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Research Article

Early Diagnosis of Breast Cancer Using Image Processing Techniques

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Cancer is a noncommunicable chronic disease that indistinctly affects people of any nationality, race, ethnicity, age, or social class. Because of its unpredictability, receiving the diagnosis of this disease is almost always alarming for the patient. Breast cancer, especially among women, occupies a prominent position in this ranking. However, if diagnosed early, there is an excellent chance of a cure. In this sense, digital technologies have been advancing at an increasingly fast pace to support the early diagnosis of the disease. Clinical analysis of breast cancer is commonly performed using diagnostic imaging. One of the most used exams considered the main one for the early detection of this type of cancer is mammography. This exam allows the visualization of breast tissue from image screening using X-rays. In this sense, the use of computational techniques is essential to assist medical professionals in diagnosing this disease, thus making prevention and early diagnosis even more effective in the current context. The present work is limited to the use of digital technologies (image processing and artificial intelligence) that cooperate with the early diagnosis of breast cancer, which supports the medical professional to analyze images and be able to diagnose, from an early stage, the emergence of breast cancer of the disease, significantly increasing the chances of curing it. It can be gathered from this research how the discovery of X-rays and the growth in this sector combined with cutting-edge technology have benefitted in the early detection of the disease and even offered the cure of many cases.

1. Introduction

Defined as a malignant tumour, cancer, unlike an individualized disease, is characterized as a set of illnesses that encompasses more than 200 pathologies, whose malignant abnormal cells, usually very aggressive, grow uncontrollably, invading adjacent organs and tissues, and can spread throughout the body giving rise to tumours in other regions. In this case of dissemination, there is the so-called metastasis. Such cells before becoming cancerous were normal; however, they deformed when they suffered damage to their functioning at some previous time, which led them to reproduce quickly and disorderly with an increase in glucose consumption [1].

The disease is a state of abnormality, imbalance of the body and/or mind. One of the diseases that most frighten and carry perplexities about tomorrow is cancer. This, for a long time, involved in a negative reductionism and entangled in the culture of civilizations with great intensity, frightened many who did not even pronounce the word cancer. Today, with the technological advances in medicine, this mentality has been changing, since, if the treatment is started early, there are chances of cure. Breast cancer whose signs/symptoms are detected early on provides effective

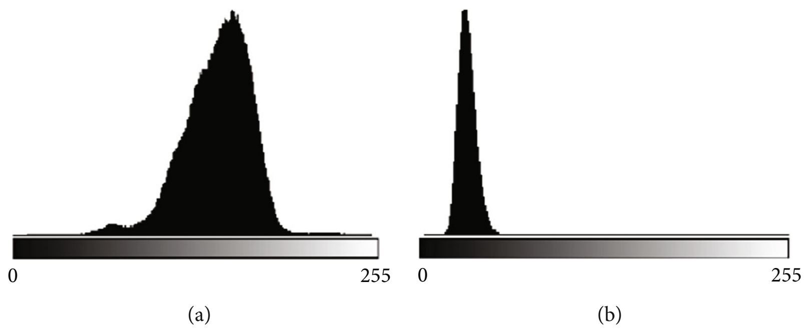


Figure 1: Histograms: (a) clear image and (b) dark image.

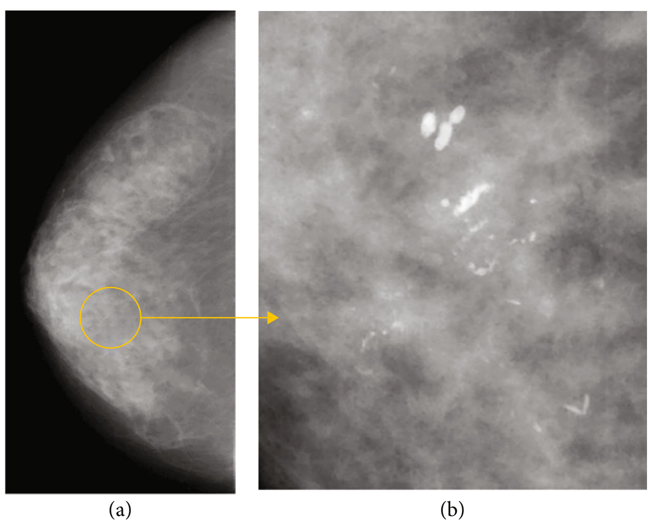


Figure 2: (a) Left breast. (b) Cut out the area of interest.

results with early treatment. This type of cancer ranks second in the rate of occurrences of this disease in the world, only behind nonmelanoma skin [2].

Considered to be the most precise and most accessible technique of practice to process images and computational speed, thresholding has been frequently used in the scope of image segmentation. This technique is also known as binarization [3], which "consists of splitting the histogram, converting pixels whose grey tone is greater than or equal to a certain threshold value (T) into white and the others into the black".

All this progress, which has contributed significantly to medicine, stems from the discovery of X-rays just over 126 years ago. In the case of breast cancer, advances in radiology have increased the survival of many women and prevented many others from developing the disease when they make an early diagnosis. In this sense, the binarization system [4] creates digital image processing techniques, which allow the generation of essential parameters for the analysis of mammographic images; it also refines the precision in the revelation of tumours, anatomical alterations, and structural lesions, making the diagnosis elucidative for the taking decision on patient prevention/treatment.

That said, this literature review article's objective is to demonstrate the relevance of the thresholding technique in the diagnosis of breast cancer. To achieve this objective, we first discuss digital imaging, histogram, binary image, thresholding, and, finally, the importance of breast cancer prevention based on this technological evolution.

2. Review of Literature

Among the types of cancer, breast cancer is the one that kills the most in the world, but among women in the Arabic region, the highest mortality rate is breast cancer. It is a problem that can be minimized, with the prevention or increased patient survival, when an early diagnosis is made. "Mammography is, by itself, the most important imaging method in the detection of breast alterations, with a sensitivity close to 90%". On the one hand, dense breasts and breasts of young patients (those with more significant glandular tissue) interfere with the sharpness of the mammographic image resolution. On the other hand, breasts of women close to menopause (whose parenchymal tissue involutes atrophy, becoming fatter as the years go by) provide good image quality and definition. In medicine, most medical diagnoses today stem from the use of imaging. "Image processing focuses on developing procedures to extract information from an image in an adequate way for computational processing" [5].

Radiology today is a diagnostic and therapeutic support specialty since it includes from conventional radiology to mammography, computed tomography, ultrasound, magnetic resonance, nuclear medicine, positron emission tomography, and radiotherapy [6]. In radiology, technologies have been advancing very fast and are becoming increasingly indispensable in the continuous development of this area. The various procedures require the radiologist an intersection of his technical-scientific knowledge with others, such as administrative ones, for the adequate performance of his function. It must have an "integrated and complementary multidisciplinary action, incorporating complex processes and cutting-edge technologies, with large investments in equipment, techniques and inputs" [4].

The early breast lesions are detected, the more mastectomy is reduced, and the chances of survival increase. Even considered the "gold standard" method in detecting breast cancer, mammography can present a false positive that leads to unnecessary biopsies because it has low specificity despite its high sensitivity. Wild and Neal were the pioneers in

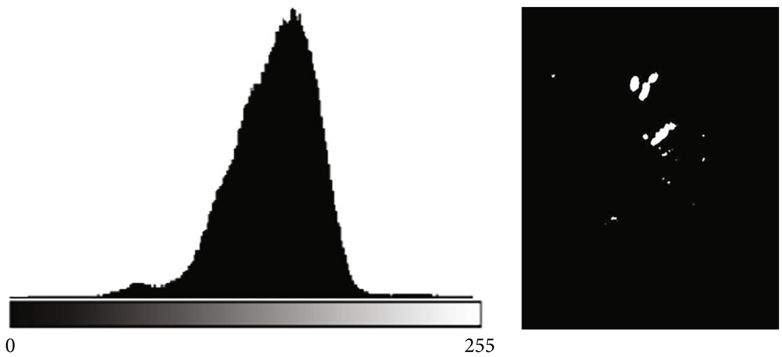


Figure 3: (a) Histogram of (b). (b) Threshold with value $L = 200$.

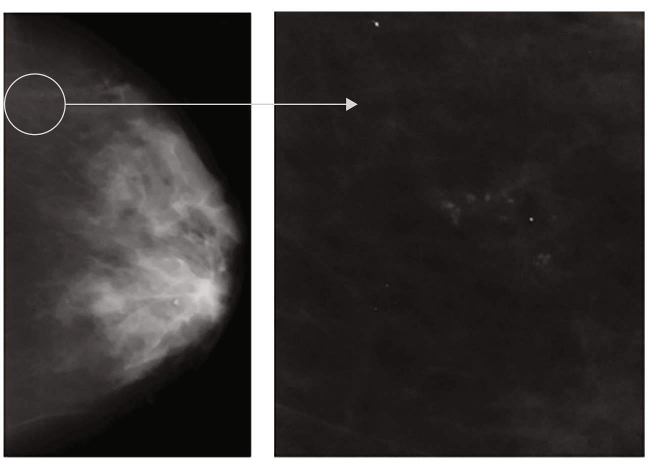


Figure 4: (a) Histogram of (b). (b) Threshold with value $L = 61$.

proposing the use of ultrasound in the examination of the breasts. Since then, it has been proven that ultrasound imaging techniques can identify many of the cancers missed by mammographic techniques, especially those that occur in women with dense breasts. Furthermore, ultrasound imaging has the advantage of being noninvasive, low-cost, and there is no need for ionizing addition. Despite the above advantages, it largely depends on developing efficient segmentation algorithms [7].

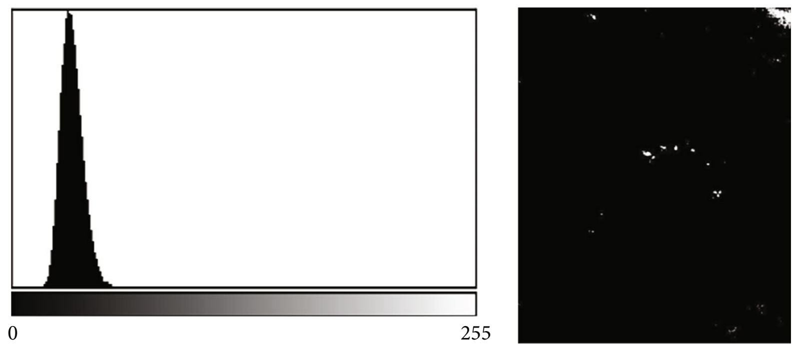
There is a frequency distribution/frequency diagram graphically represented in columns/rectangles from a dataset that, beforehand, is tabulated and segmented into uniform classes, known as a histogram. In an image, this "indicates the number or percentage of pixels that the image has in a certain level of grey or colour". And so, it generates an image quality indicator referring to contrast and light intensity [8]. Significant data are obtained from the highlighted regions/objects with binary images, segmented into objects and background. Through digitization, the image relates to the truth with a virtual potency. A simulation with an infinite property makes it an image imagination. With a mouse click, the real is configured.

In the binary vision system, thresholding stands out as an efficient and simple-to-implement strategy that uses pixel intensity as a separator; it is a type of segmentation (local threshold, global threshold, and multiple thresholds), which is the process that fragments the image into distinct regions, each with pixels with similar attributes. "A system created to perform digital image processing is usually composed of five elements: image acquisition, storage, processing itself, communication and display of the final result of the process". Particularly in healthcare, the computer diagnostic system automatically or semiautomatically detects anomalies in imaging exams. The image is segmented, subdividing it, to distinguish the "object of interest from the image's background", which occurs through the segmentation that subdivides the image. Using thresholding, we define "a threshold value capable of separating the object of interest from the background and then an image in gray levels becomes a binary image". The information that is obtained from these techniques helps the doctor's work. These are just some concepts and techniques for creating digital medical images [9].

Wang et al. (2019) state that the development of equipment quality control techniques reached "conventional radiology, dental, conventional mammography services, processors that should be controlled daily, fluoroscopy equipment with image intensifier and some initiative in computed tomography". It was imperative to establish mastery over the irradiation of patients. The equipment began to be calibrated and operated in more controlled environments, which triggered a more significant number of shielding calculation services and the performance of radiometric surveys. With time and the advancement of digital technology, the detectors capture radiological images with properties capable of leading "to the evaluation of different magnitudes from those used in screen-film systems".

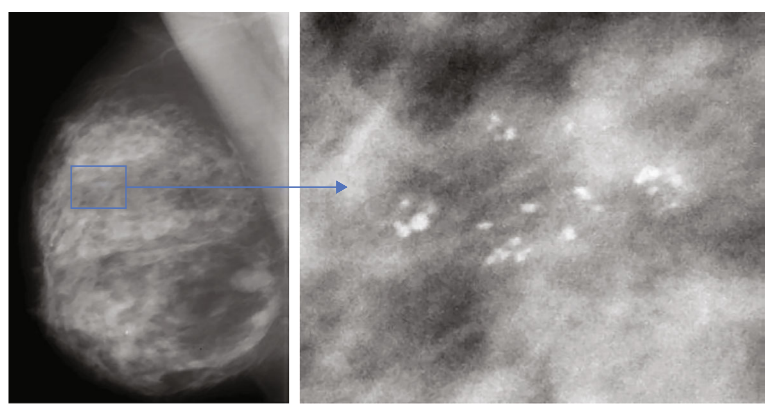
In this sense, Fiorica [3] considers that in a context of more restrained budgets, it is essential that the acquisition of equipment "be subjected to a rigorous cost-benefit evaluation process". In addition, he comments that the incessantly growing interventional radiology enables minimally invasive therapies based on more accurate imaging means, unlike past decades in which "radiology was an exclusively diagnostic activity and without clinical contact".

For R. Thyagarajan and S. Murugavalli (2012), "Radiology has been undergoing profound changes since the end



(a) (b)

Figure 5: (a) Right breast. (b) Cut out the area of interest.



(a) (b)

Figure 6: (a) Histogram of (b). (b) Threshold with value $L = 171$.

of the 20th century. In the coming years, it is expected the emergence of multiple technologies that will certainly be disruptive, but that will also create new opportunities".

3. Methodology

The images used as input for the results of this work were downloaded from an image bank. Heath et al. [5] provided an updated and standardized version of the Digital Database for Screening Mammography (DDSM); from this dataset, the CBIS-DDSM (a subset of cured breast images of the DDSM) was used, which includes uncompressed images, selection, and data curation by trained mammographers. Python 3.6.8 in the Jupiter Web development environment is the language used to generate the thresholding algorithm. Figure 1 shows the flowchart structure of the entire work. The entire project can be viewed as a flowchart, as shown in the accompanying picture.

3.1. Digital Image. A digital image is a function $f(x, y)$discretized in spatial coordinates and brightness. This function produces luminance by reflectance at each point (x, y).

3.2. Histogram. The histogram represents the number of pixels of each grey level in a monochromatic image. These values are usually represented by a bar graph that provides for each grey level the corresponding pixel count in the image.

3.3. Thresholding. It is a technique that separates the regions of an image when it has two classes (the background and the object). Because thresholding produces a binary image as an output, this process is often called binarization [14]. In the thresholding operation, an input image $f(x, y)$ with N shades of grey produces in the output a binary image $T(x, y)$ according to the rule:

If $f(x, y) \geq L$, then $T(x, y) = 1$; otherwise, $T(x, y) = 0$, where L is the cut-off point or threshold. This threshold value L can be obtained either manually or automatically.

4. Results and Discussion

The microcalcification thresholding process is based on checking pixels with high light intensity, taking into account each clipping image. The cropped image contains possible areas of microcalcification concentrations. To find these microcalcifications, the image histogram is performed, and from this, a cut point (threshold) is visualized to separate the image into two tones (black or white). The threshold was found manually (supervised by the specialist).

From the original image (Figure 2(a)), the CBIS-DDSM also provides ROI (region of interest) images (Figure 2(b)).

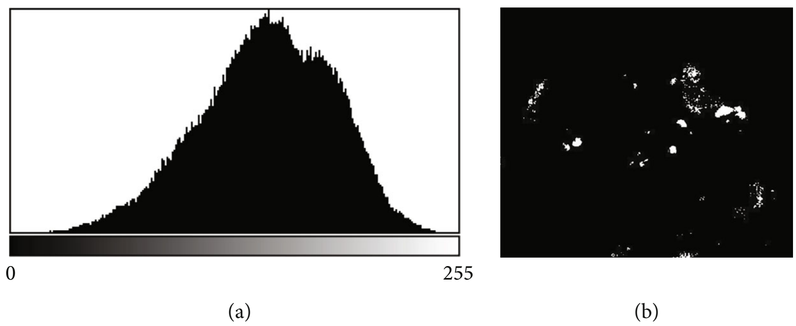


FIGURE 7: (a) Original image. (b) Cut out the area of interest.

The resulting image of the thresholding algorithm can be seen in Figure 3b, in which a binary image is generated with a cut-off point at $L = 200$. As can be seen in the histogram (Figure 3(a)), there is a higher frequency of pixels with greater luminous intensity (light pixels) in the clipping image (Figure 2(b)); possibly, these pixels with lighter tones are microcalcifications of the original image.

In the histogram (Figure 4(a)) that was generated by Figure 5(b), there is a higher frequency of low light intensity pixels (dark pixels), which leads to a low cut-off point, $L = 61$ (Figure 4(b)). It can be noted that the upper and lower edges of the image are outside the central region where the microcalcifications are located.

In the histogram (Figure 6(a)) generated by Figure 7(b), there is a balance of pixels in low and high light intensity. The cut-off point used was $L = 171$ (Figure 6(b)). It can be noted that the upper and lower edges of the image are outside the central region where the microcalcifications are located.

5. Conclusions

From the discovery of X-rays to the present day, the literature in the field of radiology has demonstrated its commitment to transformations and improvements in the direction of medicine, with radiological images becoming increasingly enlightening and providing the radiologist with greater confidence in making a diagnosis and deciding on the best treatment for the patient [11-14].

Specifically, in the case of breast cancer, research using thresholding has demonstrated that technological advances in radiology contribute to making firmer and more accurate decisions [15], preventing premature deaths, disease progression, and traumatic surgical treatments such as mastectomy; on the contrary, it favours, from an early diagnosis, a high-quality survival for the patient as well as a cure.

Data Availability

The data underlying the results presented in the study are available within the manuscript.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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