Introduction

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

Miscellanea

Prerequisites
– Signals and systems
– Matlab

Course Grading
– Assignments (50%)
– Final examination (50%)

Bibliography

Bibliography (cont...)

Contents
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.

Common image formats include:
- 1 sample per point (B&W or Grayscale)
- 3 samples per point (Red, Green, and Blue)
- 4 samples per point (Red, Green, Blue, and “Alpha”, a.k.a. Opacity)

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.

What is DIP? (cont…)

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

- **Low Level Process**
  - **Input:** Image
  - **Output:** Image
  - **Examples:** Noise removal, image sharpening

- **Mid Level Process**
  - **Input:** Image
  - **Output:** Attributes
  - **Examples:** Object recognition, segmentation

- **High Level Process**
  - **Input:** Attributes
  - **Output:** Understanding
  - **Examples:** Scene understanding, autonomous navigation

In this course we will stop here.

History of Digital Image Processing

**Early 1920s:** One of the first applications of digital imaging was in the newspaper industry
- The Bartlane cable picture transmission service
- Images were transferred by submarine cable between London and New York
- Pictures were coded for cable transfer and reconstructed at the receiving end on a telegraph printer
**History of DIP (cont…)**

**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

**Applications – Imaging modalities**

**Applications: Image Enhancement**
19 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.

20 Applications: Artistic Effects

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

21 Applications: Medicine

X-ray imaging

22 Applications: Medicine (cont...)

Gamma-ray imaging

23 Applications: Medicine (cont...)

- Radio frequencies
- Magnetic Resonance Imaging (MRI)

24 Applications: Medicine (cont...)

Ultrasound
Applications: Medicine (cont...)

3D tomography and rendering with transparencies (1)

Take slice from MRI scan of canine heart, and find boundaries between types of tissue
- Image with gray levels representing tissue density
- Use a suitable filter to highlight edges

Applications: Medicine (cont...)

3D tomography and rendering with transparencies (2)

Applications: GIS

Geographic Information Systems
- Satellite imagery
- Terrain classification (LANDSAT)
- Meteorology (NOAA)

Applications: GIS (cont...)

Night-Time Lights of the World data set (infra red)
- Global inventory of human settlement
- Not hard to imagine the kind of analysis that might be done using this data
Applications: Industrial Inspection

Human operators are expensive, slow and unreliable
Make machines do the job instead
Industrial vision systems are used in all kinds of industries
Can we trust them?

Applications: PCB Inspection

Printed Circuit Board (PCB) inspection
- Machine inspection is used to determine that all components are present and that all solder joints are acceptable
- Both conventional imaging and x-ray imaging

Applications: Law Enforcement

Image processing techniques are used extensively by law enforcers
- Number plate recognition for speed cameras/automated toll systems
- Fingerprint recognition
- Enhancement of CCTV images

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

Image Acquisition
Image Restoration
Morphological Processing
Segmentation
Object Recognition
Representation & Description

Key Stages in Digital Image Processing: Image Acquisition

Image Restoration
Morphological Processing
Segmentation
Object Recognition
Representation & Description
Key Stages in Digital Image Processing:

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

Problem Domain: Colour Image Processing, Image Compression
C. Nikou – Digital Image Processing (E12)
Key Stages in Digital Image Processing:
- Image Compression
- Image Restoration
- Morphological Processing
- Segmentation
- Object Recognition
- Representation & Description

Problem Domain: Colour Image Processing

Summary
We have looked at:
- 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

Important: Acquire some experience with Matlab.