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**
- **http://www.maths.lth.se/course/medim/2018/**

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

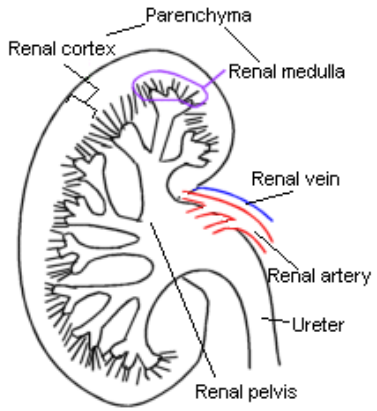
Research on Medical Image Analysis

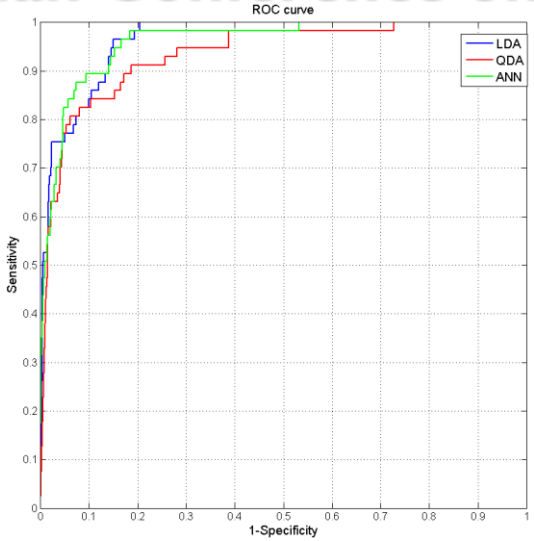
- Mathematical imaging group
  - http://www2.maths.lth.se/matematiklth/vision/
- Cardiac MR Group
  - http://www.med.lu.se/klinvetlund/klinisk_fysiologi/forskning/cardiac_mr_group

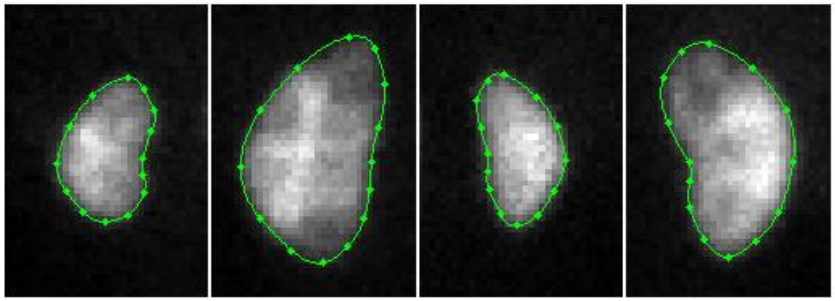
Examples

Detection and Diagnosis of Kidney Lesions

Scandinavian Conference on Image Analysis, 2011



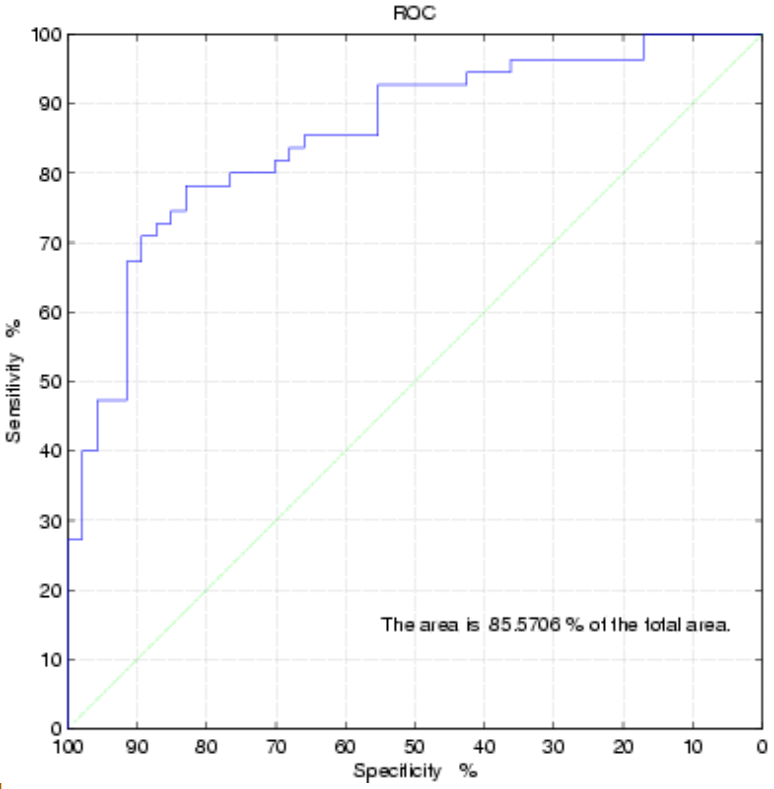


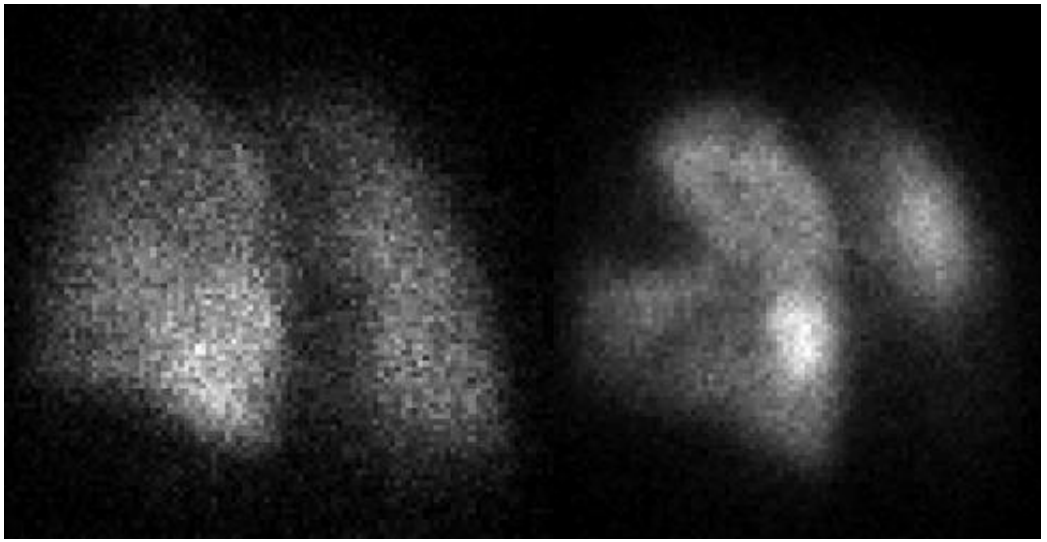


	LDA	QDA	ANN
Area under ROC curve (AUC)	0.964	0.935	0.960
Sensitivity (%)	96.5	96.5	96.5
Specificity (%)	84.8	61.2	83.4
Positive Predictive value (%)	35.0	17.4	32.9
Negative Predictive value (%)	99.7	99.5	99.6
Mis-classification rate (%)	14.2	36.0	15.6

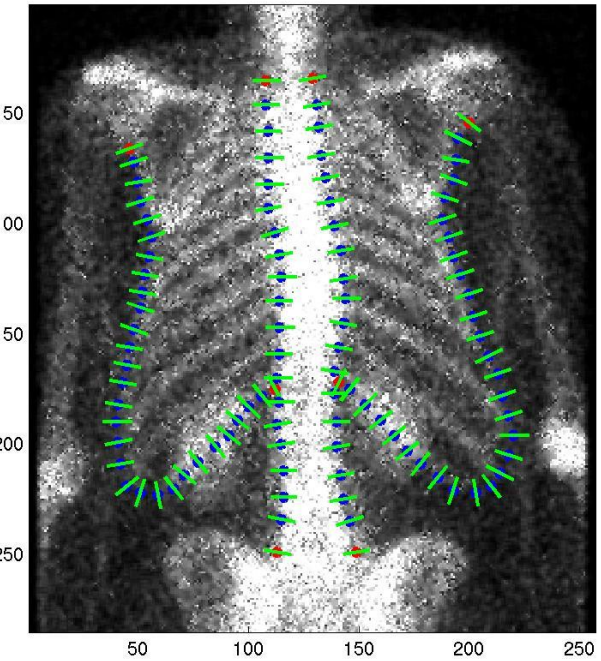
Diagnosis of Pulmonary Embolism

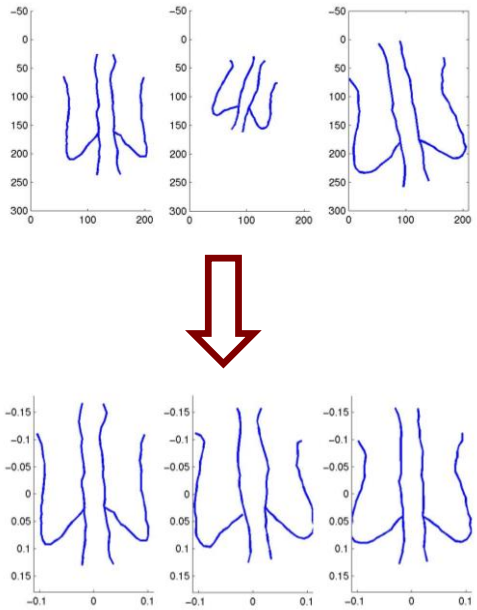
European Journal of Nuclear Medicine, 2000

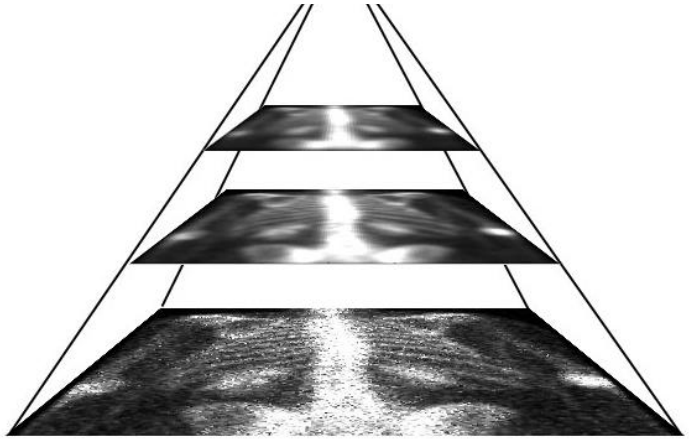


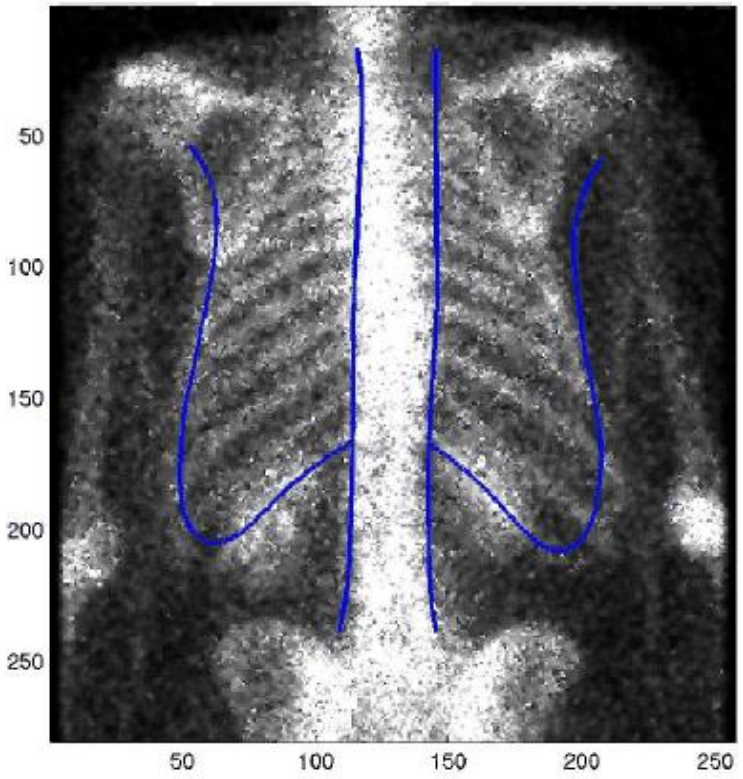


Segmentation – shape variation methods
Understanding both appearance and shape

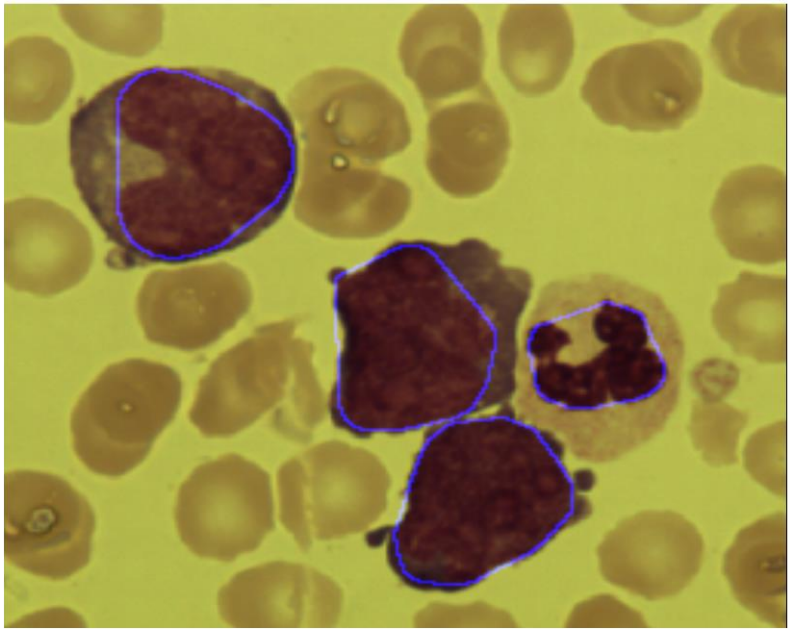


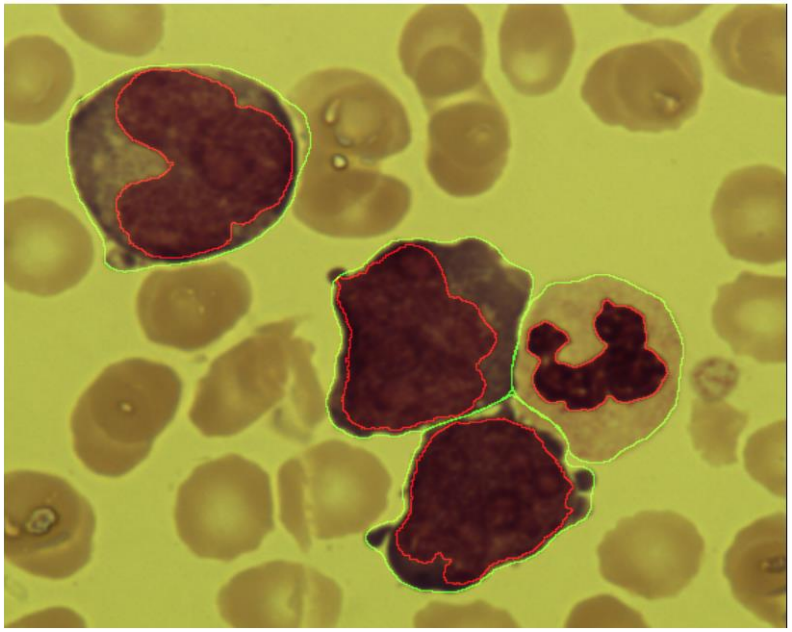






Segmenting white blood cells





Septum segmentation in ultrasound images

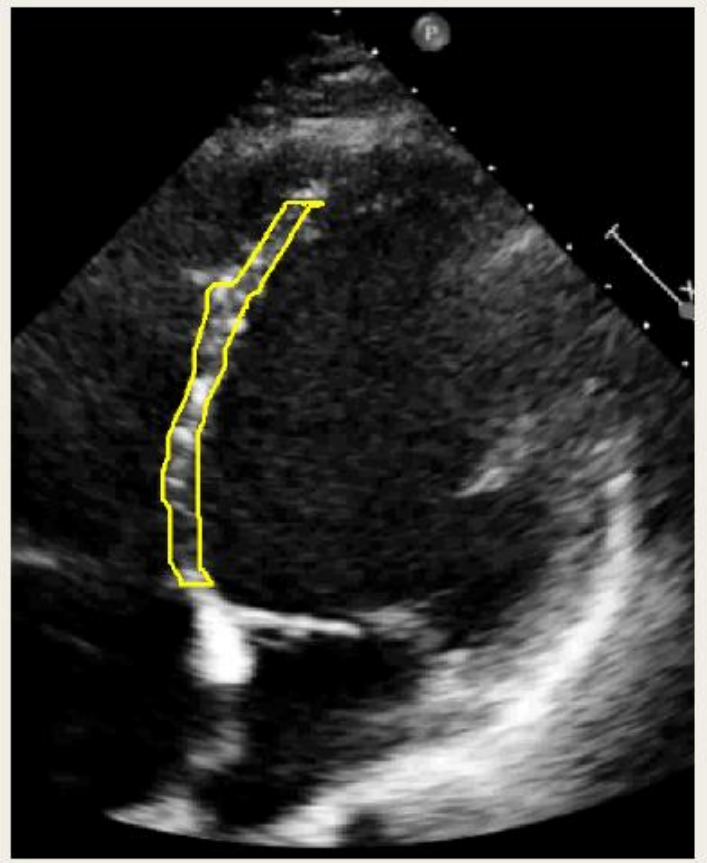


Fig. 2. The inter-ventricular septum marked with a yellow line obtained with our shortest path segmentation

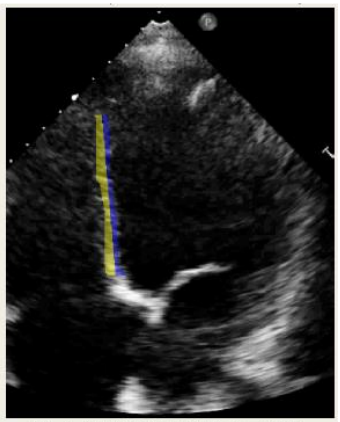


Fig. 8. Assessment: straight. $s = 0.279$.

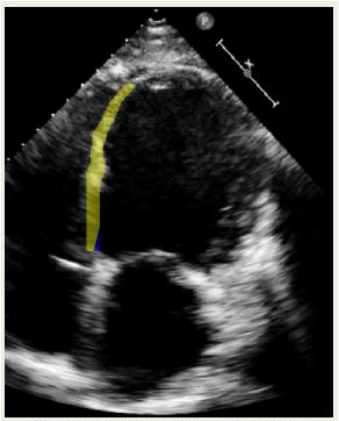
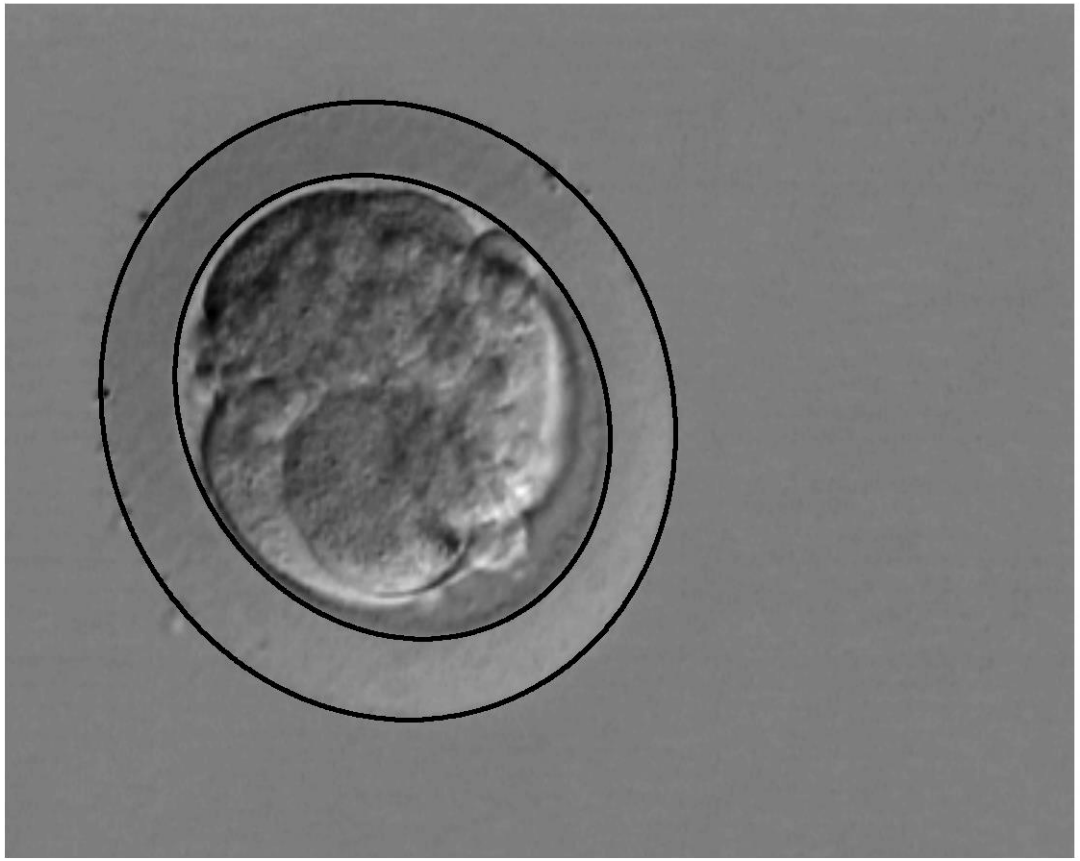
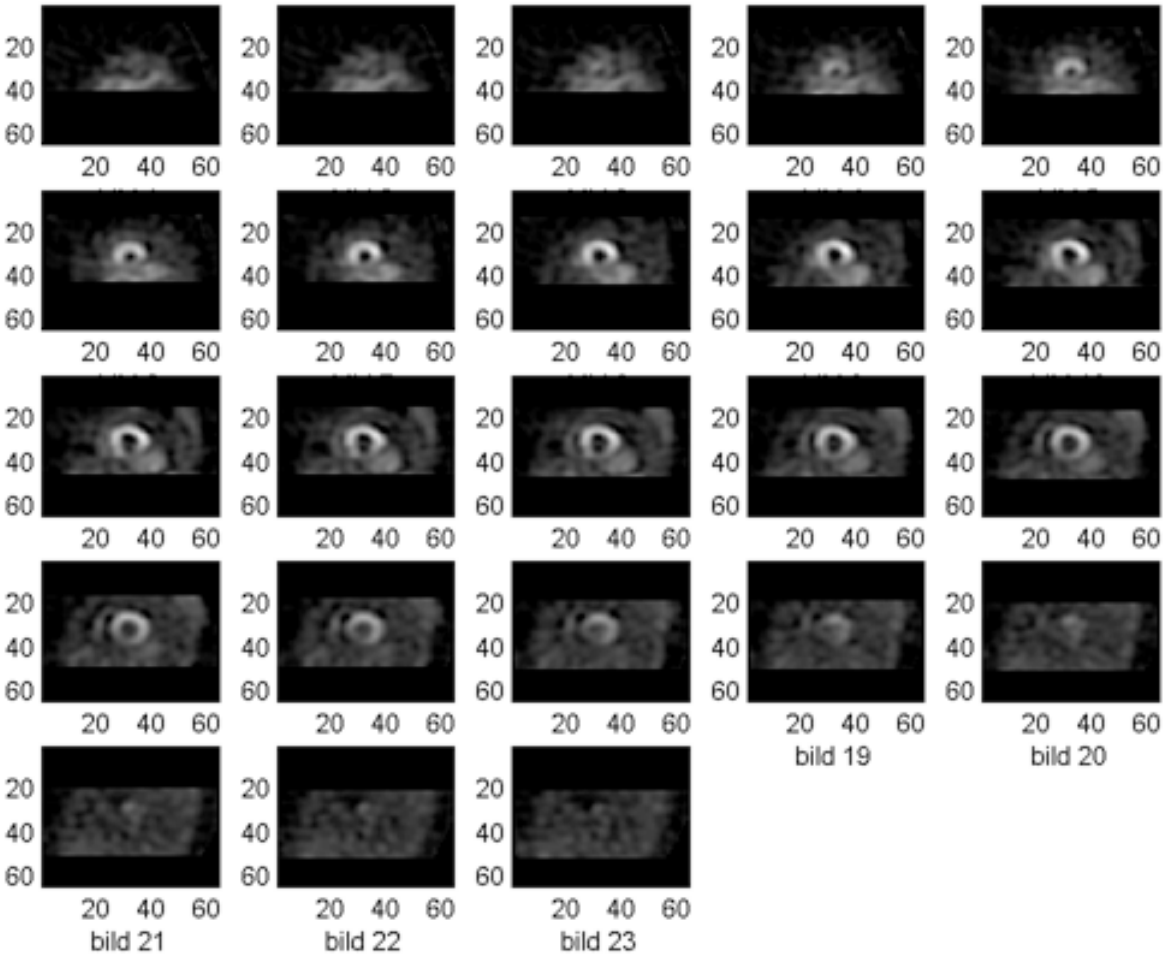


Fig. 10. Assessment: bulges towards the right ventricle. $s = 0.896$.

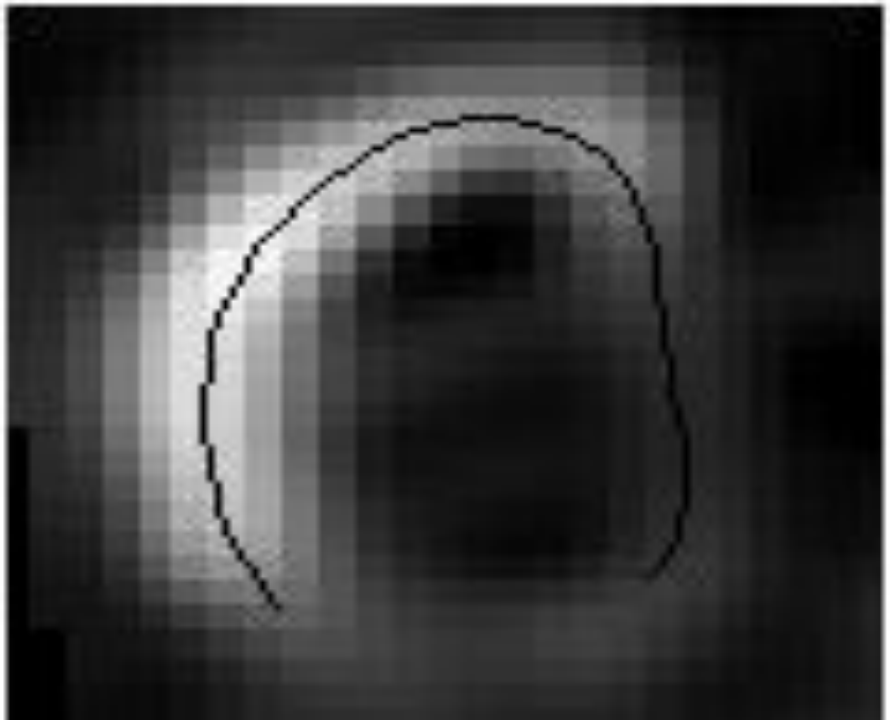
Segmentation of the Zona Pellucida



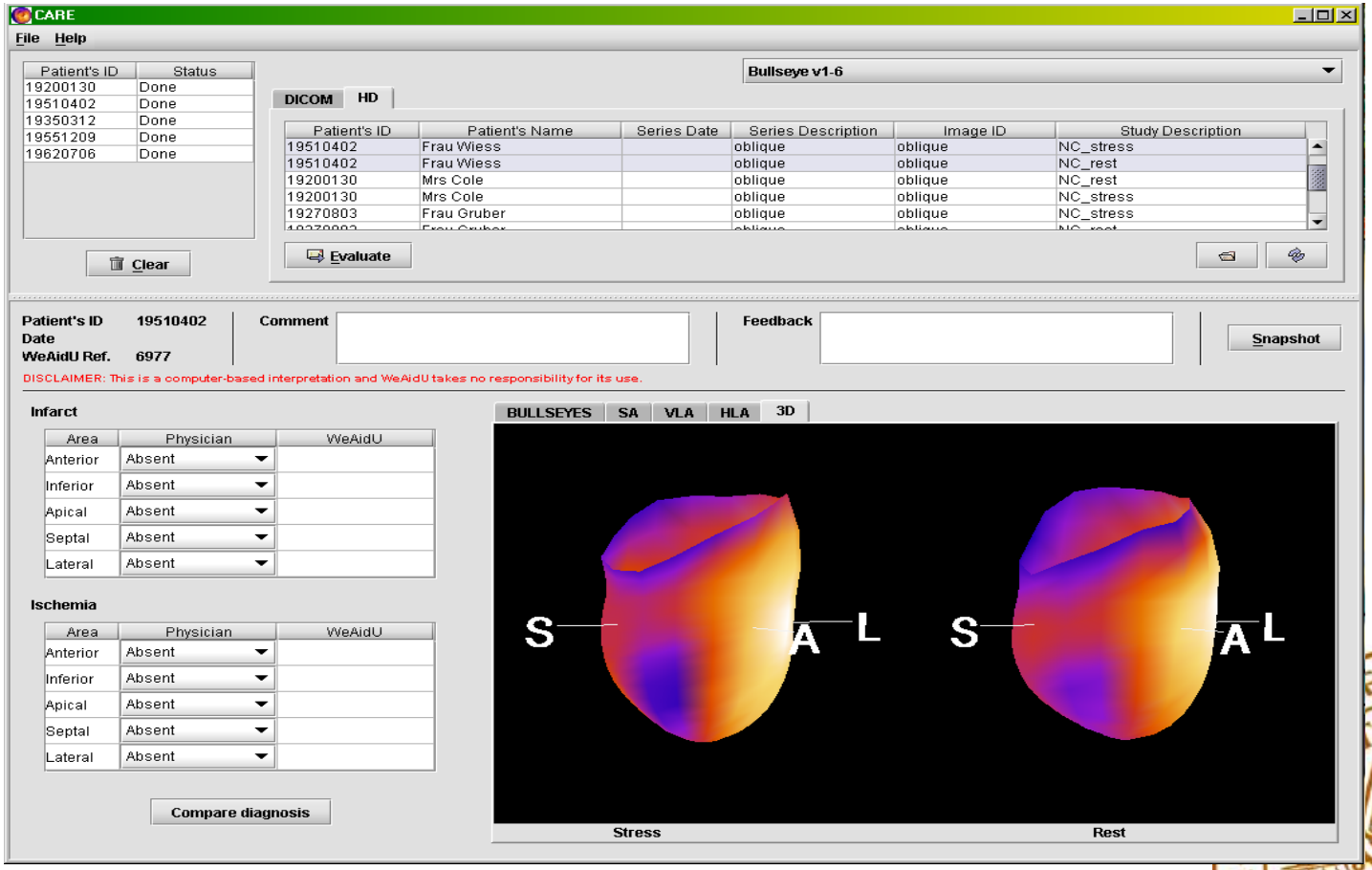
SCINT - Heart



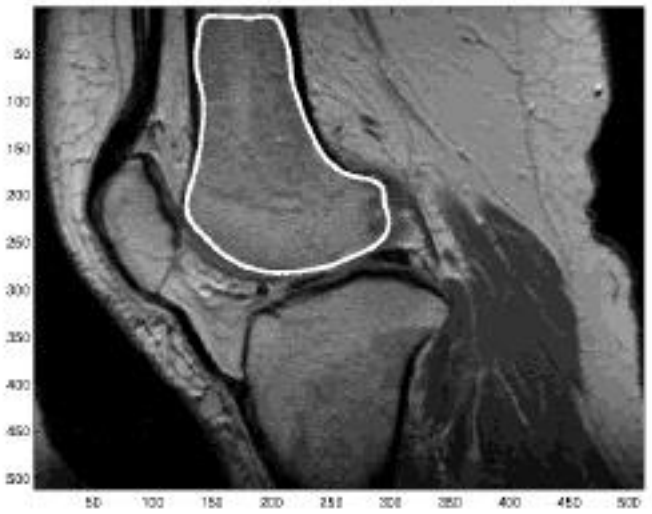
Segmentation results



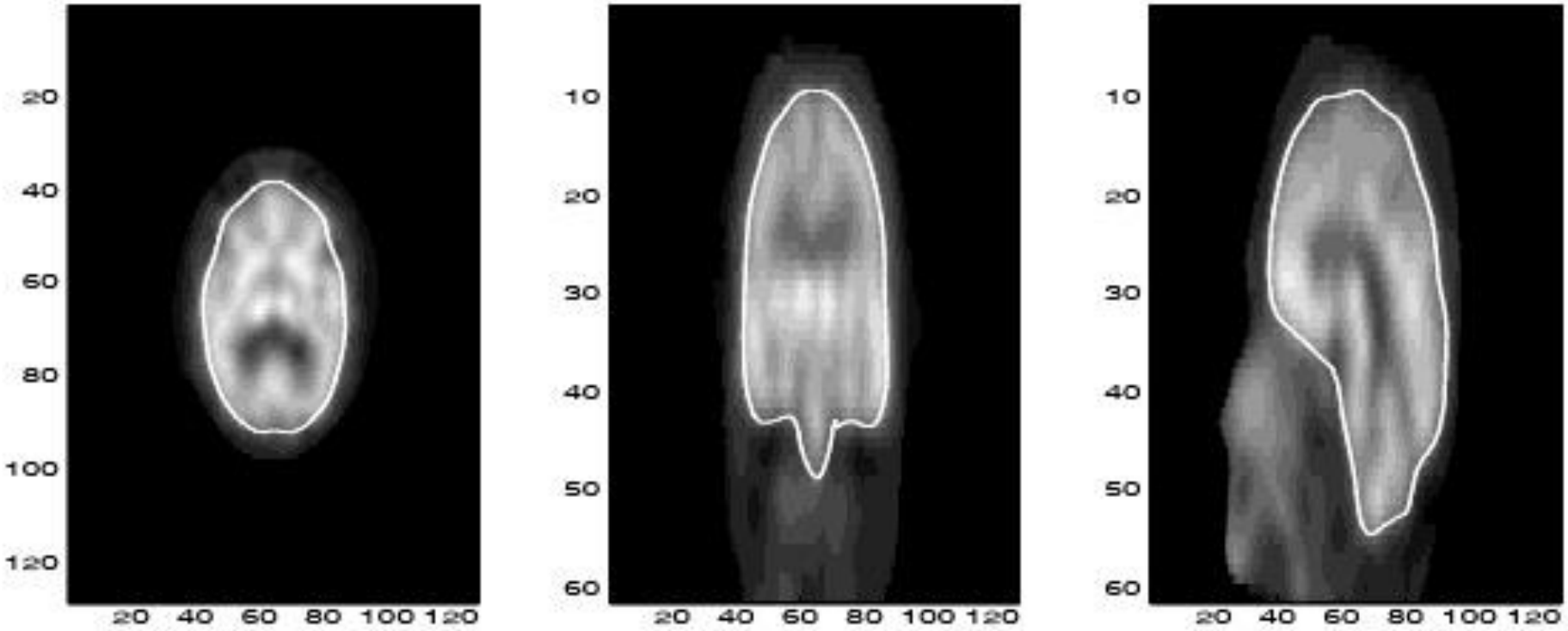
Exini Diagnostics



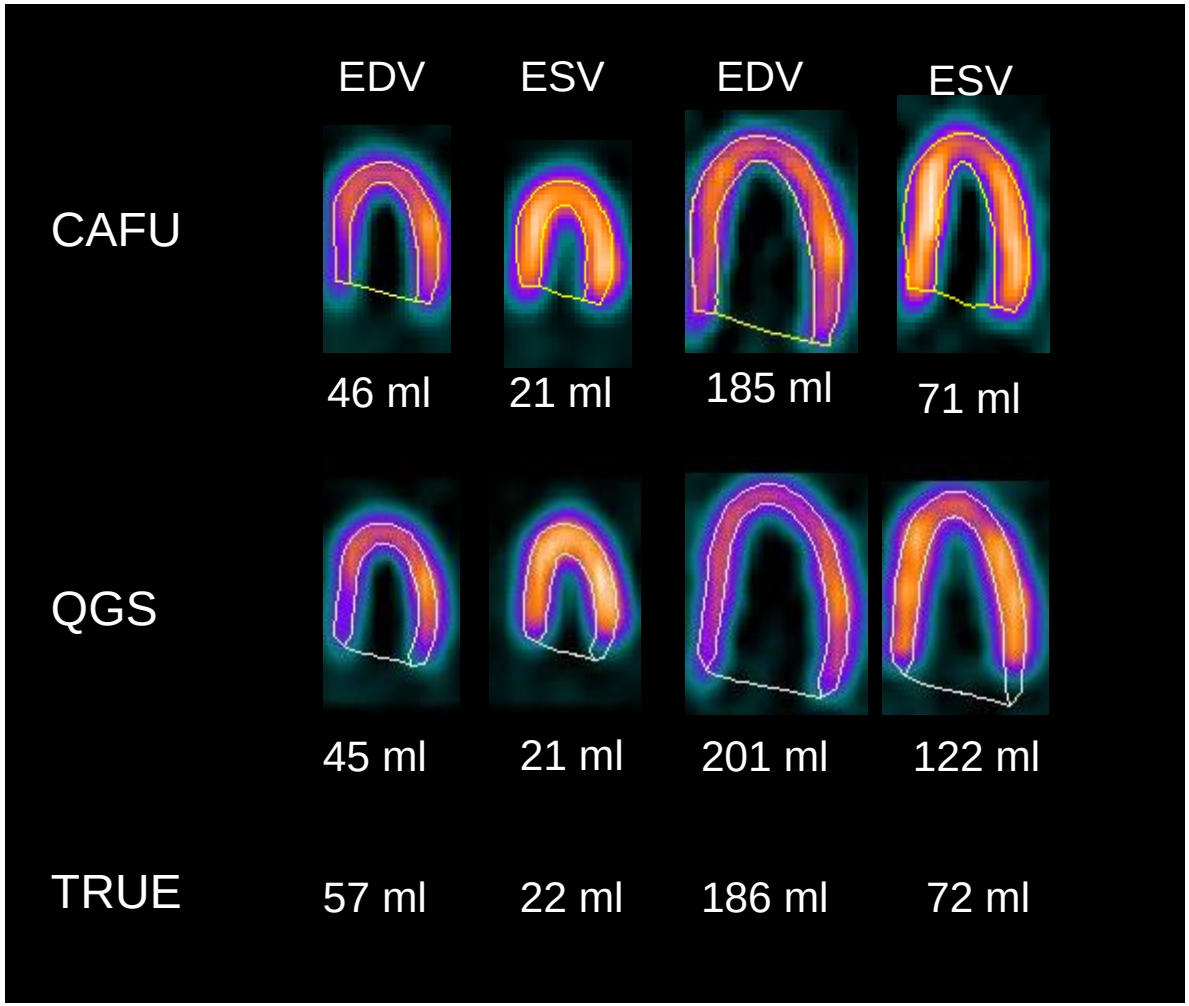
MR – knee injuries



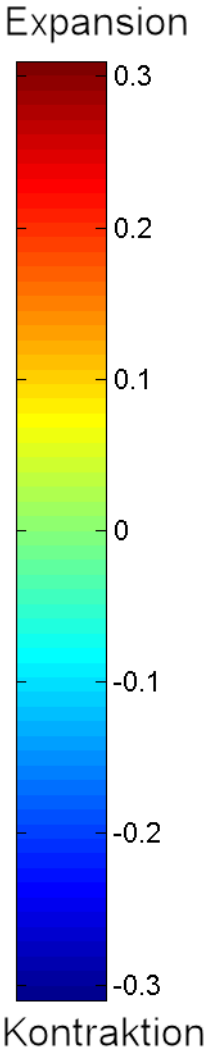
SPECT – brain (dementia)



Gated SCINT - heart



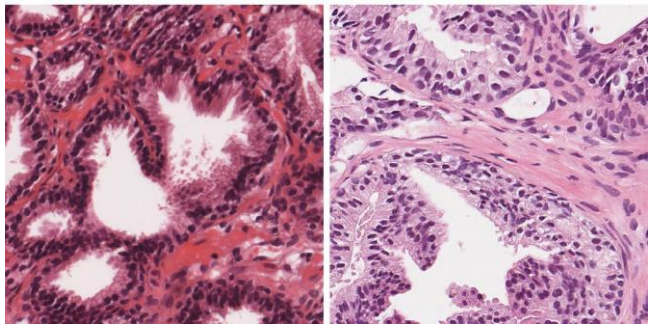
Longitudinal expansion of left ventricle



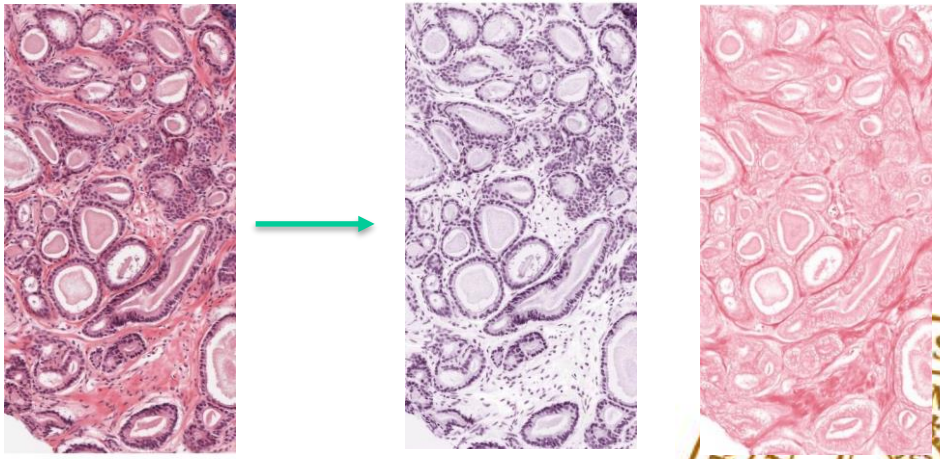
Digital Pathology (prostate biopsies)

Digital stain separation to reduce variations between different labs

Typical stain variation:



Digital stain separation:



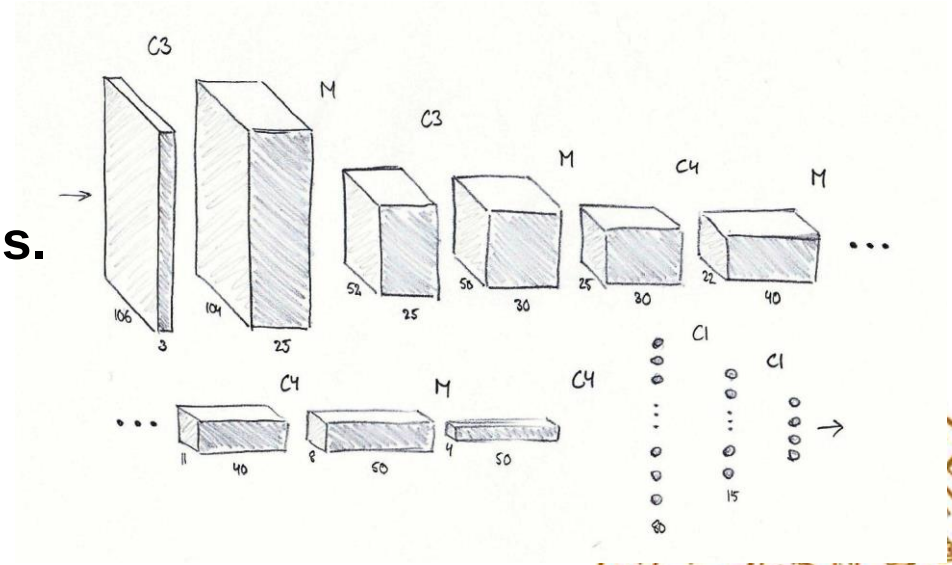
This makes it possible to normalize the stains individually, thus making different stain concentrations look similar.

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.



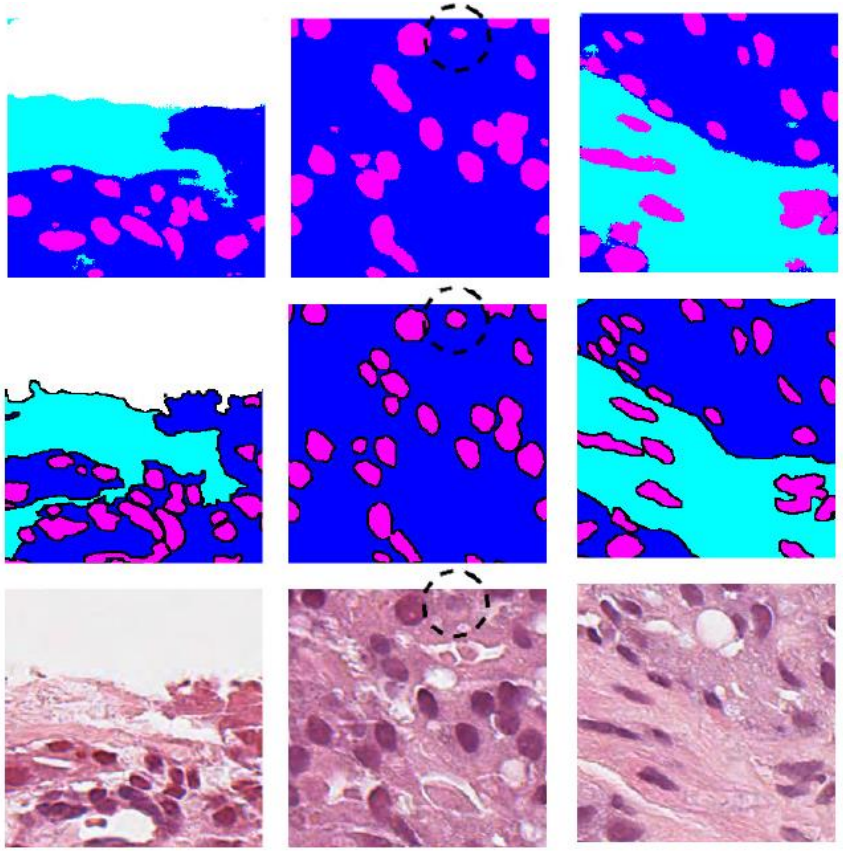
Segmentation Results

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

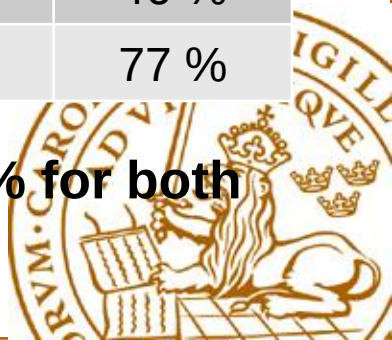
Accuracies when RGB images are used as input:

Training data \ Validation data	Dataset A	Dataset B
Dataset A	93 %	32 %
Dataset B	60 %	75 %

Accuracies when stain separated images are used as input:

Training data \ Validation data	Dataset A	Dataset B
Dataset A	91 %	46 %
Dataset B	60 %	77 %

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 inlieers

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 corresondences 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.**