Fast 3D Optical Mammography using ICG Dynamics for Reader-Independent Lesion Differentiation

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Introduction

Why alternatives to the gold standard of X-ray mammography?

- Very reader-dependent diagnosis
- Need for a better differentiation between malignant and benign lesions
- Non-invasive (radiation free) alternative for breast cancer screening and monitoring preferred

General Benefits of optical mammography:

- Non-invasive, no radiation
- Tomographic imaging
- Functional information
- Dynamic imaging possible
  - Ability to track changes of internal parameters (Hb, HbO etc) or extrinsic contrast agents over time
Motivation

Fast 3D Diffuse Optical Imaging (SR >1 Hz):

- Early Bolus kinetics can now be adequately imaged

Measuring early bolus kinetics over the entire breast can help differentiating between malignant and benign or healthy breast tissue
Optical Mammography with 1.9 Hz Temporal Resolution

- DYNOT 232 optical tomography system
  (NIRx Medizintechnik, Berlin, Germany//NY, USA)

Study Design:
- 22 patients: 14 malignant + 8 benign lesions, 3 controls
- 25mg ICG bolus within 5-10 sec
- Reconstruction (NIRx NAVI Software) of relative absorption changes
- 31 co-located source/detector fibers: 961 S&D, 760 and 830nm
- ~ 2 complete volume scans per second
- 830nm

in each of 2243 FEM nodes/ 14000 isometric voxel

P. Schneider et al., Rofo 183(10):956-63 (2011)

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Bolus Peak Mapping

Time-to-Peak

Peak Amplitude

Timeframes
1 frame = 0.5 s
In general: A priori information about the localization of the lesion and an experience reader is necessary.
Peak-Time grouped Amplitude (PTA)

Mean time courses of voxel with equal peak time

Case 1: 53y, 33mm invasive ductal carcinoma

Case 2: 22y, 22mm fibroadenoma

TTP = 0.5 sec
TTP = 1 sec
TTP = 1.5 sec
TTP = 2 sec
TTP = 5 sec
TTP = 7.5 sec

malignant

benign

mean breast

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Mean PTA-curves over all patients

Mean peak time grouped amplitudes (PTA) over time

Significant Difference of PTA at TTP= 1.5sec between the malignant and benign lesions (Wilcoxon test, p=0.0015)
**Decision Boundary for Reader Independent Classification:**

PTA = 84.4% of the mean bolus signal

### Classification Rates for 22 patients

<table>
<thead>
<tr>
<th>Malignant, mean lesion size (range)</th>
<th>Detection Rate</th>
<th>Benign, mean lesion size (range)</th>
<th>Detection Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invasive ductal carcinoma, 29mm (8-51mm)</td>
<td>8/9</td>
<td>Fibro-cystic mastopathy, 11mm</td>
<td>1/1</td>
</tr>
<tr>
<td>Invasive lobular carcinoma, 25mm</td>
<td>1/1</td>
<td>Fibroadenoma, 24mm (10-51mm)</td>
<td>5/6</td>
</tr>
<tr>
<td>Invasive lobular ductal carcinoma, 17mm</td>
<td>0/1</td>
<td>Pseudoangiomatous stromalhyperplasia (PASH), (44mm)</td>
<td>1/1</td>
</tr>
<tr>
<td>Metaplastic carcinoma, 28mm (19-37mm)</td>
<td>2/2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ductal carcinoma in situ, 80mm</td>
<td>1/1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>12/14</strong></td>
<td></td>
<td><strong>7/8</strong></td>
</tr>
</tbody>
</table>

Summary

- High-frame rate DOT allows to adequately image early bolus kinetics.
- Extracting “Peak time grouped amplitudes” out of those kinetic curves can be used for an automatic differentiation between malignant and benign breast lesions.

Outlook

- To further investigate the robustness of the suggested approach more patient data are needed.

- Cooperation with the Machine Learning Group of the Technical University Berlin
  - Classifying PTA values at TTP=1.5 sec: mean loss: 0.19±0.02
  - Classifying PTA curves (TTP: 0 – 40sec): mean loss: 0.10±0.03
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- C.H. Schmitz

- Machine Learning Group, Technical University Berlin
- S. Fazli, B. Blankertz

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Thank you for your attention!