Automatic classification of mammographic breast density

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Automatic classification of mammographic breast density

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Institute of Diagnostic and Interventional Radiology, University Hospital Zurich
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• Machine Learning on Medical Imaging Data - Radiologists’ Perspective

• Automatic classification of mammographic breast density

• Can we apply this science?
• Acquire Patient Information
• Select Adequate Modality
• Acquire Images
• Describe Findings
• Integrate Knowledge
• Classify
• Act/Recommend
• Understand the clinical problem

• Target those tasks that
  • profit from standardization
  • are tedious (but still require a long training period)

• Provide transparent solutions that
  • mimic the human decision making process
  • are adaptable to the clinical workflow
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• Can we apply this science?
Automatic classification of mammographic breast density (BD)

- Women with high BD have a 2- to 6-fold increased risk of developing breast cancer\(^1\)
- For dense breast the sensitivity of the screening mammography drops from 87% to 63\(^2\)
- Patients with high BD require additional imaging, such as tomosynthesis, ultrasound or breast MR to increase the cancer detection chances\(^3\)


\(^3\)Berg et al. Combined screening with ultrasound and mammography vs mammography alone in women at elevated risk of breast cancer. JAMA. 2008;299(18):2151-63
Automatic classification of mammographic breast density (BD)

- ACR-BD classification is observer-dependent (inter-reader agreement ranging between 0.43 and 0.89) \(^1\)
- Radiologists routinely reading mammographies perform better \(^2\)


Automatic classification of mammographic breast density (BD)

- **Data**: 20,578 diagnostic mammography views from 5,221 unique patients (age = 58±12 years) acquired between 2012 and 2013.

- **Labeling**: views of the single patient were linked to the ACR BI-RADS density from the corresponding radiological report using a home-written text searching MATLAB script (Release 2013b, MathWorks, Natick, MA, USA).

- **Balanced dataset**: 12,932 labeled mammography views were successfully linked to the ACR BI-RADS density from the corresponding radiological report. After data augmentation (ImageDataGenerator Keras) a balanced training and validation dataset subdivided into 4 classes composed of n = 22,414 MLO projections and n = 22,439 CC projections was available.
Automatic classification of mammographic breast density (BD)

Hardware and software: consumer-grade desktop computer equipped with an Intel i7-7700 CPU with 16 GB RAM and an NVIDIA 1080 GTX graphics processing unit with 8 GB graphics RAM. The computer was running Ubuntu Linux 16.04 with Tensorflow 1.0.1.
Automatic classification of mammographic breast density (BD)

Performance over the validation dataset

<table>
<thead>
<tr>
<th>View</th>
<th>Accuracy</th>
<th>Number of epochs</th>
<th>Computation time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mediolateral Oblique</td>
<td>90.9 %</td>
<td>91</td>
<td>20.3 hours</td>
</tr>
<tr>
<td>Cranio-Caudal</td>
<td>90.1 %</td>
<td>94</td>
<td>21.6 hours</td>
</tr>
</tbody>
</table>
Automatic classification of mammographic breast density (BD)
Test against the expert readers’ consensus: CC view

**Confusion Matrix**

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>94.7%</td>
<td>5.3%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>B</td>
<td>20.7%</td>
<td>79.3%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>C</td>
<td>0.0%</td>
<td>2.7%</td>
<td>75.7%</td>
<td>21.6%</td>
</tr>
<tr>
<td>D</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

**ROC space**

**Cohen’s kappa**
Automatic classification of mammographic breast density (BD)

Test against the expert readers’ consensus: MLO view

**ROC space**

**Confusion Matrix**

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>B</td>
<td>9.1%</td>
<td>87.9%</td>
<td>3.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>C</td>
<td>0.0%</td>
<td>0.0%</td>
<td>100.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>D</td>
<td>0.0%</td>
<td>0.0%</td>
<td>8.7%</td>
<td>91.3%</td>
</tr>
</tbody>
</table>
Automatic classification of mammographic breast density (BD)

- The dCNN allows for accurate classification of breast density based on the ACR BI-RADS system.
- The performance of the dCNN are comparable to those of experienced radiologists.
- The proposed technique may allow accurate, standardized, and observer independent breast density evaluation of mammographies.
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Can we apply this science?

Mammography → MD>c → Ultrasound

False → Imaging Data → Diagnosis

http://www.diagnosticimaging.com/radiology-comics/
Can we apply this science?

Applied sciences: sciences that are put to practical use. (Collins)

- **Number of recall examinations**
- **Efficiency radiographer´s workflow**
  - The reduction of recall examinations is cost saving and relieves the psychological burden on patient
- **Patient satisfaction**
  - Efficient workflow improves patient’s perception of the safety and efficiency of the provided care
  - Standardized assessment of high BD allows the prompt schedule of the US
Thank you
Grazie mille

Project name
Artificial Intelligence in oncological Imaging Network