Smart Healthcare: Deep Learning Algorithms for Breast Cancer Detection in Computer-Aided Diagnosis Systems Based on Medical Imaging -A Systematic Review.

Wassima MANSSOUR wmanssour@insea.ac.ma
M2SI – National Institute of Economics and Applied Economics
Supervisor: M. KABBAJ, akabbaj@insea.ac.ma

Abstract- ***Cancer is one of the leading causes of death in the world, with approximately 10 million or 1 in 6 deaths in 2020. The most common types of cancer are breast cancer, lung cancer, colon cancer, rectal cancer, and prostate cancer. Also, about one-third of cancer deaths are due to tobacco use, high obesity index, alcohol consumption, low fruit and vegetable intake, and lack of exercise.***
Nowadays, many computer-aided (CAD) systems are good at detecting different types of tumors in different body organs. They are analyzed through various modality. B. Magnetic Resonance Imaging (MRI), Computer tomography (CT), mammography, positron emission tomography (PET), etc.
In this paper we focus on breast cancer. We present a survey and a comprehensive analysis of existing methods for detecting tumors of the breast. We describe the deep learning approach, the medical images used, and the results obtained.

I. Introduction

Cancer is a general term for a large group of diseases that can affect any part of the body [1]. Other terms used are malignant tumors and neoplasms. A characteristic of cancer is that abnormal cells can form rapidly, grow beyond normal limits, and invade adjacent parts of the body and spread to other organs. The latter process is called metastasis. Widespread metastasis is the leading cause of death from cancer.

Cervical and breast cancer are serious public health concerns in Morocco. Not only are they one of the most common cancers in women (36.1% for breast cancer, 12.8% for cervical cancer), but delays in diagnosis cause a significant amount of death[2]. For that reason, we decided to conduct a systematic review of the latest research on the field of Breast cancer Detection using Deep Learning algorithms based on the different medical imaging modalities.

1. Computer-Aided Diagnosis Systems

There are limits to the clinical interpretation of medical images due to the nature of the visual system of the human eye / brain reader fatigue, distraction, the presence of overlapping structures in the image, and screening program. These restrictions are use of CAD, which may improve detection, diagnostic performance, and ultimately patient care.

In the field of medical imaging, computer-aided detection (CADe) or computer-aided diagnosis (CADx) is a computer-aided system that helps physicians make quick decisions [3, 4]. Medical images address the information in images that doctors need in a short amount of time to evaluate and analyze anomalies.

Much effort has been put into the development of the CAD system. It is based on advances in digital image processing, pattern recognition and artificial intelligence. Computer-aided detection uses computer output to locate suspicious lesions. The radiologist is then responsible for characterizing and diagnosing the abnormality and managing the patient. In general, a complete CAD system included segmented structures, anomaly detection, their extraction, and the ability to classify the tumors. Therefore, CAD systems can be divided into four main layers:

- The first step is preprocessing to prepare the image for subsequent steps such as cleaning and removal of the medical image noise.
- The second step is the segmentation of the region of interest in the image.
- The third step is feature extraction and selection. At this stage, features are extracted from the cleaned-up image and the most discriminating features are selected. Selected function is possible distinguish between normal and cancerous areas.
- Final stage of CAD system is a classification considered to be the heart CAD. This is a data mining process that assigns labels or classes Different groups aimed and extracting hidden patterns from large datasets using different machine techniques.

2. Types of Breast Cancer Detection Imaging

Breast cancer is the second leading cause of death in women worldwide. According to the American Cancer Society, about 1 in 8 women develop breast cancer in their lifetime, and only 5-10% of breast cancers occur in women with a clear genetic link [3]. Therefore, early detection contributes to better quality of life, financial treatment and spiritual peace for patients and their families.

Mammography, X-rays, ultrasound, PET, MRI, CT, tomography, and CE mammography are a variety of commonly used diagnostic imaging methods discussed in the literature [5]. Some of these modalities are recommended, as the breast is usually considered a sensitive part of the human body. Mammography is considered a safe diagnostic imaging method in the early stages. At low x-ray doses, mammography is a basic screening test for breast cancer and captures more visible internal details of the breast [4].

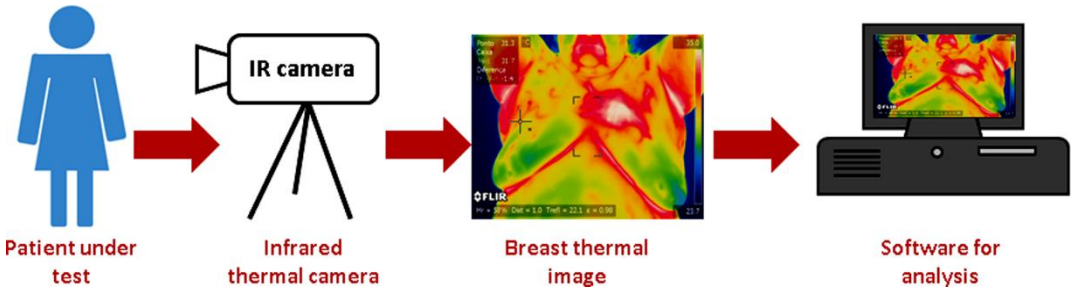
- Thermography

Thermography, also called thermal imaging, uses a special camera to measure the temperature of the skin on the breast's surface. It is non-invasive test that involves no radiation.

Thermography is based on two ideas:

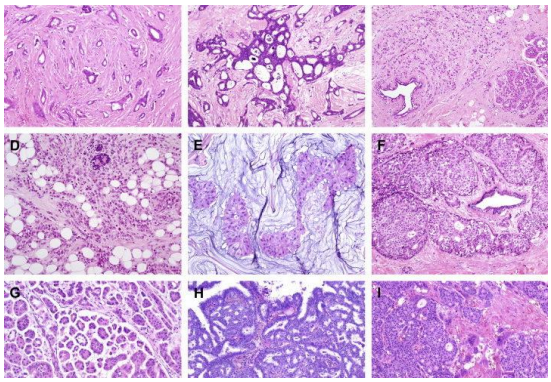
- Because cancer cells are growing and multiplying very fast, blood flow and metabolism are higher in a cancer tumor.
- As blood flow and metabolism increase, skin temperature goes up.

Thermography has been available for several decades, but there is no evidence to show that it's a good screening tool to detect breast cancer early, when the cancer is most treatable[6].



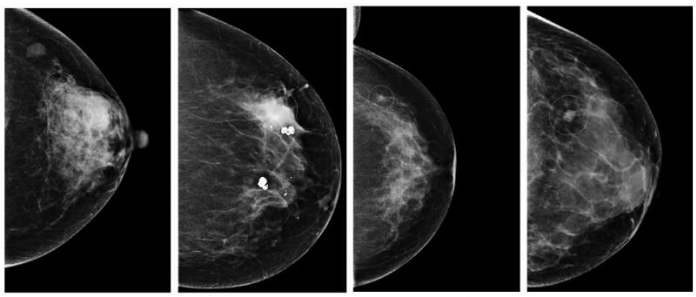
- Histopathology

  Histopathology is the diagnosis and study of diseases of the tissues and involves examining tissues and/or cells under a microscope. Histopathologists are responsible for making tissue diagnoses and helping clinicians manage a patient's care [7].



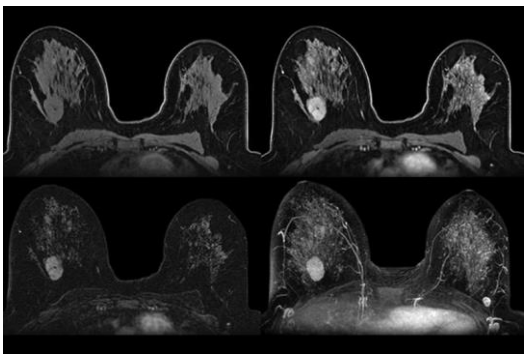
- Mammography

  Mammograms are done with a machine designed to look only at breast tissue. The machine takes x-rays at lower doses than the x-rays done to look at other parts of the body, like the lungs or bones. The mammogram machine has 2 plates that compress or flatten the breast to spread the tissue apart. This gives a better-quality picture and allows less radiation to be used.



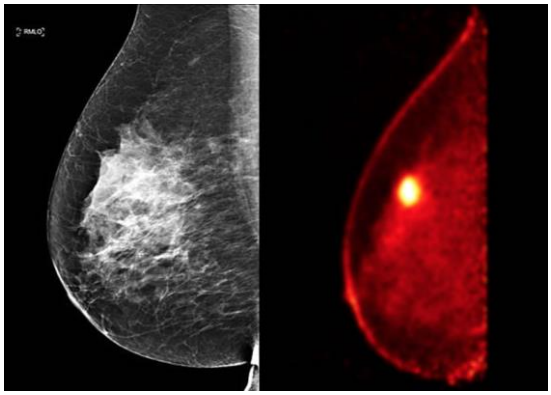
- MRI

  The MRI machine is a large, cylindrical (tube-shaped) machine that creates a strong magnetic field around the patient. The magnetic field, along with radio waves, alters the hydrogen atoms' natural alignment in the body. Computers are then used to form a two-dimensional (2D) image of a body structure or organ based on the activity of the hydrogen atoms. Cross-sectional views can be obtained to reveal further details. MRI does not use radiation.



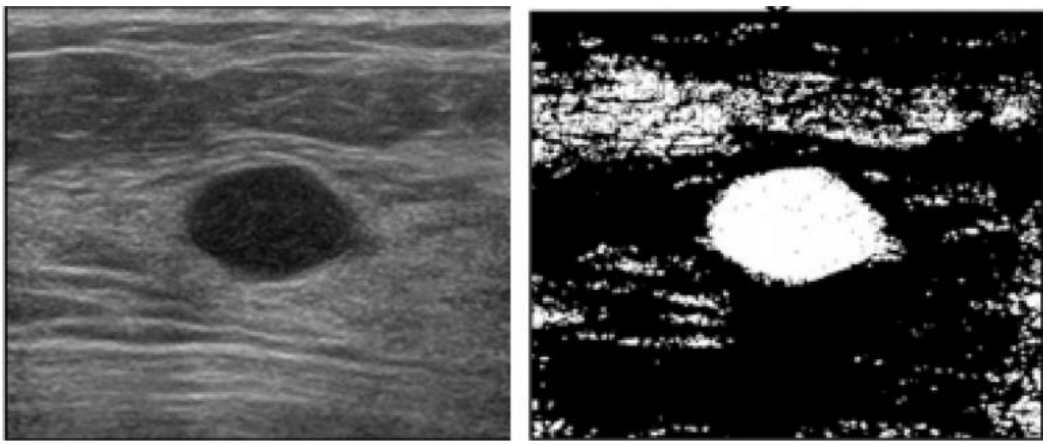
- PET/CT

  A positron emission tomography (PET) scan is an imaging test that uses a radioactive substance (called a tracer) to look for potential spread of breast cancer. This tracer can help identify areas of cancer that an MRI or CT scan may not show.
  A PET scan requires a small amount of radioactive material (tracer). This tracer is given through a vein (IV), usually on the inside of your elbow, or in a small vein in your hand. The tracer travels through your blood and collects in organs and tissues and gives off a signal that helps the radiologist see certain areas or disease more clearly.



- Ultrasound

  Ultrasound is an imaging test that sends high-frequency sound waves through your breast and converts them into images on a viewing screen. The ultrasound technician places a sound-emitting probe on the breast to conduct the test. There is no radiation involved[6].



II. Methodology

1. Research Criteria

   This survey has the objective of identify and compare the recent research related to the breast cancer detection and the CAD systems based on the different medical images and Machine/Deep Learning Techniques.

   Our main questions are:

   - What are the most used modalities of medical imaging used for developing and testing the DL models?
   - What are the MLT used in the case of breast cancer detection?
   - What are the datasets used?

2. Data collection

   For the selection of articles to review, we relied on Google Scholar, and the most famous journals like: , Springer Link (http://www.springerlink.com), Science Direct (Elsevier) (http://www.sciencedirect.com), IEEE Xplore (http://www.ieeexplore.ieee.
   org, and (https://www.ncbi.nlm.nih.gov/pubmed/).

   Some of the search keywords we used are: “breast cancer”, “Medical image classification”, “deep learning for cancer detection”, “CAD”, “CNN”, “Breast cancer and DL”.

   We chose 3 principal classifications to narrow the articles selected:

   - The date of publication: must be recent 2016-2022.
   - The medical image used: DM, US, MRI, Histological images, Thermal imaging.
   - The MLT used: CNN, KNN, ANN, SVM and other.

III. Comparison Analysis

Reference	Title	Year	Imaging Modality	DL Method	Dataset	Results
[9]	Breast Cancer Multi-classification from Histopathological Images with Structured Deep Learning Model	2017	Histopathological Images	Structured Deep Learning Model	BreaKHis	93.2% accuracy
[10]	Histopathological Image Analysis for Breast Cancer Detection Using Cubic SVM	2020	Histopathological Images	Cubic SVM	BreaKHis	92.3% accuracy
[11]	Breast Cancer Detection from Thermography Based on Deep Neural Networks	2019	Thermography Images	Deep Neural Networks	DMR Mastology Research	88.89% accuracy
[12]	Classification of mammogram for early detection of breast cancer using SVM classifier and Hough transform	2019	Mammograms	SVM	MIAS database	94% accuracy
[14]	Classification of static infrared images using pre-trained CNN for breast cancer detection	2021	Thermal Imaging	CNN	DMRIR	91.67% accuracy

IV. Discussion

In this study [9], they propose a breast cancer multi-classification method using a newly proposed deep learning model. The structured deep learning model has achieved remarkable performance (average 93.2% accuracy) on a large-scale dataset, which demonstrates the strength of the method in providing an efficient tool for breast cancer multi-classification in clinical settings.

The experimental analysis of the proposed approach here[10] has been done on publicly available dataset BreakHis. For experimental purpose they have tested K-Nearest neighbor (KNN), Random Forest, and about six flavors of (SVM) Support Vector classification algorithms. The experimental result shows that proposed approach for detection and classification rate of breast cancer has been achieved maximum 92.3%accuracy with a cubic SVM classifier. The analysis of the results is verified with the help of classifier goodness parameters like accuracy, precision, recall, f-score, specificity, confusion matrix and ROC curve.

In this work[13] breast cancer detection using maximization estimation is done to acquire more accuracy. Increasing the intensity class in the estimation maximization produce better results. Usual shape features can't be used for this purpose because we are considering the entire image for feature extraction and classification. Also, by using Hough transform normal and abnormal classes are effectively classified. Use of more intensity features like mean, variance and entropy can improve the results. By having SVM classifier we obtained the accuracy range of 94%.

In this work [14], they have use three state of the art CNNs (VGG-16, Densenet201, and Resnet50) combined with transfer learning to classify static thermography images (sick and healthy). In our experiments, the best results have an F1-score of 0.92, 91.67% for accuracy, 100% for sensitivity, and 83.3% for specificity obtained with the Densenet using 38 static images for each class.

VII. Conclusion and Further Work

Early detection of breast cancer remains the cornerstone of breast cancer control. Breast self-examination is recommended by the World Health Organization to raise women awareness of breast cancer risks. In this research, we tried to discover and analyze the different methods and DL techniques used in the breast cancer detection, based on the different imaging modalities. SVM, CNN and DNN remains the most used DL algorithms for CAD systems. And mammograms are the most medical imaging technique used.

This work was a first opportunity to conduct research in the intersection of the medica and technological sectors. It still under development to add mor recent articles, and compare the results based on the type of medical imaging and the DL used.

References

[1] https://www.who.int/news-room/fact-sheets/detail/cancer

[2] https://www.contrelecancer.ma/en/detection_precoce_action

[3] Doi K. Computer-aided diagnosis in medical imaging: Historical review, current status and future potential. Computerized Medical Imaging and Graphics. 2017;31(4):198-211

[4] Li Q, Nishikawa RM, editors. Computer-Aided Detection and Diagnosis in Medical Imaging. Taylor & Francis, CRC Press, New York; 2015

[5] B. Mughal and M. Sharif, "Automated detection of breast tumor in different imaging modalities: a review," Current Medical Imaging Reviews, vol. 13, pp. 121-139, 2017.

[6] https://www.breastcancer.org/screening-testing/thermography

[7] https://www.rcpath.org/discover-pathology/news/fact-sheets/histopathology.html

[8] Magnetic resonance imaging texture analysis classification of primary breast cancer | SpringerLink

[9] https://www.nature.com/articles/s41598-017-04075-z

[10] https://ieeexplore.ieee.org/document/9071218

[11] https://ieeexplore.ieee.org/document/8946367

[12] https://sci-hub.st/10.1016/j.measurement.2019.05.083

[13] https://sci-hub.st/10.1016/j.measurement.2019.05.083

[14] https://sci-hub.st/10.1109/CBMS52027.2021.00094