CS101: Applications of Computer Vision and Deep Learning

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Credit Hours: 3

Course Description

The surge in integrating computer vision algorithms into daily activities has prompted the development of this comprehensive course. Commencing with foundational Python3 programming, the curriculum advances toward the pragmatic implementation of programming concepts using the widely recognized OpenCV library, renowned for its classical computer vision methodologies. Participants will not only explore the intricacies of the PyTorch framework but also attain mastery in designing models tailored explicitly for classification and image segmentation—critical algorithms in both industry and research domains. The course goes beyond theoretical understanding, offering potential hands-on experience in creating a deployable real-world application, effectively showcasing the practical application of acquired skills.

This introductory program seamlessly blends theoretical concepts with immersive, hands-on tutorials, making it an ideal choice for individuals eager to delve into the realm of computer vision. The tutorial-driven approach is meticulously designed to cater to those enthusiastic about applying classical and cutting-edge deep learning algorithms to real-world scenarios, thereby enriching their comprehension and practical application skills in the field. For those who have previously taken computer vision courses, there may be some overlap in theory; however, this course distinguishes itself by providing complementary support in terms of programming and application—an invaluable asset widely utilized in the industry for creating real-world applications.

Required Materials

- Course materials, e.g., slides, jupyter notebook would be made available via Google Classrooms.
- Pointers to additional resources week-wise will be made via course website or via Google classrooms.

Prerequisites

Only a willingness to learn and explore.

Course Objectives

Upon completion, students will demonstrate proficiency in coding computer vision algorithms using Python3 and OpenCV. Additionally, they will possess a foundational understanding of PyTorch and preliminary deep learning algorithms relevant to both research and industry applications.

Grading Policy

(Tentative, total - 100%) Relative grading will be used.

- **30%**: Assignments (about 1-2) with viva.
- **20%**: Recitation.
- **20%**: Mid-semester examination.
- **30%**: End-semester examination.

Tentative Topics

Part - 1: Python3 Refresher

Lecture 1: Python3 Programming Refresher.

Part - 2: OpenCV Details

Lecture 2: Installation, GUI features, Basic Operations, Colorspaces, Geometric Transformations, Image Thresholding, Image Smoothing.

Lecture - 3: Morphological Operations, Image Gradients, Canny Edge Detection, Image Pyramids.

Lecture - 4: Contours, Histogram, Fourier Transform.

Lecture - 5: Template matching, Hough transform - Line, Hough transform - Circle, Watershed, Grab-Cut.

Lecture - 6: Feature detection, Harris Corner, Shi-Tomasi Detector, SIFT, SURF.

Lecture - 7: FAST, BRIEF, Feature Matching, Homography.

Lecture - 8: Video (Optical Flow, Background subtraction methods, Meanshift and Camshift).

Lecture - 9: HaarCascade, Camera Calibration, Pose Estimation, Epipolar Geometry, Depth Map from stereo image.

Lecture 10: K-Means Clustering, K-Nearest Neighbor, Image Denoising, Image Inpainting, High Dynamic Range (HDR).

Part - 3: Pytorch Fundamentals

Lecture 11: Introduction to Pytorch and Tensors, Feed Forward Neural Networks, Back-propagation, Gradient descent, Classifier example, Activation functions.

Lecture 12: Optimizers, Convolutional Neural Networks, Convolution operation, Maxpool.

Lecture 13: Basic Methodology - Train - Validation - Test Pipeline, Design a Classifier using Pytorch, Autoencoders - theory and example.

Lecture 14: Segmentation - Single class and Multi-Class, Theory: U-Net, Attention U-Net, ResU-Net, DeepLabV3+.

Lecture 15: Application - Design a Segmentation Network using Pytorch.

Lecture 16: VAEs - Theory.

Lecture 17: Application - Design a VAE using Pytorch.

Lecture 18: GANs - Theory.

Lecture 19: Application - Design a GAN using Pytorch.

Lecture 20: (Tentative) Guest Lecture: Transformer & Vision Transformer Theory and Tutorial, Seshadri Mazumder, CVIT, IIIT Hyderabad.

Lecture 21: (Tentative) Guest Lecture: Stable Diffusion Theory and Tutorial, Seshadri Mazumder, CVIT, IIIT Hyderabad.