Introduction to **Image Processing**

**ELEC 3218**

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Processing Scheme

Acquire image

Low-level processing

Links to signal processing

High-level processing

U/G Overview
What can image analysis achieve?
Applications of Image Processing/Vision

- Image Coding (MPEG/JPEG)
- Product Inspection
- Robotics
- Modern Cameras
- Medical imaging
- Demography (applied politics?)
- Biometrics (recognising people)
(Southampton’s) Biometrics
What is an image?

pixel $p(x, y)$
Images are made up of bits

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<thead>
<tr>
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<tbody>
<tr>
<td>(a) original image</td>
<td>(b) bit 0 (LSB)</td>
<td>(c) bit 1</td>
<td>(d) bit 2</td>
</tr>
<tr>
<td>(e) bit 3</td>
<td>(f) bit 4</td>
<td>(g) bit 5</td>
<td>(h) bit 6</td>
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<td></td>
<td>(i) bit 7 (MSB)</td>
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How many bits?

- Dynamic range of b/w video is 45 db, giving 8 bits
- Human dynamic range ~35 db, 5-6 bits.
- Colour (RGB) needs three 8-bit bytes
- (sampling theory applies here too)
Effects of Resolution

(a) 64×64  (b) 128×128  (c) 256×256
Image sensors market 2011
Image Formation

[Diagram of image formation process with lens and projected image]
Digital Camera

[Diagram of a digital camera with annotations for iris, focus, lens, CCD, and serial output]
Pixel Sensors

(a) passive

(b) active

Pixel Sensors
Spectral Sensitivity

![Graph showing spectral sensitivity of different entities like Sun Emission, Silicon Sensitivity, and Human Sensitivity.](image)
CCD Operation

a. 
- Insulator
- Electrode
- Well
- Grounded back surface
- P type silicon

b. 
- Light photon

b. 
- Light photon

b. 
- Light photon

b. 
- Light photon

U/G Overview
CCD Sensing Element

Pixel sensors

Horizontal transport register

Vertical transport register

Signal conditioning

Video output

Control

Control inputs
CCD Architecture
CMOS vs CCD?

- **Low power** will always win
- **Digital** tends to be repeatable but space hungry
- **Analog** tends to be less stable, but space efficient
- Some lower level attributes need closer examination
Sensor Characteristics

- Linearity
- Sensitivity
- SNR
- Shading
- Spectral Sensitivity
- Shutter Speeds (Integration Time)
- Readout Rate
Linearity

It is generally desirable that the relationship between the input physical signal (e.g. photons) and the output signal (e.g. voltage) be linear. In practice the relationship between input, \( i \), and output, \( o \), is frequently given by:

\[
o = \text{gain} \times i^\gamma + \text{offset}
\]

where \( \gamma \) is the *gamma* of the recording medium. (For a truly linear recording system we must have \( \gamma = 1 \) and \( \text{offset} = 0 \).

CCD chip (\( \gamma = 1.0 \)), Vidicon Tube (\( \gamma = 0.6 \))
Sensitivity

There are two ways to describe the sensitivity of a camera. First, we can determine the minimum number of detectable photoelectrons. This can be termed the \textit{absolute} sensitivity. Second, we can describe the number of photoelectrons necessary to change from one digital brightness level to the next, that is, to change one \textit{analog-to-digital unit} (ADU). This can be termed the \textit{relative} sensitivity.
In modern camera systems the noise is frequently limited by:

* **amplifier noise** in the case of colour cameras;
* **thermal noise** which, itself, is limited by the chip temperature $K$ and the exposure time $T$, and/or;
* **photon noise** which is limited by the photon production rate and the exposure time $T$. 
Others

The length of time that an image is exposed— that photons are collected— may be varied in some cameras. Historically, this exposure time is usually termed *shutter speed* although integration time would be more appropriate.

There are *progressive scan* camcorders (expensive) and *interlaced* ones
Acquisition System

A Computer Interface - the Framegrabber
DV Camcorder

Simplified Block Diagram of a DV Camcorder in Record Mode
Light Field = Array of (virtual) Cameras
Kinect
Kinect’s depth sensor uses **structured light** created by a beam of **infrared** laser light passing through a diffraction grating. This projects a grid of 50000 infrared **dots** across the **playing** area.
Image Processing Support

- WWW homepages
- Worksheets
- Demos: http://www.ecs.soton.ac.uk/~msn/book/new-demo/
- Links
- Notes
- Book
Recommended Textbook

http://www.ecs.soton.ac.uk/~msn/book

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2. Images, sampling and frequency domain processing
3. Basic image processing operations
4. Low-level feature extraction (including edge detection)
5. Feature extraction by shape matching
6. Flexible shape extraction (snakes and other techniques)
7. Object description
8. Introduction to texture description, segmentation and classification
9. Moving Object Extraction and Description
10. Appendices

3rd Edition 2012 (Current price ~ £44 Amazon)

U/G Overview
Worksheet Support

- Mathcad
- Used in lectures
- Free download viewer
- Used for independent study
- Some Matlab, but incomplete
Finally

✓ Enjoy!
✓ Email:

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