Computer Assisted Image Analysis
TF 3p and MN1 5p

Course homepage:
http://www.it.uu.se/edu/course/homepage/bild1/vt06/

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

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What is a digital image?
### Why digital image analysis?

<table>
<thead>
<tr>
<th>Human</th>
<th>Computer</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Identification</td>
<td>+ Measuring absolute values</td>
</tr>
<tr>
<td>+ Recognition</td>
<td>+ Perform Calculations</td>
</tr>
<tr>
<td>+ See and describe relationships</td>
<td>+ Never gets tired</td>
</tr>
<tr>
<td>+ Interpretation using experience</td>
<td>+ Cheap</td>
</tr>
<tr>
<td></td>
<td>+ Fast</td>
</tr>
<tr>
<td></td>
<td>+ Objective</td>
</tr>
</tbody>
</table>
Which inner square is the brightest?
How much is dark and bright respectively?
Application examples
(agricultural, environmental)
More application examples

(medical, biomedical)
Electromagnetic spectrum
Creating a digital image
Sensors

- Pointscanner
- Linescanner
- Arraysscanner
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
Space \((x,y)\) sampling
Space \((x,y)\) sampling
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

256

32

8

2
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 $[0\text{-}\text{max}]$, $\text{max}=2^{n-1}$

<table>
<thead>
<tr>
<th>$n$</th>
<th>Integer Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>[0 1]</td>
<td>&quot;binary image&quot;</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*10^6]</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.

\[ g(x,y) \rightarrow f(x,y) \]

Re-sampling:
original image  
rotation with NN interpolation  
rotation with bi-linear
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 \(\frac{1}{4}\) of its size.

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

NN-interpolation

bi-linear interpolation