Ultrasonic Tissue Characterization for the Classification of Prostate Tissue

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Overview

- Motivation
- Methods
- Information Model
- System Overview
- Clinical Study
- Results
- Conclusion

Motivation

Prostate cancer is ...

... one of the highest cancer risks in men in the western world

... among the highest in cancer mortality statistics

Current methods of diagnostics ...

... lack reliability (DRE, TRUS, PSA)

... are operator dependent (DRE, TRUS)

Current therapies ...

... are only successful at an early stage

Methods...

- Intention: Classification of prostate tissue

  Detection of tumors at an early stage

  Rendering of malignant areas for biopsy / surgery / therapy

- Compensation of disturbing effects

  Depth dependent diffraction & US system effects by PSF(ω,z)

  Attenuation by estimation of α

- Multifeature approach

  Spectral parameters: backscatter & attenuation

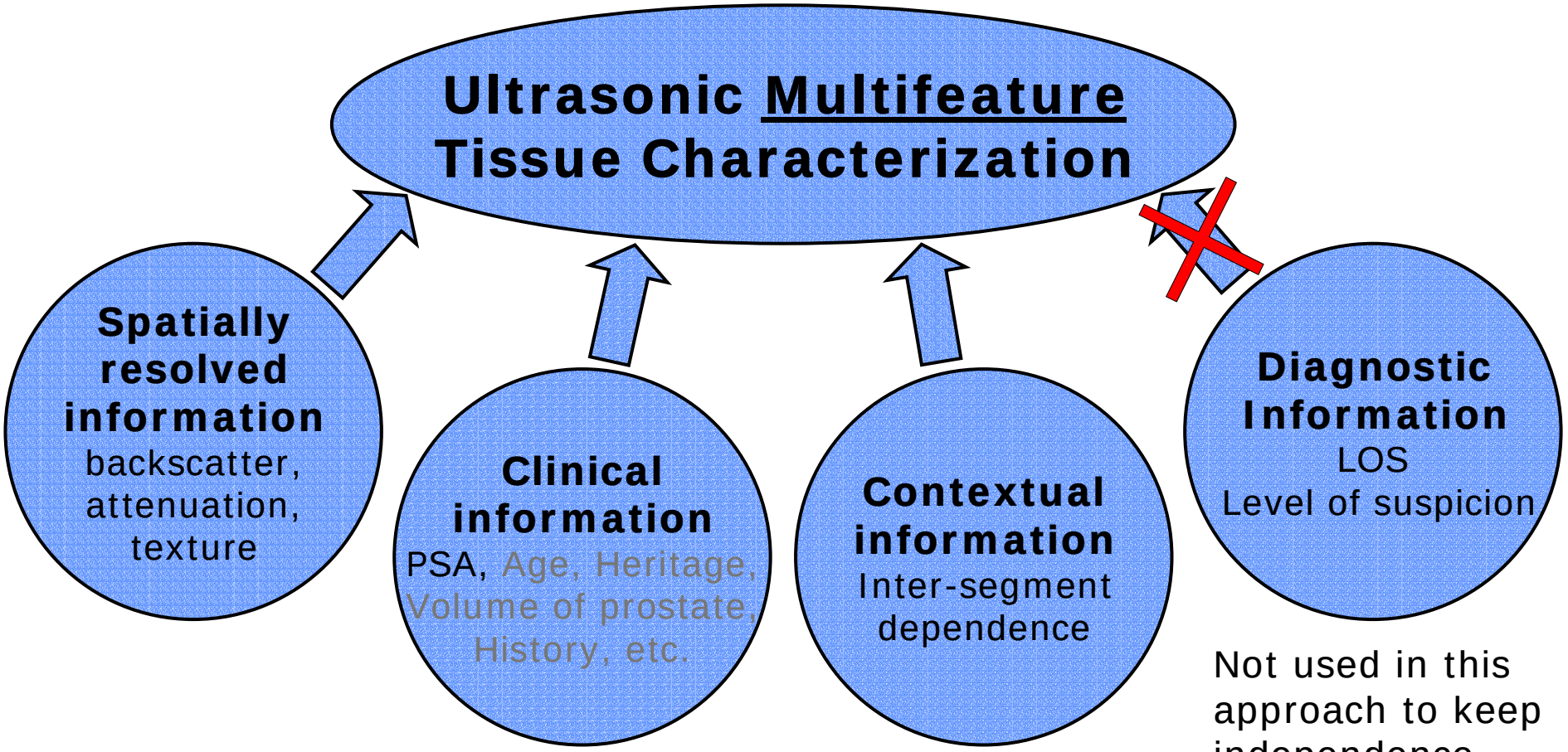
  Texture parameters: 1. and 2. order

  Morphological parameters

...Methods

- Gold standard: histological findings
  after radical prostatectomy
- Two Neuro-Fuzzy Inference Systems in parallel
  for nonlinear classification
- Preselection of tumors during training
  1. Hypo- and hyperechoic tumors (TRUS visible)
  2. Isoechoic tumors (TRUS invisible)
- Use of contextual information
  in morphological post processing

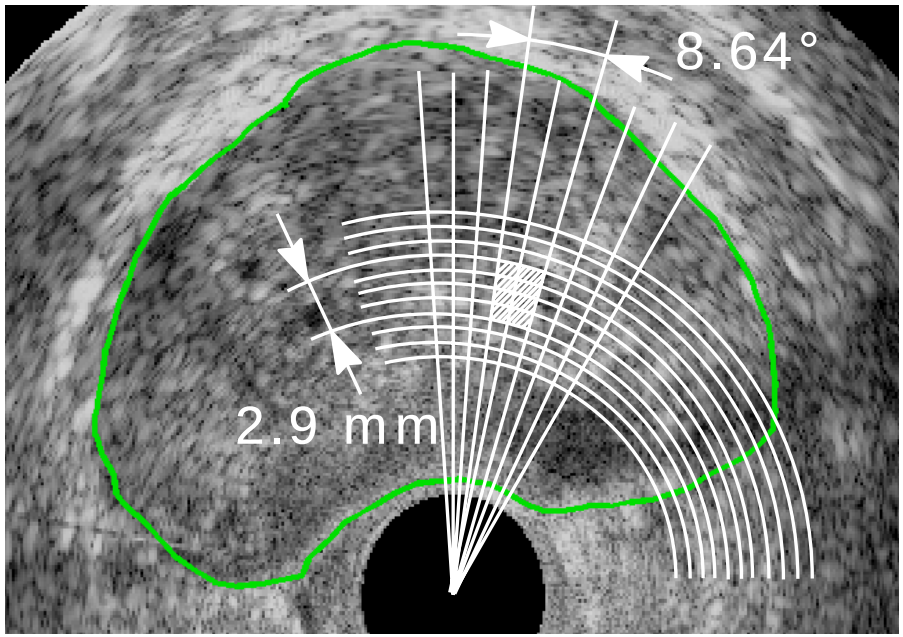
Information Model



Not used in this approach to keep independence from operator

Spatially Resolved Information

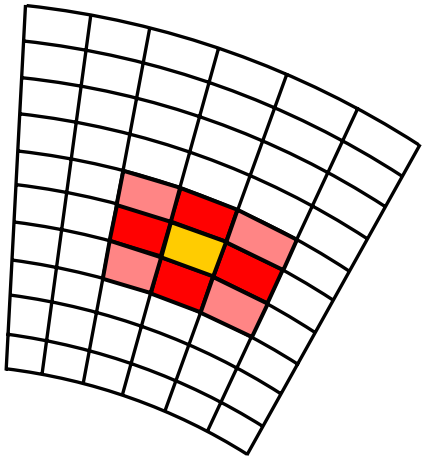
- Divide each RF-dataset in up to 1000 ROIs
- Depth of each ROI is 2.9 mm
- Width of each ROI equals 8.64 degrees
- Calculate parameters for each ROI
- Obtain spatially resolved parameter maps



→ Combine parameter maps using fuzzy inference

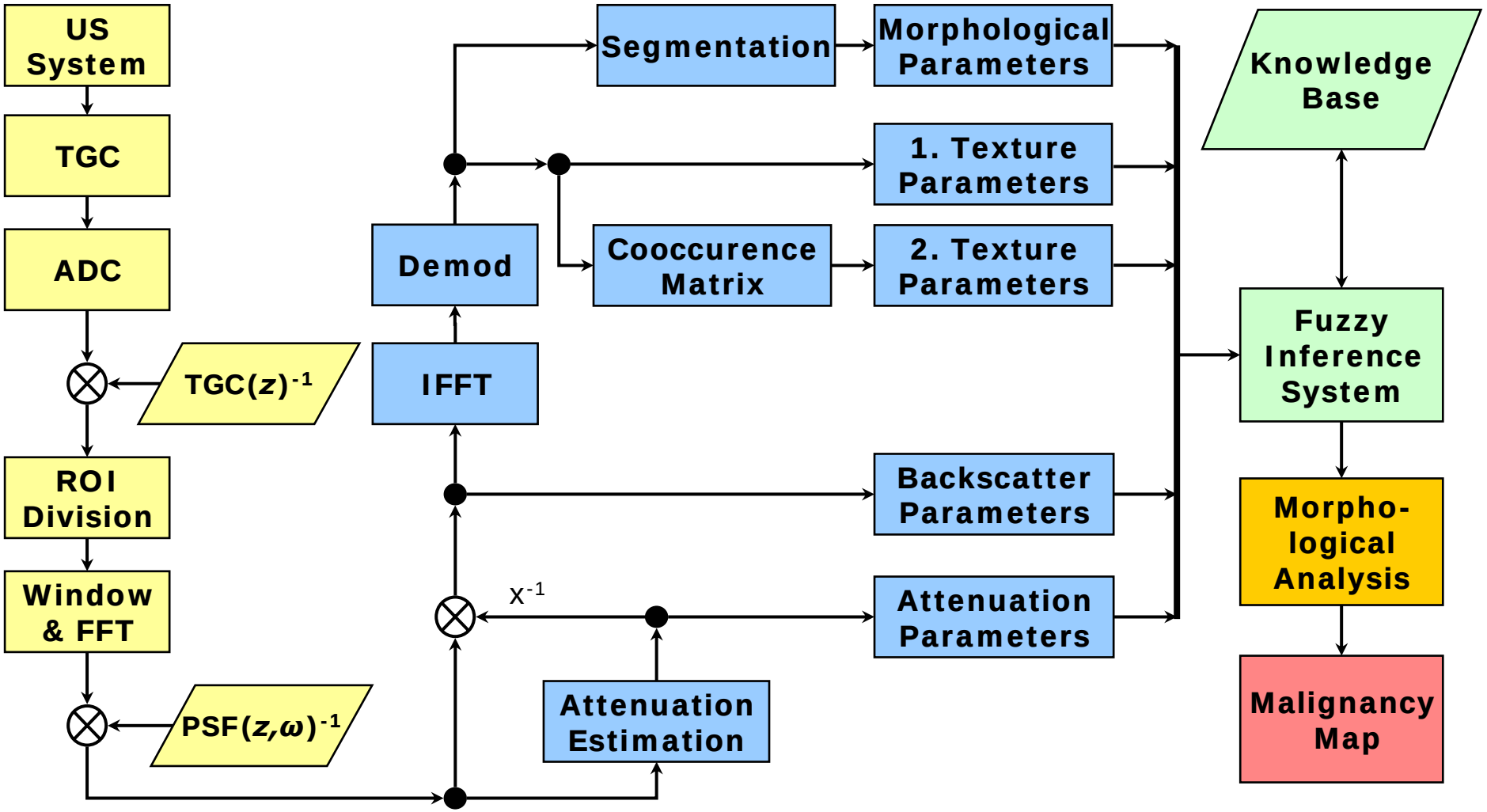
Contextual Information

- Contextual features contain information derived from ROIs surrounding the ROI being analyzed
- Assumptions:
  - → Probability for ROI to be positive is high, if surrounded by ROIs classified as positive
  - → Probability for ROI to be negative is high, if surrounded by ROIs classified as negative



- If gold standard is known, optimal size of neighborhood can be calculated (iterative process)
- 'Straight forward' approach:
  Low pass filtering and thresholding of binary malignancy maps
- Disadvantage: Loss of resolution

System Overview



Clinical Study

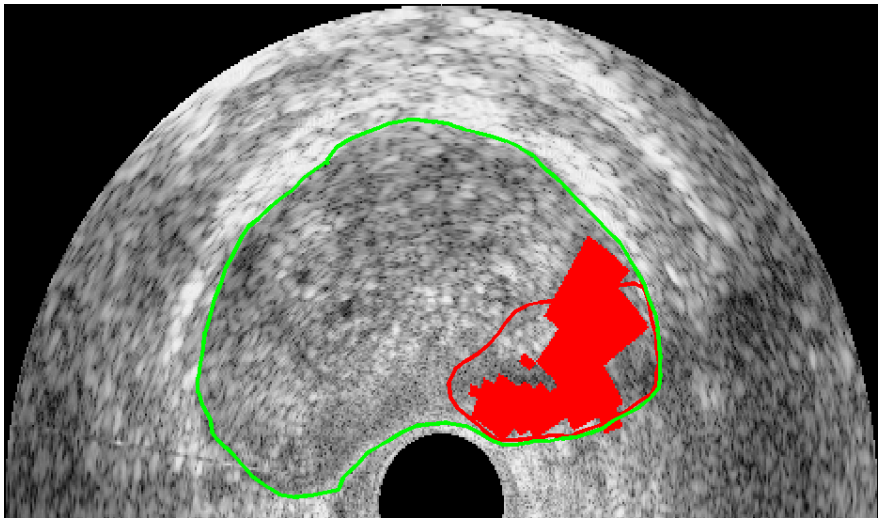
- 100 patients
- All patients suspicious PSA, DRE or TRUS
- With ‘gold standard’:

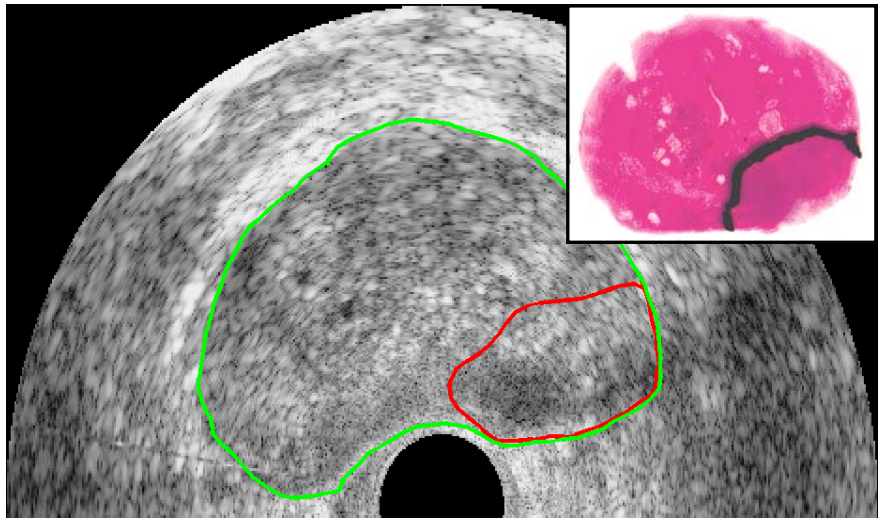
  130,000 benign segments

  40,000 malign segments (1/3 is isoechoic)

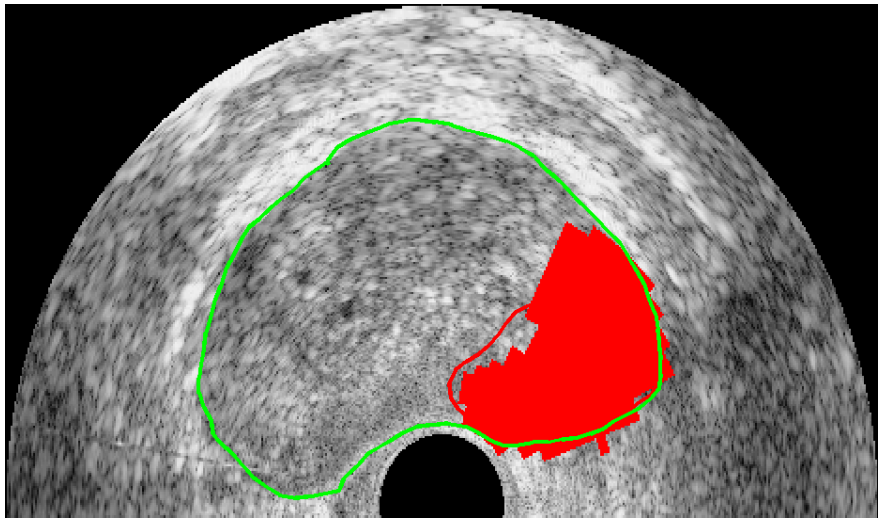
ROC area A_z	hypoechoic & hyperechoic	isoechoic
w/o context	$A_z = 0.84$	$A_z = 0.80$
with context	**$A_z = 0.86$**	**$A_z = 0.84$**

Only spatially resolved information is used





Spatially resolved information and contextual information is used



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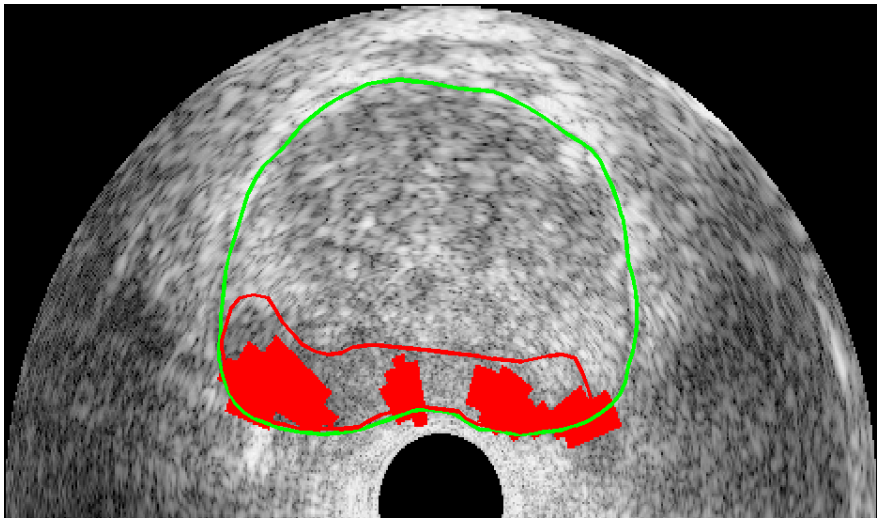

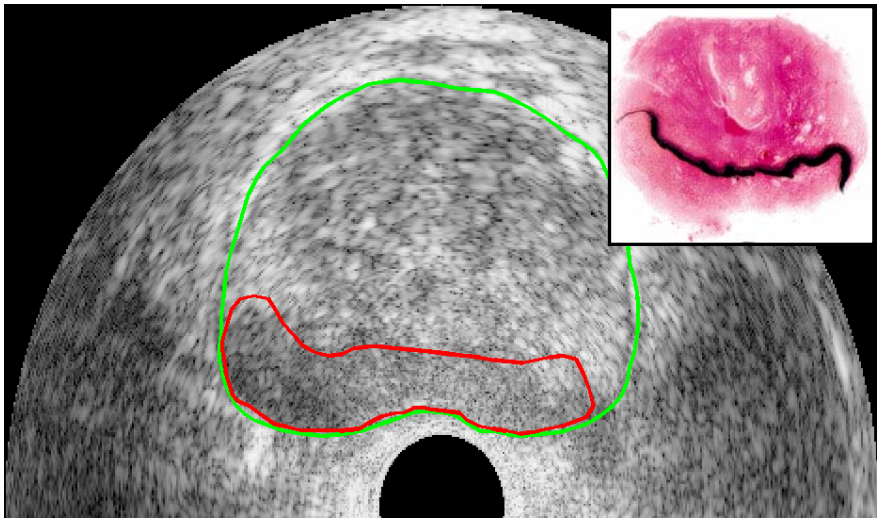

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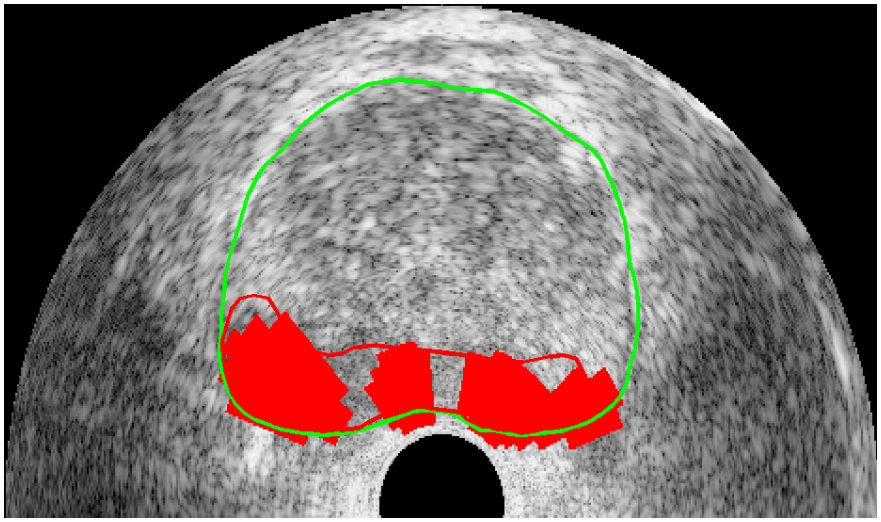
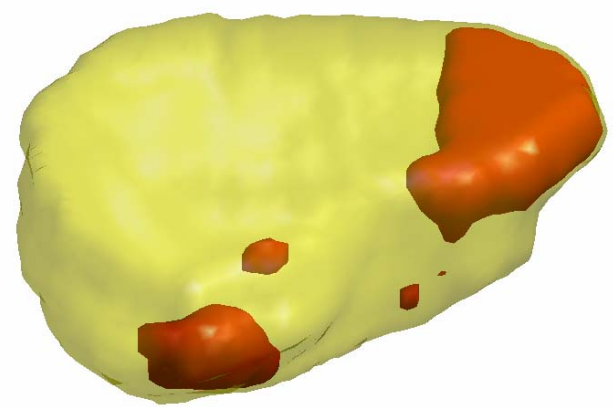


Volume Reconstruction

- Expansion of malignancy maps into three dimensions
- Volumes can be rotated
- Arbitrary slices can be extracted



Applications:

- Guided needle Biopsy
- Brachy therapy
- Thermal therapy
- HIFU
- Surgery planning
- Disease staging

Conclusion

- Ultrasonic Tissue Characterization can detect isoechoic tumors
- ROC area of A_z=0.86 and A_z=0.84
- Improved early detection of prostate carcinoma is possible
- Biopsy guidance and therapy planning can be improved
- Results are operator independent
- Contextual information ...
  ... can improve classification results
  ... makes malignancy maps easier to read
- Future: Use of contextual information of three dimensions

Thank you!