جـــامـــعـــة مـحـمـد بـــن زايـــد
للـــذكـــاء الاصـــطـــنـــاعـــي
MOHAMED BIN ZAYED UNIVERSITY
OF ARTIFICIAL INTELLIGENCE

Core Courses Syllabi

CV704 - Advanced Computer Vision

Title	Advanced Computer Vision
Code	CV704
Loading	4 Credit-hours
Prerequisites	• Understanding of the concepts covered during CV 701 Human and Computer Vision (Masters course). • Hands-on experience with Python and Pytorch or equivalent language/ library
Catalog Description	This course provides focused coverage of the following special topics: 1) image restoration and enhancement, 2) hand-crafted features, and 3) visual object tracking. The students will develop skills to critique the state-of-the-art works on the aforementioned problems. Moreover, students will be required to implement papers with the aims of, (1) reproducing results reported in the papers and (2) improving performance of the published works. This course builds upon concepts from Human and Computer Vision (course code: CV701) and assumes familiarity with fundamental concepts in image processing.
Goal	This graduate course aims to inculcate a deeper understanding of the algorithms for image restoration and enhancement, hand-crafted features, and visual target tracking, so the students become capable of researching, developing, and implementing these methods for solving computer vision problems of real-world scale. Additionally, a significant goal of this course is to enhance students' teamwork skills by requiring them to participate in group projects and develop their communication and analytical skills by engaging them in reading group activities.
Content	The course covers three modules: **(I)** Image Restoration and Enhancement, **(II)** Hand-crafted Features, and **(III)** Visual Object Tracking.
Recommended Textbooks	1. D. A. Forsyth, and J. Ponce, *Computer vision: A Modern Approach*, 2nd edition, Pearson, 2003. 2. R. Szeliski, *Computer Vision: Algorithms and Applications*, Springer Verlag, 2011.
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 may be useful: R. C. Gonzalez and R. E. Woods, *Digital Image Processing*, 4th edition, Pearson, 2018.

Teaching Week	Topics
1	**Image Restoration and Enhancement (Module I)** This module covers the following topics: 1) super resolution, 2) image denoising, 3) image inpainting, and 4) image enhancement **Lecture** • Overview of image restoration and enhancement tasks • Relevant papers and assigned reading: - D.G.S.B.M Irani, "Super-resolution from a single image", *IEEE International conference on computer vision*, 2009. - C. Dong, C. C. Loy, K. He, and X. Tang, "Image super-resolution using deep convolutional networks", *IEEE transactions on pattern analysis and machine intelligence*, 2014. - A. Buades, B. Coll, and J. M. Morel, "A non-local algorithm for image denoising", *IEEE International conference on computer vision*, 2005. - H. C. Burger, C. J. Schuler, and S. Harmeling, "Image denoising: Can plain neural networks compete with BM3D?", *IEEE International conference on computer vision*, 2012. - M. Bertalmio, G. Sapiro, V. Caselles, and C. Ballester, "Image inpainting", *Annual conference on computer graphics and interactive techniques*, 2000. - D. Pathak, P. Krahenbuhl, J. Donahue, T. Darrell, and A. A. Efros, "Context encoders: Feature learning by inpainting", *IEEE International conference on computer vision*, 2016. - W. Dong, L. Zhang, G. Shi, and X. Wu, X., "Image deblurring and super-resolution by adaptive sparse domain selection and adaptive regularization", *IEEE Transactions on image processing*, 2011. **Lab** • Discussion on choosing a relevant paper to implement for the project • Start Project-1 work
2	**Image Restoration and Enhancement (contd.)** **Lecture:** • Introduction to super resolution & deblurring • Reading group activity on selected papers related to "Super Resolution & Deblurring": - D.G.S.B.M Irani, "Super-resolution from a single image", *IEEE International conference on computer vision*, 2009. - C. Dong, C. C. Loy, K. He, and X. Tang, "Image super-resolution using deep convolutional networks", *IEEE transactions on pattern analysis and machine intelligence*, 2014. - W. Dong, L. Zhang, G. Shi, and X. Wu, X., "Image deblurring and super-resolution by adaptive sparse domain selection and adaptive regularization", *IEEE Transactions on image processing*, 2011. **Lab** • Continue Project-1 work

Teaching Week	Topics
3	**Image Restoration and Enhancement (contd.)** **Lecture:** • Introduction to denoising • Reading group activity on selected papers related to "Denoising": - A. Buades, B. Coll, and J. M. Morel, "A non-local algorithm for image denoising", *IEEE International conference on computer vision*, 2005. - H. C. Burger, C. J. Schuler, and S. Harmeling, "Image denoising: Can plain neural networks compete with BM3D?", *IEEE International conference on computer vision*, 2012. **Lab** • Continue Project-1 work
4	**Image Restoration and Enhancement (contd.)** **Lecture:** • Introduction to inpainting • Reading group activity on selected papers related to "Inpainting": - M. Bertalmio, G. Sapiro, V. Caselles, and C. Ballester, "Image inpainting", *Annual conference on computer graphics and interactive techniques*, 2000. - D. Pathak, P. Krahenbuhl, J. Donahue, T. Darrell, and A. A. Efros, "Context encoders: Feature learning by inpainting", *IEEE International conference on computer vision*, 2016. **Lab:** • Preparation of presentation on the selected papers • Continue Project-1 work
5	**Image Restoration and Enhancement (contd.)** **Lecture:** • Presentation of the projects by different groups **Lab:** • Peer review of project reports **Assessment 1.2:** • In-class exam covering Module I – Image Restoration and Enhancement

Teaching Week	Topics
6	**Hand-Crafted Features (Module II)** This module overviews the following feature extractors: Scale-Invariant Feature Transform (SIFT), Speeded up Robust Features (SURF), Histogram of Oriented Gradients (HoG), Shape Context, Local Binary Patterns (LBP), Speeded up Robust Features (SURF), Moment Invariants and Steerable Filters. **Lecture** • Introduction to hand-crafted features • Relevant papers and assigned reading: - D. G. Lowe, "Distinctive image features from scale-invariant keypoints", *International journal of computer vision*, 2004. - N. Dalal, and B. Triggs, "Histograms of oriented gradients for human detection", *IEEE International conference on computer vision*, 2005. - S. Belongie, J. Malik, and J. Puzicha, "Shape matching and object recognition using shape contexts", *IEEE Transactions on Pattern Analysis & Machine Intelligence*, 2002. - T. Ahonen, A. Hadid, and M. Pietikainen, "Face description with local binary patterns: Application to face recognition", *IEEE Transactions on pattern analysis and machine intelligence*, 2006. - H. Bay, T. Tuytelaars, and L. V. Gool, "Surf: Speeded up robust features", *European conference on computer vision*, 2006. - W. T. Freeman, and E. H. Adelson, "The design and use of steerable filters", *IEEE Transactions on pattern analysis and machine intelligence*, 1991. - M. K. Hu, "Visual pattern recognition by moment invariants", *IRE transactions on information theory*, 1962. **Lab** • Discussion on choosing a relevant paper to implement for the project • Start Project-2 work
7	**Hand-Crafted Features (contd.)** **Lecture** • Introduction to SIFT feature detection and description • Introduction to HoG and shape context • Reading group activity on relevant papers: - D. G. Lowe, "Distinctive image features from scale-invariant keypoints", *International journal of computer vision*, 2004. - D. G. Lowe, "Object recognition from local scale-invariant features", *IEEE International conference on computer vision*, 1999. - N. Dalal, and B. Triggs, "Histograms of oriented gradients for human detection", *IEEE International conference on computer vision*, 2005. - S. Belongie, J. Malik, and J. Puzicha, "Shape matching and object recognition using shape contexts", *IEEE Transactions on Pattern Analysis & Machine Intelligence*, 2002. **Lab** • Continue Project-2 work

Teaching Week	Topics
8	**Hand-Crafted Features (contd.)** **Lecture** • Introduction to LBP & SURF • Discussion of relevant papers: - T. Ahonen, A. Hadid, and M. Pietikainen, "Face description with local binary patterns: Application to face recognition", *IEEE Transactions on pattern analysis and machine intelligence*, 2006. - H. Bay, T. Tuytelaars, and L. V. Gool, "Surf: Speeded up robust features", *European conference on computer vision*, 2006. **Lab** • Continue Project-2 work
9	**Hand-Crafted Features (contd.)** **Lecture** • Introduction to moment invariants and steerable filters • Discussion of relevant papers: - W. T. Freeman, and E. H. Adelson, "The design and use of steerable filters", *IEEE Transactions on pattern analysis and machine intelligence*, 1991. - M. K. Hu, "Visual pattern recognition by moment invariants", *IRE transactions on information theory*, 1962. **Lab** • Preparation of presentation on project-2 work • Continue Project-2 work
10	**Hand-Crafted Features (contd.)** **Assessment 2.1** • Presentation of the projects by different groups **Lab** • Peer review of project reports **Assessment 2.2** • In-class exam covering Module II – Hand-Crafted Features

Teaching Week	Topics
11	**Visual Object Tracking (Module III)** This module covers seminal papers on deep learning based video object tracking, popular methods in the pre-deep learning era and open challenges. **Lecture** • Introduction to visual object tracking • Relevant papers and assigned reading: - D. Comaniciu, V. Ramesh, and P. Meer, "Kernel-based object tracking", *IEEE Transactions on pattern analysis and machine intelligence*, 2003. - M. Isard, and A. Blake, "Condensation—conditional density propagation for visual tracking", *International journal of computer vision*, 1998. - B. Babenko, M. H. Yang, and S. Belongie, "Robust object tracking with online multiple instance learning", *IEEE Transactions on pattern analysis and machine intelligence*, 2010. - M. Kristan, J. Matas, A. Leonardis, T. Vojíř, R. Pflugfelder, G. Fernandez, G., Nebehay, F. Porikli, and L. Čehovin, "A novel performance evaluation methodology for single-target trackers", *IEEE transactions on pattern analysis and machine intelligence*, 2016. **Lab** • Discussion on choosing a relevant paper to implement for the project • Start Project-3 work
12	**Visual Object Tracking (contd.)** **Lecture** • Visual object tracking - prior to deep learning • Discussion of relevant papers: - B. Babenko, M. H. Yang, and S. Belongie, "Robust object tracking with online multiple instance learning", *IEEE Transactions on pattern analysis and machine intelligence*, 2010. - J. Kwon, and K. M. Lee, "Visual tracking decomposition", *IEEE conference on computer vision and pattern recognition*, 2010. **Lab** • Continue Project-3 work

Teaching Week	Topics
13	**Visual Object Tracking (contd.)** **Lecture** • Visual object tracking datasets and challenges • Discussion of relevant papers: - M. Muller, A. ibi, S. Giancola, S. Alsubaihi, and B. Ghanem, "Trackingnet: A large-scale dataset and benchmark for object tracking in the wild", *European conference on computer vision*, 2018. - H. Fan, L. Lin, F. Yang, P. Chu, G. Deng, S. Yu, H. Bai, Y. Xu, C. Liao, and H. Ling, "Lasot: A high-quality benchmark for large-scale single object tracking", *arXiv preprint arXiv:1809.07845*, 2018. - M. Kristan, J. Matas, A. Leonardis, T. Vojíř, R. Pflugfelder, G. Fernandez, G., Nebehay, F. Porikli, and L. Čehovin, "A novel performance evaluation methodology for single-target trackers", *IEEE transactions on pattern analysis and machine intelligence*, 2016. **Lab** • Continue Project-3 work
14	**Visual Object Tracking (contd.)** **Lecture** • Visual object tracking - deep learning era • Discussion of relevant papers: - A. He, C. Luo, X. Tian, and W. Zeng, "Towards a better match in siamese network based visual object tracker", *European conference on computer vision*, 2018. - F. Li, C. Tian, W. Zuo, L. Zhang, and M. H. Yang, "Learning spatial-temporal regularized correlation filters for visual tracking", *IEEE conference on computer vision and pattern recognition*, 2018. **Lab** • Preparation of presentation on project-3 work • Continue Project-3 work
15	**Visual Object Tracking (contd.)** **Assessment 3.1** • Presentation of the projects by different groups **Lab** • Peer review of project reports **Assessment 3.2** • In-class exam covering module III – Visual Object Tracking