



# **Computer Vision and Image Processing (CSEL-393)**

## **Lecture 1: Introduction**

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## Introduction

- Instructor: Dr. Qurat ul Ain Akram , PhD in Computer Science
- **Area of Research:** Digital Image Processing, Computer Vision, Natural Language Processing
- **Research Projects:** 12+ Research Experience
- Teaching Experience:
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## Introduction

- Preferred Prior Knowledge: Linear algebra, calculus, programming in Python/Numpy.
- Text Books:
  1. Gonzalez, R. C. and Woods, R. E., Digital Image Processing, Second Edition, Pearson-Prentice Hall, Inc., 2002. ISBN 81-7758-168-6.
  2. Richard Szeliski, Computer Vision, Algorithms and Applications, 2<sup>nd</sup> Ed,  
<https://szeliski.org/Book/>

## Grading

Mid Terms	25%
Quizzes/Assignments	10%
Projects	10%
Final	55%

## Learning Outcomes

1. Describe the fundamentals and basic concepts of image processing related to image segmentation, compression, enhancement and camera calibration
2. Explain and test image processing and computer vision fundamentals for image enhancement, segmentation and feature extraction.
3. Apply popular machine learning techniques for computer vision problems

## Course Outline

- Image Processing
  - Image Formation
  - Image Acquisition
  - Image Enhancement
  - Image restoration
  - Morphological operations
  - Color Image Processing
  - Image compression
  - Image Filtering and Image Segmentation
- Computer Vision
  - Image Descriptors and Features Extraction
  - Machine Learning
  - Object Recognition

## Weekly Plan

Week	Topics
1	Introduction and Goals of Computer Vision and Image Processing, Image Formation Concepts Image acquisition Display using digital devices
2	Image enhancement in spatial domain <ul style="list-style-type: none"> <li>a) Intensity transformations</li> <li>b) Histogram and its analysis</li> <li>c) Convolution and spatial filtering</li> </ul>
3	Image enhancement in frequency domain <ul style="list-style-type: none"> <li>a) Basic concepts related to Fourier transform</li> <li>b) Sampling in frequency domain and introduction to DFT</li> <li>c) Filtering in frequency</li> </ul>
4	Image restoration <ul style="list-style-type: none"> <li>a) Introduction to restoration model</li> <li>b) Different types of noises and their models</li> <li>c) Image restoration in spatial and frequency domains</li> </ul>

## Weekly Plan

Week	Topics
5	Morphological operations for binary and gray images a) Introduction to morphological operations b) Morphological operation for binary and gray scale images
6	Color image processing a) Formation of color image b) Different color models c) Analysis of colored images
7	Image compression a) Compression models, compression ratio, types of redundancy b) Variable length coding c) Lossy and lossless compression d) Image/video communication
8	Image filtering and Image Segmentation

## Weekly Plan

Week	Topics
9	Midterm Exam
10	Image Descriptors and Features: edges, corners, texture based features
11	Image Descriptors and Features: edges, corners, texture based features
12	Fundamentals of Machine Learning

## Weekly Plan

Week	Topics
13	Applications of Computer Vision: Artificial Neural Network for Pattern Classification, Convolutional Neural Networks, Autoencoders
14	Applications of Computer Vision: Object Recognition and Image Understanding
15	Applications of Computer Vision: Object Recognition and Image Understanding
16	Final term Exam

## Image Processing and Computer Vision

- Image Processing (IP):
  - Subset of Computer Vision (CV)
  - Image Processing is the field of enhancing the images by tuning many parameter and features of the images. For example, transformations are applied to an input image and the resultant output image is returned. Some of these transformations are- sharpening, smoothing, stretching etc.
  - Input: Image
  - Output: Image

## Image Processing and Computer Vision

- Computer Vision (CV):
  - In Computer Vision, computers or machines are made to gain high-level understanding from the input digital images or videos with the purpose of automating tasks that the human visual system can do.
  - Input: Image/ Videos
  - Output: Automation of cognitive functions associated with vision

## Classification of DIP and Computer Vision Processes

- **Low-Level Process: (DIP)**
  - Primitive operations where inputs and outputs are images; major functions: image pre-processing like noise reduction, contrast enhancement, image sharpening, etc.
- **Mid-Level Process (DIP and Computer Vision)**
  - Inputs are images, outputs are attributes (e.g., edges); major functions: segmentation, description, classification / recognition of objects
- **High-Level Process (Computer Vision)**
  - Make sense of an ensemble of recognized objects; perform the cognitive functions normally associated with vision

## Applications

- 56 most popular computer vision applications (<https://viso.ai/applications/computer-vision-applications/>)
- Computer Vision In Sports
  - Player Pose Tracking
  - Stroke Recognition
  - Sports Team Behaviors Analysis

## Earth viewers (3D modeling)



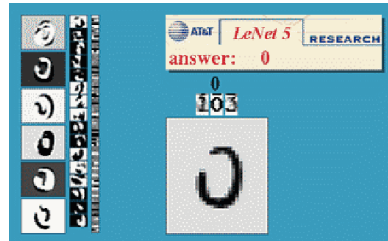
Image from Microsoft's [Virtual Earth](#)  
(see also: [Google Earth](#))



## Optical character recognition (OCR)

Technology to convert scanned docs to text

- If you have a scanner, it probably came with OCR software



Digit recognition, AT&T labs  
<http://www.research.att.com/~yann/>



License plate readers  
[http://en.wikipedia.org/wiki/Automatic\\_number\\_plate\\_recognition](http://en.wikipedia.org/wiki/Automatic_number_plate_recognition)

## Face detection

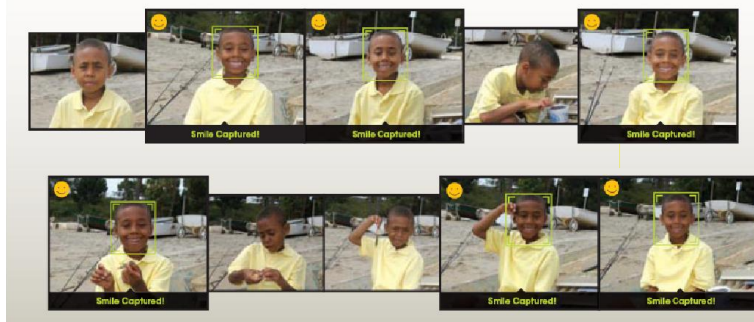


- Many new digital cameras now detect faces
  - Canon, Sony, Fuji, ...

## Smile detection?

### The Smile Shutter flow

Imagine a camera smart enough to catch every smile! In Smile Shutter Mode, your Cyber-shot® camera can automatically trip the shutter at just the right instant to catch the perfect expression.



[Sony Cyber-shot® T70 Digital Still Camera](#)

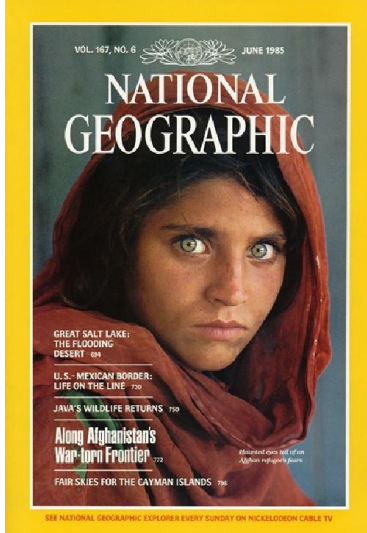
## Object recognition (in supermarkets)



[LaneHawk by EvolutionRobotics](#)

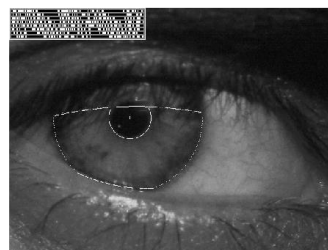
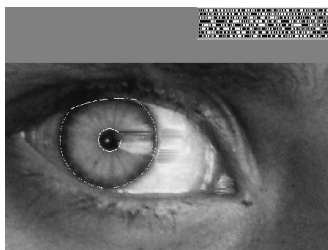
“A smart camera is flush-mounted in the checkout lane, continuously watching for items. When an item is detected and recognized, the cashier verifies the quantity of items that were found under the basket, and continues to close the transaction. The item can remain under the basket, and with LaneHawk, you are assured to get paid for it...”

## Face recognition



Who is she?

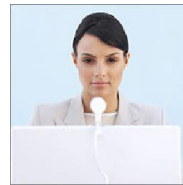
## Vision-based biometrics



## Login without a password...



Fingerprint scanners on many new laptops, other devices

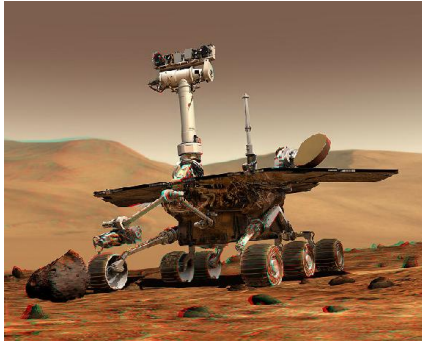


Face recognition systems now beginning to appear more widely  
<http://www.sensiblevision.com/>

## Object recognition (in mobile phones)



## Robotics

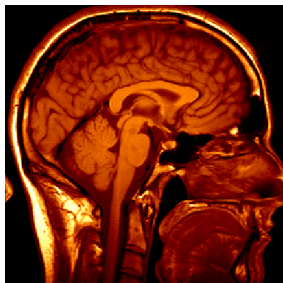


NASA's Mars Spirit Rover  
[http://en.wikipedia.org/wiki/Spirit\\_rover](http://en.wikipedia.org/wiki/Spirit_rover)



<http://www.robocup.org/>

## Medical imaging



3D imaging  
MRI, CT



Image guided surgery  
[Grimson et al., MIT](#)



COVID Detection

## Skin Tone Detection



## Facial Expression Recognition

