre-requisite: Data Structure, Basic Probability/Statistics, a good working knowledge of any programming language (python, matlab, C/C++), Linear algebra, Vector calculus. Image Processing is desirable. (See section 5 for more detail)

1. Outline: Nowadays, the use of visual information technology is growing exponentially. Most of the big IT companies like Google, Microsoft, Amazon, Facebook, etc. are working over the visual data analysis. Many startups also came in recent years in Computer Vision area. Computer Vision also has very strong relevance in Robotics and Industrial Automation. It can be utilized very effectively in smart manufacturing, medical field, biometrics area, etc.

2. Objectives: The goal of computer vision is to compute the properties of the three-dimensional world from digital images. Problems in this field include reconstructing the 3D shape of an environment, determining how things are moving, and recognizing people and objects and their activities, all through analysis of images and videos. This course will provide an introduction to computer vision, with topics including image formation, feature detection, motion estimation, image mosaics, 3D shape reconstruction, object/face detection and recognition, and deep learning. Applications of these techniques include building 3D maps, creating virtual characters, organizing photo and video databases, human computer interaction, video surveillance, automatic vehicle navigation, robotics, virtual and augmented reality, medical imaging, and mobile computer vision. **This is a project-based course**, in which student will implement the computer vision algorithms throughout the semester.

3. Course Outline (Topics): The following list of topics is tentative. Based on available time slots, some topics may be dropped or added or reordered.
Feature Detection, Description, Correspondence and Alignment: Introduction and Overview, Light, Image Formation, Filtering, Edge Detection, Feature Detection, Harris Corner Detection, Invariance and Blob Detection, Feature Descriptors and Matching, Image Transformations, Image Alignment, RANSAC, Hough Transform, etc.
Perspective and 3D Geometry: Camera Models, Single-view Geometry and Calibration, Image Stitching, Epipolar Geometry, Stereo, Structure from Motion, etc.
Recognition and Learning: Intro to Recognition, Viola-Jones Face Detection, Bag-of-Words Model, Convolutional Neural Networks, Image Classification, Object Detection, Segmentation, Image Generation, etc.

4. Books/References:

Simon Prince, Computer Vision: Models, Learning, and Interface, Cambridge University Press, 2012
Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010
Forsyth and Ponce, Computer Vision: A Modern Approach, Prentice Hall, 2002
Mubarak Shah, Fundamentals of Computer Vision, 1997
Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016
Duda, Hart and Stork, Pattern Classification (2nd Edition), Wiley, 2000,

Koller and Friedman, Probabilistic Graphical Models: Principles and Techniques, MIT Press, 2009,
Strang, Gilbert. Linear Algebra and Its Applications 2/e, Academic Press, 1980.

5. Pre-Requisites:

No prior experience with computer vision is assumed, although previous knowledge of Image Processing or Machine Learning will be helpful. The following skills are necessary for this class:

- Data structures: You'll be writing code that builds representations of images, features, and geometric constructions.
- Programming: Projects are to be completed and graded in Python. If you've never used Python that is OK, as long as you have programming experience.
- Math: Linear algebra, vector calculus, and probability.

6. Grading Policy:

Assignments and term project should include explanatory/clear comments as well as a short report describing the approach, detailed analysis, and discussion/conclusion. Note that the grading policy may change based on the number of registration in the course.

15% Mid-Exam-1
15% Mid-Exam-2
30% End-Exam
15% Assignments/Quizzes
25% Term Project

7. Industry Impact:

Most of the big IT companies like Google, Microsoft, Amazon, Facebook, etc. are working over the visual data analysis. Many startups also came in recent years in Computer Vision area. Computer Vision also has very strong relevance in Robotics and Industrial Automation. It can be utilized very effectively in smart manufacturing. Followings are the Most Exciting Applications of Computer Vision across Industries: Automotive, Retail, Financial Services, Healthcare, etc.

8. List of Companies Working On Related Topics:

The major IT companies like Google, Microsoft, Amazon, Facebook, etc. are working over the visual data analysis in the field of computer vision. The general topics of interest include image recognition, object detection, image segmentation, face recognition, medical image analysis, biometric systems, smart manufacturing, robotics, healthcare, smart transportation, etc.

Followings are some of the industries working in Computer Vision area in India: Microsoft Research (Vision and Media), Yahoo! Labs, Qualcomm, GE Global Research, Samsung India, Samsung Electro-Mechanics, Philips Innovation Campus, IBM Research, Vizzitec, Siemens, Kritikal Solutions, Vision Labs, Tonbo Imaging, RHL Vision, Tachyon Technologies, Soliton, Infosys Labs, HP Labs, MATLAB, TCS, TCS Innovation Labs, Xerox, Xerox Research Centre, CMC Ltd., Uurmi Systems, Optra Systems, Media Mint, Pari Robotics, Sitara Soft, Amagi Media Labs, Accenture, Whodat, Hyperverge, Maxerience, Snapshopr, GazeMetrix, Wazzat Fashion, PathPartner, Aindra, Ice Cream Labs, Myntra, SensoVision sytems, Gridbots Technologies, etc.

A more global list of companies is available at these following links:
https://www.cs.ubc.ca/~lowe/vision.html
http://www.lengrand.fr/computer-vision-companies/
https://angel.co/computer-vision

9. Resources:

a) Computer Vision: Foundations and Applications (CS131)
   By Prof. Juan Carlos Niebles and Prof. Ranjay Krishna, Stanford, USA
   Link: http://vision.stanford.edu/teaching/cs131_fall1819/index.html
b) Computer Vision (16-385)
   By Prof. Ioannis (Yannis) Gkioulekas, Carnegie Mellon, USA

Link: http://www.cs.cmu.edu/~16385/

c) Computer Vision (CS 376)

By Prof. Kristen Grauman, University of Texas at Austin, USA

Link: http://vision.cs.utexas.edu/376-spring2018/

d) Computer Vision (CS 6476)

By Prof. James Hays, Georgia Tech, USA

Link: https://www.cc.gatech.edu/~hays/compvision/

e) Introduction to Computer Vision (CS5670)

By Prof. Noah Snavely, Cornell University, USA

Link: http://www.cs.cornell.edu/courses/cs5670/2018sp/

f) Computer Vision (CSE/EE 576)

By Prof. Linda Shapiro, University of Washington, USA

Link: https://courses.cs.washington.edu/courses/cse576/18sp/

g) Computer Vision (CS 763)

By Prof. Arjun Jain, Indian Institute of Technology, Bombay, India

Link: https://github.com/cs763/Spring2018

10. Course Ethics:

Please note down the following activities leading to a fair academic honesty:

- All class work is to be done independently.
- It is best to try to solve problems on your own, since problem solving is an important component of the course, and exam problems are often based on the outcome of the assignment problems.
- You are allowed to discuss class material, assignment problems, and general solution strategies with your classmates. But, when it comes to formulating or writing solutions you must work alone.
- You may use free and publicly available sources, such as books, journal and conference publications, and web pages, as research material for your answers. (You will not lose marks for using external sources.)
- You may not use any paid service and you must clearly and explicitly cite all outside sources and materials that you made use of.
- I consider the use of uncited external sources as portraying someone else's work as your own, and as such it is a violation of the University's policies on academic dishonesty.
- Instances will be dealt with harshly and typically result in a failing course grade.

Course Plan Submitted By

Dr. Shiv Ram Dubey
Assistant Professor
Department of Computer Science and Engineering
Indian Institute of Information Technology, Sri City
Andhra Pradesh - 517646, India.
E-mail: srdubey@iiits.in
Web: https://sites.google.com/site/shivram1987/