Medical Image Analysis
Guest Lecture,
2018-10-04

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Advertisement

- FMAN30
- Medical Image Analysis
- 7.5hp
- Study period 2
- 4 hand-ins
Learning objectives

- **Describe** different image acquisition techniques used in medical imaging, e.g. X-Ray, CT, MR, Ultrasound, PET, Scint and SPECT.
- **Explain** and **use** medical image analysis algorithms to perform registration, segmentation and classification
- **Decide** on appropriate algorithms for solving medical image analysis problems
- **Implement** automated medical analysis systems
- **Validate** the results of automated medical analysis systems
Research on Medical Image Analysis

- Mathematical imaging group
  - http://www2.maths.lth.se/matematiklth/vision/
- Cardiac MR Group
  - http://www.med.lu.se/klinvetlund/klinisk_fysiologi/forskning/cardiac_mr_group
Examples
Detection and Diagnosis of Kidney Lesions
Scandinavian Conference on Image Analysis, 2011

<table>
<thead>
<tr>
<th></th>
<th>LDA</th>
<th>QDA</th>
<th>ANN</th>
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<tbody>
<tr>
<td>Area under ROC curve (AUC)</td>
<td>0.964</td>
<td>0.935</td>
<td>0.960</td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>96.5</td>
<td>96.5</td>
<td>96.5</td>
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<tr>
<td>Specificity (%)</td>
<td>84.8</td>
<td>61.2</td>
<td>83.4</td>
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<tr>
<td>Positive Predictive value (%)</td>
<td>35.0</td>
<td>17.4</td>
<td>32.9</td>
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<tr>
<td>Negative Predictive value (%)</td>
<td>99.7</td>
<td>99.5</td>
<td>99.6</td>
</tr>
<tr>
<td>Mis-classification rate (%)</td>
<td>14.2</td>
<td>36.0</td>
<td>15.6</td>
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</table>
Diagnosis of Pulmonary Embolism

European Journal of Nuclear Medicine, 2000
Segmentation – shape variation methods
Understanding both appearance and shape
Segmenting white blood cells
Septum segmentation in ultrasound images

Fig. 2: The inter-ventricular septum marked with a yellow line obtained with our shortest path segmentation.

Fig. 8: Assessment straight: $s = 1216$.

Fig. 10: Assessment: bulges towards the right ventricle. $s = 0.896$. 
Segmentation of the Zona Pellucida
Segmentation results
Exini Diagnostics
MR – knee injuries
SPECT – brain (dementia)
### Gated SCINT - heart

<table>
<thead>
<tr>
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<th>EDV</th>
<th>ESV</th>
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<tbody>
<tr>
<td><strong>CAFU</strong></td>
<td>46 ml</td>
<td>21 ml</td>
<td>185 ml</td>
<td>71 ml</td>
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<tr>
<td><strong>QGS</strong></td>
<td>45 ml</td>
<td>21 ml</td>
<td>201 ml</td>
<td>122 ml</td>
</tr>
<tr>
<td><strong>TRUE</strong></td>
<td>57 ml</td>
<td>22 ml</td>
<td>186 ml</td>
<td>72 ml</td>
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</table>
Longitudinal expansion of left ventricle
Digital Pathology (prostate biopsies)

Digital stain separation to reduce variations between different labs

Typical stain variation:

Digital stain separation:

This makes it possible to normalize the stains individually, thus making different stain concentrations look similar.
Deep Learning Approach (CNN)

Idea for Deep Learning:
Let the computer itself optimize an algorithm by training on a large dataset.

Typically optimizes 100,000 to 100,000,000 parameters.

Convolutional Neural Networks specially designed for image analysis.
Segmentation Results

Segmentation into: Background, Stroma, Epithelial Cytoplasm and Nuclei

Original Images:

Ground Truth Segmentation:

Results:
Classification Results

Classification into four classes: Benign, Gleason 3, Gleason 4 and Gleason 5

<table>
<thead>
<tr>
<th>Validation data</th>
<th>Dataset A</th>
<th>Dataset B</th>
</tr>
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<tbody>
<tr>
<td>Training data</td>
<td>93 %</td>
<td>32 %</td>
</tr>
<tr>
<td>Dataset A</td>
<td>93 %</td>
<td>32 %</td>
</tr>
<tr>
<td>Dataset B</td>
<td>60 %</td>
<td>75 %</td>
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Accuracies when RGB images are used as input:

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<td>77 %</td>
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</table>

Accuracies when stain separated images are used as input:

Accuracies for when the datasets are combined are 84 % for both types of inputs.
Details on Registration
RANSAC-based registration

- Given a tentative list of point correspondences and a geometric transformation
- Select at random a minimum number of point correspondences needed to determine the transformation
- Calculate the transformation
- Determine the number of inliers and outliers
- Repeat a pre-determined number of iterations
- Estimate the best transformation from all inliers in the set containing most inliers
Euclidean (rigid)

- Two point correspondences needed
- The rotation angle can be determined by the angle between the lines between the points
- The translation can be determined from a linear system of equations
Similarity (rigid+scale)

- Two point correspondences needed
- The scale can be determined from the quotient of the distances between the points
- The rotation angle can be determined by the angle between the lines between the points
- The translation can be determined from a linear system of equations
Affine

- Two affine transformation contains 6 parameters
- Thus three point correspondences are needed
- The transformation can be obtained directly from a linear set of equations obtained from $y = Ax + t$ for the three different point correspondences.