CITS 4402 Computer Vision

Associate Professor Ajmal Mian

Lecture 01 - Introduction
Organization

- Unite coordinator: Assoc/Prof Ajmal Mian
  - Room 1.12
  - Consultation time: Mon 11:00am to 12:00pm

- Lecturer: Dr Mehdi Ravanbakhsh
Organization

- Laboratory Demonstrators
  - Dr Pouria Ramzi (Wed 2:00 -- 4:00pm)
  - Mr Hasan Zaki (Thu 2:00 – 4:00pm)


- Readings
  - Wikipedia. [available online](#)
Assessment

- Laboratory Assignments 25%
  - 5 labs x 5%
  - Upload your Matlab code on cssubmit

- Group Project 25%
  - 2 to 3 members per group
  - Demonstration/Presentation in the lab
  - Upload your Matlab code and project report on cssubmit

- Final Exam 50%
  - Mix of descriptive and multiple choice questions
  - See Exam paper 2014 on the unit website for a sample
What is Computer Vision?

- Automatic extraction of information from:
  - Images and Videos
  - Range data (from Kinect like sensors)
  - Magnetic Resonance Images (MRI)
  - CT scans, radiograms, mammograms or any type of spatial data

- Input image(s), output measurements or decisions such as:
  - Object height, length or distance etc
  - Location of faces, identities etc
  - %age of cancerous cells
  - Will I collide with the car approaching from...
Remember this robot?

*Terminator 2*
Every picture tells a story

- Goal of computer vision is to write computer programs that can interpret images
- Also known as
  - Machine Vision
  - Robot Vision
  - Image Analysis
  - Image Understanding
  - Video Understanding
Computer Vision Applications

- Most digital cameras detect faces for face priority focus
  - Canon, Sony, Fuji, …
Facebook Photo Auto-tagging

**We've Suggested Tags for Your Photos**

We’ve automatically grouped together similar pictures and suggested the names of friends who might appear in them. This lets you quickly label your photos and notify friends who are in this album.

**Tag Your Friends**

Francis Luu

[Save Tags]
CamFind

CamFind - Visual Search Engine
Image Searcher, Inc. - December 30, 2014
Tools

Installed

This app is compatible with your device.

Install

Move the cursor to where you want to enter text.
Google Maps
Google Maps – Street View
Google Maps – Street View

Going beyond the streets...
Google Maps – Street View
Street View – Stitching Images
Street View – Stitching Images
Street View – Stitching Images
Street View – Reading Street Numbers
Google Street View Dataset
Street View – Hiding Personal Details
Microsoft Virtual Earth 3D
Smart Cars

Our Vision. Your Safety.

- rear looking camera
- forward looking camera
- side looking camera

› EyeQ Vision on a Chip
› Vision Applications
  Road, Vehicle, Pedestrian Protection and more
› AWS Advance Warning System

News
- Mobeye Advanced Technologies Power
  Volvo Cars World First Collision Warning With Auto Brake System
- Volvo: New Collision Warning with Auto Brake Helps Prevent Rear-end

Events
- Mobeye at Equip Auto, Paris, France
- Mobeye at SEMA, Las Vegas, NV
Mobileye Pedestrian Detection

![Image of pedestrian detection system]
Mercedes S 500 Self-Driving Car
Driverless buses were operating in South Perth!

Antoinette on the RAC Intellibus 05_11_2016

Driving around the South Perth Esplanade, Western Australia, in a "DRIVER LESS" Intelligent Bus. It felt safe, quiet and a real adventure.
WHO IS HIRING?

computer Vision jobs in United States

Upload your resume - Let employers find you

Jobs 1 to 10 of 1,876

Computer Vision Engineer
A9.com - 2 reviews - Seattle, WA +2 locations
Specific computer vision skills in object detection, recognition, 3D computer vision, and/or tracking. Create world-class computer vision products....
1 day ago - save job - more...

Computer Vision Engineer
OGSystems - 3 reviews - Portland, OR
Computer Vision Engineer. Modern Computer Vision Principles & Techniques. Bachelor's degree in computer science, information technology or equivalent work...
12 days ago - save job - more...

Computer Vision Engineer
Blizzard Entertainment - 96 reviews - Irvine, CA
Experience implementing algorithms in Computer Vision and/or Machine Learning. The Computer Vision Engineer is responsible for the development of cutting-edge...
15 days ago - save job - more...

Computer Vision Engineer
Nauto - Palo Alto, CA
Familiarity with OpenCV or other computer vision libraries Perks. Merging artificial intelligence with computer vision. Nauto’s systems detect and react to what...
11 days ago - save job - more...

Computer Vision Engineer
ArrayFire - United States
C++ and experience with computer vision. We are looking for C++ programmers with a computer vision background....
26 days ago - save job - more...

Research Scientist - Computer Vision
Computer Vision @ UWA – 3D Face Recognition
Computer Vision @ UWA – 3D Action Recognition

![3D human body model with joints marked]
Computer Vision @ UWA – 3D Face Morphing
Hyperspectral face recognition
Computer Vision @ UWA – Realtime Aircraft Tracking
Computer Vision @ UWA – Undergraduate project on automatic object recognition

https://www.youtube.com/watch?v=SKO1qYTCmNU
## Computer Vision @ UWA – Hyperspectral Image Analysis

<table>
<thead>
<tr>
<th></th>
<th>RGB</th>
<th>400nm</th>
<th>520nm</th>
<th>640nm</th>
<th>700nm</th>
</tr>
</thead>
<tbody>
<tr>
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Computer vision @ UWA – Machine Intelligence Group

acija https://www.youtube.com/channel/UCy-HDqRqdYS3UUiclqqfFxQ
Computer Vision @ UWA – Interactive 3D face morphing demo

Let us open Matlab
Image Formation
Image Formation in the Human Eye

- When the eye is properly focused, light from an object outside the eye is imaged on the retina
- Retina consists of two types of light receptors: rods and cones
- Rods
  - Cover all of retina
  - 75-150 Million
  - Several rods connected to one optical nerve (low-resolution)
  - Sensitive to small light intensities (dim-light vision)
  - Equal response to all colours
Image Formation in the Human Eye

- When the eye is properly focused, light from an object outside the eye is imaged on the retina.
- Retina consists of two types of light receptors: rods and cones.
- Cones:
  - Concentrated at fovea.
  - 6-7 Million.
  - One cone connected to one optical nerve (high-resolution).
  - Sensitive to bright light (bright-light vision).
  - Sensitive to colours.
Image Formation in the Human Eye
The Electromagnetic Spectrum

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Wavelength (meters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{21}$</td>
<td>$10^{-12}$</td>
</tr>
<tr>
<td>$10^{20}$</td>
<td>$10^{-11}$</td>
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<tr>
<td>$10^{19}$</td>
<td>$10^{-10}$</td>
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<td>$10^{-9}$</td>
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<td>$10^{5}$</td>
<td></td>
</tr>
</tbody>
</table>

- Hard X-rays
- Ultraviolet
- Infrared
- Radio waves

- Gamma rays
- Soft X-rays
- Visible spectrum
- Microwaves

- Ultraviolet: $0.4 \times 10^{-6}$
- Violet: $0.5 \times 10^{-6}$
- Blue: $0.6 \times 10^{-6}$
- Green: $0.7 \times 10^{-6}$
- Yellow: $0.8 \times 10^{-6}$
- Orange: $0.9 \times 10^{-6}$
- Red: $1 \times 10^{-6}$
- Infrared
Trichromatic Vision

- **Cone cells** are of three types, each containing a **photosensitive pigment** that responds to a particular wavelength of light
- S-cones are sensitive to “short” wavelengths, corresponding to the **blue colour**
- M-cones are sensitive to “medium” wavelengths, corresponding to the **green colour**
- L-cones are sensitive to “long” wavelengths, corresponding to the **red colour**
Digital Cameras – Image Sensing
Digital Cameras – Image Formation

Illumination (energy) source

Imaging system

Scene element

(Internal) image plane

Output (digitized) image
Reflection of Light

- Incident light is reflected in two main forms
  1. Diffuse reflection: light scattered *isotropically* in all directions (shows true colour of the object)
  2. Specular reflection: Incident light reflected in a specific direction (mirror-like effect)
- Most materials exhibit a mixture of diffuse and specular reflections
Image Formation

\[ f(x, y) = i(x, y)r(x, y) \]

- \( f(x, y) \) is the image
- \( i(x, y) \) is the illumination (specular reflection)
- \( r(x, y) \) is the reflection (diffuse reflection)

\[ 0 < i(x, y) < \infty \]
\[ 0 < r(x, y) < 1 \]
Sampling and Quantization
Continuous Image Projected onto a Sensor Array
Representing Image as a Matrix

\[
\begin{array}{c}
\text{Origin} \\
0 & 1 & 2 & 3 & \cdots & \cdots & N - 1 \\
0 & \bullet & \bullet & \bullet & \cdots & \cdots & \bullet \\
1 & \bullet & \bullet & \bullet & \cdots & \cdots & \bullet \\
2 & \bullet & \bullet & \bullet & \cdots & \cdots & \bullet \\
3 & \bullet & \bullet & \bullet & \cdots & \cdots & \bullet \\
\vdots & \bullet & \bullet & \bullet & \cdots & \cdots & \bullet \\
M - 1 & \bullet & \bullet & \bullet & \cdots & \cdots & \bullet \\
\end{array}
\]

One pixel \( f(x, y) \)
Representing Image as a Matrix

\[
f(x, y) = \begin{bmatrix}
f(0, 0) & f(0, 1) & \cdots & f(0, N - 1) \\
f(1, 0) & f(1, 1) & \cdots & f(1, N - 1) \\
\vdots & \vdots & \ddots & \vdots \\
f(M - 1, 0) & f(M - 1, 1) & \cdots & f(M - 1, N - 1)
\end{bmatrix}
\]

\[
A = \begin{bmatrix}
a_{0,0} & a_{0,1} & \cdots & a_{0,N-1} \\
a_{1,0} & a_{1,1} & \cdots & a_{1,N-1} \\
\vdots & \vdots & \ddots & \vdots \\
a_{M-1,0} & a_{M-1,1} & \cdots & a_{M-1,N-1}
\end{bmatrix}
\]
Representing Image as a Matrix

\[ f(x, y) \]

One pixel

\[ M - 1 \]

\[ x \]

\[ y \]

\[ 0 \]

\[ 1 \]

\[ 2 \]

\[ 3 \]

\[ \ldots \]

\[ N - 1 \]
Computer Vision – Make Sense of Numbers

255 255 240  ...  255
255 248 232  ...  255
252 247 238  ...  239
.:.:.:.
.:.
255 255 255  ...  255
Summary

- Why study computer vision?
- Computer vision @ UWA
- Image formation in the human eye
- Digital imaging
- Digital image representation