Thermal Imaging: Opportunities and Challenges for Breast Cancer Detections

INVITED TALK
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Agenda

- Introduction
  - Breast Cancer Statistics
  - Most used Breast Cancer Screening Tools
- Introduction to Thermography
- Our Contribution
- Thermography Opportunities and Challenges
- Conclusion
Introduction: Breast Cancer Statistics

- **Global Cancer Observatory (GCO)** is a project which provides access to the most recent estimates of the cancer incidence, mortality and prevalence for most of cancers worldwide. [http://gco.iarc.fr/](http://gco.iarc.fr/)
- **Breast cancer today**
  - [http://gco.iarc.fr/today/home](http://gco.iarc.fr/today/home)
- **Breast cancer tomorrow**
  - [http://gco.iarc.fr/tomorrow/home](http://gco.iarc.fr/tomorrow/home)
Cancer today

Estimated number of new cases in 2018, worldwide, all cancers, both sexes, all ages

Total: 18,078,957

Estimated number of new cases in 2018, worldwide, all cancers, females, all ages

Total: 8,622,539
Brest cancer today

Estimated number of new cases in 2018, breast, all ages

- Asia: 911,014 (43.6%)
- Europe: 522,513 (25%)
- Africa: 245,511 (1.2%)
- Oceania: 166,609 (8.1%)
- Latin America and the Caribbean: 199,734 (9.6%)
- North America: 262,347 (12.8%)

Total: 2,088,849

Estimated number of deaths in 2018, breast, all ages

- Asia: 310,577 (49.6%)
- Europe: 137,707 (22%)
- Africa: 74,672 (11.8%)
- Oceania: 4,802 (0.8%)
- Latin America and the Caribbean: 52,556 (8.4%)

Total: 626,679
Brest cancer tomorrow

Estimated number of incident cases from 2018 to 2040: breast, females, all ages

- 2018: 2,088,849
- 2025: 2,407,748
- 2030: 2,634,512
- 2040: 3,059,829
Breast Cancer Incidence 2018 all World
Breast cancer statistics (UK)

- There are around 55,200 new breast cancer cases in the UK every year,
  - that's around 150 every day (2014-2016).

- Breast cancer is the most common cancer in the UK,
  - accounting for 15% of all new cancer cases (2016).

- In females, breast cancer is the most common cancer, with around 54,500 new cases in 2016.

- Since the early 1990s, breast cancer incidence rates have increased by around a quarter (24%) in females.

Source: https://www.cancerresearchuk.org/
Best Way for Breast Cancer Treatment

- Early detection and treatment
  - It is the best current way for reducing the morbidity and mortality of this disease.
Ideal Breast Cancer Screening Method

- It would be a method that is:
  - sensitive enough to early detect breast cancer,
  - specific enough to differentiate malignant from benign lesions,
  - easily accessible to the general public,
  - financially feasible, and
  - unlikely to cause harm to the patient.
Thermography, Mammography or Ultrasound

- Both mammography and ultrasound are structural (anatomical) tests,
- Thermography is a functional (physiological) test.
- Thermography captures images for the breast and surrounding area and provides us with risk assessment,
- Mammography and ultrasound detect structural abnormalities.
- Mammography can observe small size lesion 2mm<, thermography can.

Mammography Limitations

- As reported in [1], mammography has difficulty in imaging dense breast tissues,
- its performance is poor in younger women and harmful,
- it couldn’t detect breast tumor less than 2 mm.
- It is a high cost system
  - based on https://www.modernhealthcare.com/, the cost of digital mammography devices are between:
    - $200,000 to $500,000
What is Thermography

- **Thermal imaging** uses a special camera to measure the temperature of the skin on the breast's surface.
- Thermography is a **breast imaging modality** that measures **radiation from the surface** of the breast to **detect localised temperature variations** which could be the result of **cancerous** or **precancerous** cell expansion.
What is Thermography (Cont.)

- The idea is that:
  - Cancer cells grow and multiply very fast.
  - In a cancer tumour, **blood flow and metabolism increase**, which increases **skin temperature**.

- When analysing thermograms, there are two key indicators of **breast abnormality**
  - asymmetry between breasts and
  - the **determination** of areas of a breast with a **high level of blood perfusion**
Thermography in UK

October 2019 at BBC News:

- **Bal Gill**, 41, from Slough in Berkshire, was at the Camera Obscura and World of Illusions at the top of the Royal Mile with her family in May 2019.

  - When she went into the **museum's thermal imaging** camera room she noticed her left breast was a **different colour**.

  - When she returned home she **saw a doctor** who **confirmed she had breast cancer**.

  - She discovered that thermal imaging cameras can be used as a tool by oncologists.

https://www.bbc.co.uk/news/uk-scotland-edinburgh-east-fife-50139540
Thermography in UK (Cont.)

About us

Located near Formby in Liverpool (Head Office), Medical Thermal Imaging Ltd has been providing Thermography services for over a decade.

We have a skilled team of board-certified Thermologists operating from upwards of 40 locations nationwide and medical doctors to support you and interpret your images, to give the best possible experience.

We use the most advanced high-resolution Medical Thermal Imaging systems to ensure we obtain the best possible images and accuracy for interpretation. Thermography is 100% Safe, Free from Radiation, Compression free, Non-contact and suitable for all ages.

Thermography is adjunctive to other tests and can provide additional information to assist in further health tests.
Our Contribution
This paper aims to propose a **fully automatic** breast segmentation approach and then using the segmented ROI to diagnosis whether the breast contains **any abnormality**.

### Algorithm 1 Segmentation Method

1. Read original grayscale thermal image, $I$
2. Read $M = I$'s height
3. Read $N = I$'s width
4. Read the coordinates $Y_1$ and $Y_2$ where $Y_1 = 1/4 \times M$ and $Y_2 = M - 0.2 \times M$
5. Extract the ROI where $ROI = imcrop(I, [X_1, X_2, Y_1, Y_2])$, where $X_1 = 0$ and $X_2 = N$
6. Convert the ROI to binary image by using threshold with value equal to 0.4 (trial and error) to differentiate body from background
7. Remove columns from the image width having $value = 0$

**Accuracy**

![Graph showing accuracy for different scenarios: Quadratic, Polynomial, RBF, Linear]

- First Scenario
- Second Scenario
- Third Scenario
- Fourth Scenario
The aim of this study was to propose an approach for **automatic classification** for thermograms to normal and abnormal.
# Thermogram Breast Cancer Detection: A Comparative Study of Two Machine Learning Techniques

Fayez AlFayez, Mohamed W. Abo El-Soud, and Tarek Gaber

## Table 7. The comparison between the proposed work and the other related work

<table>
<thead>
<tr>
<th>Paper/Criteria</th>
<th>Dataset Size</th>
<th>Public/Private Dataset</th>
<th>Classifiers</th>
<th>Accuracy</th>
<th>Specificity</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Kennedy[2009]</td>
<td>–</td>
<td>Private</td>
<td>TH(1:5)scale</td>
<td>–</td>
<td>–</td>
<td>95%</td>
</tr>
<tr>
<td>Pramanik[2016]</td>
<td>40 malignant 60 benign</td>
<td>Public(DMR)</td>
<td>FANN</td>
<td>90%</td>
<td>85%</td>
<td>95%</td>
</tr>
<tr>
<td>Acharyya[2010]</td>
<td>40 normal 60 malignant 29 healthy</td>
<td>Private</td>
<td>SVM</td>
<td>88.10%</td>
<td>90.48%</td>
<td>85.71%</td>
</tr>
<tr>
<td>Gaber[2015]</td>
<td>34 malignant 70 abnormal 50 normal</td>
<td>Public(benchmark)</td>
<td>SVM</td>
<td>92.06%</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Gogo[2018]</td>
<td>–</td>
<td>Private</td>
<td>SVM(Poly)</td>
<td>98%</td>
<td>98%</td>
<td>98%</td>
</tr>
<tr>
<td>Sathish[2018]</td>
<td>705 normal 200 benign 440 malignant</td>
<td>Public (DMR)</td>
<td>E. Bagg. Trees AdaBoost</td>
<td>87%</td>
<td>90.6%</td>
<td>83%</td>
</tr>
<tr>
<td><strong>Our Solution</strong></td>
<td></td>
<td></td>
<td></td>
<td>80.04%</td>
<td>84%</td>
<td>61.6%</td>
</tr>
</tbody>
</table>

**Note:**
- **ELM** (Extreme Learning Machine)
- **MLP** (Multilayer Perceptron)
Thermography: Opportunities and Challenges
Thermography Opportunities

- Breast thermography may be the first method that detects **asymmetries in the temperature** distributions of breast.
- Examples of such asymmetries include:
  - **Angiogenesis** (new blood vessel formation)
  - inflammation
- This is a kind of a **future risk assessment**. If **discovered earlier**, a woman could work closely with her doctor with regular checkups to monitor her breast health.
  - Like what “Bal Gill” did ☺.

10.9.2015
Thermography Opportunities

- It is known that, in younger women, breast cancers are usually more aggressive and have poorer survival rates.
- Breast thermography could be a good solution as it offers them a valuable imaging tool beginning with baseline imaging at age 20.
- Concer.org recommend that:
  - Women ages 40 to 44 should have the choice to start annual breast cancer screening with mammograms.
Thermography Opportunities

- As cheap screening tool,
- Breast thermography could be a good solution for poor countries which suffer from high rate of breast cancer incidence and mortality, e.g. most African’s and Asian’ countries.
Thermography Challenges

- Public Database
  - In 2004, a systematic review of screening techniques, only ultrasound, MRI, and mammography had sufficient data to determine their utility as screening tools.
  - Thermography was among other that was excluded due to lack of rigorous data.
    - There is no a large body of evidence that supports the use of thermography as a tool for breast screening in asymptomatic women.
    - Most studies use small sample sizes and the results vary significantly.
Thermography Challenges

- **Public Database**
  - Tell 2014, there was **NO public thermograms database** to support more research in this area.
  - On June 2014, the **ONLY** public database (**149 patients**) was introduced\(^1\).
  - However, **One database is not enough** to assess whether such very crucial screening method is good as a standalone one.

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Thermography Challenges

- **Validation** of equipment and image acquisition protocols
- Thermographs must be taken under carefully **controlled environmental conditions** to produce the most accurate results.

- There are no standard protocols for this. Generally it requires:
  - temperature-controlled room with no **uncontrolled heat** or **light sources** (such as sunlight coming through a window).
  - Prior to screening, the patient is often required to
    - avoid using lotions on her chest, remove outer layers of clothing and
    - sit in a temperature-controlled waiting room for >15 minutes
Thermography Challenges

Research:

Researchers have to do more research to tackle this challenge using or developing analytical techniques to support the potential benefits of thermography.

- Deep learning
- Transfer learning
Conclusion

1. Thermal imaging is **not** a stand alone screening test for breast cancer,
   - but it can make a useful contribution to **risk assessment for women of all ages**.
2. It is a **safe** form of screening that does not involve any radiation or trauma to the breast.
3. The US-FDA views thermography as an “**adjunctive**” **tool**, to a primary screening mammography.
4. More research efforts and evidence are still needed.
Conclusion

- Thermal imaging is **not** a stand alone screening test for breast cancer,
  - but it can make a useful contribution to **risk assessment for women of all ages**.
- It is a **safe** form of screening that does not involve any radiation or trauma to the breast.
- More research efforts and evidence are still needed.
Conclusion (Cont.)

- While thermography is not well evidenced (tell now) for use as a standalone screening tool,
  - its use as an adjunctive imaging procedure along with mammography should be considered, particularly for those with dense breast tissue.
References

Can we develop a high accuracy rate CAD system for breast cancer detection using the low cost and non-invasive thermal technology to help many women around the world to survive the breast cancer?

Thanks for your attention

Further questions, contact me:
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