General

- Instructor: Dr. Mubarak Shah
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Course

- **Class Time**
  - Tuesdays, Thursdays 12 Noon to 1:15PM
  - 383 ENGR

- **Office hours**
  - Tuesdays 1:15 PM to 2:00 PM
  - Thursdays 11 AM to 12 Noon
  - And by appointment

- **Grading**
  - Midterm 20%
  - Final 30%
  - Assignments 10%
  - Programs 40%

- **Grading Policy:**
  - 90 - 100 = A;
  - 80 - 89 = B;
  - 70 - 79 = C;
Course

**Reference Texts:**
- Mubarak Shah, "Fundamentals of Computer Vision".

**Course Slides from Previous Years**
Topics We’ll Cover

- Image Filtering, Edge Detection, Interest Point Detectors
- Motion and Optical Flow
- Region Segmentation
- Object Detection and tracking
- Line and Curve Detection
- Shape Analysis
- Stereopsis
- Imaging Geometry, Camera Modeling and Calibration

We may change order
Computer Vision

- The ability of computers to see.
  - Image Understanding
  - Machine Vision
  - Robot Vision
  - Image Analysis
  - Video Understanding
A picture is worth a thousand words.
A word is worth a thousand pictures.

A HUNT
Image

- 2-D array of numbers (intensity values, gray levels)
  - Gray levels 0 (black) to 255 (white)
  - Color image is 3 2-D arrays of numbers
    - Red
    - Green
    - Blue
- Resolution (number of rows and columns)
  - 128X128
  - 256X256
  - 512X512
  - 640X480
Image Formats

- TIF
- PGM
- PBM
- GIF
- JPEG
Video

- Sequence of frames
- 30 frames per second

Formats
- AVI
- MPEG
- Quick Time
Video Clip
Sequence of Images
Image Formation

- Light Source
- Camera (extrinsic and intrinsic parameters)
- Scene (Surface reflectance, Surface shape)
Perspective Projection (Pin Hole)

\[
\begin{align*}
-y &= \frac{f}{Y} \\
Y &= \frac{Z}{f} \\
y &= -\frac{fY}{Z} \\
x &= -\frac{fX}{Z}
\end{align*}
\]
Orthographic Projection

Image Plane

World point

\( y = Y \)

\( x = X \)
Shape from X

- Recover 3-D shape from 2-D image(s)
  - Stereo
  - Motion
  - Shading
  - Texture
  - Contours
Stereo
Renault Stereo Pair
Depth Map
Stereo Pair
Shape from Shading
Lambertian Model

\[ S = L, \text{ light source} \]
\[ I = S \cdot N \]
Vase

(1, 0, 1)  (-1, 1, 1)  (-1, -1, 1)
Shape from Texture
Visual Motion
Hamburg Taxi seq (Optical Flow)
Optical Flow Field Examples
Video Clip & Mosaic
Structure From Motion

Reconstructed Shape
Applications of Computer Vision

- Face Recognition
- Object Recognition
- Video Surveillance and Monitoring
  - Object detection, tracking and behavior analysis
- Remote Sensing: UAVs
- Robotics
- Computer Graphics
Face Recognition
Finding People in images

**Problem 1:** Given an image \( I \)

**Question:** Does \( I \) contain an image of a person?
“Yes” Instances
“No” Instances
Localize People (Human Detection)
Human Detection

Individuals within small groups of people.
Airplanes
FACIAL EXPRESSIONS

RAISE EYE BROWS

SMILE
Detecting Driver Alertness
Lipreading
Video Surveillance and Monitoring

Automated Surveillance System (Detection & Tracking)
COCOA – System Flow

- Ego Motion Compensation
  - Feature based + Gradient

- Motion Detection
  - Accumulative Frame Differencing + Background Modeling + Object Segmentation

- Object Tracking
  - Kernel Tracking + Blob Tracking + Occlusion

Registered Images → Motion Detection → Event Detection & Indexing
Ego Motion Compensation Results - Aerial Video - EOMosaic - Alignment Mask
Ego Motion Compensation Results - II
Detection Result
Tracking Results
Tracking Results
UCF YouTube Action Dataset

- Cycling
- Diving
- Golf Swinging
- Riding
- Juggling
- Basketball Shooting
- Swinging
- Tennis Swinging
- Volleyball Spiking
- Trampoline Jumping
- Walking Dog
Making A Sandwich
Human Behavior Recognition
Key Frames Sequence 1 (350 frames), Part 1
Robot Vision (Unmanned Ground Vehicle)
Geo-registration
Geo-registration
Layer Based Video Composition
Results of Doll
Results of Mom-Daughter