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Advancing Breast Cancer Detection: Integrating IoT and Deep Learning in Next-Generation Healthcare

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Abstract: Background: Breast cancer remains a significant global health concern, and traditional diagnostic methods sometimes fall short, particularly in early detection. The rise of telehealthcare underscores the need for innovative solutions.
Objective: This study explores the potential of combining intelligent systems, such as thermal imaging cameras, with deep learning techniques, especially convolutional neural networks (CNNs), to revolutionize and improve breast cancer detection compared to traditional risk models.
Method: The study proposes a novel predictive healthcare system utilizing the Internet of Things (IoT) and Electronic Health Records (EHRs). This system aims to achieve real-time, automated breast cancer detection in diverse healthcare settings, including institutional care facilities, hospitals, and even schools. Additionally, the system seeks to facilitate early detection of potentially other health conditions by leveraging the combined power of IoT and CNN deep learning. This would involve developing user-friendly EHRs accessible to patients' healthcare providers within their institutions or nationwide.
Results: The research delves into the specific procedures and techniques required to develop this proposed comprehensive cancer detection system.
Main Findings: The study investigates whether this approach offers a potential solution to address the global challenges associated with breast cancer and contribute to improved patient well-being.
Conclusion: This research investigates the potential of a novel healthcare system integrating intelligent systems and deep learning for early breast cancer detection and potentially other health conditions. Further research is needed to evaluate the feasibility and effectiveness of this approach in real-world settings.

Keywords: *Early-Stage Breast Cancer Detection, Intelligent Systems And Deep Learning, Telehealth And Healthcare Automation, Electronic Health Records (EHRs), Public Health And Global Challenges. Internet Of Things (IoT), Machine Learning*

1. Introduction

Telehealth, a rapidly growing technology utilizing smart systems and machine learning, is transforming healthcare delivery, especially in institutional homes where patient empowerment is crucial. This paper proposes an innovative system that combines the Internet of Things

(IoT) and machine learning (ML) to create an intelligent in-home health management system for residents in institutional settings. Challenges of Telehealth: Measuring patient health objectively remains a challenge in telehealth, as interaction often occurs through digital

platforms. This highlights the need for proactive engagement between healthcare professionals and patients.

This research proposes the development of IoT-based Electronic Health Records (EHRs) for institutional homes. This system leverages IoT sensors to collect real time physiological data, which is then analyzed using ML algorithms. This allows for: • Automated health monitoring: Abnormal health conditions can be detected, potentially leading to earlier intervention and improved outcomes.

• Early detection of ill-health: The system might predict potential health emergencies, enabling timely medical attention.

• Scalability and data collection: The use of IoT sensors facilitates easy data collection and scalability for sickness detection within the residential setting.

• Data analysis: The collected data, known as "big data," can be further analyzed to improve healthcare delivery and disease prevention strategies.

Motivation: Breast cancer remains a significant global health concern, with millions of diagnoses and deaths annually. Early detection is crucial for improving survival rates, particularly in low- and middle-income countries. The proposed system aims to address this by:

• Providing remote monitoring: It offers continuous health monitoring for residents, potentially leading to earlier detection of breast cancer and other health issues.

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• Enhancing accessibility: This system can be implemented in institutional homes, potentially reaching individuals who may face barriers to traditional healthcare access.

This research proposes an innovative application of smart IoT-based EHRs for breast cancer detection in institutional homes. This system has the potential to improve early detection, empower residents, and contribute to better health outcomes, particularly in underserved communities.

Figure 1 shows the components of the proposed Smart Health system within the stipulated environment.

This study, therefore, proposes a Smart IoT-based cancer detection system using CNN ML algorithms to significantly automate the early detection of cancer and the health status of institutional residential users,

especially institutional user that lacks the technological systems that detect cancer and other diseases early enough to prolong the lives of users. [5] lack of investigation on how breast cancer health monitoring and detection systems would be implemented will lead policymakers and academics into an empty toolbox. The study's objective includes the following:

1. Investigate the integration of IoT and ML in generating EHR of institutional home users through thermal images and vital signs to provide health monitoring and cancer detection.
2. Propose a two-factor health predicting system framework that deploys IoT, ML, and EHR technologies in an institutional home.

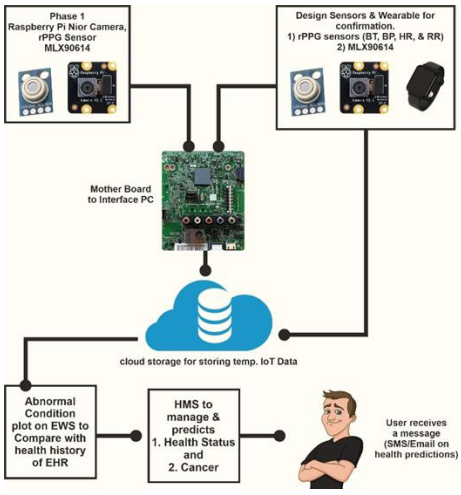

Fig 1. Component of proposed Smart Health system.

3. Investigate the development of a low-cost and user-friendly InsHome Health Management System for healthcare detection solutions for homes in schools and other institutional homes.

2. Review of Related Papers

The Internet of Things, also known as innovative systems or intelligent systems, provides the capabilities for developing Health Monitoring Systems even though it poses operational challenges that require future directions with effective frameworks [6]. IoT invention remains a catalyst that has revolutionized traditional healthcare delivery methods globally since traditional healthcare systems have shown a threat of inefficiency, especially during the pandemic era, when standard healthcare delivery was the only hope for most countries. Remote healthcare, on the other hand, can provide health delivery more efficiently and with high-quality service delivery [2], [3], [7].

Table 1: Review of Existing Systems

Author / Reference	Tools/Sensors/ Software used	Technique/ Algorithms used	Limitation	Accuracy (%)
[19]	Remote IoT-Based Blockchain Monitoring Management System for Smart Hospitals.	Blockchain	No CNN or ML technique	N/A
[14]	Detecting Breast Cancer using Thermal Image.	Deep learning (CNN)	Limited Dataset	100%
[20]	Breast Cancer Diagnostic Model using Histopathological Images.	Deep learning (CNN)	Manual Data Input	76%
[18]	Lightweight Model for IoMT using Histopathological Image.	Deep learning (CNN)	Manual Data Input	96.88 %
[21]	Smart Intelligent System	AI analytic platform	Manual Data Input	92%
[22]	Breast Cancer Meta-learning Model	Deep learning (CNN)	Not Smart System	90%

The combination of IoT and machine learning has increased the interoperability of data from all sectors and stakeholders and the maintenance of anonymity in near-real-time healthcare delivery [8]. The emergence of IoT, sensor networks, and other supporting technologies (figure 1) has significantly improved the development of healthcare delivery (telehealth or remote healthcare) fundamentally through health measurement and monitoring [9].

Internet of Things (IoT) aids in gathering data from an external environment through a gateway into a database using sensors, controllers, interfaces, actuators, and buses. In this system, the health vitae will be collected. Machine learning techniques such as CNN, called ConvNet, are deep learning network architectures that technically train machines directly from assigned data [10]. [11] defined CNN as an artificial neural network that models training with multiple hidden layers developed through duplicating the biological cerebral cortex within a convolutional layer and other layers such as pooling, BN, and fully connected.

CNNs are particularly useful for finding patterns in microscopic and digital images to recognize categories, available objects, and their classes. It has also been scientifically proven more effective for classifying other media, such as audio, time series, and signal data. [19][20] for accurate and effective clinical diagnosis automation that involves using thermal images as physiological health data, CNN outperforms most ML techniques [14].

Electronic health records (EHRs) provide an electronic, real-time patient record-centered health database stored purposely to ensure confidentiality, integrity, and availability. The stored health data provides an instantly and more secure patient record to authorized users for their intended uses. [15] maintains that HERs are central data usually collected during routine clinical practice from patients to aid healthcare provision or medical research purposes.

3. Breast Cancer

Breast cancer is a form of cancerous cells in the breast and comes after skin cancer as the most common cancer diagnosed in women globally. Even though breast cancer affects both men and women, the cancer mainly occurs in women. Continued improvement of health systems has made tremendous progress in finding a cancer screening method that best predicts cancerous cells in humans.

This is because research has proven that detecting cancer at the earliest stages mainly provides a significant chance for cure [7]. Regardless of the screening method, various medical organizations, stakeholders, and breast cancer advocacy groups have made recommendations regarding breast cancer examination or screening guidelines. It is, therefore, the health professional's and patient's decision to select a preferred screening method depending on the level and the risk factors for cancer.

Over the years, healthcare professionals worldwide have approached cancer diagnosis methods using a physical exam: this involves pressing the breast gently to feel for lumps as an indication of cancer or abnormalities. Other physical examinations may inquire about observing changes such as skin color or enlargement of organs [16]. Laboratory tests: this is a method of diagnosis that requires physiological treatments such as urine and blood tests to detect the presence of cancer. Depending on the cancer type, an upgraded laboratory test called biopsy is necessary to collect the requisite physiological samples to help in this detection procedure [17].

A typical example of biopsy is where the blood sample is compiled from a cancer patient to conduct a blood test known as complete blood count (testing for the amount and category of white blood cells in the body), which is effective in diagnosing leukemia cancer. Finally, image-based tests, or imaging tests, require using bones and other organs. Imaging tests use the bones and internal organs in a non-invasive method to aid in the diagnostics of cancer among cancer patients. Methods mainly used in imaging may include bone scans, Computerized Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), or ultrasound and X-ray.

The infrared camera should have the ability to capture the images of passers-by, deploy the CNN to identify the gender, and also further use the EHR thermal images generated to determine the cancerous cells in the breast, also referred to as grave diseases [18]. The surface area of a cancerous breast increases in temperature, but due to a lack of detective systems that can zoom in on the temperature of the breast area. It has been a challenge to detect breast cancer; therefore, an “IoT-based system that can detect changes in breast temperature distribution contactless is required”[14]. An earlier study by [14] outlines limitations regarding representative dataset, poor kernel, and heavyweight CNN model, which all contribute to a lack of confidence in their developed model as the recommended future efforts to optimize representative dataset, augmentation algorithms, and assembling segmentation techniques that assign an adequate kernel that can build a lightweight CNN model is significant. [18] the study by Gupta and Co. Addresses the challenge of creating a light.

4. Resources and Materials

4.1 Dataset

Research shows that convolutional neural networks, a deep learning technique used in ML, perform better on image classification. [1], [11]–[14], [23]–[26] all indicate the

relevancy of deep learning techniques such as convolutional neural networks in image classification. This study deploys a dataset described in Table 2, from https://www.kaggle.com/datasets/asdeepak/thermal-images-for-breast-cancer-diagnosis-dmrir, to conduct the premunire testing of the proposed system, as shown in figure 2. The dataset initially is Portuguese lang outlines usage and has the description in Table 2 to investigate the performance of CNN and possible parameter turnings that can increase the performance of the CNN model during the training of the model.

This study will use the build system (sensors, model, and software) to test live at the Parul University Hospital with live users to promote discussion on efficacy since early detection contributes significantly to treating cancerous cells and existing technologies are capable of detecting only tumor or lamb size of more than 20 mm.

Table 2: Dataset Description

DATASET DESCRIPTION	**MEANING IN ENGLISH**	**ACTUAL USE RELATING TO WORK**
Thiago Alves Elias da Silva's Imagens e Matrizes da Tese de	Images and matrices of Thiago Alves Elias da Silva's thesis.	The images for Thiago Silva;s thesis.
Desenvolvimento da Metodologia	Development of the Methodology	Training Dataset
12 Novos Casos de Testes	12 New Test Cases	Test Images
SAUDA╞üVEIS	Healthy	Images arranged in folders for pictures of healthy patients
DOENTES	Sick	Images arranged in folders for images of sick patients

The classification is also determined in classes: Normal (None-Cancerous person) or Sick (abnormal patient with cancerous tumor) [20][14][18]. This study further classifies sick patients into light (less than 20 mm) and severe (tumor size bigger than 20mm). Further classification helps determine the stage of the tumor and, by extension, shows the treatability of the cancer. Early detection also remains the foundation of breast cancer control [14].

To ensure automatic segmentation and augmentation in detecting a tumor in the breast, as shown in Figure 2, this study deploys CNN that selects the Region of Interest (ROI) (thoracic cavity) of patients before the IoTs data, capturing the images that need to be processed. A deep image recording of the patients' posttrial bodies would be captured as CNN selects the ROI and hence selects the breast area only.

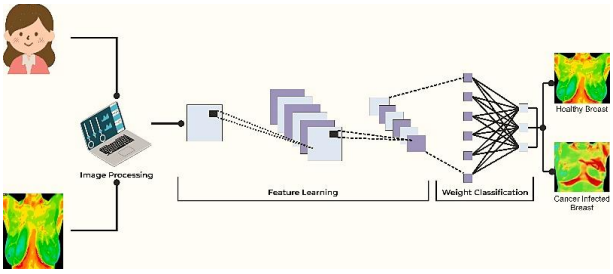

Fig 2. The proposed system selection of the RIO.

The limitation in Sub-Based Papers 1 and 2 is that the histopathological images must be inputted manually before the CNN algorithm can be run to detect the presence of Cancer. This process is not very different from traditional hospitals' existing manual cancer detection system. In an intelligent health ecosystem, IoT cameras collect these images randomly from system users and securely send this health data to the internally generated electronic health records to finally analytically predict the presence of Cancer tumors within the health systems.

Even though **Shahirah Zahir (2021)** is in agreement with **ROSLIDAR (**2019) and **Gupta (2021**) on the need to have a breast cancer detection system in hospitals or clinics, they all see a shortcoming proposed model and therefore recommend the improvement of their models through effective network layer design and the ensemble of ConvNet algorithms.

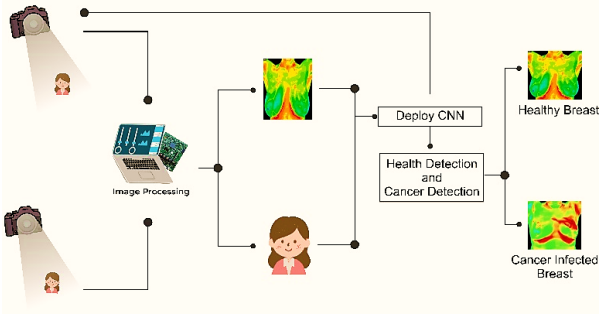

Fig 3: Proposed 2-Factor Cancer Detection Framework.

As shown in figure 3, The two-factor framework collects thermal images from the system users in phase one from the entrance of the institutional doors, and the second phase, based on the initiation prediction of the system, makes a

further request of the user to phase two scanning of the users' RIO.

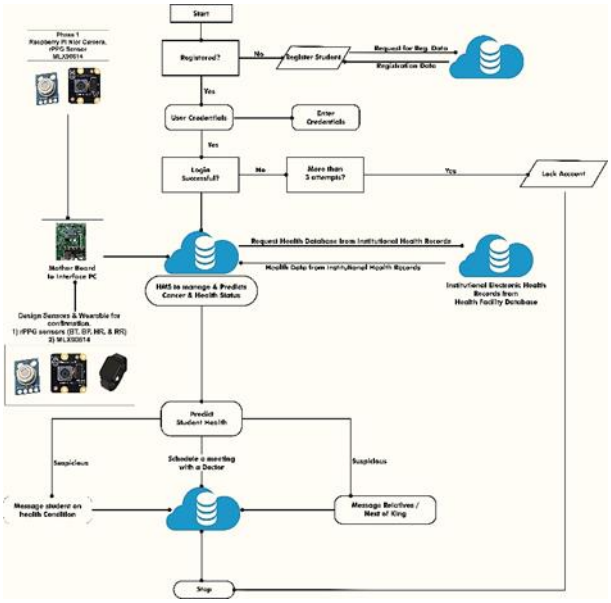

Fig 4. Data Flow Diagram

This is significantly vital since the proposed system learning accuracy would be high, leading to early detection of cancerous tumors because patients with no synthons of cancer (no complications or no pain in their breast) and have no intention or plans of going to the hospital would be prompted automatically if their institutions have installed our proposed system as shown in figure 4. The limitations in previous models or studies are the gaps in automating the data collection, model performance, and the fact that patients remain the primary initiators of the cancer detection system: patients need to visit a health facility before the images of their thoracic can be captured or scanned and manually inputted in the predictive model or system to begin the prediction process.

5. Conclusion

Traditional healthcare delivery lacks artificial intelligence to automated healthcare systems to effectively detect and diagnose cancer and other major diseases that pose a threat to man's existence in both developed and developing countries. Breast cancer is a global disease that has caused more deaths among women and men than any other cancer globally. But lack of a comprehensive cancer detection framework that integrates the three pillars of cancer treatment (early detection, timely diagnosis, and treatment) is a challenge that must be addressed. United Nations SGD 3 and 4 seem unachievable, which threatens the human race worldwide. The search to develop effective remote healthcare delivery has intensified over the years, especially in the era of pandemics, which has reduced the interest in physical healthcare provision by healthcare providers and seekers. The proposed system uses a contactless remote system to improve healthcare seekers' or unaware cancer automatic scanning and further interaction on telehealth platforms within their institutional home or health facility.

The cancer detection system using IoT-based EHRs and convolutional neural Networks (CNN) in schools and other institutional homes will automate cancer detection and health monitoring to ensure a healthy environment among residential users. The study seeks to develop and experiment with EHRs-Based RMS built to generate EHR data from sensors and use Convolutional Neural Network (CNN) to intelligently enable machine learning algorithms to detect or diagnose the cancer status within institutional homes for users' complete safety and well-being.

6. Future Work

The further scope of this paper is to design and implement a comprehensive component of the proposed system that holistically integrates sensors and the CNN machine learning algorithms to generate patents data warehouse of big data in an all-in-one low-cost intelligent cancer diagnosis system to be used in institutional homes especially, the educational institutions. Furthermore, our forthcoming efforts will address potential challenges, such as data security, ethical considerations, and user-friendliness. Striving for compliance with regulatory frameworks and ethical guidelines will be central in the development and deployment phases. In summary, the ongoing and future endeavors will revolve around the holistic development of an affordable, intelligent cancer diagnosis system. This system aims to revolutionize cancer detection within educational institutions, potentially transforming how healthcare is delivered in institutional settings.

References

[1] A. Sriram et al., "A Smart Solution for Cancer Patient Monitoring Based on Internet of Medical Things Using Machine Learning Approach," Evidence-based Complementary and Alternative Medicine, vol. 2022, 2022, doi: 10.1155/2022/2056807.

[2] E. V. D. Subramaniam, K. Srinivasan, S. M. Qaisar, and P. Pławiak, "Interoperable IoMT Approach for Remote Diagnosis with Privacy-Preservation Perspective in Edge Systems," Sensors, vol. 23, no. 17, p. 7474, Aug. 2023, doi: 10.3390/s23177474.

[3] N. Y. Duodu and W. Patel, "Advanced EHR System in Homes-In-Schools' Automation Using Internet of Things and Machine Learning."

[4] "Global Breast Cancer Initiative Implementation Framework Assessing, strengthening and scaling up services for the early detection and management of breast cancer."

[5] L. Montel et al., "Implementing and monitoring the right to health in breast cancer: selection of indicators using a Delphi process," Int J Equity Health, vol. 22, no. 1, Dec. 2023, doi: 10.1186/s12939-023-01964-w.

[6] N. Y. Philip, J. J. P. C. Rodrigues, H. Wang, S. J. Fong, and J. Chen, "Internet of Things for In-Home Health Monitoring Systems: Current Advances, Challenges, and Future Directions," IEEE Journal on Selected Areas in Communications, vol. 39, no. 2, pp. 300–310, 2021, doi: 10.1109/JSAC.2020.3042421.

[7] F. Jamil, S. Ahmad, N. Iqbal, and D. H. Kim, "Towards a remote monitoring of patient vital signs based on iot-based blockchain integrity management platforms in smart hospitals," Sensors (Switzerland), vol. 20, no. 8, Apr. 2020, doi: 10.3390/s20082195.

[8] C. Krittanawong et al., "Integration of novel monitoring devices with machine learning technology for scalable cardiovascular management," Nat Rev Cardiol, vol. 18, no. 2, pp. 75–91, 2021, doi: 10.1038/s41569-020-00445-9.

[9] F. Ningsih, Fitrianingsih, and L. A. Didik, "Indonesian Physical Review," Indonesian Physical Review, vol. 2, no. 3, pp. 1–8, 2019.

[10] Dr. Nikhat Akhtar, Dr. Hemlata Pant, Apoorva Dwivedi, Vivek Jain, and Dr. Yusuf Perwej, "A Breast Cancer Diagnosis Framework Based on Machine Learning," Int J Sci Res Sci Eng Technol, pp. 118–132, May 2023, doi: 10.32628/ijsrset2310375.

[11] H. Q. Xu, X. Shao, S. Hui, and L. Jin, "Supervised breast cancer prediction using integrated dimensionality reduction convolutional neural network," PLoS One, vol. 18, no. 5 MAY, May 2023, doi: 10.1371/journal.pone.0282350.

[12] M. M. Srikantamurthy, V. P. S. Rallabandi, D. B. Dudekula, S. Natarajan, and J. Park, "Classification of benign and malignant subtypes of breast cancer histopathology imaging using hybrid CNN-LSTM based transfer learning," BMC Med Imaging, vol. 23, no. 1, Dec. 2023, doi: 10.1186/s12880-023-00964-0.

[13] S. Balasubramaniam, Y. Velmurugan, D. Jaganathan, and S. Dhanasekaran, "A Modified LeNet CNN for Breast Cancer Diagnosis in Ultrasound Images," Diagnostics, vol. 13, no. 17, p. 2746, Aug. 2023, doi: 10.3390/diagnostics13172746.

[14] R. Roslidar et al., "A Review on Recent Progress in Thermal Imaging and Deep Learning Approaches for Breast Cancer Detection," IEEE Access, vol. 8. Institute of Electrical and Electronics Engineers Inc., pp. 116176–116194, 2020. doi: 10.1109/ACCESS.2020.3004056.

[15] S. Yang, P. Varghese, E. Stephenson, K. Tu, and J. Gronsbell, "Machine learning approaches for electronic health records phenotyping: a methodical review," J Am Med Inform Assoc, vol. 30, no. 2, pp. 367–381, Jan. 2023, doi: 10.1093/jamia/ocac216.

[16] S. Sayed et al., "Training health workers in clinical breast examination for early detection of breast cancer in low- and middle-income countries," Cochrane Database of Systematic Reviews, vol. 2023, no. 4. John Wiley and Sons Ltd, Apr. 18, 2023. doi: 10.1002/14651858.CD012515.pub2.

[17] K. M. Hernandez et al., "Contrived Materials and a Data Set for the Evaluation of Liquid Biopsy Tests: A Blood Profiling Atlas in Cancer (BLOODPAC) Community Study," Journal of Molecular Diagnostics, vol. 25, no. 3, pp. 143–155, Mar. 2023, doi: 10.1016/j.jmoldx.2022.12.003.

[18] K. Datta Gupta, D. K. Sharma, S. Ahmed, H. Gupta, D. Gupta, and C. H. Hsu, "A Novel Lightweight Deep Learning-Based Histopathological Image Classification Model for IoMT," Neural Process Lett, vol. 55, no. 1, pp. 205–228, Feb. 2023, doi: 10.1007/s11063-021-10555-1.

[19] N. Iqbal, F. Jamil, S. Ahmad, and D. Kim, "Toward Effective Planning and Management Using Predictive Analytics Based on Rental Book Data of Academic Libraries," IEEE Access, vol. 8, pp. 81978–81996, 2020, doi: 10.1109/ACCESS.2020.2990765.

[20] S. Zahir, A. Amir, N. A. H. Zahri, and W. C. Ang, "Applying the Deep Learning Model on an IoT Board for Breast Cancer Detection based on Histopathological Images," in Journal of Physics: Conference Series, IOP Publishing Ltd, Mar. 2021. doi: 10.1088/1742-6596/1755/1/012026.

[21] M. Riveira-Martin, A. Rodríguez-Ruiz, R. Martí, and M. Chevalier, "Multi-vendor robustness analysis of a commercial artificial intelligence system for breast cancer detection," Journal of Medical Imaging, vol. 10, no. 05, Apr. 2023, doi: 10.1117/1.jmi.10.5.051807.

[22] M. D. Ali et al., "Breast Cancer Classification through Meta-Learning Ensemble Technique Using Convolution Neural Networks," Diagnostics, vol. 13, no. 13, p. 2242, Jun. 2023, doi: 10.3390/diagnostics13132242.

[23] R. Roslidar et al., "A Review on Recent Progress in Thermal Imaging and Deep Learning Approaches for Breast Cancer Detection," IEEE Access, vol. 8. Institute of Electrical and Electronics Engineers Inc., pp. 116176–116194, 2020. doi: 10.1109/ACCESS.2020.3004056.

[24] A. Sriram et al., “A Smart Solution for Cancer Patient Monitoring Based on Internet of Medical Things Using Machine Learning Approach,” Evidence-based Complementary and Alternative Medicine, vol. 2022, 2022, doi: 10.1155/2022/2056807.

[25] S. Zahir, A. Amir, N. A. H. Zahri, and W. C. Ang, “Applying the Deep Learning Model on an IoT Board for Breast Cancer Detection based on Histopathological Images,” in Journal of Physics: Conference Series, IOP Publishing Ltd, Mar. 2021. doi: 10.1088/1742-6596/1755/1/012026.

[26] S. Zahir, A. Amir, N. A. H. Zahri, and W. C. Ang, “Applying the Deep Learning Model on an IoT Board for Breast Cancer Detection based on Histopathological Images,” in Journal of Physics: Conference Series, IOP Publish

[27] Ramani, Bhupendra, Kamini Solanki, and Warish Patel. "Anxiety Detection Using Physiological Data and Wearable IoT Devices: A Survey." Handbook of Research on Applied Intelligence for Health and Clinical Informatics (2022): 31-43. IGI Global.

[28] Patel, Warish D., et al. "VitaFALL: Advanced Multi-Threshold Based Reliable Fall Detection System." Recent Advances in Computer Science and Communications (Formerly: Recent Patents on Computer Science) 15.1 (2022): 32-39. Bentham Science Publishers.

[29] Biju, Roshima, et al. "Framework for classification of chest X-rays into normal/COVID-19 using Brownian-Mayfly-Algorithm selected hybrid features." Mathematical Problems in Engineering 2022 (2022): Hindawi.

[30] Duodu, Nana Yaw, and Warish Patel. "Advanced EHR system in homes-in-schools’ automation using internet of things and machine learning." Journal of Information and Optimization Sciences 43.8 (2022): 1953-1962. Taylor & Francis.

[31] Manic, K. Suresh, et al. "Research Article Extraction and Evaluation of Corpus Callosum from 2D Brain MRI Slice: A Study with Cuckoo Search Algorithm." 2021.

[32] Jain, Mayuri, and Warish Patel. "Review on LiDAR-Based Navigation Systems for the Visually Impaired." SN Computer Science 4.4 (2023): 323. Springer Nature Singapore.

[33] Patel, Warish D., et al. "NXTGeUH: LoRaWAN based NEXT generation ubiquitous healthcare system for vital signs monitoring & falls detection." 2018 IEEE Punecon. IEEE, 2018.

[34] Pandya, S., et al. "I-MsRTRM: developing an IoT based iNTELLIGENT Medicare system for real-time remote health monitoring." 8th IEEE International Conference on Computational Intelligence and Communications Networks (CICN-2016), Tehari, India, 2016.

[35] Kothari, Aansi A., et al. "A novel approach towards context-based recommendations using support vector machine methodology." Procedia Computer Science 57 (2015): 1171-1178. Elsevier.

[36] Sen, Sumanta, and Warish Patel. "Most Accurate Prediction of Liver Disease using the Ensemble Technique." 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), 2022: 1364-1368. IEEE.

[37] Patel, Dr. Warish, Kushwaha Akhilesh, Dr. Swapnil Parikh, and Prof. Ankit Chauhan. "MACHINE LEARNING PERSPECTIVE FOR CLOUD COMPUTING SECURITY: A REVIEW." Semiconductor Optoelectronics 41.11 (2022): 372-384. Semiconductor Optoelectronics.