MULTISPECTRAL PHOTOSENSOR FUSION AND MATLAB-BASED IMAGE PROCESSING FOR PRECISION BREAST CANCER DIAGNOSIS

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Abstract:

Purpose: This study aims to develop an improved method for breast cancer detection by combining MATLAB-based image processing with a multispectral photosensor. **Method:** Using multiple wavelengths, this method carefully examines microstructural morphological differences between breast cancer cells. MATLAB's Gray Level Co-occurrence Matrix (GLCM) features facilitate texture pattern extraction, which in turn, malignant phase identification and prediction becomes easier. **Result:** Research on variability in the different stages of cancer makes multifaceted approach with the help of spectral insights and computer methods to provide important information about optimal photosensor captured response. The response in differentiation requires improvement in the accuracy of cancer cell detection. **Conclusion:** MATLAB-based image processing with a multispectral photosensor will greatly facilitate the early detection and transformation of clinical interventions for better prognosis of breast cancer.

Keywords – Photo sensor, MATLAB, GLCM, early detection, breast cancer

Introduction:

In light of the intricate and pervasive nature of cancer, a major worldwide health issue, ongoing developments in diagnostic techniques are essential for improved understanding and timely identification. To meet this need, we present a novel multimodal approach that combines MATLAB-based image processing along with the unique information provided by multispectral photo sensors that operate over 900 nm, 700 nm, and 380 nm wavelengths. This ground-breaking method overcomes the constraints of traditional diagnostics by painstakingly dissecting minute details in the architecture and makeup of cancer cells.

Histology & macroscopic imaging have played a major role in cancer diagnosis in the past, which emphasizes the necessity for a greater comprehension of cellular complexities to enable early identification and focused treatment approaches (O'Kelly 2021). The MATLAB framework shows itself to be an advanced platform that allows one to apply complex image-processing techniques to extract subtle properties from cellular images. In this work, the contrast, homogeneity, & energy features of the Grey Level Co-occurrence Matrix (GLCM) are especially used to identify complex textural patterns that are suggestive of cancerous cells.

An examination of the results using a double-blind comparison method is incorporated into the study to guarantee objectivity and reduce prejudice (Zimmermann 2020). This multidisciplinary framework goes beyond conventional methods to investigate the consequences of various wavelengths, offering a distinct viewpoint for determining cancer stages and assessing photo sensor responses. This goal with this combined approach is to improve patient outcomes while also pushing the envelope on early detection and improving the accuracy of cancer cell classification methods.

Given the multifaceted and pervasive nature of cancer-related issues, this study addresses the critical need for ongoing improvements in diagnostic techniques to improve understanding and facilitate early identification. The new multimodal approach combines the distinct information that a multispectral photosensor at 900 nm, 700 nm, & 380 nm wavelengths supply with MATLAB-based image processing. This innovative method goes beyond the constraints of traditional diagnostic methods to uncover subtleties in the arrangement and makeup of cancer cells. The combined use of multispectral photo-sensors with MATLAB-based image analysis not only rectifies the inadequacies of current techniques but also emphasizes the vital significance of interpreting complex cellular attributes for enhanced cancer diagnosis and customized treatment approaches.

One of the biggest problems in oncology today is breast cancer, which is caused by cellular abnormalities in the breast tissue. From a physiological perspective, this illness is defined by the unchecked proliferation of mammary cells, which eventually results in the development of cancerous tumors. It is essential to differentiate between malignant and benign cellular alterations to make an accurate diagnosis and take prompt action.

Breast cancer is characterized by a complex physiological landscape that includes minute changes in signaling pathways, genetic expression, and cellular shape. Conventional diagnostic techniques, which frequently depend on histopathological examinations, offer significant insights but could miss the minute molecular details that highlight the variety amongst breast cancer subtypes. It is essential to comprehend these subtleties in order to develop individualized and focused treatment plans.

The main goal of this research is to combine MATLAB-based image processing with multispectral photo-sensors to improve the accuracy of breast cancer diagnosis. The goals of this research include investigating the distinct optical signatures offered by multispectral sensors, creating sophisticated image processing workflows in the MATLAB guidelines to extract subtle textural structures suggestive of breast cancer, assisting in early detection by identifying subtle cellular deviations, reducing biases by conducting a double-blind contrast analysis, examining the importance of various wavelengths for distinguishing separate cancer stages, and advancing personalized medicine by offering an in-depth awareness of the physiological terrain of malignant breast cells.

This research is driven by the need to improve the accuracy of a breast cancer diagnosis, given the disease's worldwide effect and the shortcomings of existing diagnostic techniques. Through the combination of MATLAB-based image processing and multispectral photo-sensors, the goal is to decipher complex physiological subtleties at the cellular level, offering a more thorough comprehension of breast cancer. The need for early diagnosis through sophisticated image processing procedures is what motivates this research, which will ultimately lead to better patient outcomes and more potent therapeutic approaches. The dedication to pulling past the limits of current methods for the improvement of personalized and targeted treatments is highlighted by the efforts to mitigate biases, investigate the significance regarding various wavelengths, and contribute to beneficial changes in diagnostics.

The landscape of breast cancer diagnosis has witnessed a profound transformation with the advent of cutting-edge technologies aiming to unravel the intricate cellular intricacies of this complex disease. Among these, multispectral imaging stands out as a beacon of promise, allowing for a profound exploration of cellular nuances across a myriad of wavelengths (Abdel-Nasser 2016). Researchers have demonstrated the transformative potential of multispectral photo-sensors in unveiling the intricate heterogeneity embedded within breast tissues. These studies underscore the critical role of multispectral imaging and serve as a cornerstone for this research, motivating the exploration of this technology's untapped potential in breast cancer diagnostics.

Simultaneously, the computational prowess of MATLAB has become a stalwart companion in the realm of medical image processing (He 2019). The groundbreaking studies demonstrate the versatility of MATLAB in extracting granular textural patterns from medical images, a capability that is pivotal in this quest to unravel the complex cellular landscape of breast tissues (Wahab 2023). The computational finesse of MATLAB not only refines the precision of cellular feature extraction but also lays the groundwork for this proposed methodology, heralding a new era in the quest for nuanced breast cancer diagnostics. The convergence of multispectral imaging and MATLAB-based image processing stands at the forefront of technological synergy, is promising a paradigm shift in breast cancer diagnostics (Beletkaia 2020). Pioneering work in colorectal cancer detection serves as a beacon of inspiration, offering tangible evidence of the synergistic benefits derived from combining multispectral data with MATLAB algorithms (Kashif 2020). This cross-disciplinary approach stimulates this imagination and compels us to explore the uncharted territories of breast cancer diagnosis, fueled by the potential of this integrated strategy.

Amidst the technological crescendo, the quest for early breast cancer detection reverberates with increasing urgency. Studies contribute significantly to this narrative, emphasizing the pivotal role of near-infrared spectrum analysis in unlocking unique characteristics within breast tissue for early cancer identification (Sadoughi 2018). This insight, coupled with complementary studies, provides a rich tapestry of knowledge that informs this mission to leverage multispectral imaging and MATLAB-based methodologies in the relentless pursuit of early breast cancer detection (Elston 1999).While technological prowess takes center stage, the imperative of addressing biases and ensuring the objectivity of diagnostic methodologies cannot be overstated (Udupa 2002). Advocacy for double-blind comparison analyses resonates deeply as we meticulously integrate evaluation processes to not only mitigate biases but to fortify the robustness of this proposed multispectral and MATLAB-based diagnostic approach (Cserni 2003).Beyond the technological and methodological facets, studies delve into the molecular and cellular intricacies contributing to breast cancer progression. This foundational understanding, akin to the deciphering of a complex code, serves as the guiding compass in this interpretation of multispectral data and the extraction of meaningful features through MATLAB-based analyses (Ghesu 2016). In the realm of breast cancer, where molecular nuances play a pivotal role, this knowledge becomes paramount. As we venture further into the wavelength nuances of cancer staging, studies provide invaluable insights (Greenspan 2016). These works contribute to this understanding of how specific wavelengths can be strategically employed to enhance the sensitivity and specificity of cancer detection. In this research, we aspire to build upon this foundation, seeking to unravel the symphony of wavelengths that holds the key to a more refined and accurate breast cancer diagnosis (Sahiner 1996). In synthesizing insights from these studies, this research aims not merely to contribute a chapter but to script an entirely new narrative in the saga of breast cancer diagnostics. It is an endeavor to integrate multispectral imaging, MATLAB-based image processing, and rigorous evaluation methodologies into a symphony of innovation (Kooi 2017). Drawing from the triumphs and wisdom of previous studies, this work seeks to not only advance the field of breast cancer diagnostics but to redefine the narrative, ushering in an era of early detection and more effective clinical interventions. This effort aims to reinvent the narrative and bring in an era of early diagnosis with improved clinical interventions in addition to advancing the science of breast cancer diagnosis by drawing on the knowledge and successes of earlier studies.

Thus, this work is consistent with the effort to gain a better comprehension of the physiological nuances unique with breast cancer cells. The core of the study involves multispectral photo-sensors that function at different wavelengths combined with MATLAB-based image processing. Researchers aim to contribute to the improvement of diagnostic techniques by exploring the cellular nuances specific to breast cancer. This will ultimately open the door for more precise and successful treatment interventions in the complex field of breast cancer.

Methods:

Ethical Clearance: The protocol used in the study was approved by the Ethical Committee, Adamas University. Breast cancer patient signed informed consent form.

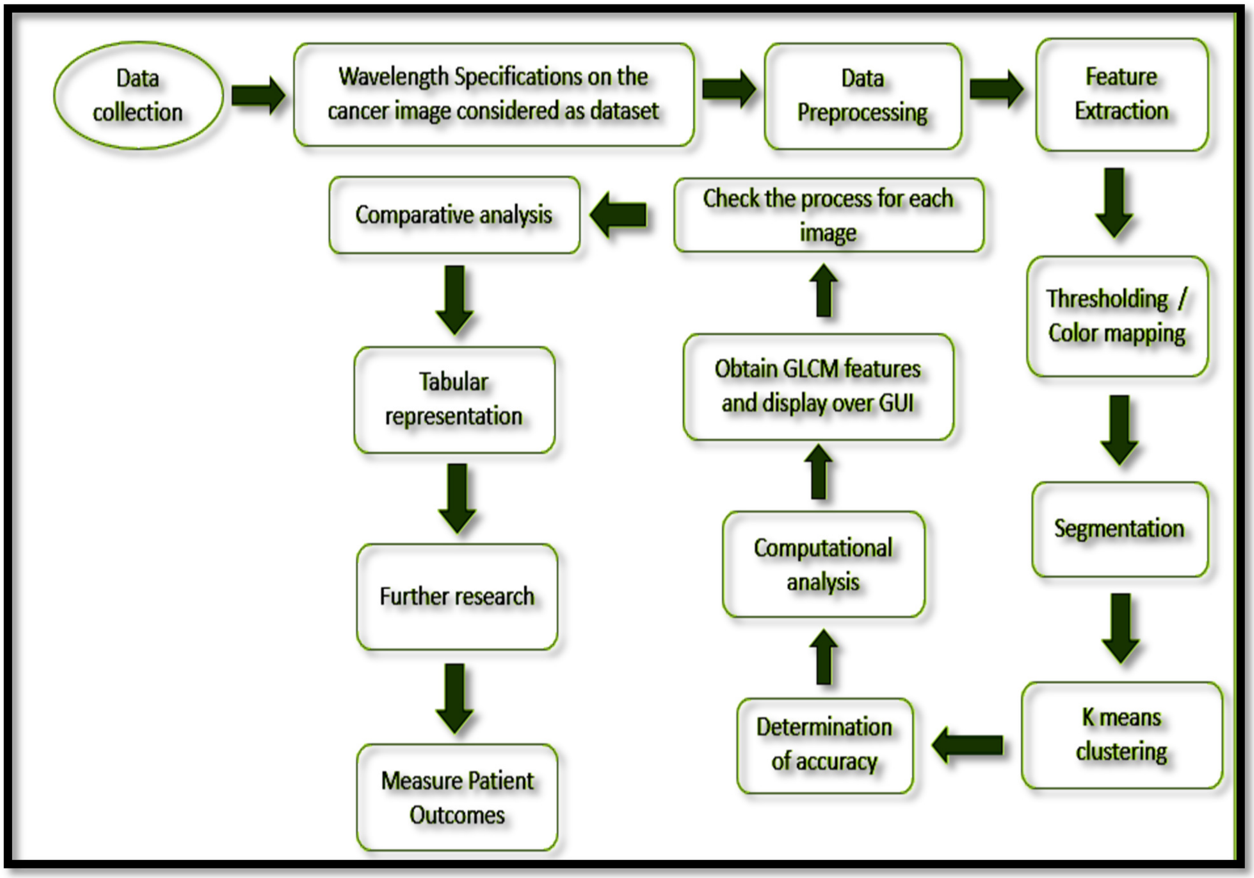


Figure 1: Methodology

Multidimensional photosensors functioning at wavelength of 900, 700, & 380 nm were employed in this work. To enhance and refine the collected images, preprocessing techniques were applied using MATLAB for image processing. Then, characteristics from the Grey Level The co-occurrence Matrix (GLCM) were obtained to recognize intricate textural patterns that might indicate cancerous cells. These traits included vigthis, uniformity, and contrast. A double-blind comparative analysis was conducted to preserve objectivity, and physiological correlations were employed in an attempt to link the characteristics that were taken out and the characteristics of cancer cells that were previously known.

After tabular analysis and outcomes, the results were graphically visible and relatively supported.

Results:

The respective dataset with a specific label of a carcinogenic cell has been taken to show the working of the sensor or detection of the cancer cell in the specific wavelength.

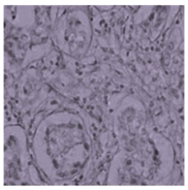
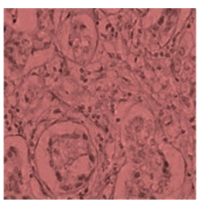
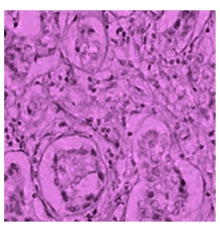
Cancer cell to be taken as input	Wavelength specified (nm)	Name of range	Title of the figure
	380	Violet / Ultraviolet	Figure a
	700	Red	Figure b
	900	False Infrared	Figure c

Table 1: Cancer cell in different wavelengths

Figure 'a' results:

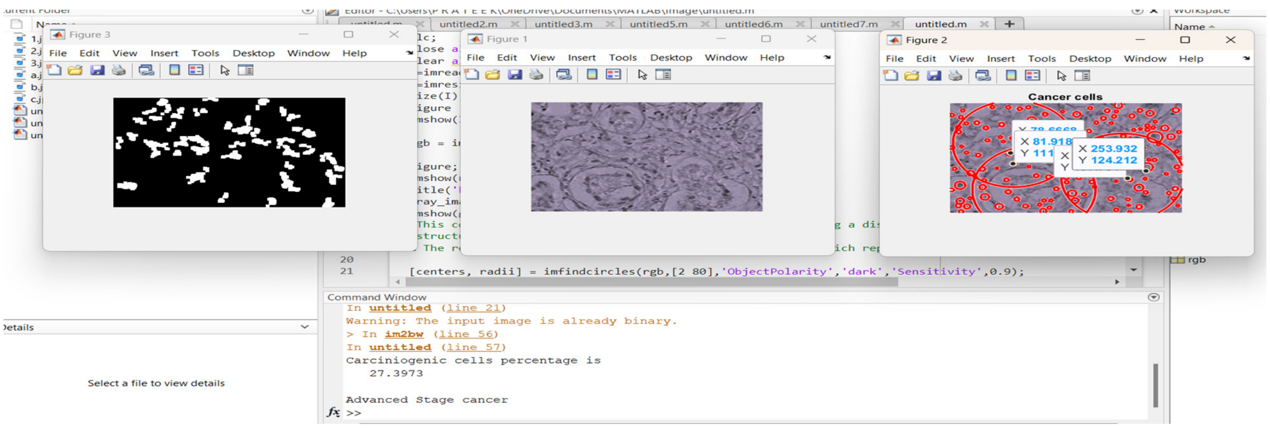


Figure 2: Detects higher stage of cancer

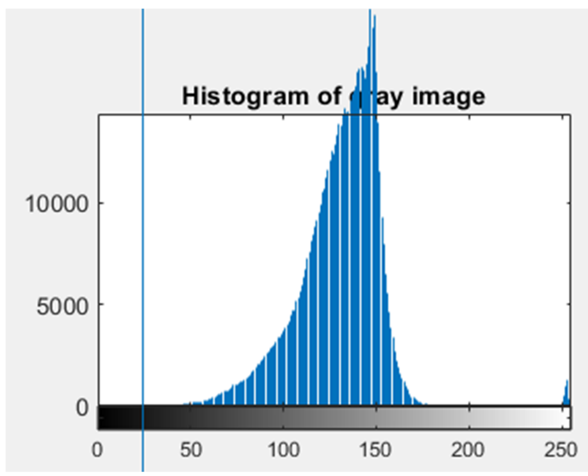


Figure 3: Computed Histogram

Figure 4: Ostu Threshold

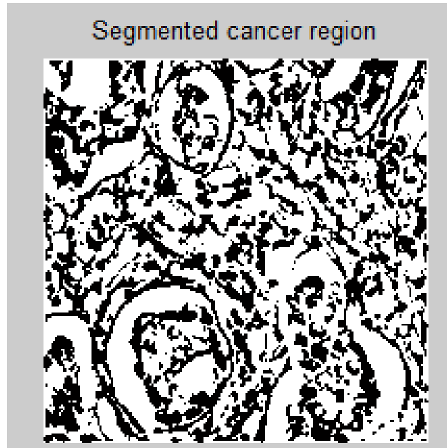


Figure 5: Segmenting the cancer region

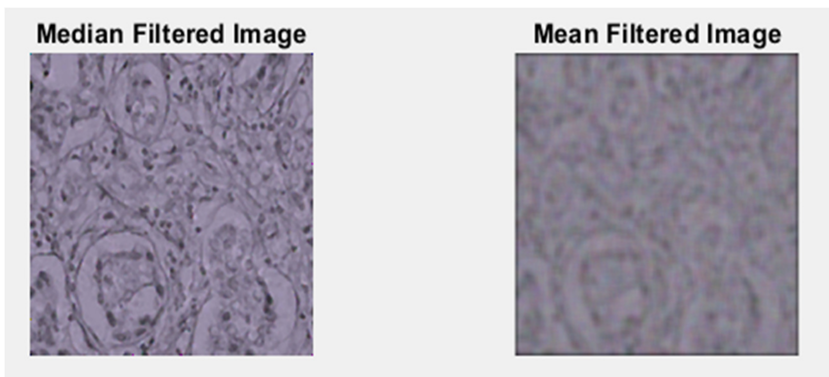


Figure 6: Image Filtering

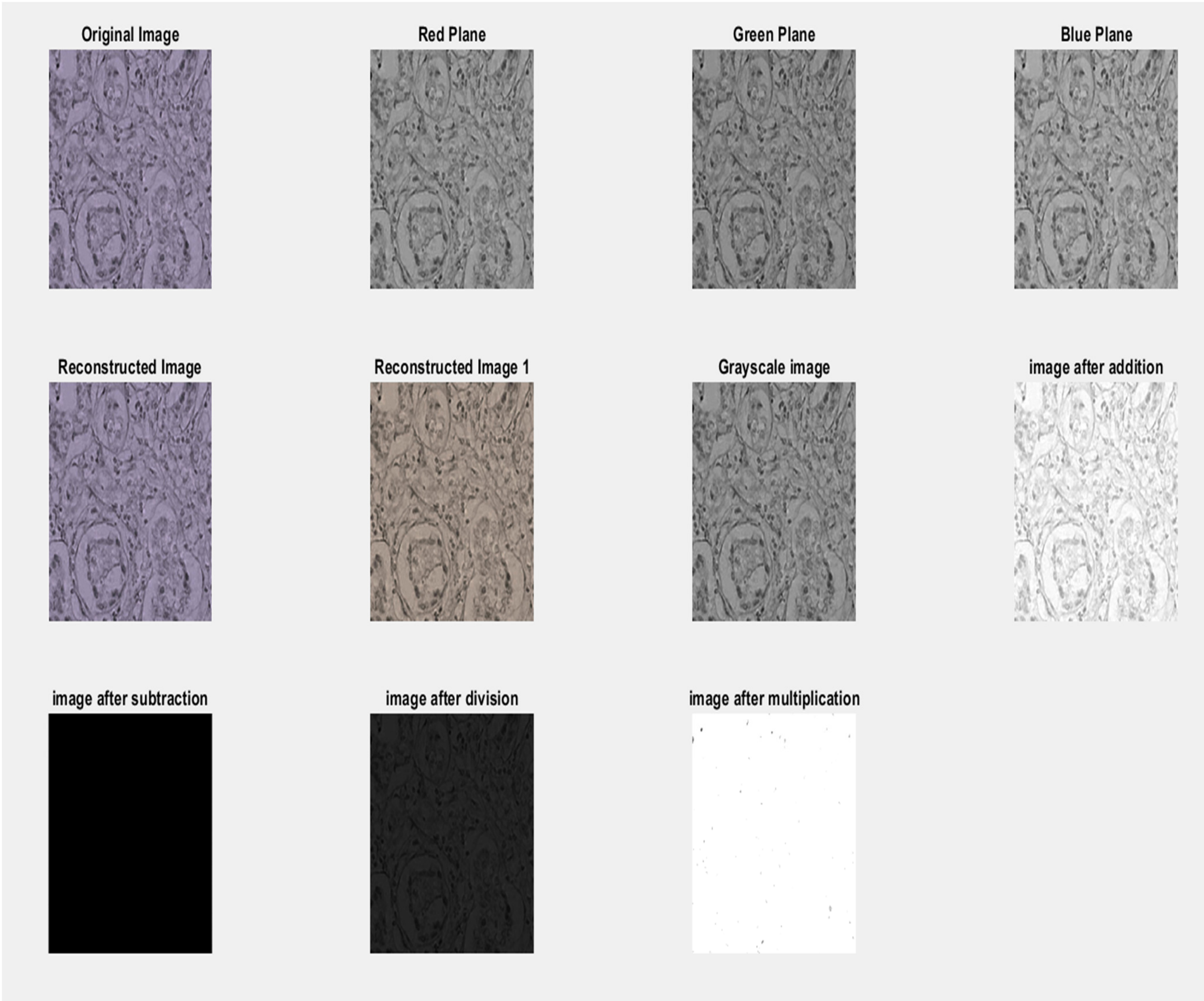


Figure 7: Plane slicing

Figure ‘b’ results:

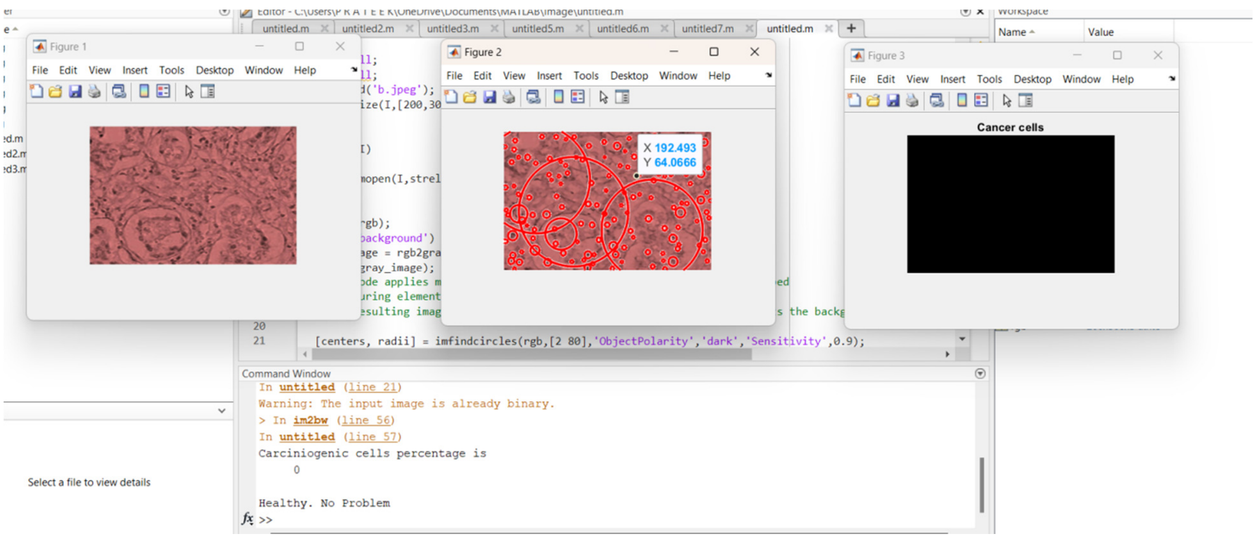


Figure 8: cancer cells not detected

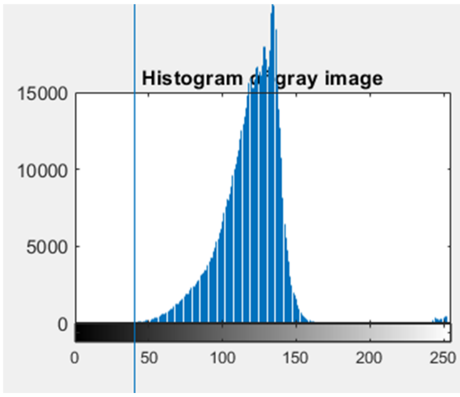


Figure 9: Computed Histogram

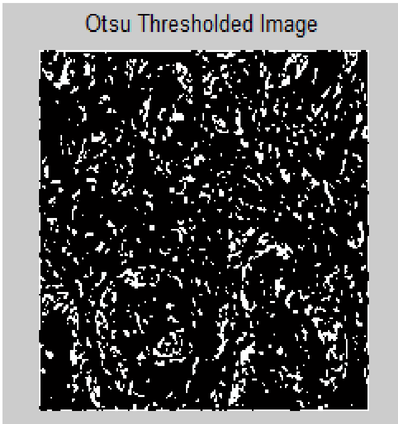


Figure 10: OstuThresholding

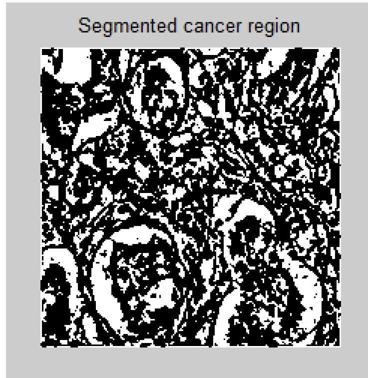


Figure 11: Segmentation of cancer cells

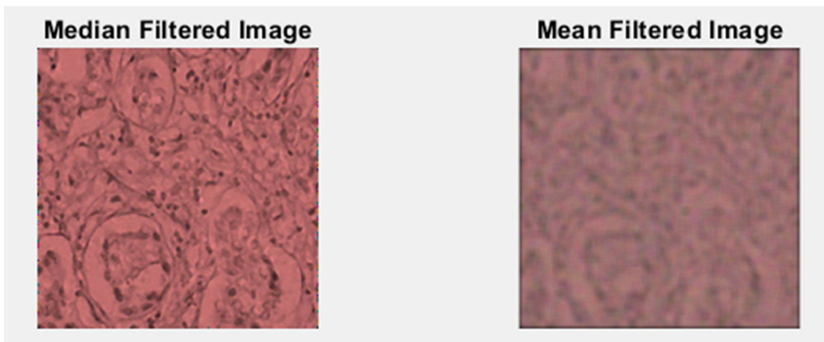


Figure 12: Filtering of image

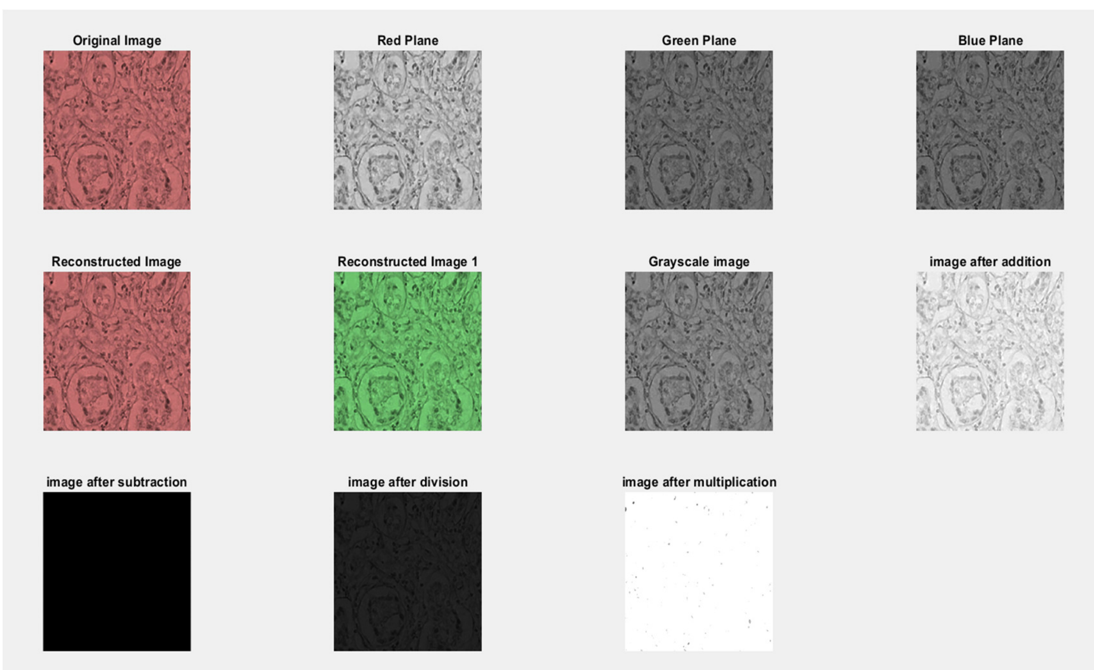


Figure 13: Plane slicing

Figure ‘c’ results:

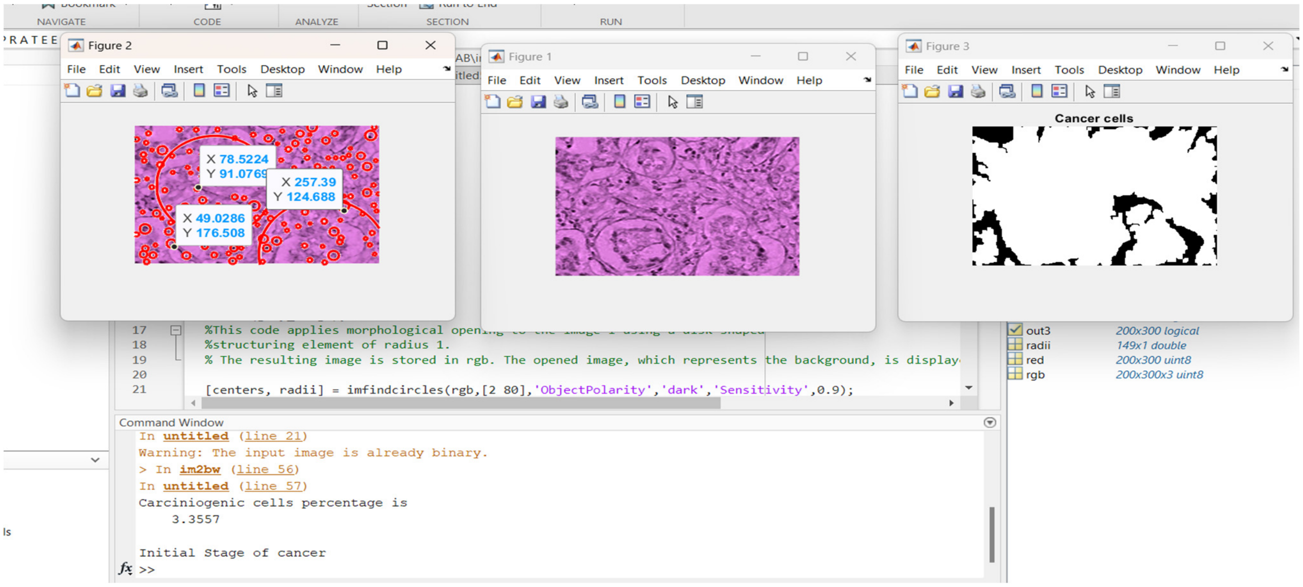


Figure 14: Cancer cells are detected at this particular wavelength

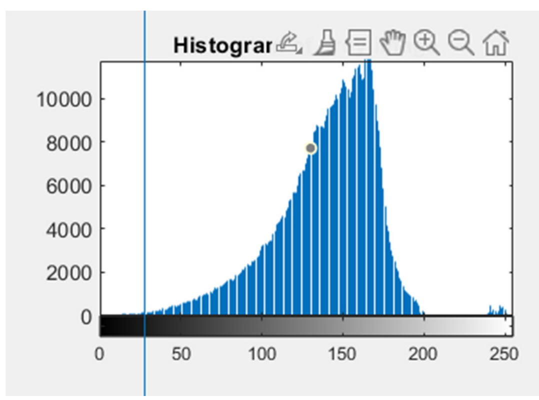


Figure 15: Computed Histogram

Figure 16: OstuThresholding

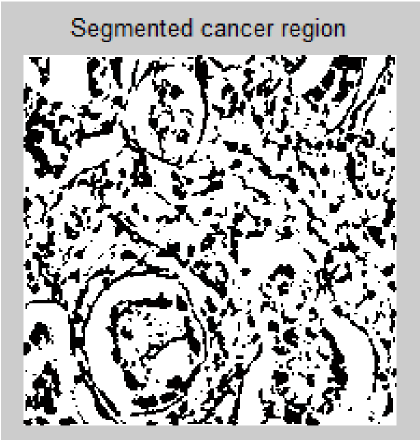


Figure 17: Cancer region segmentation

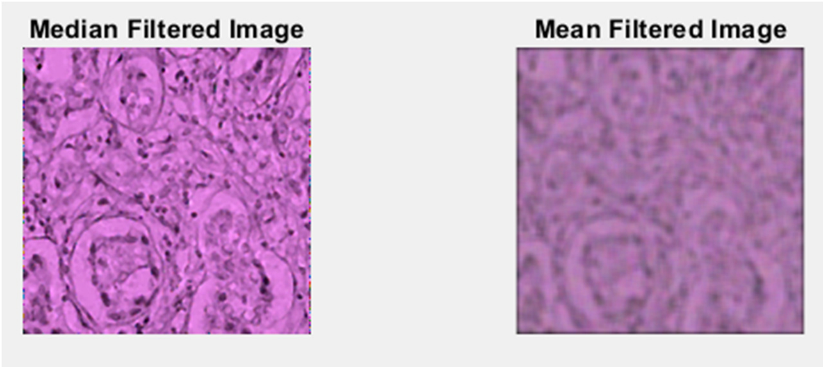


Figure 18: Filtering on image

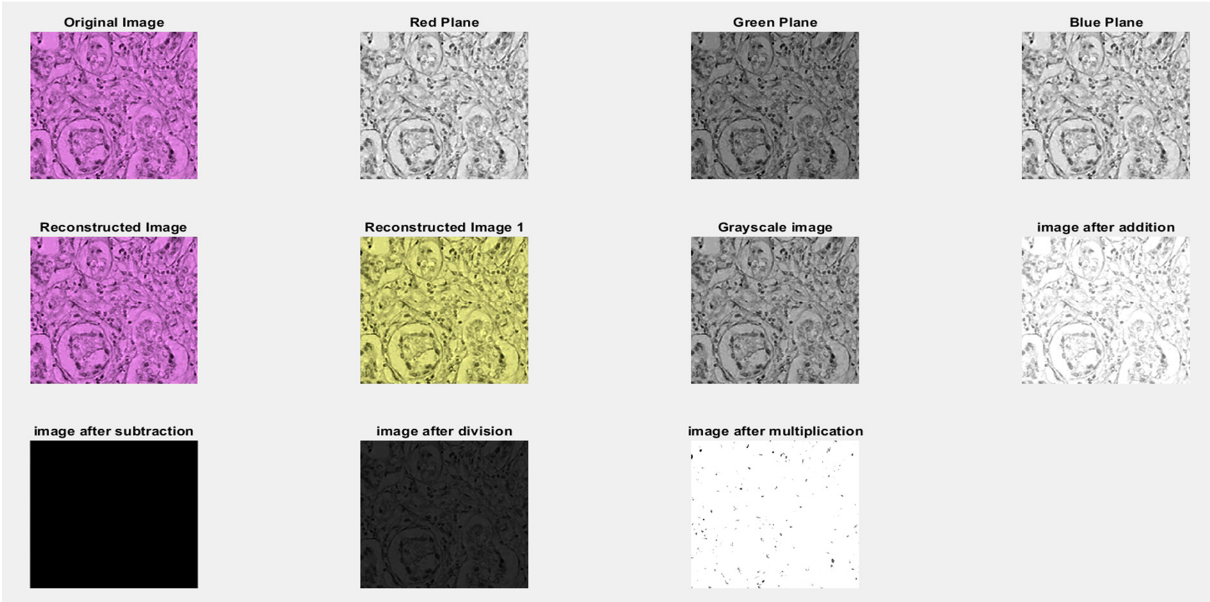


Figure 19: Plane slicing

As part of the comparative study, an opposition table of several GLCM features is now displayed alongside various photos.

Figure label	Contrast	Correlation	Energy	Homogeneity	Carcinogenic cell concentration	Status detected	Accuracy
Figure a	0.1915	0.6802	0.4142	0.9843	27.37	Abnormal	83.33%
Figure b	0.2011	0.4516	0.4722	0.8993	0.00	Normal	66.67%
Figure c	0.1062	0.6235	0.5518	0.8882	3.35	Abnormal	85.43%

Table 2: GLCM Features: A Comparative Analysis

Discussion:

Significant in analogous to the result obtained it is a clear depiction that the sensor is suitable for detecting light in the false IR area but is overly sensitive to violet rays when it comes to identifying cancerous cells. It is also completely ineffective when it comes to identifying cells that fall under the wavelength of red light.

Conclusions:

In summary, by combining advanced multispectral imaging, MATLAB-based image processing, and physiological correlations, this research significantly advances methods for detecting cancer cells. It is possible to uncover small variations in cellular patterns indicating of malignancies and add a dimension of diagnostic accuracy by combining a range of a wavelength and extracting significant elements from the Grey Layer Co-occurrence the matrix (GLCM). This process also identifies the precise wavelength for cancer cell detection. The results are more objective thanks to the double-blind comparison research, and the physiological relationships that are investigated strengthen the bond between biological comprehension and computational insight. Beyond technological breakthroughs, the research emphasizes the necessity for multidisciplinary cooperation to bring about significant advances in cancer diagnosis. Better patient outcomes are a common aim shared by the worldwide healthcare community, and this research work may lead to the development of detection tools and focused therapeutic interventions.

List of Abbreviations:

MATLAB – Matrix Laboratory

GLCM – Gray Level Co – Occurrence Matrix.

IR – Infrared.

Declarations:

Availability of data and material:

MATLAB is open source software and the cancer data is taken from live subject.

Competing interests:

There are no conflicts of interest.

Funding:

No applicable funding.

Authors'contributions:

All the authors' contributed equally throughout the entire research work entitled "MULTISPECTRAL PHOTOSENSOR FUSION AND MATLAB-BASED IMAGE PROCESSING FOR PRECISION BREAST CANCER DIAGNOSIS".

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Conflict of interest:

On behalf of all authors, the corresponding author states that there is no conflict of interest.

References

Abdel-Nasser M, Moreno A, Puig D. Breast Cancer Detection in Thermal Infrared Images Using Representation Learning and Texture Analysis Methods. Electronics. 2019; 10.3390/electronics8010100

Beletkaia E, Dashtbozorg B, Jansen RG, Ruers TJ, Offerhaus HL. Nonlinear multispectral imaging for tumor delineation. J Biomed Opt. 2020; 10.1117/1.JBO.25.9.096001

Cserni G, Amendoeira I, Apostolikas N et al. Pathological work-up of sentinel lymph nodes in breast cancer. Review of current data to be considered for the formulation of guidelines. Eur. J. Cancer. 2003;39(12):1654-1667.

Elston C.W, Ellis IO, Pinder SE. Pathological prognostic factors in breast cancer. Crit Rev Oncol Hematol. 1999; 10.1016/S1040-8428(99)00034-7

Ghesu FC, Krubasik E, Georgescu B et al. Marginal Space Deep Learning: Efficient Architecture for Volumetric Image Parsing. IEEE Trans. Med. Imag. 2016; 10.1109/TMI.2016.2538802

Greenspan H, Ginneken van B, Summers RM. Guest editorial deep learning in medical imaging: overview and future promise of an exciting new technique. IEEE Trans. Med. Imag. 2016; 10.1109/TMI.2016.2553401

He T, Puppala M, Ezeana CF, Huang YS, Chou PH, Yu X, Chen S, Wang L, Yin Z, Danforth RL, Ensor J. A Deep Learning-Based Decision Support Tool for Precision Risk Assessment of Breast Cancer. JCO Clin Cancer Inform. 2019; 10.1200/CCI.18.00121

Kashif M, Malik KR, Jabbar S, Chaudhry J. Application of machine learning and image processing for detection of breast cancer. In: Lytras MD, Sarirete A, editors. Innovation in Health Informatics. Academic Press; 2020. pp. 145¨C162.

Kooi T, Litjens G, Ginneken van B, et al. Large scale deep learning for computer aided detection of mammographic lesions. Med Image Anal. 2017;35:303-312.

O'Kelly D, Campbell III J, Gerberich JL, Karbasi P, Malladi V, Jamieson A, Wang L, Mason RP. A scalable open-sthisce MATLAB toolbox for reconstruction and analysis of multispectral optoacoustic tomography data. Sci Rep. 2021; 10.1038/s41598-021-97726-1

Sadoughi F, Kazemy Z, Hamedan F, Owji L, Rahmanikatigari M, Azadboni TT. Artificial intelligence methods for the diagnosis of breast cancer by image processing: a review. Breast Cancer: Targets Ther. 2018;10:219-230.

Sahiner B, Chan HP, Petrick N et al. Classification of mass and normal breast tissue: a convolution neural network classifier with spatial domain and texture images. IEEE Trans. Med. Imag. 1996; 10.1109/42.538937

Udupa JK, Herman GT. Medical image reconstruction, processing, visualization, and analysis: the MIPG perspective. IEEE Trans. Med. Imag. 2002; 10.1109/TMI.2002.1000253

Wahab N, Khan A, Lee YS. Transfer learning based deep CNN for segmentation and detection of mitoses in breast cancer histopathological images. Microscopy. 2019; 68(3): 216-233.

Zimmermann BB, Deng B, Singh B, Martino M, Selb J, Fang Q, Sajjadi AY, Cormier J, Moore RH, Kopans DB, Boas DA. Multimodal breast cancer imaging using coregistered dynamic diffuse optical tomography and digital breast tomosynthesis. J Biomed Opt. 2017; 10.1117/1.JBO.22.4.046008