Computer Assisted Image Analysis
TF 3p and MN1 5p

Course homepage:
http://www.it.uu.se/edu/course/homepage/bild1/vt05/

Course book:
Gonzales & Woods Digital Image Processing, 2nd ed.
Book homepage:
http://www.imageprocessingplace.com/

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Introduction
11/4, Lecture 1, Ida-Maria
GW 1, 2.1-2.4

What is a digital image?

Why digital image analysis?
Human
+ Identification
+ Recognition
+ See and describe relationships
+ Interpretation using experience

Computer
+ Measuring absolute values
+ Perform Calculations
+ Never gets tired
+ Cheap
+ Fast
+ Objective

Which inner square is the brightest?

How much is dark and bright respectively?'
Application examples
(agrucultural, environmental)

More application examples
(medical, biomedical)

Electromagnetic spectrum

Creating a digital image

Sensors
- Pointscanner
- Linescanner
- Arrayscanner

Course Contents
- Digitization
- Point-wise operations
- Local neighbourhood operations
- Fourier transform
- Segmentation
- Mathematical morphology
- Object description and representation
- Wavelets
- Image restoration
- Color
- Classification
- Image coding and compression
Fundamental steps in problem solving using digital image analysis

- Problem
  - Image acquisition
  - Preprocessing
  - Segmentation
- Representation and Description
  - Classification, recognition, interpretation
- Solution

Image processing or image analysis

- Blue eyes
- 8cm ears
- Greek flag

Digital Images

A 2D gray-scale image \( f(x,y) \)

The value of \( f(x,y) \) is the intensity or grey level at position \( x,y \)

When an image is digitized it is sampled in

- **SPACE** \( (x,y) \): image sampling
- **AMPLITUDE** \( f(x,y) \): grey-level quantization

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94 103 104 119 143 153 157 158
103 104 106 117 149 155 158 160
109 128 136 120 95 117 149 155 160
110 130 144 129 78 97 151 158 160
109 137 157 119 78 101 185 188 161
109 143 157 134 87 85 134 216 209 172
104 123 166 161 155 134 204 223 178 181
125 131 172 179 185 238 237 220 206
131 148 172 175 188 220 239 237 220 206
161 163 162 163 163 163 163 163 163 163
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Methods for image sampling (in space)

- Uniform - same sampling frequency everywhere
- Adaptive - higher sampling frequency in areas with greater detail (not very common)
- The discrete sample is called a **pixel** (from picture element) in 2D and **voxel** (from volume element) in 3D and is usually square (cubic), but can also have other shapes (i.e. elongated or hexagonal grids).
Sampling density and resolution

• Resolution is the smallest discernible detail in an image.
• The sampling density (together with the imaging system) limits the resolution.
• Sampling density at scanning is often measured in dpi = dots per inch = pixels per 2.5 cm on the input object (e.g. paper). The “dot-size” may however be greater than the distance between two samples, leading to a lower resolution. Always test!
• Sample twice as often as the smallest detail you need to resolve.

Grey-level quantization

Grey-level quantization

Methods for quantization (in amplitude)

• Uniform (linear) – the intensities of the object are mapped directly to the gray-levels of the image
• Logarithmic - higher intensity resolution in darker areas (the human eye is logarithmic)

Common quantization levels

f(x,y) is given integer values [0-max], max=2^n-1

<table>
<thead>
<tr>
<th>n</th>
<th>[0, max]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>[0, 1]</td>
<td>“binary image”</td>
</tr>
<tr>
<td>5</td>
<td>[0, 31]</td>
<td>maximum the human eye can resolve (locally)</td>
</tr>
<tr>
<td>8</td>
<td>[0, 255]</td>
<td>1 byte, very common</td>
</tr>
<tr>
<td>16</td>
<td>[0, 65535]</td>
<td>common in research</td>
</tr>
<tr>
<td>24</td>
<td>[0, 16*2^10]</td>
<td>common in color images (i.e. 3*8 for RGB)</td>
</tr>
</tbody>
</table>

Choice of sampling

• What will the image be used for?
• What are the limitations in memory and speed?
• Will we only use the image for visual interpretation or do we want to do any image analysis?
• What information is relevant for the analysis (i.e. color, spatial and/or gray-level resolution)?
Re-sampling, grey-level interpolation

- Nearest neighbour, NN
- Bilinear, interpolation from four closest neighbours.

Re-sampling:

Original image rotation with NN interpolation
Rotation with bilinear interpolation

Aliasing when sampling

The image information may be obscured if the sampling frequency is different from "frequencies" in the image.

Examples of aliasing effects

The frequency of thin lines is too low to be correctly represented when the image is sub-sampled to 1/4 of its size.

This image was scanned from a magazine, resulting in a pattern due to the frequency of the raster in the printing.