Introduction

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Images taken from:
Digital Image Processing course by Brian Mac Namee, Dublin Institute of Technology.

"One picture is worth more than ten thousand words"
Anonymous

Prerequisites
– Signals and systems
– Matlab

Course Grading
– Assignments (50%, at least 6/10)
– Final examination (50%)

This lecture will cover:
– What is a digital image?
– What is digital image processing?
– History of digital image processing
– State of the art examples of digital image processing
– Key stages in digital image processing
What is a Digital Image?

A **digital image** is a representation of a two-dimensional image as a finite set of digital values, called picture elements or pixels.

Pixel values typically represent gray levels, colours, heights, opacities etc.

**Remember digitization** implies that a digital image is an approximation of a real scene.

For most of this course we will focus on grey-scale images.

What is Digital Image Processing?

Digital image processing focuses on two major tasks:
- Improvement of pictorial information for human interpretation
- Processing of image data for storage, transmission and representation for autonomous machine perception

Some argument about where image processing ends and fields such as image analysis and computer vision start.

The continuum from image processing to computer vision can be broken up into low-, mid- and high-level processes.

**Early 1920s**: One of the first applications of digital imaging was in the newspaper industry.
- The Bartlane cable picture transmission service
- An image was transferred by submarine cable between London and New York in 3 hours
- Pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer.
Mid to late 1920s: Improvements to the Bartlane system resulted in higher quality images
- New reproduction processes based on photographic techniques
- Increased number of tones in reproduced images

1960s: Improvements in computing technology and the onset of the space race led to a surge of work in digital image processing
- 1964: Computers used to improve the quality of images of the moon taken by the Ranger 7 probe
- Such techniques were used in other space missions including the Apollo landings

1970s: Digital image processing begins to be used in medical applications
- 1979: Sir Godfrey N. Hounsfield & Prof. Allan M. Cormack share the Nobel Prize in medicine for the invention of tomography, the technology behind Computerised Axial Tomography (CAT) scans

1980s - Today: The use of digital image processing techniques has exploded and they are now used for all kinds of tasks in all kinds of areas
- Image enhancement/restoration
- Artistic effects
- Medical visualisation
- Industrial inspection
- Law enforcement
- Human computer interfaces

Imaging modalities

Gamma-ray imaging
- Positron Emission Tomography (PET)
- Cygnus Loop natural radiation of the star (exploded 15k years ago)
- Valve of a nuclear reactor
X-ray imaging

- Chest X-ray
- Absorption of energy
- Angiography
  - Catheter with contrast medium
- Computed Axial Tomography (CAT)
- Manufacturing errors in electronic circuits
- Cygnus Loop

Ultraviolet imaging

- Fluorescence microscopy
  - Normal corn
  - Corn infected by smut disease
  - Cygnus Loop

Visible and infrared imaging

- Light microscopy
  - Taxol (anticancer agent) 250x
  - Cholesterol 40x
  - Microprocessor 60x
  - Nickel oxide thin film 600x
  - Surface of audio CD 1750x
  - Organic superconductor 450x

Visible and infrared imaging (cont.)

- Night-time lights of the world
  - Infrared band
  - Useful for estimating the percent of total electrical energy

Visible and infrared imaging (cont.)

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Visible and infrared imaging (cont.)

- Industrial inspection
  - Circuit board controller
  - Pill container
  - Bottle filling
  - Air pockets in plastic parts
  - Burned flakes
  - Intraocular implant
    - Structured light for detecting lens deformations (damages at 1 and 5 o’clock)

Law enforcement
- Fingerprint for database search
- Automated counting
- Bill identification
- Licence plate detection and reading

Image Processing (2002)

Images taken from Gonzalez & Woods, Digital

Imaging in the microwave

- Radar is the dominant application
  - It emits pulses and receives them back at its antenna

Imaging in the radio band

- Magnetic Resonance Imaging (MRI)
  - Patient placed in a magnet and radio wave pulses are emitted through the body
  - Resonance takes place with tissues (e.g., water molecules)

Imaging in the radio band

- Astronomy

Other imaging modalities

- Ultrasound imaging
Other imaging modalities (cont.)

- Electron Microscopy (EM)
  - Works like a slide projector emitting a beam of electrons instead of light
  - The transmitted beam is projected on a phosphor screen
  - The interaction of the beam with the slide produces light which is recorded
  - Scanning Electron Microscopy (SEM)
  - Transmission Electron Microscopy (TEM)
  - Very high magnification (10000x)

Applications: Image Enhancement

One of the most common uses of DIP techniques: improve quality, remove noise etc

Applications: The Hubble Telescope

Launched in 1990 the Hubble telescope can take images of very distant objects
However, an incorrect mirror made many of Hubble’s images useless
Image processing techniques were used to fix this

Applications: Artistic Effects

Artistic effects are used to make images more visually appealing, to add special effects and to make composite images

Applications: Medicine

3D tomography and rendering with transparencies
Applications: HCI

Try to make human computer interfaces more natural
- Face recognition
- Gesture recognition

Does anyone remember the user interface from “Minority Report”? These tasks can be extremely difficult.

Key Stages in Digital Image Processing

1. Image Aquisition
2. Image Enhancement
3. Image Restoration
4. Morphological Processing
5. Object Recognition
6. Representation & Description

Key Stages in Digital Image Processing:

- Segmentation
- Image Restoration
- Morphological Processing
- Image Enhancement
- Image Acquisition

Problem Domain:
- Colour Image Processing
- Image Processing

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Summary

We have looked at:
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Important: Acquire some experience with Matlab.