Predicting Malignancy from Mammography Findings and Image Guided Core Biopsies

2nd Breast Cancer Workshop 2015 – April 7th 2015
Porto, Portugal

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Outline

• Breast Cancer
• Objectives
• Dataset
• Methodology
• Results and Analysis
• *MammoClass* (online tool)
• Conclusions
Breast Cancer

- **USA:**
  - About 1 in 8 women (≈ 12%) will develop invasive breast cancer during lifetime
  - In 2014:
    - 232,670 invasive cancers
    - 40,000 (≈ 17%) expected to die

  *Source: U. S. Breast Cancer Stats. – accessed April 2015*

- **Portugal:**
  - About 1 in 11 women (≈ 9%) will develop invasive breast cancer during lifetime
  - Per year:
    - 5600 new cases
    - 1500 deaths (27%)

  *Source: Laço Association – accessed April 2015*
Breast Screening Programs

- Reduction of death rate in 30%
- **Mammography:**
  The cheapest and most efficient method to detect cancer in a preclinical stage
Mamography - BI-RADS® Descriptors
Outline

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Objectives

- Build classifiers capable of predicting **mass density** and **malignancy** from a reduced set of mammography findings

- Reduce the number of unnecessary biopsies

Outline

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Dataset

- Source:

- 348 cases

- Each case refers to a breast nodule *retrospectively* classified according to BI-RADS® system

- From mammographies results

- Collected between October 2005 and December 2007
Attributes

13 attributes

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<th>Benign (%)</th>
<th>Malignant (%)</th>
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<td>age_at_mammo</td>
<td>230 (66.1%)</td>
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Masses classification

Prospective

- Classification of feature mass density just by one radiologist:
  - low density;
  - iso-dense;
  - high density;

- Brief and superficial medical report (at the time of imaging);

- Classification under stress.

Retrospective

- Classification by a group of experienced physicians that re-assess all exams;

- Review of mass density classification made by radiologist (prospective study);

- Classification without stress;

- Reference standard for mass density.

mass density

\textit{density\_num}

mass density

\textit{retro\_density}
Masses classification

348 cases (retrospectively classified)

180 (≈ 52%)
(prospectively classified)

168 (≈ 48%)
Outline

- Breast Cancer
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- Conclusions
Methodology

- WEKA
- Paired Corrected T-Tester
  - Significance level: 0.05
Methodology - Experiments

10 x stratified. c. v.

- **E₁** – Predicting malignancy with *retro_density*
- **E₂** – Predicting malignancy with *density_num*
- **E₃** – Predicting malignancy without mass density

- **E₄** – Predicting *retro_density*
- **E₅** – Predicting *density_num*

* in all experiments the low and iso densities were merged into a single class
Methodology - Algorithms applied

- ZeroR (baseline classifier)
- OneR
- DTNB
- PART
- NaiveBayes
- BayesNet (TAN)

- J48
- DecisionStump
- RandomForest
- SimpleCart
- NBTree

- SMO

rules
bayes
functions

internal parameter variation
Results

348

180  168

10 x strat. c.v.  test
## Results - Experiments

10 x stratified. c. v.

<table>
<thead>
<tr>
<th>Exp</th>
<th>Algorithm</th>
<th>CCI</th>
<th>K</th>
<th>F</th>
<th>AUROC</th>
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<td>E1</td>
<td>SMO</td>
<td>85.6±7.3</td>
<td>0.69±0.16</td>
<td>0.80±0.11</td>
<td>0.84±0.08</td>
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<td>E1</td>
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<td>81.6±8.2</td>
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<td>0.61±0.20</td>
<td>0.76±0.12</td>
<td>0.88±0.08</td>
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<td>E1</td>
<td>J48</td>
<td>80.7±9.3</td>
<td>0.59±0.20</td>
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<td>E2</td>
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<td>83.9±7.7</td>
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<td>0.87±0.09</td>
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<td>E2</td>
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<td>0.82±0.09</td>
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<td>J48</td>
<td>76.3±9.9</td>
<td>0.49±0.22</td>
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<td>E4</td>
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<td>74.4±8.8</td>
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<td>0.22±0.24</td>
<td>0.54±0.16</td>
<td>0.64±0.14</td>
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</table>

*Predicting malignancy with retro_density*

*Predicting retro_density*
Results - Experiments

Predicting density
Results - Experiments

10 x stratified. c. v.

• $E_4$ – Predicting $retro_{density}$

CCl: 81.3% (+/-8.2)
Sens: 0.57 (+/- 0.20)
Spec: 0.92 (+/- 0.07)
F: 0.64 (+/- 0.17)

Radiologist’s accuracy = 70 %
Classifier ≈ 81 %
Results - Experiments

TEST

• $E_6$ – Predicting *retro_density*
  (model $E_4$ applied)

CCI: 84.5%
Sens: 0.57
Spec: 0.90
F: 0.55
Results - Experiments

Predicting malignancy
Results - Experiments

10 x stratified. c. v.

- E₁ – Predicting malignancy with \textit{retro\_density}

\begin{itemize}
  \item CCI: 85.6\% (+/-7.3)
  \item Sens: 0.78 (+/- 0.15)
  \item Spec: 0.91 (+/- 0.07)
  \item F: 0.80 (+/- 0.11)
\end{itemize}
Results - Experiments

TEST

- $E_8$ – Predicting malignancy with \textit{retro\_density} (model $E_1$ applied)

- SVM’s
  - CCI: 81.0%
  - Sens: 0.57
  - Spec: 0.90
  - F: 0.63

- SVM’s
  - CCI: 80.4%
  - Sens: 0.57
  - Spec: 0.89
  - F: 0.62

CCI: 81.0% (+/- 0.4)
Sens: 0.57 (+/- 0.15)
Spec: 0.90 (+/- 0.07)
F: 0.63 (+/- 0.11)

CCI: 80.4% (+/- 0.4)
Sens: 0.57 (+/- 0.15)
Spec: 0.89 (+/- 0.07)
F: 0.62 (+/- 0.11)
MammoClass

Online tool freely available at:

MammoClass
MammoClass

Enter Data

Patient's age 47
Mass size 15
Breast Composition Heterogeneously dense
Mass shape Round
Mass clockface location 12.0
Mass margins (1) Circumscribed
Mass margins (2)
Mass margins worst Mass Margins (1)
Mass density Iso/Low
Side Left
Quadrant Upper Inner
Depth Middle

Result
Prediction: mass benign with a probability of 98.8%.

Disclaimer: The predictions are made available in the hope that they may be useful, but they should not be considered definitive or a substitute for professional medical advice.
Conclusions

a) We built models (integrated in MammoClass) that predict malignancy and mass density based on mammography findings;

b) Machine learning classifiers to predict mass density may aid radiologists during the prospective mass classification;

c) One of our classifiers can predict malignancy even in the absence of mass density, since we can fill up this attribute using our mass density predictor.
Thank you!

http://cracs.fc.up.pt/mammoclass

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ines@dcc.fc.up.pt
rwoods@gmail.com
eburnside@uwhealth.org
Appendices
State of the Art


**Conclusions:**

_mass density_ can be an _important_ attribute when predicting _malignancy_.

State of the Art

- 4 datasets
- Main target of study: Breast Cancer
State of the Art


Data distribution

- 348

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<th>retro_density</th>
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<td>high</td>
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<tr>
<td>malignant</td>
<td>59 (70.2%)</td>
<td>59 (22.3%)</td>
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<td>benign</td>
<td>25 (29.8%)</td>
<td>205 (77.7%)</td>
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<tr>
<td>Total</td>
<td>84 (24.1%)</td>
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Data distribution

- 180

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<td>high</td>
<td>iso</td>
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<tr>
<td>malignant</td>
<td>42 (75.0%)</td>
<td>29 (23.4%)</td>
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<td>71 (39.4%)</td>
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<tr>
<td>benign</td>
<td>14 (25.0%)</td>
<td>95 (76.6%)</td>
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<td>109 (60.6%)</td>
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<td>Total</td>
<td>56 (31.1%)</td>
<td>124 (68.9%)</td>
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<tr>
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<td>81 (45.0%)</td>
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Data distribution

- 168

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