جامعة محمد بن زايد للذكاء الاصطناعي
MOHAMED BIN ZAYED UNIVERSITY OF ARTIFICIAL INTELLIGENCE

Core Courses Syllabi

CV703 - Visual Object Recognition and Detection

Title	Visual Object Recognition and Detection
Code	CV703
Loading	4 Credit-hours
Prerequisites	• 701: Human and Computer Vision (or equivalent) • Basics of Linear Algebra, Calculus and Probability and Statistics demonstrated through relevant coursework • Proficiency in Python and Pytorch
Catalog Description	This course provides a comprehensive overview of different concepts and methods related to visual object recognition and detection. In particular, the students will learn a large family of successful and recent state-of-the-art architectures of deep neural networks to solve the tasks of visual recognition, detection and tracking.
Goal	The aim of this course is to enable students to build state-of-the-art systems for automatic image and video understanding to answer complex questions such as, what objects are present in a complex scene and where are they located? Students will be equipped with the skills for designing, implementing, training and evaluating complex neural network architectures to solve visual object recognition and detection problems.
Content	This course covers the following major modules: **(I)** hand-crafted features, **(II)** convolutional neural networks (CNNs), **(III)** training CNNs, **(IV)** object detection, **(V)** image segmentation, and **(VI)** visual object tracking.
Recommended Textbooks	1. R. Szeliski, *Computer Vision: Algorithms and Applications*, Springer Verlag, 2011. ISBN: 1848829345 2. I. Goodfellow, Y. Bengio, A. C. Courville, *Deep Learning*, MIT Press, 2016. ISBN: 9780262035613
Recommended References & Supplemental Material	Relevant research papers, tech reports, and surveys for each topic, where needed, are identified in the teaching plan ahead. In addition, the following textbook will be useful: D. A. Forsyth, and J. Ponce, *Computer vision: A Modern Approach*, 2nd edition, Pearson, 2003. ISBN: 013608592X

Teaching Week	Topics
1	**Course Overview and Motivation** **Lecture** • Introduction to visual object recognition • Overview of object recognition in biological systems • Overview of detection, localization and segmentation **Lab** • Tutorial on Python • Practice problems to gain familiarity with libraries: Numpy, Pytorch, etc.
2	**Introduction to Hand-Crafted Features** **Lecture** • Feature descriptors: Classic handcrafted methods such as SIFT, SURF, HoG **Lab** • Perform empirical evaluation of hand-crafted descriptors (SIFT, SURF, HoG) for image classification, and submit a report
3	**Importance of Context in Visual Recognition** **Lecture** • Compound descriptors and metrics • The role of context in visual recognition **Lab** • Assignment # 1 due
4	**Introduction to CNNs for Visual Recognition** **Lecture** • Convolutional neural networks: history, convolutions, pooling, normalization **Lab** • Implement forward pass and backward pass for convolution and pooling layers
5	**Training CNNs** **Lecture** • Training convolutional neural networks: data augmentation, optimizers, and regularizers **Lab** • Design, train, and test a 5-layer CNN using cross entropy loss function on CIFAR-10 dataset

Teaching Week	Topics
6	**Performance comparison of popular CNNs** **Lecture** • Compare the state-of-the-art convolutional neural networks for image classification: AlexNet, VGG, GoogLeNet, ResNet and SEnet **Lab** • Assignment # 2 due
7	**Visualizing CNNs and their learned feature spaces** **Lecture** • Understanding and visualizing convolutional neural networks: tSNE embeddings, deconvnets and data gradients **Lab** • Visualize the fc-7 layer feature space of VGG-16 with the tSNE embedding tool after randomly choosing 50 instances from all categories of the CIFAR-10 dataset.
8	**Introduction to Visual Object Detection** **Lecture** • Introduction to object detection • History of object detection methods **Lab** • Prepare and submit a 2-page survey on classic object detection approaches
9	**Object Detection Approaches - Prior to Deep Learning** **Lecture** • Holistic object detection methods • Deformable part-based object detection **Lab** • Interface Viola-Jones face detector with a webcam
10	**Deep Learning based Object Detection (Two-stage Detectors)** **Lecture** • Deep learning for object detection (part 1): Two-stage object detection methods (from R-CNN to Faster R-CNN) **Lab** • Assignment # 3 due
11	**Deep Learning based Object Detection (Single-stage Detectors)** **Lecture** • Deep learning for object detection (part 2): Single-stage object detection methods (e.g., YOLO and SSD) **Lab** • Apply a state-of-the-art object detector on any low light image dataset and discuss the results

Teaching Week	Topics
12	**Overview of different Segmentation Approaches** **Lecture** Overview of: • Semantic segmentation • Instance segmentation • Panoptic segmentation **Lab** • Run off-the-shelf codes of semantic segmentation, instance segmentation and panoptic segmentation methods on a set of images (that will be provided in the lab)
13	**Introduction to Visual Object Tracking** **Lecture** • Introduction to visual object tracking • Object tracking based on particle filtering **Lab** • Implement the integral histogram approach
14	**Deep Learning based Object Tracking** **Lecture** • Deep learning based object tracking • Fully-convolutional siamese networks for visual object tracking **Lab** • Assignment # 4 due
15	**Guest Lecture & Review** **Lecture** • Guest lecture on a trending topic **Lab** • Review and Exam Preparation