Breast segmentation in MRI: Comparison of DIAG and MeVis approaches

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Overview

1. Introduction
2. Methods
3. Material and evaluation
4. Results
5. Conclusions

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1. Introduction

- Breast cancer is the most importat health problem for women.

- Breast cancer screening:

  1. Regular mammography

     - Sensitivity of mammography drops with density

  2. Magnetic Resonance Imaging (MRI)

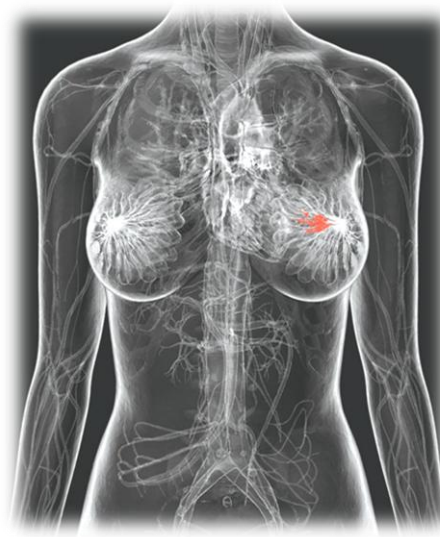   - Before surgery
     - High-density breasts
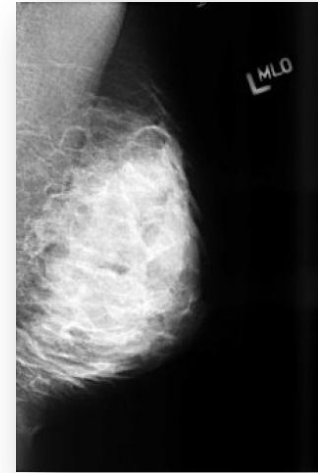
Mammography MLO view
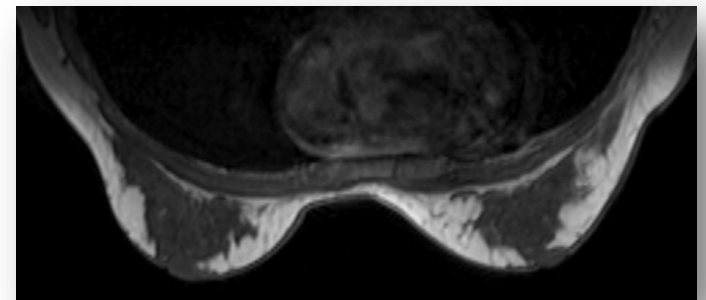
2D axial slice from 3D MRI volume

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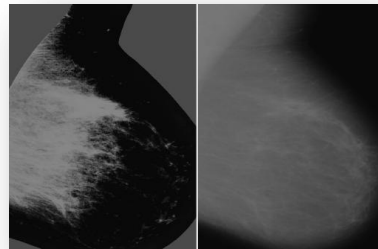
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1.1 Breast density

- Breast tissue density important risk factor for developing breast cancer.

- High density: 2-6 times higher risk

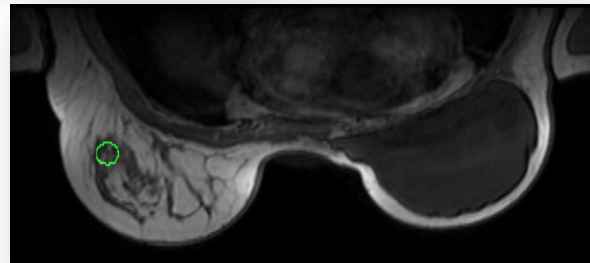- Dense tissue estimation in different image modalities.

1.2 Why in MRI?

- Good contrast between breast tissues.

- Research interest:
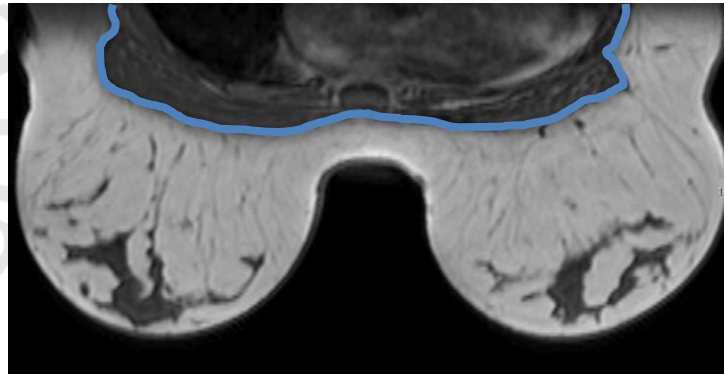 - Validation breast tissue segmentation in mammography.

  - CAD in breast MRI.

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1.3 How in MRI?

- Similar image intensity values for pectoral muscle and dense tissue voxels.

1. Separation of the breast from the body.
2. "Thresholding" on breast area.

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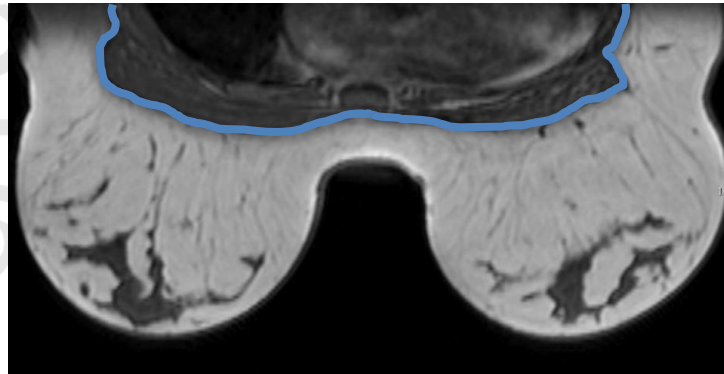
1.3 How in MRI?

- Similar image intensity values for pectoral muscle and dense tissue voxels.

1. **Separation of the breast from the body.**

2. "Thresholding" on breast area.

1.4 Breast segmentation

- Comparison of 3 breast segmentation methods
  - **MeViS breast** segmentation method [1].
  - **DIAG probabilistic atlas** breast segmentation method.
  - **DIAG multi-atlas** breast segmentation method.

[1] Wang et al.: Fully automated segmentation of the Pectoralis Muscle Boundary in breast MRI. *SPIE 2011* 7963, 2011

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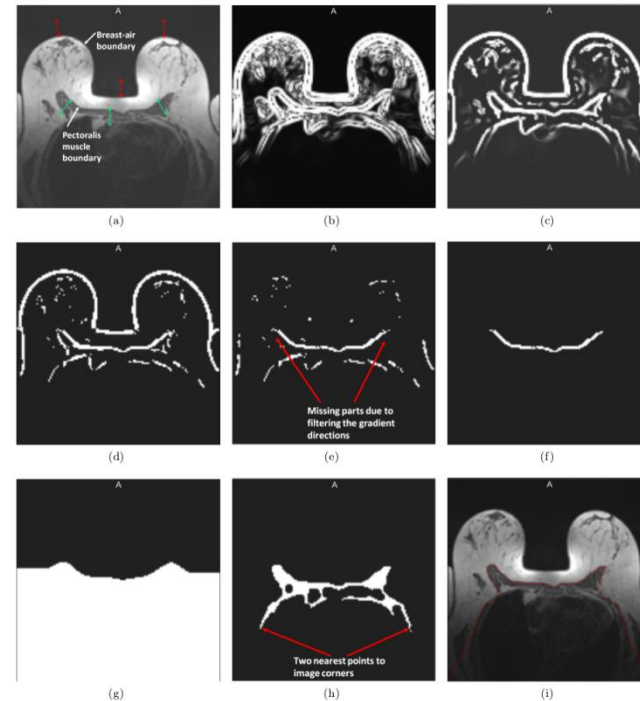Radboud University Nijmegen   Medical Centre

2. Methods

1. MeViS
   – Pectoral boundary by Hessian sheet detector.

2. DIAG Atlas-based methods
   – Multi-atlas
   – Probabilistic atlas
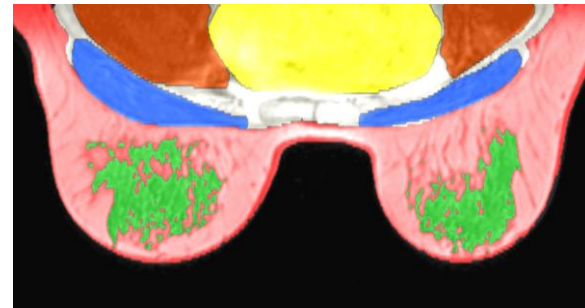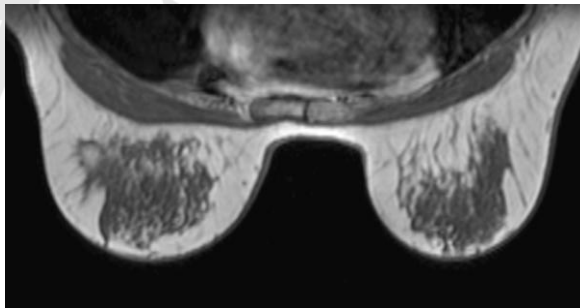
2.1 MeViS method [1]

- Segmentation method for **breast and pectoralis boundary** based on Hessian matrix for sheet detection.

[1] Wang et al.: Fully automated segmentation of the Pectoralis Muscle Boundary in breast MRI. *SPIE 2011* 7963, 2011

2.2 DIAG atlas-based methods

- 27 fully manual segmented cases:
  - Background, breast tissues, pectoral muscle, lungs and heart.

- Background segmentation by slice-by-slice Region Growing

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2.2 DIAG atlas-based methods

- Goal: **accurate segmentation of the body**.

- Registration focused on body area:

  1. Sternum alignment (translation):
     - First-derivative based filter and 3D connected component analysis.
     - High output for voxels in strong edge y direction
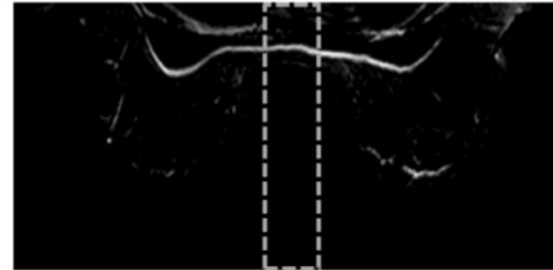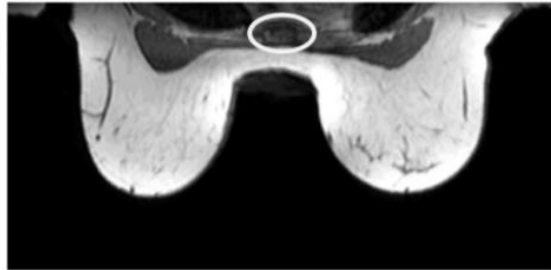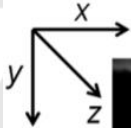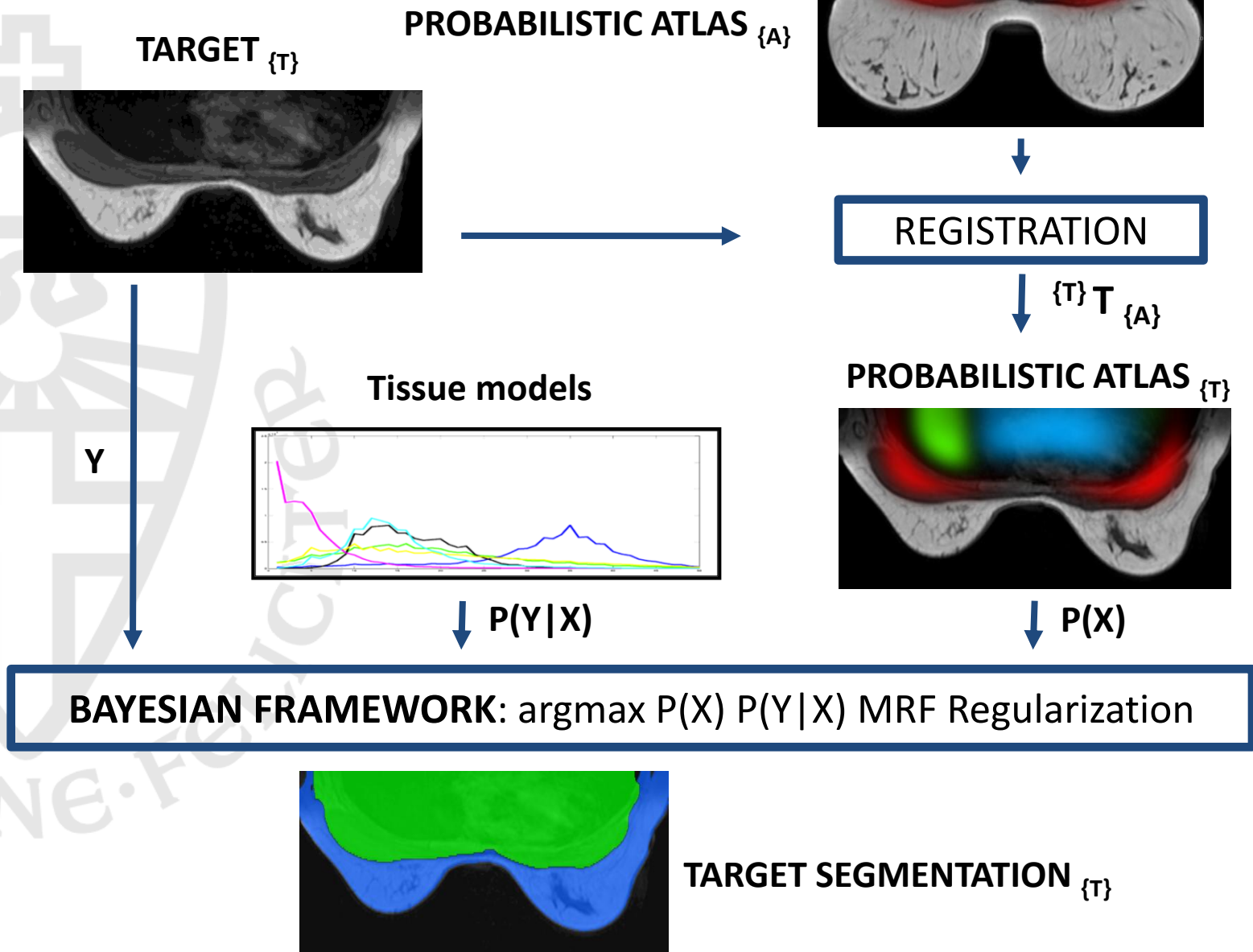

  2. B-Splines non-rigid registration [1]

[1] D.Rueckert et al: Nonrigid registration using free-form deformations: application to breast MR images. IEEE Trans Med Imaging. 1999 August; 18(8):712-21.

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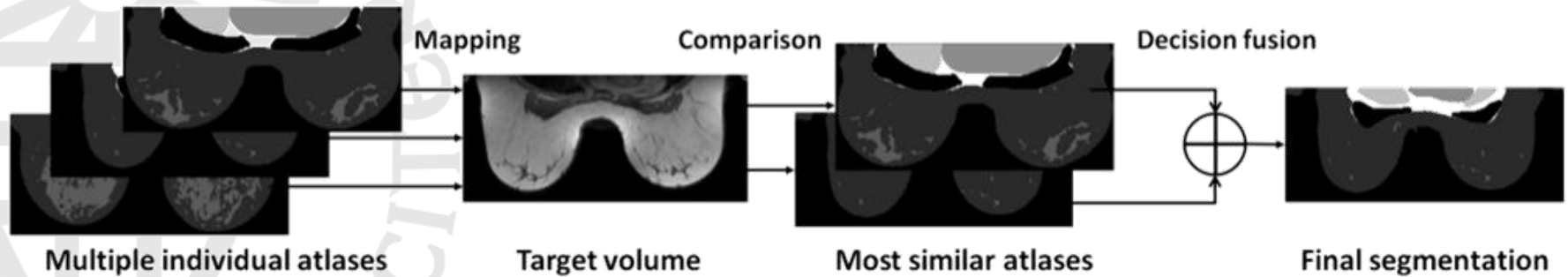Radboud University Nijmegen

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2.2.1 DIAG Probabilistic atlas

2.2.1 DIAG Probabilistic atlas

TARGET $_{\{T\}}$

PROBABILISTIC ATLAS $_{\{A\}}$

REGISTRATION

$^{\{T\}}T_{\{A\}}$

Tissue models

Y

PROBABILISTIC ATLAS $_{\{T\}}$

$P(Y|X)$

$P(X)$

BAYESIAN FRAMEWORK: argmax P(X) P(Y|X) MRF Regularization

TARGET SEGMENTATION $_{\{T\}}$

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2.2.2 DIAG Multi-atlas

Mapping → Comparison → Decision fusion

Multiple individual atlases → Target volume → Most similar atlases → Final segmentation

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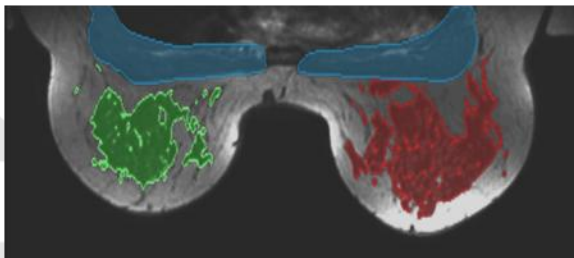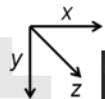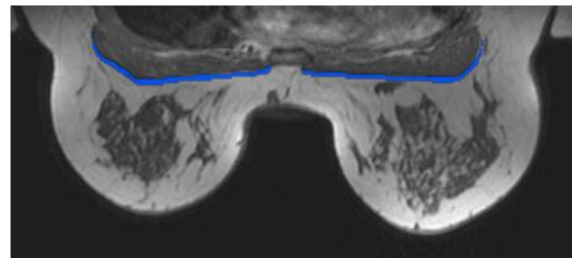
3. Material and evaluation

- 52 MRI cases with no sign of malignancy.

- All cases segmented by the 3 methods.

- 3 different measures to precisly quantify the error.

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Reference standard
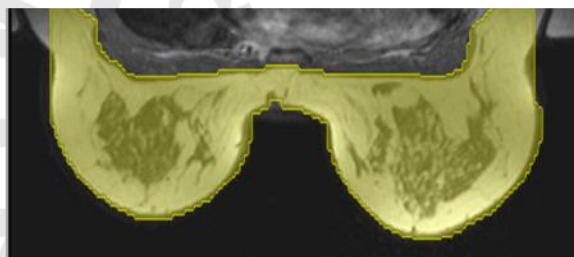

Dense tissue and pectoral muscle
manual segmentations

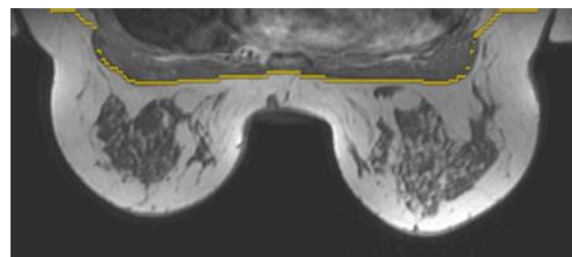Pectoral sufrace from pectoral muscle
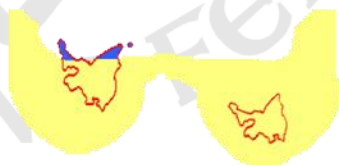manual segmentations

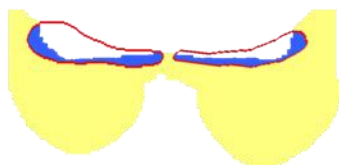# Automatic segmentation

Automatic breast segmentation

Pectoral sufrace from breast
automatic segmentations

Evaluation

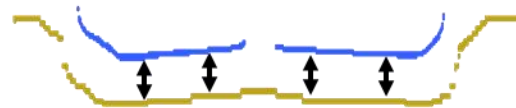1. Dense tissue error

2. Pectoral muscle error

3. Pectoral surface distance

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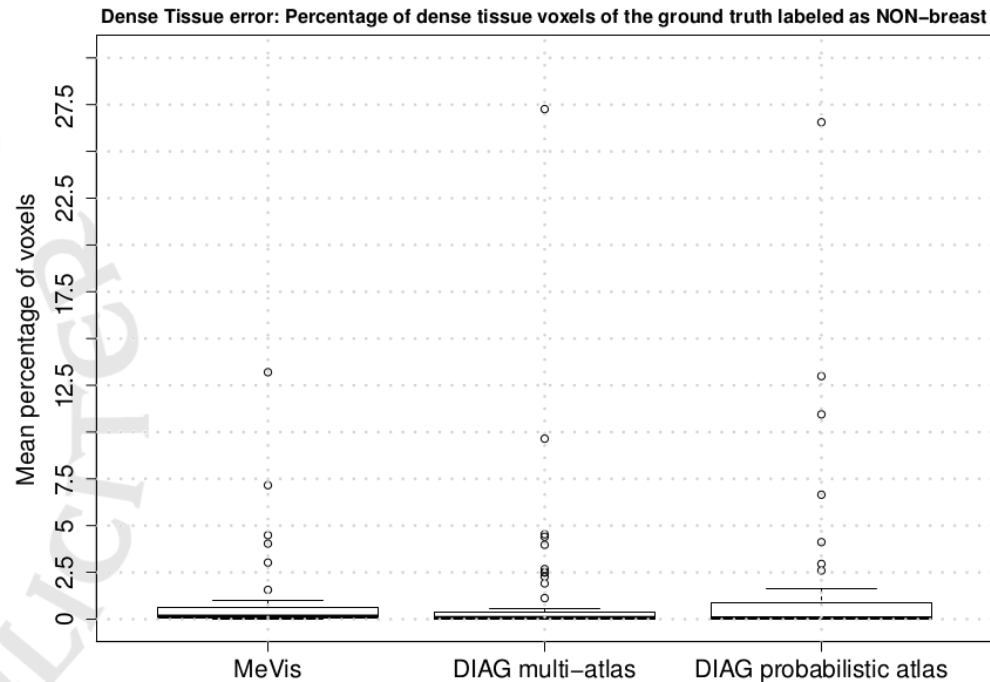
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4.1 Dense tissue error

- Percentage of dense tissue voxels of the reference standard that are NOT included in the breast segmentation.

Dense Tissue error: Percentage of dense tissue voxels of the ground truth labeled as NON–breast

Method	Mean (%) ± StDev (%)	Median (%)
MeVis	0.873% ± 2.174%	0.163%
DIAG multi-atlas	1.291% ± 4.050%	0.087%
DIAG probabilistic	1.513% ± 4.348%	0.070%

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4.2 Pectoral muscle error

- Percentage of pectoral muscle voxels of the reference standard that ARE included in breast segmentation.

Pectoral muscle error: Percentage of pectoral muscle voxels of the ground truth labeled as breast
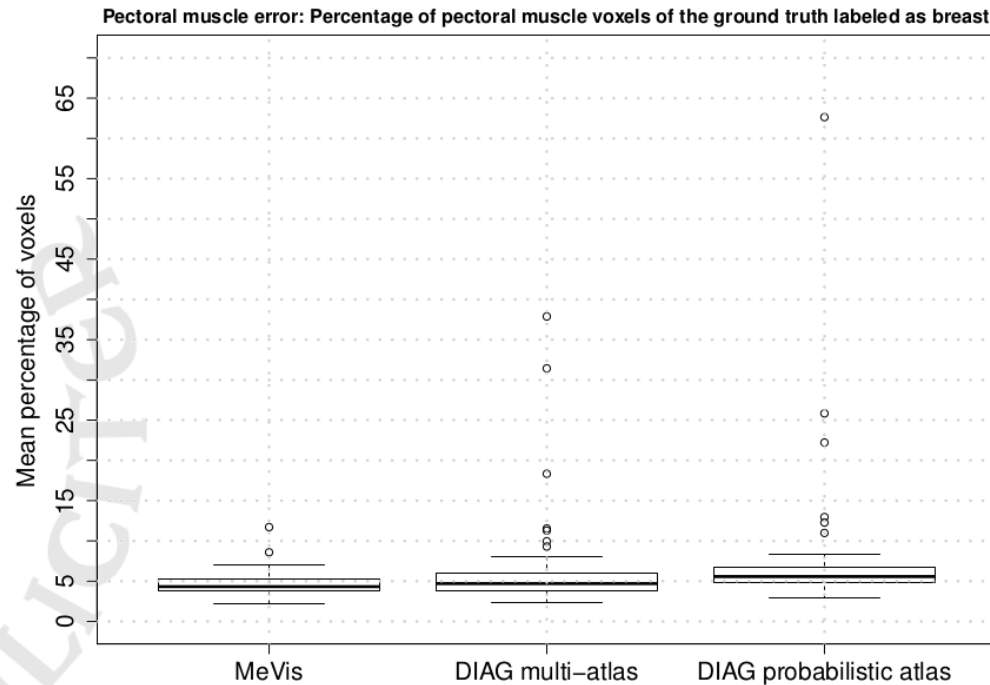
Method	Mean (%) ± StDev (%)	Median (%)
MeVis	4.660% ± 1.548%	4.316%
DIAG multi-atlas	6.498% ± 6.353%	4.697%
DIAG probabilistic	7.662% ± 8.780%	5.566%

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4.3 Pectoral surface distance

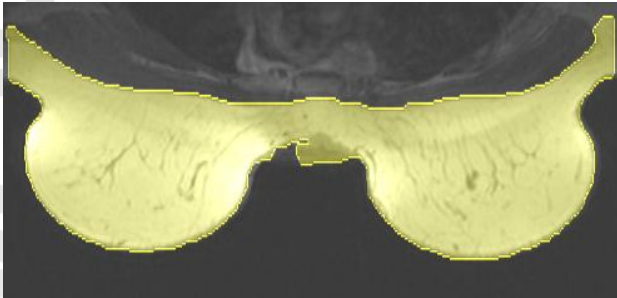- Percentage of pectoral muscle voxels of the reference standard that ARE included in breast segmentation.

Pectoral muscle surface average distance
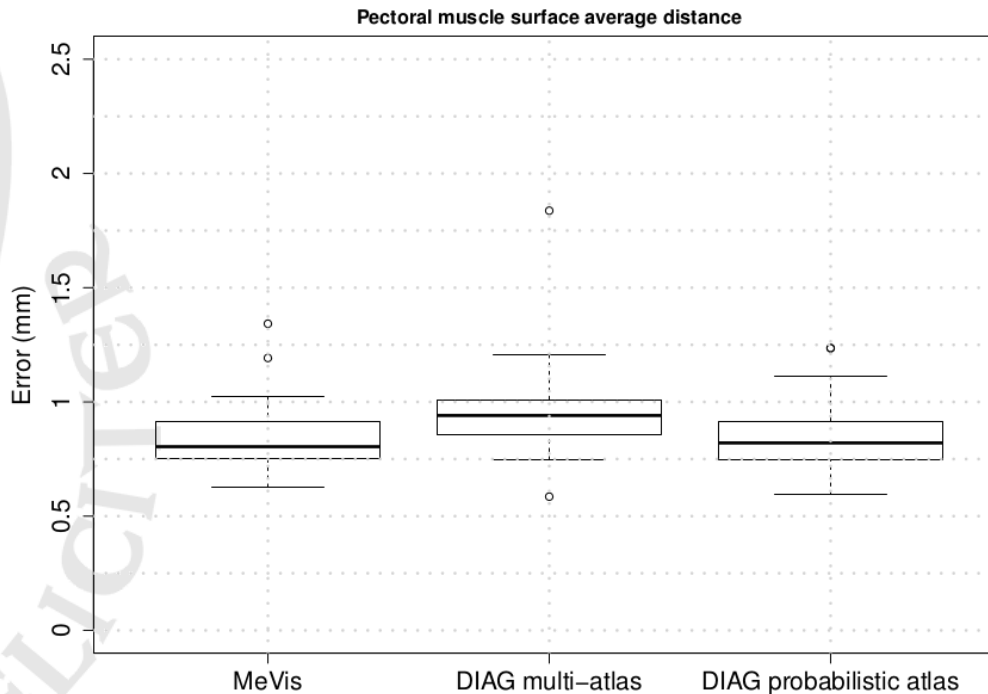
Method	Mean $\pm$ StDev (mm)	Median (mm)
MeVis	0.834 ± 0.136	0.804
DIAG multi-atlas	0.948 ± 0.174	0.940
DIAG probabilistic	0.836 ± 0.151	0.820

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4.4 Visual

- Example 1:

MEVIS
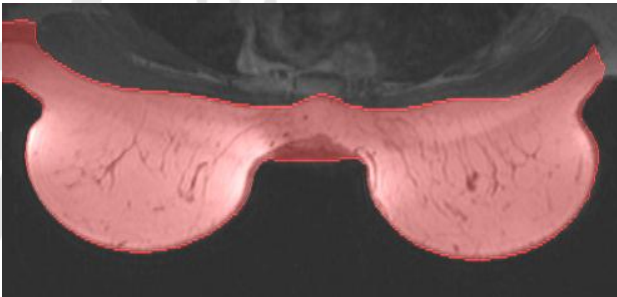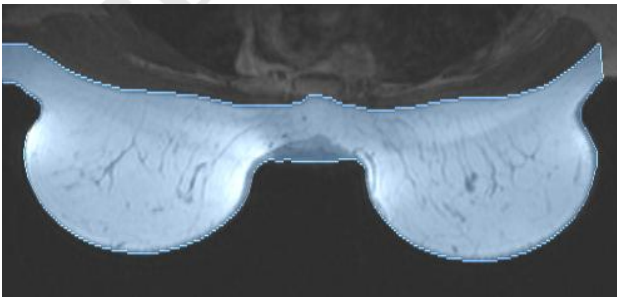
Dense tissue error:	0.09 %
Pectoral muscle error:	5.46 %
Pectoral surface distance:	0.71 mm

MULTI

Dense tissue error:	0.06 %
Pectoral muscle error:	4.34 %
Pectoral surface distance:	0.99 mm

PROBAB.

Dense tissue error:	0.04%
Pectoral muscle error:	6.14 %
Pectoral surface distance:	0.75 mm

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4.4 Visual

- Example 2:

MEVIS
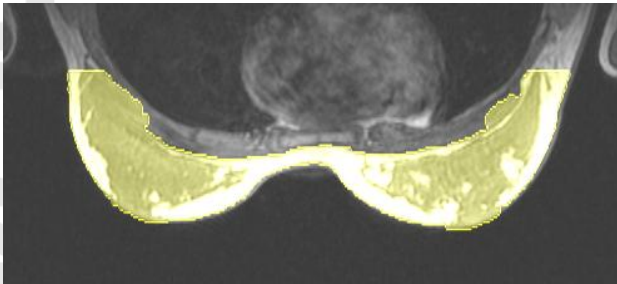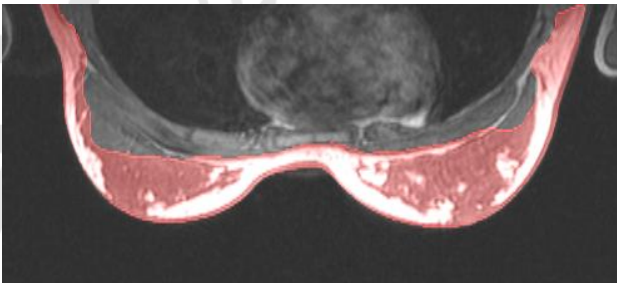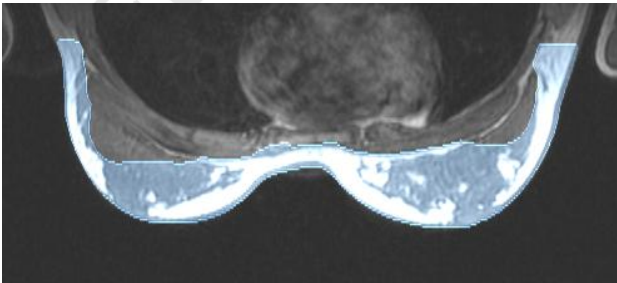
Dense tissue error:	0.87 %
Pectoral muscle error:	8.58 %
Pectoral surface distance:	0.92 mm

MULTI

Dense tissue error:	27.26 %
Pectoral muscle error:	5.28 %
Pectoral surface distance:	0.94 mm

PROBAB.

Dense tissue error:	26.56%
Pectoral muscle error:	7.00 %
Pectoral surface distance:	1.23 mm

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4.4 Visual

- Example 3:

MEVIS
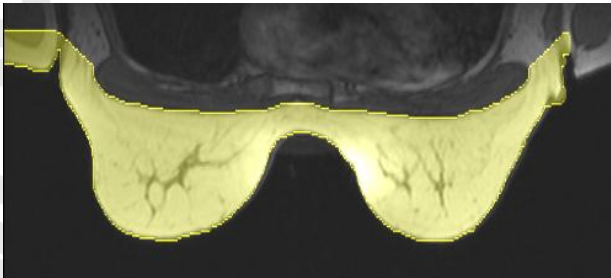
Dense tissue error:	0.55 %
Pectoral muscle error:	3.91 %
Pectoral surface distance:	0.80 mm

MULTI
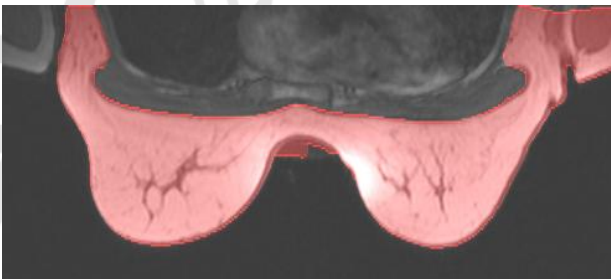
Dense tissue error:	0.14 %
Pectoral muscle error:	4.79 %
Pectoral surface distance:	0.80 mm

PROBAB.
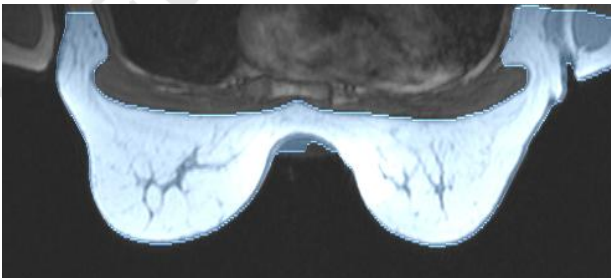
Dense tissue error:	0.12 %
Pectoral muscle error:	4.27 %
Pectoral surface distance:	0.76 mm

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4.5 Time complexity

- MeVis: 70 sec.

- Multi-atlas: 3h (minimum)

- Probabilistic atlas: 9 min.

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5. Conclusions

- MeVis method is the fastest and seems to be the most accurate.

- Difficult to define a single metric to study the performance of breast segmentation.

- Atlas-based methods too slow compared to MeViS method.

- Atlas-based methods provide segmentation of all the structures at once.

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Questions?

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