University of Salford MANCHESTER

Thermal Imaging: Opportunities and Challenges for Breast Cancer Detections

INVITED TALK

ORGANIZED BY

BCS- BRITISH COMPUTER SOCIETY,

THE CHARTERED INSTITUTE FOR IT

BY:

TAREK GABER

SCHOOL OF SCIENCE, ENGINEERING & ENVIRONMENT

UNIVERSITY OF SALFORD, UK

T.M.A.GABER@SALFORD.AC.UK

26/2/2020

Location: Manchester Metropolitan University, Room BS 5.02, Business School Building, All Saints, Manchester, M15 6BH

University of Salford MANCHESTER

Agenda

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

University of Salford MANCHESTER

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://http://gco.iarc.fr/
- **Brest cancer today**
  - http://gco.iarc.fr/today/home
- **Brest cancer tomorrow**
  - http://gco.iarc.fr/tomorrow/home

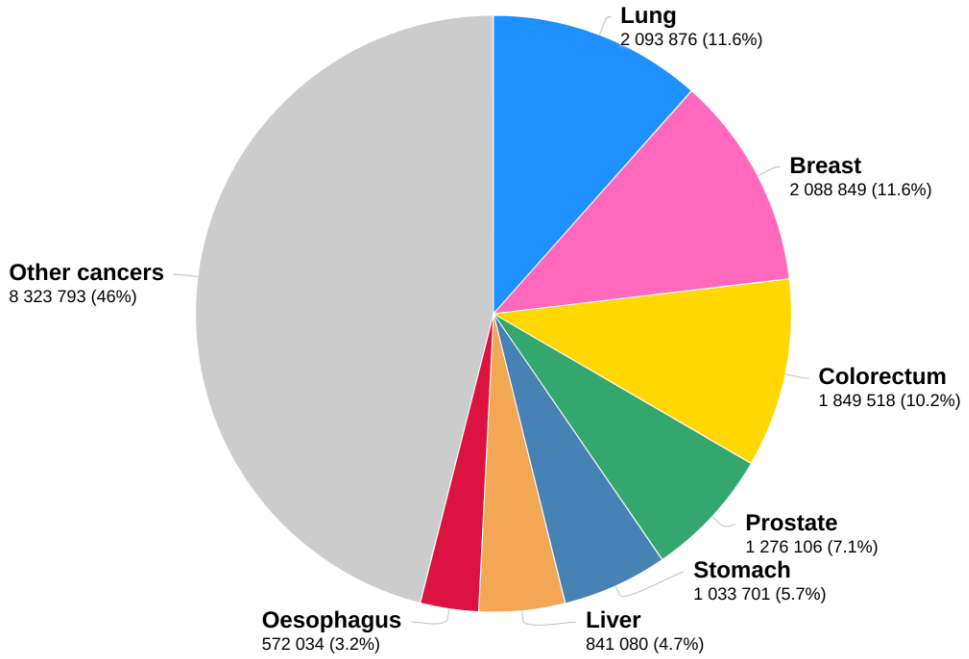
International Agency for Research on Cancer

World Health Organization

GLOBAL CANCER OBSERVATORY

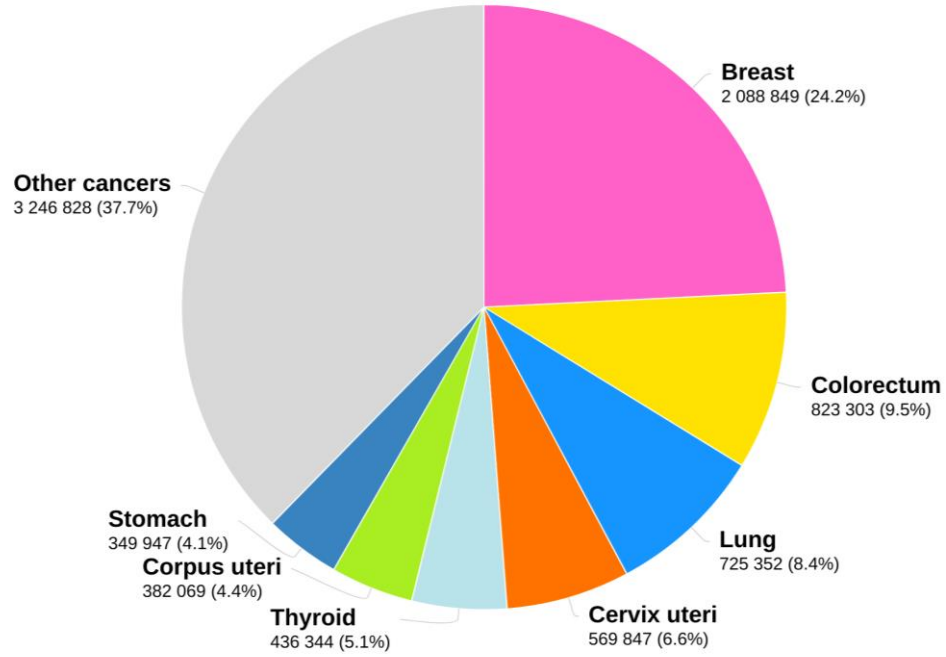
Cancer today

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

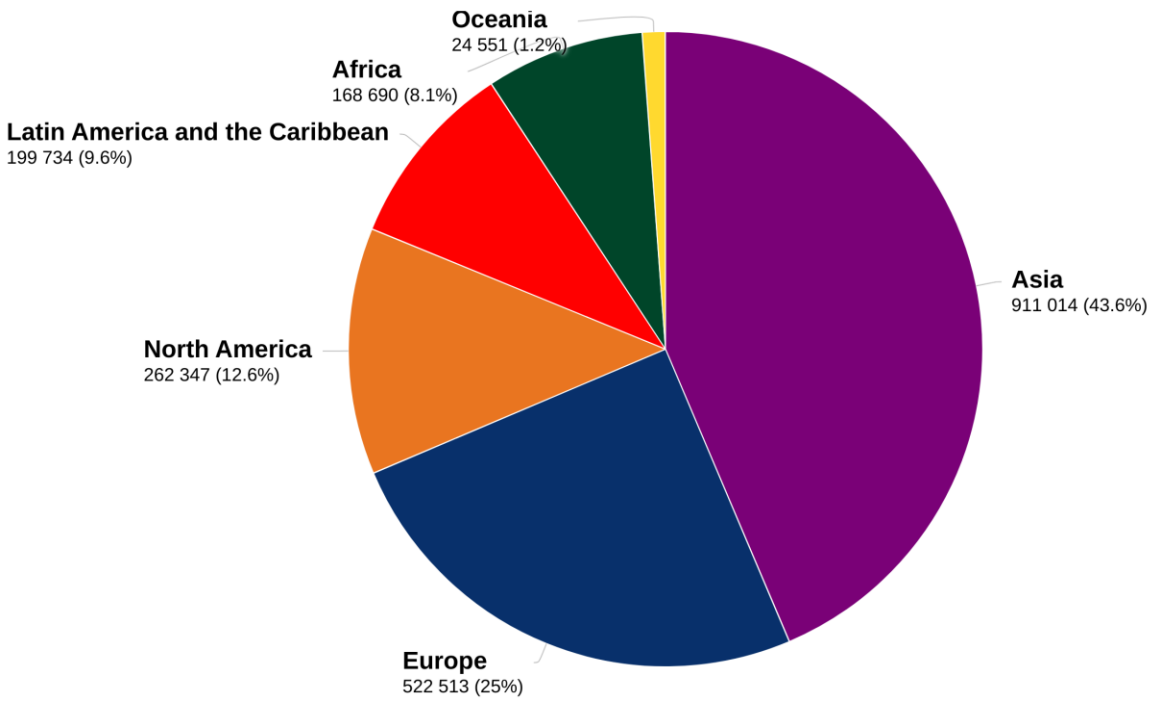


Total : 8 622 539

Data source: Globocan 2018
Graph production: Global Cancer Observatory (http://gco.iarc.fr)

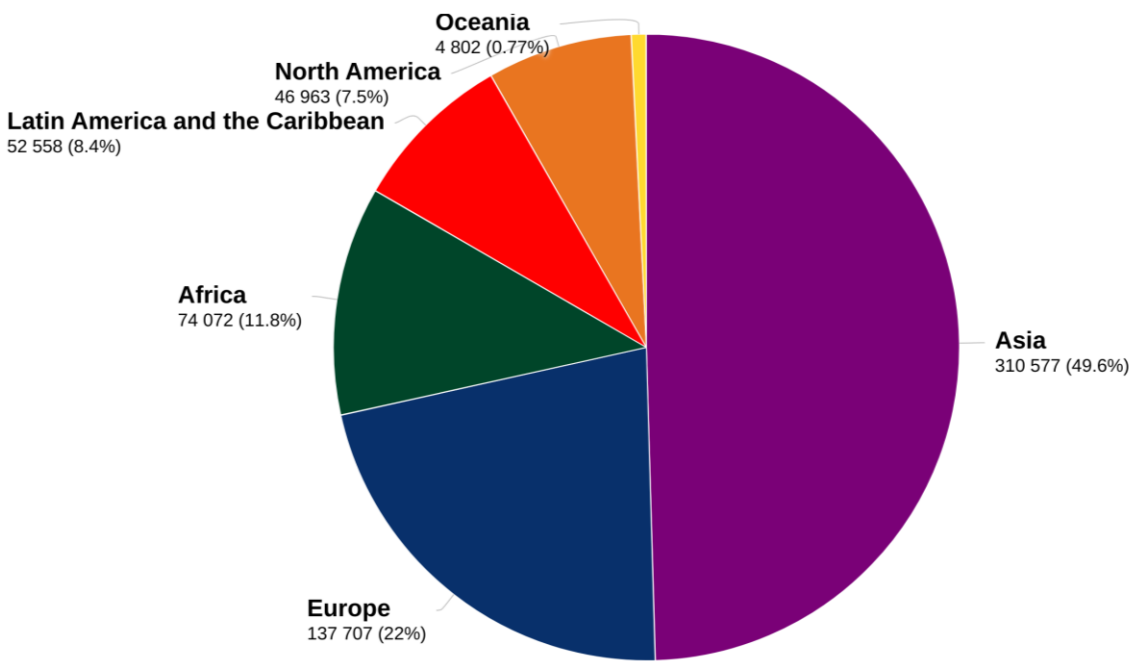
Brest cancer today

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



Total : 2 088 849

Estimated number of deaths in 2018, breast, all ages

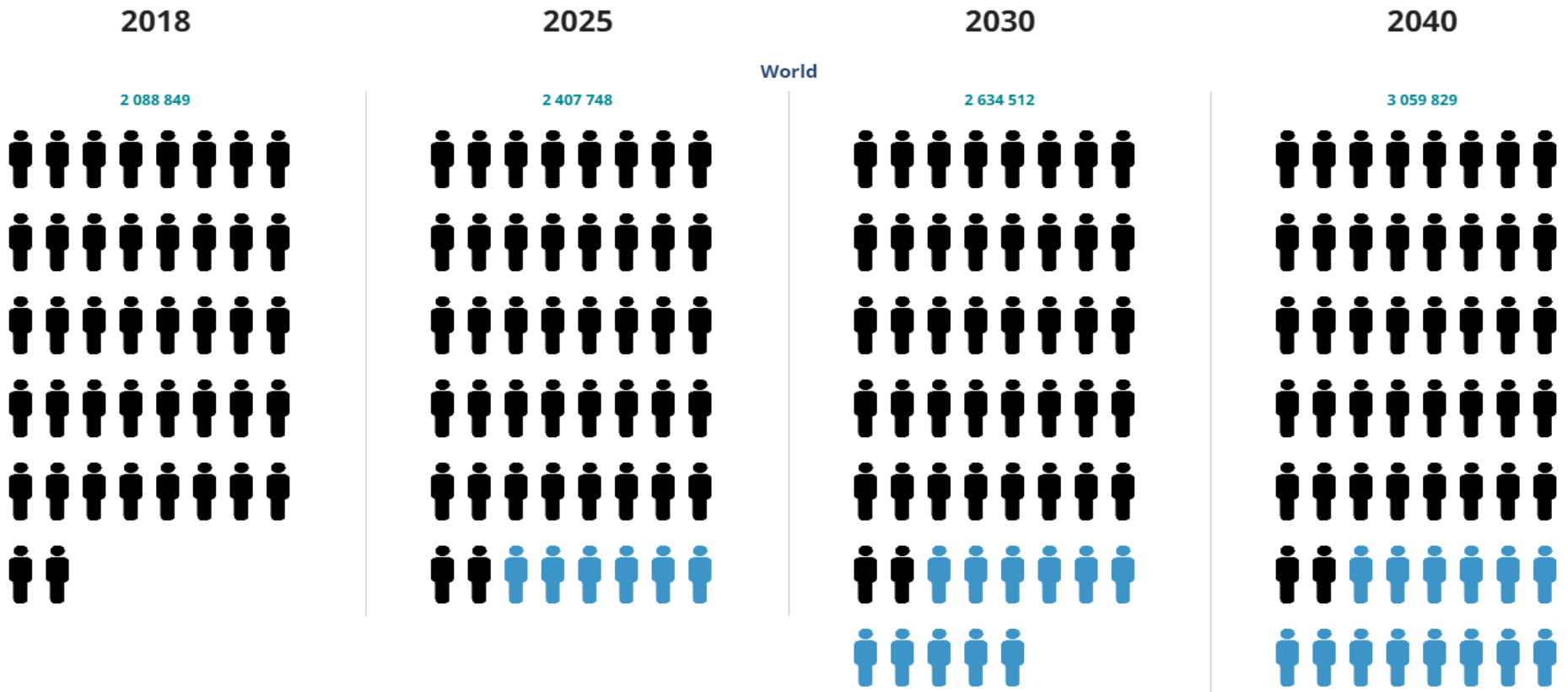


Total : 626 679

Data source: Globocan 2018
Graph production: Global Cancer Observatory (http://gco.iarc.fr)

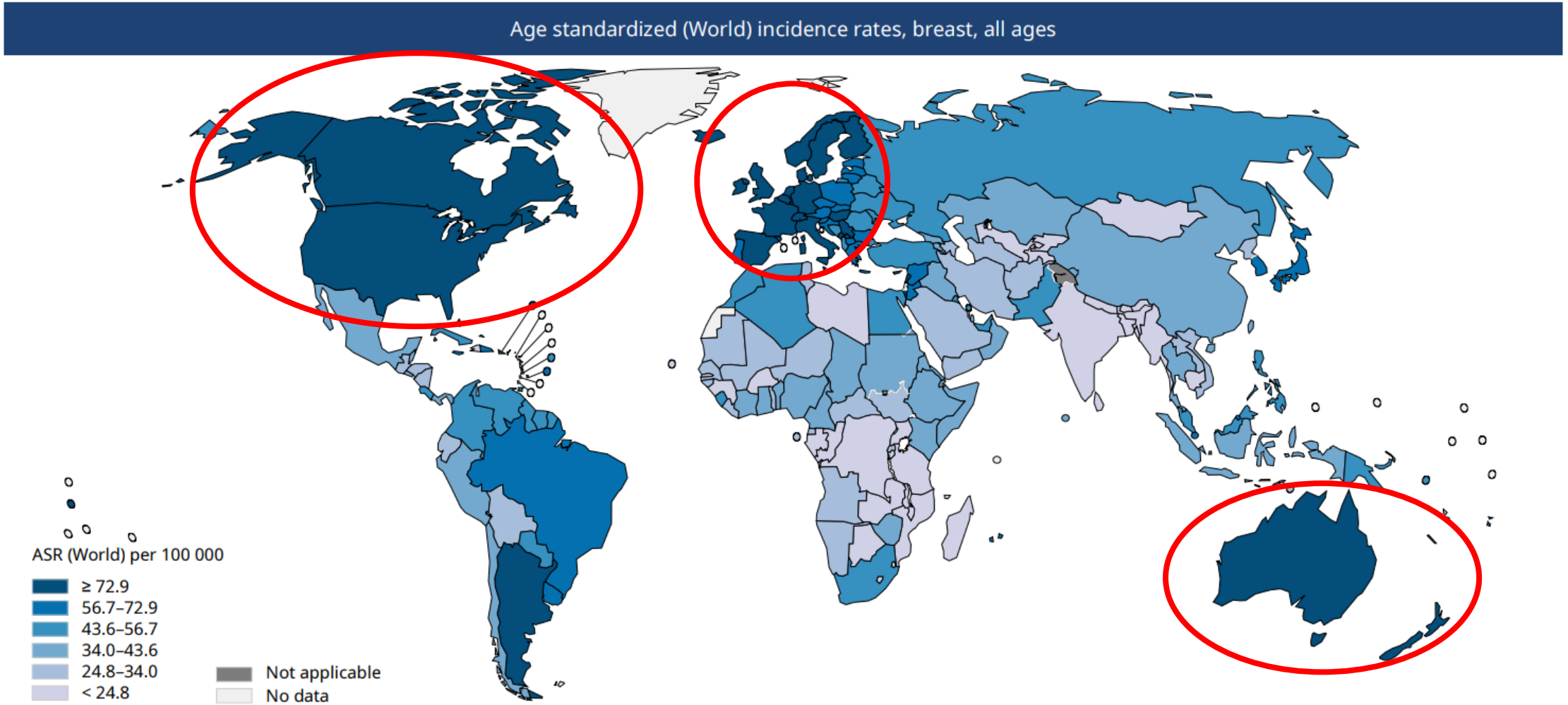
Brest cancer tomorrow

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



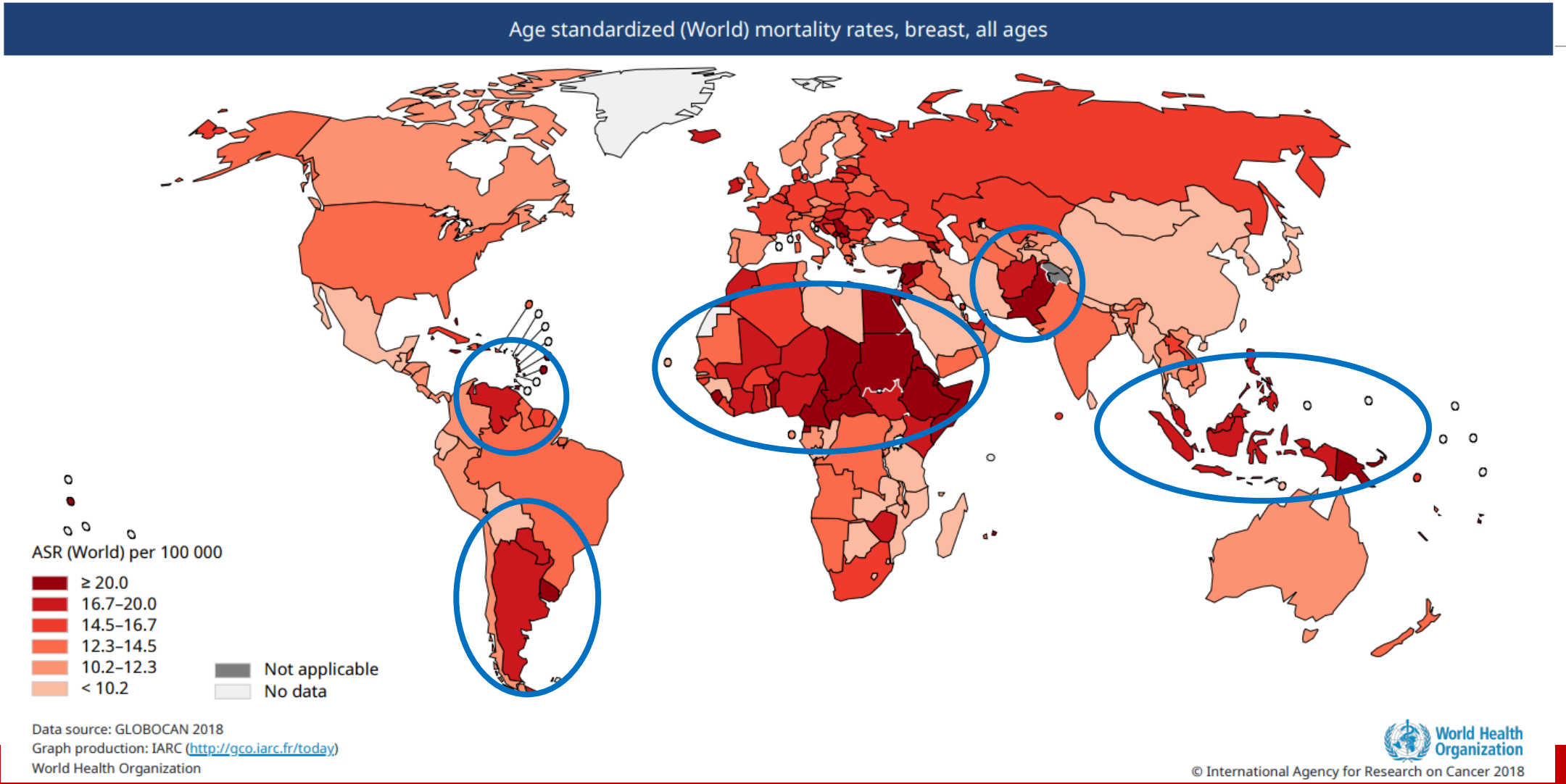
University of Salford MANCHESTER

Breast Cancer Incidence 2018 all World



University of Salford MANCHESTER

Breast Cancer Mortality 2018 all World



University of Salford MANCHESTER

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.

University of Salford MANCHESTER

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.

Mammograms vs Thermography? @"A Healthy You" https://youtu.be/fGiAKUelP7A

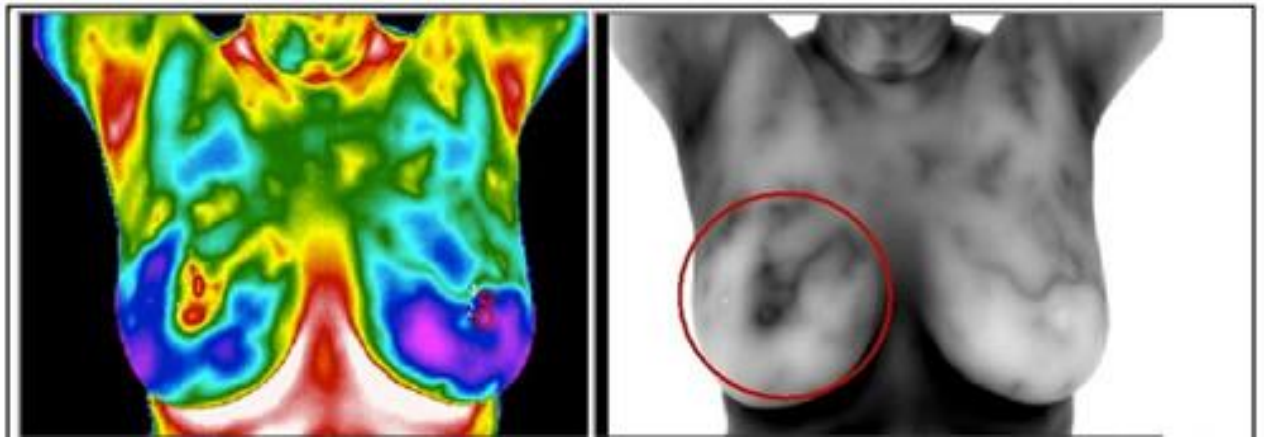
University of Salford MANCHESTER

Mammography Limitations

- As reported in [1], mammography
  - has difficultly 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

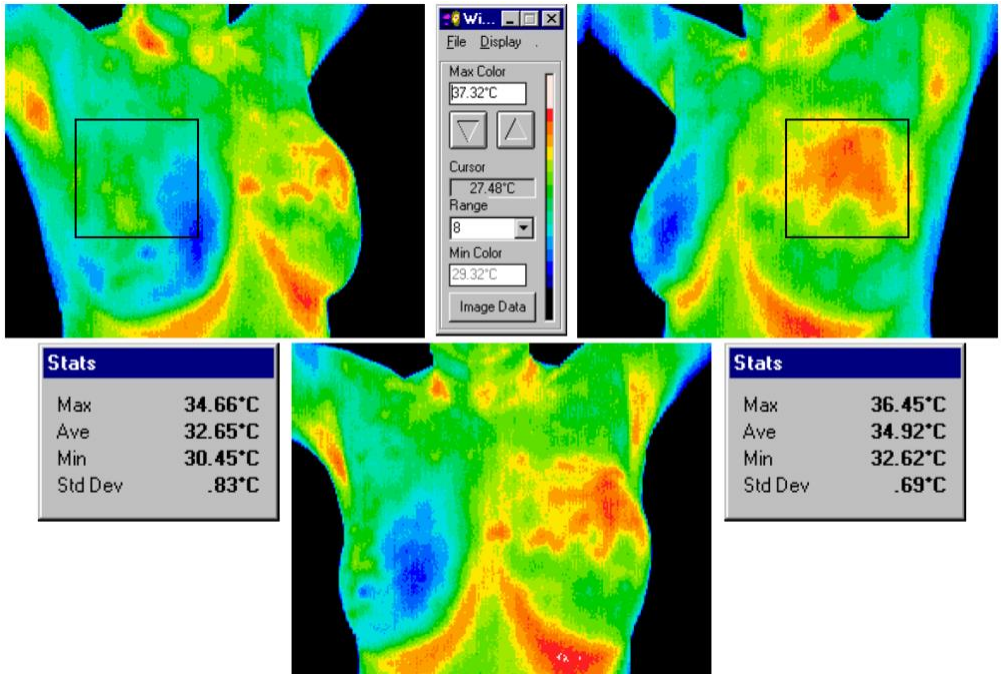
What is Thermography

- **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**



University of Salford MANCHESTER

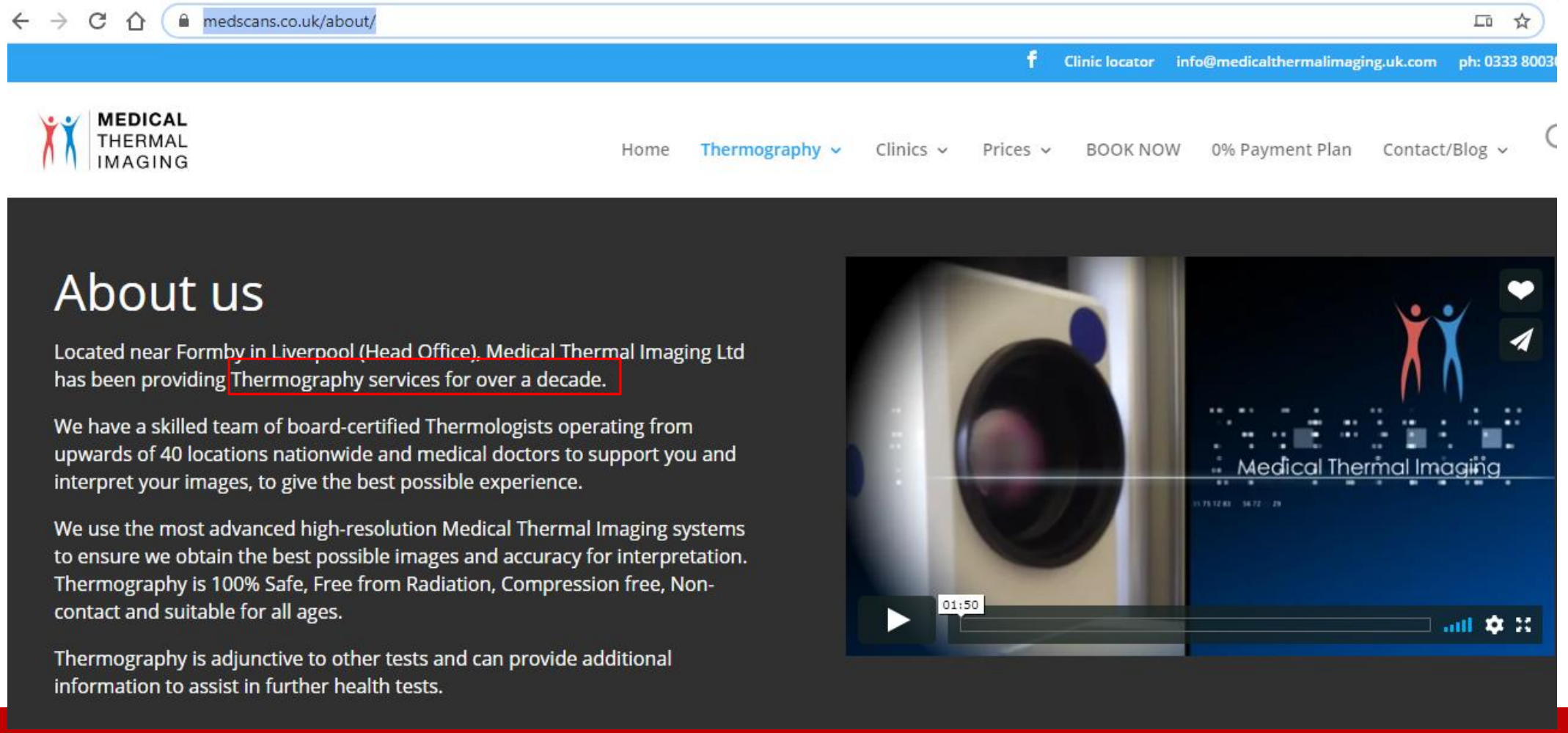
Thermography in UK

- 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

University of Salford MANCHESTER

Thermography in UK (Cont.)



Our Contribution

University of Salford MANCHESTER

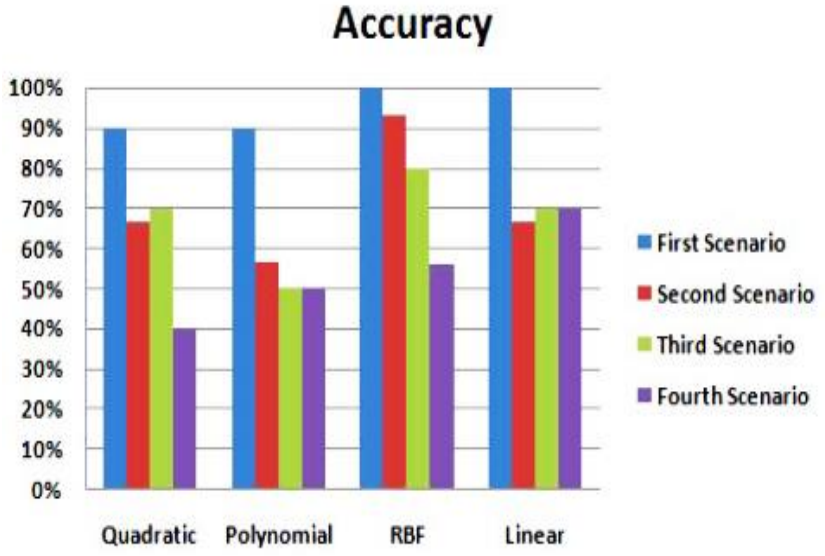
Detection of breast abnormalities of thermograms based on a new segmentation method

Publisher: IEEE

Cite This

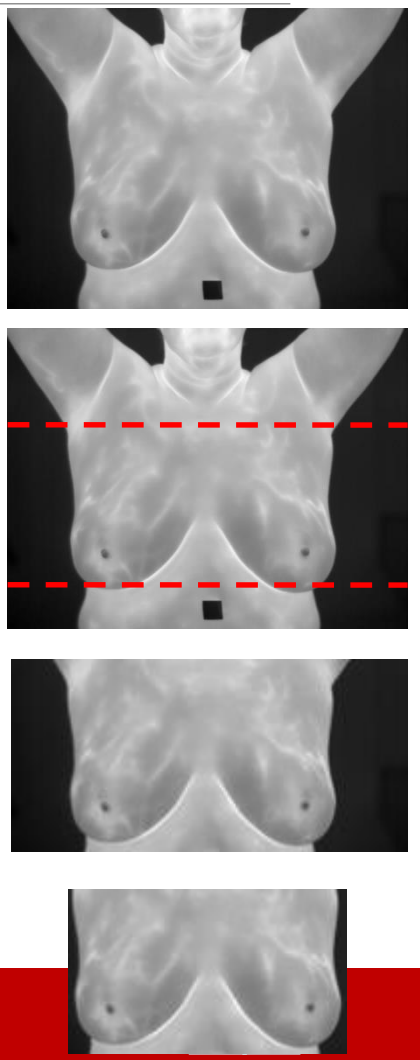
6 Author(s) Mona A. S. Ali ; Gehad Ismail Sayed ; Tarek Gaber ; Aboul Ella Hassanien ; Vaclav … **View All Authors**

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 corrdinates Y_1 and Y_2 where $Y_1 = 1/4 * M$ and $Y_2 = M - 0.2 * M$
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 $value = 0$ =0



University of Salford MANCHESTER

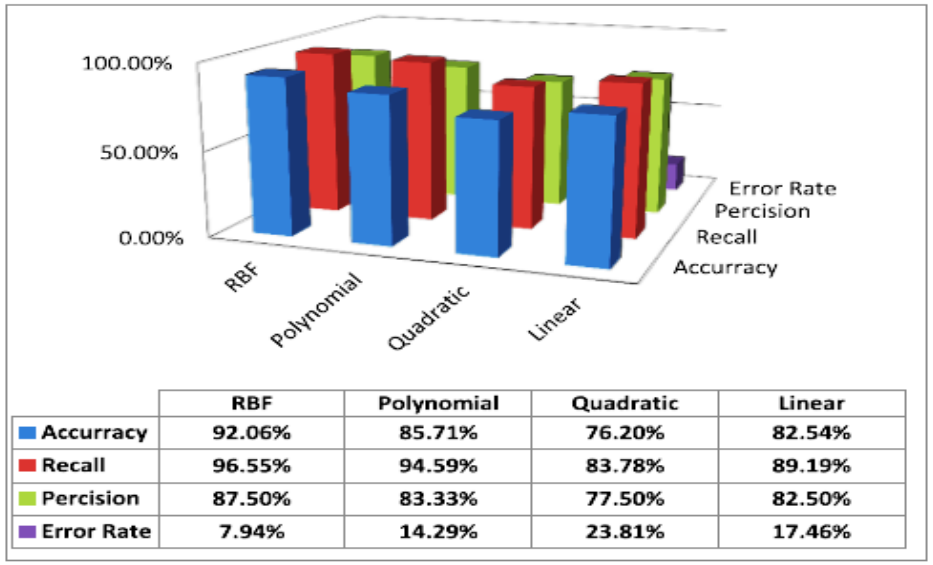
Thermogram breast cancer prediction approach based on Neutrosophic sets and fuzzy c-means algorithm

Publisher: IEEE

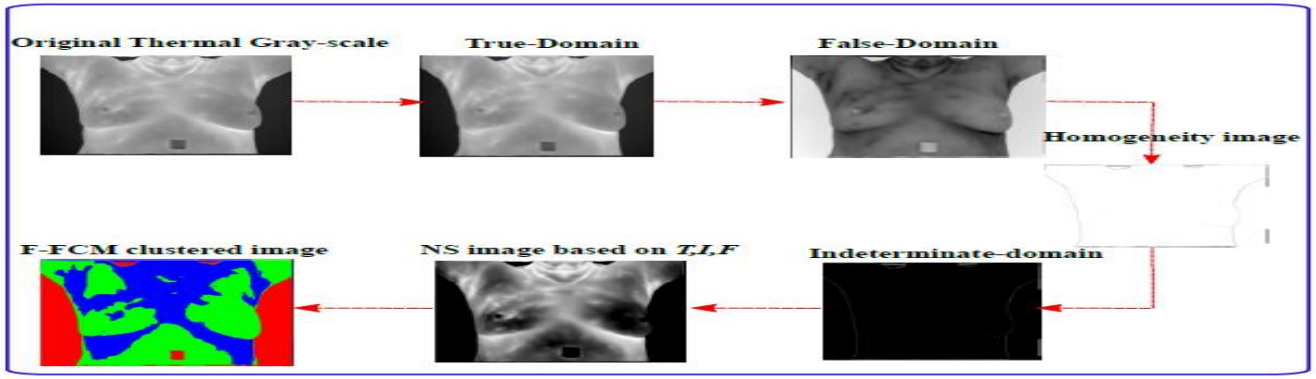
Cite This

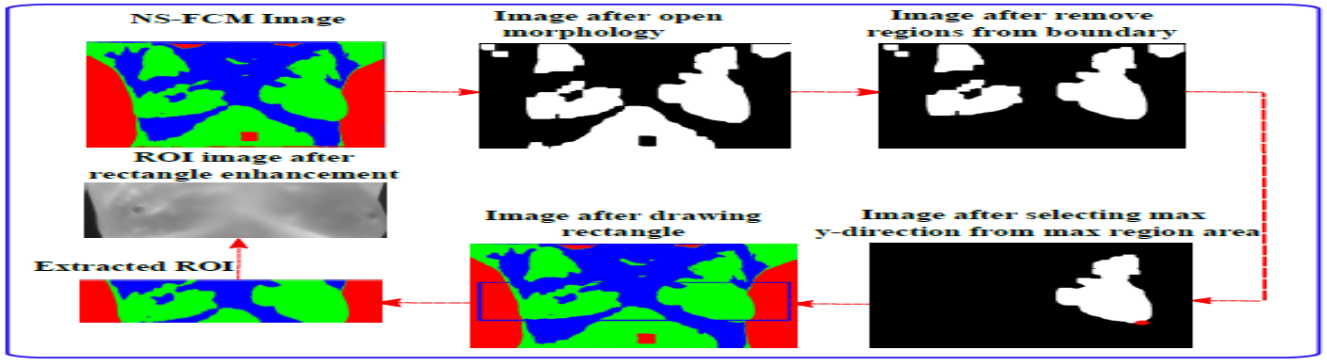
8 Author(s) Tarek Gaber ; Gehad Ismail ; Ahmed Anter ; Mona Soliman ; Mona Ali ; Noura Sem… **View All Authors**

The aim of this study was to propose an approach for **automatic classification** for thermograms to normal and abnormal.



	RBF	Polynomial	Quadratic	Linear
Accurracy	92.06%	85.71%	76.20%	82.54%
Recall	96.55%	94.59%	83.78%	89.19%
Percision	87.50%	83.33%	77.50%	82.50%
Error Rate	7.94%	14.29%	23.81%	17.46%





University of Salford MANCHESTER

applied sciences

MDPI

Article

Thermogram Breast Cancer Detection: A Comparative Study of Two Machine Learning Techniques

Fayez AlFayez [1], Mohamed W. Abo El-Soud [1,2] and Tarek Gaber [2,3,*]

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

Paper/Criteria	Dataset Size	Public/Private Dataset	Classifiers	Accuracy	Specificity	Sensitivity
A. Kennedy[2009]	–	Private	TH(1:5)scale	–	–	95%
Pramanik[2016]	40 malignant 60 benign	Public(DMR)	FANN	90%	85%	95%
Acharya[2010]	40 normal 60 malignant	Private	SVM	88.10%	90.48%	85.71%
Gaber[2015]	29 healthy 34 malignant	Public(benchmark)	SVM	92.06%	–	–
Gogo[2018]	70 abnormal 50 normal	Private	SVM(Poly)	98%	98%	98%
Sathish[2018]	–	Public (DMR)	E. Bagg. Trees AdaBoost	87%	90.6%	83%
Our Solution	705 normal 200 benign 440 malignant	Public (DMR-IR)	MLP ELM	80.04% 99.10%	84% 98.05%	61.6% 97.03%

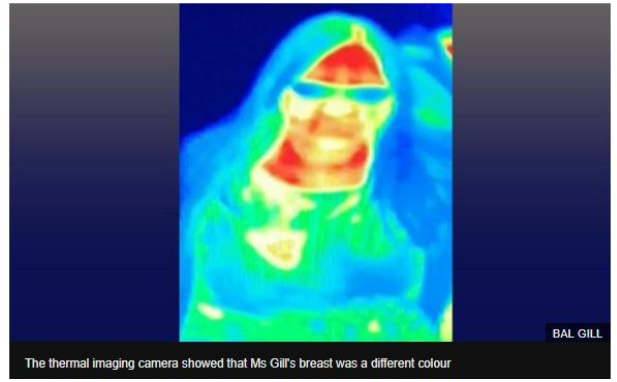
Extreme Learning Machine (ELM) *Multilayer Perceptron (MLP)*

University of Salford MANCHESTER

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 ☺.



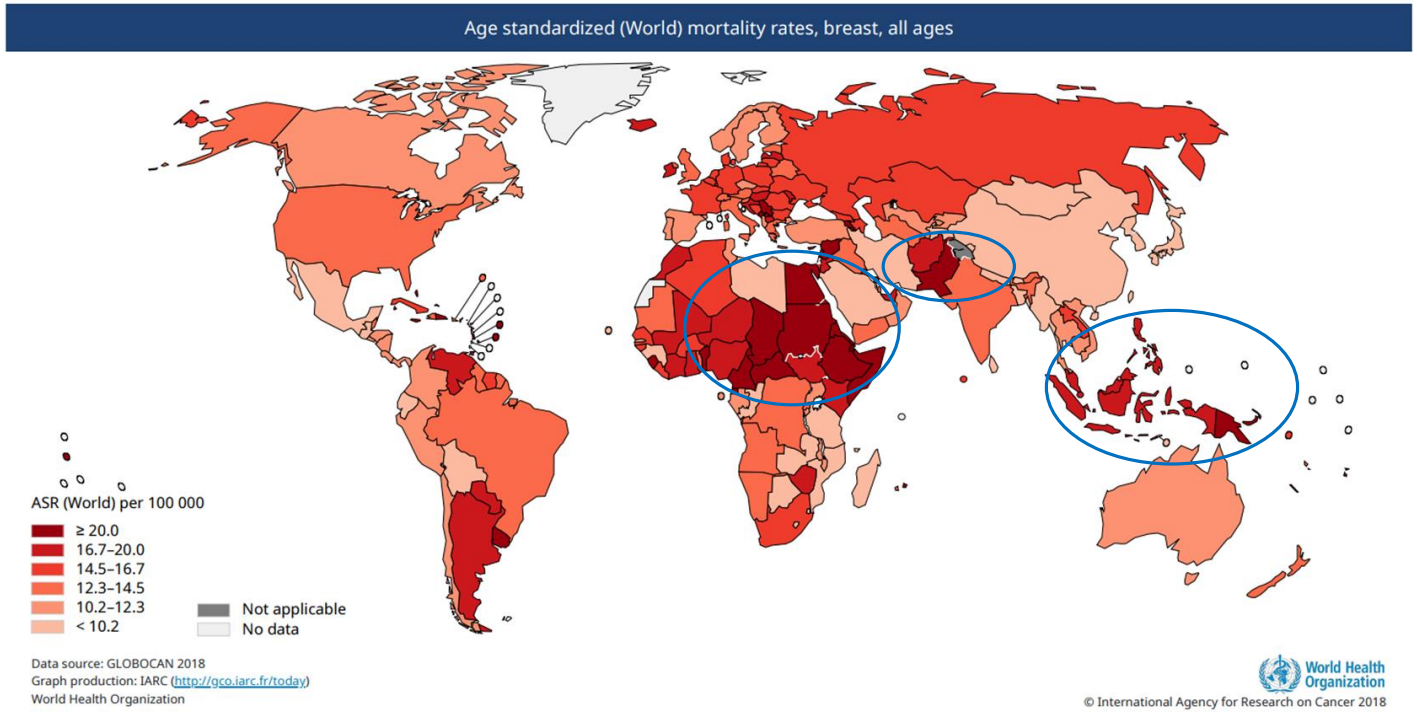
Thermography Opportunities

- It is known that, in younger women, breast cancers are usually more aggressive and have poorer survival rates.
  - Breast thermography could 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.

University of Salford MANCHESTER

Thermography Opportunities

- As cheap screening tool,
  - Breast thermography could 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.



University of Salford MANCHESTER

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.

University of Salford MANCHESTER

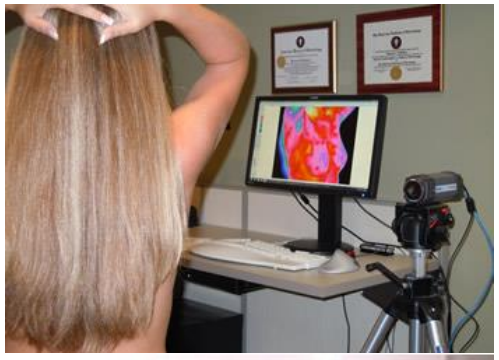
Thermography Challenges

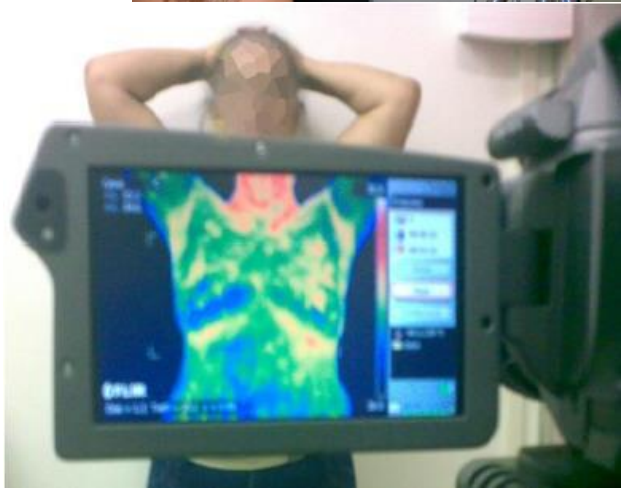
- **Public Database**
  - Tell 2014, there was NO public thermograms database to support more research in this area.
  - On June 2014, the ONLY public database (**149 patients**) was introduced[1].
    - DMR-IR database is accessible through http://visual.ic.uff.br/dmi.
  - However, **One database** is **not enough** to assess whether such very crucial screening method is good as a standalone one.

1- L. Silva, D. Saade, G. Sequeiros, A. Silva, A. Paiva, R. Bravo, and A. Conci, "A new database for breast research with infrared image," Journal of Medical Imaging and Health Informatics, vol. 4, no. 1, pp.92–100, 2014.

Thermography Challenges

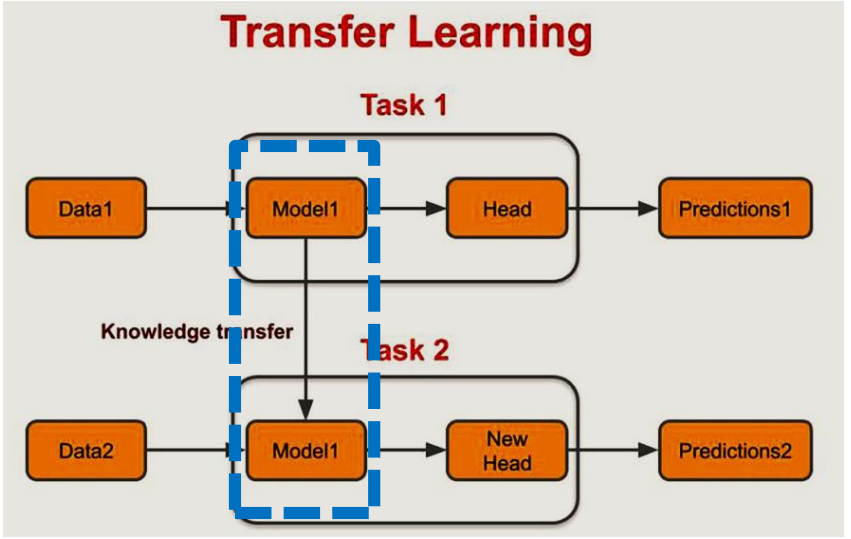
- Validation of equipment and image acquisition protocols
- Thermographs must be taken under carefully **controlled environmental conditions** to produce the most accurate results.
  - There are no standard protocols for this. Generally it requires:
    - temperature-controlled room with no **uncontrolled 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**, r**emove outer layers of clothing** and
      - sit in a temperature-controlled waiting room for >15 minutes

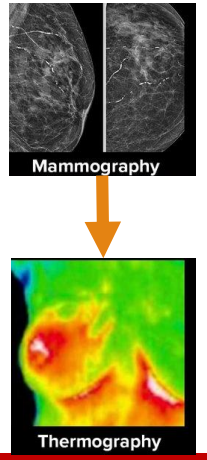




Thermography Challenges

- **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





University of Salford MANCHESTER

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.

University of Salford MANCHESTER

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.

University of Salford MANCHESTER

References

1. Wishart, G. C., et al. "The accuracy of digital infrared imaging for breast cancer detection in women undergoing breast biopsy." European Journal of Surgical Oncology (EJSO) 36.6 (2010): 535-540.
2. Breast Thermography: History, Theory, and UseIs this screening tool adequate for standalone use? By Debi Walker, ND, and Tina Kaczor, ND, FABNO
3. Gautherie, Michel. "Thermopathology of breast cancer: measurement and analysis of in vivo temperature and blood flow." *Annals of the New York Academy of Sciences* 335.1 (1980): 383-415.
4. Isard HJ, Becker W, Shilo R, Ostrum BJ. Breast thermography after four years and 10,000 studies. *Am J Roentgenol.* 1972;115(4):811-821.
5. Nathan BE, Burn JI, MacErlean DP. Value of mammary thermography in differential diagnosis. *Br Med J.* 1972;2(5809):316-317
6. Feig SA, Shaber GS, Schwartz GF, et al. Thermography, mammography, and clinical examination in breast cancer screening. *Radiology.* 1977;122(1):123-127.
7. Kontos M, Wilson R, Fentiman I. Digital infrared thermal imaging (DITI) of breast lesions: sensitivity and specificity of detection of primary breast cancers. *Clin Radiol.* 2011;66(6):536-539.
8. Arora N, Martins D, Ruggerio D, et al. Effectiveness of a noninvasive digital infrared thermal imaging system in the detection of breast cancer. *Am J Surg.* 2008;196(4):523-526
9. Yahara, Toshiro, et al. "Relationship between microvessel density and thermographic hot areas in breast cancer." Surgery Today 33.4 (2003): 243-248.
10. Mejia, Tatiana M., et al. "Automatic Segmentation and Analysis of Thermograms Using Texture Descriptors for Breast Cancer Detection." Computer Aided System Engineering (APCASE), 2015 Asia-Pacific Conference on. IEEE, 2015..

University of Salford MANCHESTER

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:

Tarek Gaber

University of Salford

t.m.a.gaber@Salford.ac.uk