National University of Sciences & Technology (NUST)
School of Electrical Engineering and Computer Science (SEECS)
Department of Software Engineering

Computer Vision

Course Code:	CS474	**Semester:**	8th
Credit Hours:	2+1	**Prerequisite Codes:**	None
Instructor:	Dr. Muhammad Shahzad	**Class:**	BESE 5
Office:	B-204, IAEC Building (2nd floor)	**Telephone:**	9085 2157
Lecture Days:	Wednesday	**E-mail:**	muhammad.shehzad@seecs.edu.pk
Class Room:	CR-01 UG Block	**Consulting Hours:**	Mondays 3-5 pm (preferably by prior email)
Lab Engineer:	Ms. Iram Tariq	**Lab Engineer Email:**	iram.tariq@seecs.edu.pk
Knowledge Group:	KGH-VML	**Updates on LMS:**	After every lecture

Course Description:

Computer vision is behind some of the most interesting recent advances in technology. From algorithms that can identify skin cancer as well as dermatologists to cars that drive themselves, it's computer vision algorithms that are behind these advances. Computer vision is being used in the real world for things like self-driving cars and pedestrian detection, but in plenty of other situations as well: face recognition, gesture recognition, optical character recognition, augmented reality, digital video fingerprinting, iris recognition, people counting, reverse image search, and more.

This course provides an introduction to computer vision including fundamentals of camera imaging geometry, feature detection and matching, stereo, motion estimation and tracking, image classification and scene understanding , and deep learning with neural networks.

Course Objective:

The objectives of this course are to:

- Introduce the fundamental problems of computer vision.
- Introduce the main concepts and techniques used to solve those problems.
- Enable students to implement vision algorithms
- Enable students to make sense of the vision literature

Course Learning Outcomes (CLOs):

		Upon completion of the course, students should demonstrate the ability to:	PLO ** Mapping	BT Level*
	CLO 1	Understand computer vision algorithms, tools and techniques.	PLO 1	C2
	CLO 2	Develop solutions for image/video understanding and recognition.	PLO 3	C3
	CLO 3	Use modern tools to solve practical problems.	PLO 5	C5

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

- *Knowledge(C-1), Comprehension(C-2), Application(C-3), Analysis(C-4), Synthesis(C-5), Evaluation(C-6)*
- *Perception(P-1), Set(P-2), Guided Response(P-3), Mechanism(P-4), Complete Overt Response(P-5), Adaption(P-6), Organization(P-7)*
- *Receiving(A-1), Responding(A-2), Valuing(A-3), Organization(A-4), Internalizing(A-5)*

** *PLOs are published on department website*

Topics to be Covered:

Introduction to Computer Vision

Linear Algebra and Matlab Premier

Feature Detection and Description

Corner, Interest Point, SIFT, SURF, HOG, Model Fitting and RANSAC…

Image / Scene Classification and Recognition

Face Recognition, Person Re-Identification, Bag of Visual Words, Deep Learning Frameworks…

Motion and Tracking

Structure from Motion, Feature tracking , Optical Flow

Lecture Breakdown (Tentative):		
Week	**Topics**	**Remarks**
1.	CV Introduction; Revision of Prerequisites; Linear Algebra,	
2.	Image Filtering, Gradients, Convolution and Correlation	
3.	Edge Detection & Model Fitting	
4.	Feature Extraction (Interest Point/ Key point Detectors, Corner Detectors)	
5.	Feature Matching	
6.	**OHT-1**	
7.	SIFT Feature Detector/ Descriptor	
8.	Fitting and Alignment, Least Square, RANSAC	
9.	Camera geometry / Stereo vision	
10.	Clustering & segmentation	
11.	Tracking Motion Feature (Optical Flows)	
12.	**OHT-2**	
13.	Statistical Visual Tracking	
14.	Object detection & recognition	
15.	Bag of Visual Words (Histogram of Oriented Gradients)	
16.	Point Cloud Image Processing / 3-D Reconstruction	
17.	Presentations	
18.	**ESE**	

Lab Experiments:	
Lab 01	Transformation Matrices
Lab 02	2D Convolution
Lab 03	Model Fitting & Edge Detection
Lab 04	Local Image Features
Lab 05	Object Detection in a Cluttered Scene Using Point Feature Matching
Lab 06	Line / Circle Detection using Hough Transform
Lab 07	Classification of Handwritten Digits
Lab 08	Classification of MINST Dataset of Handwritten Digits using HOG and various classifiers
Lab 09	Open Lab on Object Tracking
Lab 10	Image Object Category Classification using Bag of Visual Words
Lab 11	Open Lab - I
Lab 12	Open Lab - II

Tools / Software Requirement:

Student will work extensively with Matlab R 2016b, Python 3 and/or OpenCV

Books:	
Text Book:	Computer Vision: Algorithms and Applications, Rick Szeliski, Springer, 2011. http://szeliski.org/Book/
Reference Books:	1. Computer Vision: A Modern Approach, 2nd Edition by David A. Forsyth and Jean Ponce; Pearson, 2012 2. Multiple View Geometry in Computer Vision by Richard Hartley and Andrew Zisserman; Cambridge University Press

Course Assessment	
Exam:	2 One Hour Tests (OHT) and 1 End Semester Exam (ESE)
Home work:	3 Assignments
Lab Assignments:	12 Reports
Semester Project:	1 Report for the term/semester project
Quizzes:	4 - 5 Quizzes

Course Assessment Weightages (tentative)
Theory: 67%
• Quizzes: 10%
• Assignments: 10%
• OHT-1: 15%
• OHT-2: 15%
• End Semester Exam: 50%
Practical: 33%
• Labs Assignments: 70%
• Project : 30%

Grading Policy:	
Quiz Policy:	The quizzes will be unannounced and normally last for ten minutes. The question framed is to test the concepts involved in last few lectures. Number of quizzes that will be used for evaluation is at the instructor's discretion.
Assignment Policy:	In order to develop comprehensive understanding of the subject, assignments will be given. Late assignments will not be accepted / graded. All assignments will count towards the total (No 'best-of' policy). The students are advised to do the assignment themselves. Copying of assignments is highly discouraged and violations will be dealt with severely by referring any occurrences to the disciplinary committee. The questions in the assignment are meant to be challenging to give students confidence and extensive knowledge about the subject matter and enable them to prepare for the exams.
Lab Conduct:	The labs will be conducted for three hours every week. A lab handout will be given in advance for study and analysis The lab handouts will also be placed on LMS. The students are to submit their results by giving a lab report at the end of lab for evaluation. One lab report per group will be required. However, students will also be evaluated by oral viva during the lab.

Plagiarism: SEECS maintains a zero tolerance policy towards plagiarism. While collaboration in this course is highly encouraged, you must ensure that you do not claim other people's work/ ideas as your own. Plagiarism occurs when the words, ideas, assertions, theories, figures, images, programming codes of others are presented as your own work. You must cite and acknowledge all sources of information in your assignments. Failing to comply with the SEECS plagiarism policy will lead to strict penalties including zero marks in assignments and referral to the academic coordination office for disciplinary action.

BESE Program Learning Outcomes (PLO)

The BESE graduates of NUST-SEECS will demonstrate the following attributes.

(i) **Engineering Knowledge:** An ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.

(ii) **Problem Analysis:** An ability to identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

(iii) **Design/Development of Solutions:** An ability to design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.

(iv) **Investigation:** An ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.

(v) **Modern Tool Usage:** An ability to create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities, with an understanding of the limitations.

(vi) **The Engineer and Society:** An ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.

(vii) **Environment and Sustainability:** An ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

(viii) **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

(ix) **Individual and Team Work:** An ability to work effectively, as an individual or in a team, on multifaceted and /or multidisciplinary settings.

(x) **Communication:** An ability to communicate effectively, orally as well as in writing, on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

(xi) **Project Management:** An ability to demonstrate management skills and apply engineering principles to one's own work, as a member and/or leader in a team, to manage projects in a multidisciplinary environment.

(xii) **Lifelong Learning:** An ability to recognize importance of, and pursue lifelong learning in the broader context of innovation and technological developments.