Computer Vision Course Syllabus

1	**Course title**	Computer Vision
2	**Course number**	1905322
3	**Credit hours**	3
	Contact hours (theory, practical)	3
4	**Prerequisites**	Machine Learning and Neural Networks (1915370)
5	**Program title**	Artificial Intelligence
6	**Program code**	05
7	**Awarding institution**	The University of Jordan
8	**School**	King Abdullah II School for Information Technology
9	**Department**	Artificial Intelligence
10	**Level of course**	Undergraduate (UG)
11	**Year of study and semester (s)**	2023 - Autumn (1st)
12	**Final Qualification**	BSc
13	**Other department(s) involved in teaching the course**	None
14	**Language of Instruction**	English
15	**Teaching methodology**	☒Face-to-Face ☐Blended ☐Online
16	**Electronic platform(s)**	☒Moodle ☒Microsoft Teams ☐Skype ☐Zoom ☒Others http://omar.alkadi.net/
17	**Date of production/revision**	8 October 2023

18 Course Coordinator:

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19 Other instructions:

- **Textbook:** Computer Vision: Algorithms and Applications, by Richard Szeliski, Springer, 2nd edition, 2022 can be downloaded from here.
- **Programming environment:** MATLAB – MathWorks® (R2024 Release)

20 Course Description:

This course explores how computers understand the visual world, emphasizing probabilistic, statistical, and data-driven approaches in computer vision. Covering image processing, segmentation, grouping, recognition, and motion estimation, it aims to automate tasks analogous to the human visual system. The curriculum progresses from basic image processing to advanced topics like multiple view geometry, focusing on machine learning methods, particularly in supervised learning and classification. The learned algorithms have broad applications beyond vision problems, making them valuable tools for diverse challenges.

21 Course aims and outcomes:

A- Aims:
On completion of this course, students should be able to:

- Understanding image formation and filtering, including linear filters and gradient analysis for enhanced visual understanding.
- Develop advanced skills in feature detection and matching, covering texture analysis, optical flow, Hough transform, RANSAC with robust fitting, active contours, segmentation, and local invariant features.
- Understand multiple views and motion in computer vision through techniques like structure from motion, stereo vision, and integration of machine and deep learning for improved object detection.
- Explore the intersection of machine learning with computer vision, focusing on supervised learning and classification, and understand their versatility in solving a broad range of challenges.

B- Intended \ Students Learning Outcomes (ILOs/SOs):

Label	ABET Student Learning Outcomes (SOs)
SO1	Analyze a complex computing problem and to apply principles of computing and other relevant disciplines to identify solutions.
SO2	Design, implement, and evaluate a computing-based solution to meet a given set of computing requirements in the context of the program's discipline.
SO5	Function effectively as a member or leader of a team engaged in activities appropriate to the program's discipline.

On successfully completing the module, the students are expected to have gained good knowledge of:

Descriptor	Label	Course Intended Learning Outcomes Description (ILOs)
Knowledge	A	Understanding image formation and filtering techniques for enhanced visual understanding. **[SO1]**
	C	Understand complexities of multiple views and motion in computer vision, incorporating structure from motion and stereo vision. **[SO2]**
Skills	B	Develop proficiency in feature detection and matching, including texture analysis and optical flow. **[SO1]**
	D	Explore the synergy between machine learning and computer vision, focusing on supervised learning and classification. **[SO2]**
	E	Apply theoretical understanding to real-world problem-solving, utilizing algorithms across diverse domains. **[SO2]**

	F	Gain practical skills in object detection through robust techniques and deep learning integration. **[SO1]**
Competencies	G	Demonstrate how to solve real-world problems in MATLAB programming language. **[SO2]**
	H	Demonstrate teamwork and communication skills through group work activities. **[SO5]**

22 Topic Outline and Schedule:

Week	Lecture	Topic	ILO/SO	Evaluation Methods	References
1	1.1 1.2 1.3	**Introduction to Computer Vision**	A/SO1	Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
2	2.1 2.2 2.3	**Image Formation:** cameras and optics, light and color.	A/SO1	Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
3	3.1 3.2 3.3	**Image Filtering**: spatial and frequency domain filtering.	C,G/SO2	Assignment 1	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
4	4.1 4.2 4.3	**Image Filtering**: image pyramids and applications.	C,G/SO2	Programming task 1	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
5	5.1 5.2 5.3	**Feature Detection and Matching**: gradient and edges, points and corners.	C,G/SO2	Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
6	6.1 6.2 6.3	**Feature Detection and Matching**: local image features, texture analysis.	C/SO2	Programming task 2	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
7	7.1 7.2 7.3	**Feature Detection and Matching:** feature matching and Hough transform.	D,G/SO2	Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
8	8.1 8.2 8.3	**Feature Detection and Matching:** model fitting and RANSAC.	D,G/SO2	Assignment 2	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
9	9.1		B/SO1		

	9.2 9.3	**Multiple Views and Motion:** Stereo vision, epipolar geometry and structure from motion.		Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
10	10.1 10.2 10.3	**Multiple Views and Motion:** feature tracking and optical flow.	B,G/SO2	Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
11	11.1 11.2 11.3	**Machine Learning:** clustering and classification.	D/SO1	Programming task 3	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
12	12.1 12.2 12.3	**Deep learning Basics:** clustering and classification.	D/SO1	Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
13	13.1 13.2 13.3	**Object Detection:** bag of features, sliding window detection, scene recognition.	F,G/SO2	Programming task 4	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
14	14.1 14.2 14.3	**Object Detection:** Semantic Segmentation, Instance Segmentation, 3D Understanding	F/SO2	Class discussions and participation	Moodle (http://elearning.ju.edu.jo) and subject webpage (http://omar.alkadi.net/2646-2)
15	15.1 15.2 15.3	**Course wrap-up and project presentations**	H/SO5	Final project submission	-

23 Evaluation Methods:

Opportunities to demonstrate achievement of the ILOs are provided through the following assessment methods and requirements:

Evaluation Activity	Mark	Topic(s)	Period (Week)	Platform
Assignment 1	1 mark	MATLAB Basics Self-Paced Online Course	Week 1	Moodle (e-learning platform)
Assignment 2	1 mark	MATLAB APP Building Self-Paced Online course	Week 2	Moodle (e-learning platform)
Programming task 1	3 marks	Image Enhancement, Spatial and Frequency Filtering	Week 4	Moodle (e-learning platform)

Programming task 2	3 marks	Pyramids, Template Matching, Edge and Corner Detection, Filter Banks	Week 6	Moodle (e-learning platform)
Midterm exam	30 marks	-	Week 7	Moodle (JUExams platform)
Programming task 3	3 marks	RANSAC, Hough transform and Stereo Vision	Week 11	Moodle (e-learning platform)
Assignment 3	1 mark	MATLAB Machine Learning Self-Paced Online Course	Week 13	Moodle (e-learning platform)
Assignment 4	1 mark	MATLAB Deep Learning Self-Paced	Week 14	Moodle (e-learning platform)
Project Submission	7 marks	All previous tasks + Epipolar Geometry and Structure from Motion	Week 15	In-class

24 Course Requirements (e.g.: students should have a computer, internet connection, webcam, account on a specific software/platform…etc.):

PC/laptop, MATLAB – Mathworks®.

25 Course Policies:

A- Attendance policies: Students are responsible for attending online lectures and downloading and viewing all material covered uploaded to the LMS (http://elearning.ju.edu.jo) and the subject webpage at (http://omar.alkadi.net/2646-2).

B- Absences from exams and submitting assignments on time: It is the students' responsibility to turn in their homework assignments to their instructors by the announced due date/time. Not attending exams without a valid excuse is not accepted.

C- Health and safety procedures: Students should adhere to the University of Jordan health and safety rules and procedures

D- Honesty policy regarding cheating, plagiarism, misbehavior: For more details on University regulations please visit http://www.ju.edu.jo/rules/index.htm

E- Grading policy: 50% semester work comprising of assignments, quizzes and programming project to be submitted at the end of the semester, and 50% for final exam.

F- Available university services that support achievement in the course: http://elearning.ju.edu.jo

26 References:

A- Required books, assigned reading and audio-visuals:

- *Computer vision: algorithms and applications*. By Szeliski, R. (Springer Nature, 2022)

B- Recommended books, materials and media:

- *Computer vision: a modern approach,* by Forsyth, D. A., & Ponce, J. (Prentice Hall, 2002).
- *Digital Image Processing,* by Gonzalez, Rafael, Woods, Richard (Prentice Hall, 2018).
- *Computer Vision,* by Linda G. Shapiro and George C. Stockman
- *Introductory Techniques for 3-D Computer Vision,* by Emanuele Trucco & Alessandro Verri
- *Multiple View Geometry in Computer Vision,* by Richard Hartley and Andrew Zisserman
- *Deep Learning*, by Ian Goodfellow, Yoshua Bengio and Aaron Courville

27 Additional information:

For additional information, student can refer to the lecturers' website at http://omar.alkadi.net/teaching