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A Survey on AI-Powered Breast Cancer Screening and Support: A Multi-Stage Solution

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Abstract: One of the leading causes of cancer-related deaths among women worldwide is breast cancer. Although improving survival rates requires early detection, traditional screening methods like mammography and biopsy have disadvantages like high cost, radiation exposure, and restricted accessibility. ThermoScan AI is an artificial intelligence-powered smartphone app that uses infrared thermography to detect breast cancer without invasive procedures. In order to scan thermal images and accurately identify anomalies, this technology uses deep learning in the form of the DALAResNet50 model. By eliminating the dangers of traditional screening methods, ThermoScan AI offers a highly accessible and reasonably priced alternative. The app offers regular screening reminders, telemedicine support, AI-powered thermal image analysis, and personalized health monitoring. ThermoScan AI's advanced technology makes screening quick and easy. People living in rural and impoverished areas, where there are few traditional medical facilities, will particularly benefit from this innovation. ThermoScan AI has the potential to improve global breast cancer treatment and lower mortality rates through better early detection and preventive treatment. This project marks a significant advancement in the use of AI to provide effective and reasonably priced healthcare solutions.

Keywords: AI, Infrared Thermography, Deep Learning, Early Detection, Non-Invasive Screening, Mobile Health, Medical Imaging, Telemedicine, Healthcare Innovation, Breast Cancer.

I. INTRODUCTION

Breast cancer is a worldwide health concern, and millions of women are affected every year. It is one of the leading causes of cancer deaths, and its incidence is rising because of several factors such as genetic predisposition, hormonal imbalance, and lifestyle. Early diagnosis is essential for increased survival rates since prompt diagnosis ensures effective treatment and improved patient outcomes. These issues underscore the pressing necessity for an alternative, low-cost, and highly accessible breast cancer screening mechanism.

ThermoScan AI is a cutting-edge technology that employs infrared thermography and artificial intelligence to provide a low-cost, non-invasive, and accurate method of detecting breast cancer at an early stage. Infrared thermography is radiation-free imaging technology that identifies heat patterns in breast tissue and detects temperature variations that can indicate possible malignancies. When combined with deep learning models created by AI, such as the Dual-Activated Lightweight Attention ResNet50 (DALAResNet50) model, this technique enhances the accuracy of breast cancer diagnosis and reduces the dangers associated with traditional screening methods.

Developed as a mobile application, ThermoScan AI is meant to make breast cancer screening more accessible to women in rural and urban settings. The application integrates AI-based thermal image analysis, telemedicine support for remote consultations, personalized health monitoring, and scheduled screening reminders.

Through the combination of AI, medical imaging, and mobile technology, ThermoScan AI is an economical and convenient method of early breast cancer detection. It overcomes the shortcomings of traditional screening methods, promising a radiation-free and non-invasive method that is capable of reaching more individuals. With the addition of AI analysis, the system will be in a position to enhance accuracy and reliability and reduce the dependency on qualified medical professionals and provide more rapid and effective screening results.

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ThermoScan AI stands to significantly improve early detection rates, decrease mortality, and provide access to breast cancer screening, especially in underprivileged populations.

II. RELATED WORK

A. Infrared Thermal Imaging and Deep Models for the Detection of Breast Cancer

This paper explores the potential of infrared thermal imaging with deep models to detect breast cancer. The paper provides an overview of the comparison between traditional machine learning techniques and advanced deep models, namely convolutional neural networks (CNNs), to differentiate between benign and malignant tumors.
The study highlights that thermal imaging, being non-invasive and radiation-free, can be used as an early screen for cancerous growth-related abnormal heat distribution. The study states that the use of AI in analyzing thermal images is extremely accurate and effective in minimizing false positives compared to standard screening methods.

B. Development and Validation of an Infrared-Artificial Intelligence Software for Breast Cancer Detection

The current study is focused on the development of artificial intelligence-based software to screen infrared thermal images for breast cancer detection. The proposed software utilizes advanced image processing and deep learning algorithms to analyze abnormal thermal patterns for malignant growth. The validity of the system is done through comparison with mammography and has been highly sensitive and specific to detect tumors at an early stage. The study highlights the potential of AI-based thermography as an additional screening tool, particularly in low-resource settings where access to mammograms is not feasible. The paper also mentions the scalability of the software and its interfacing with hospital management systems for efficient screening and diagnostics.

C. Deep Learning-Based Approach in Surface Thermography for Inverse Estimation of Breast Tumor Size

The paper outlines a deep learning approach to estimate the size of the tumor using surface thermography and artificial intelligence. The model utilizes temperature variations at the skin surface to estimate tumor size and possible position in the breast. A feed-forward neural network is trained from thermal images to provide accurate estimates of tumor size. The research highlights the role played by AI in overcoming the limitations of subjective and inconsistent thermal image analysis through manual means. The study concludes that tumor size estimation using AI can be critical to early cancer diagnosis and treatment planning by creating real-time, non-invasive assessments.

D. Real-Time Thermography for Breast Cancer Detection with Deep Learning

The study introduces a real-time breast cancer detection platform powered by artificial intelligence that is based on infrared thermography to improve diagnostic accuracy. A novel technique applying real-time cooling techniques is utilized to optimize contrast in thermal imaging, which increases the indication of abnormal heat patterns present in cancerous tumors. The study confirms that artificial intelligence-based real-time thermography can be a rapid and efficient method of cancer screening without ionizing radiation. The article points out that such AI-based screening methods have vast potential for pre-clinical routine usage, especially in regions with poor access to mammography and traditional radiological practices.

E. Pre-Clinical Screening of Breast Cancer Using Infrared Thermography and Mobile Artificial Intelligence

The article proposes a mobile AI-based pre-clinical screening system based on infrared thermography for the identification of early signs of breast cancer. The study investigates how infrared cameras embedded in smartphones and deep learning algorithms can facilitate self-screening and early detection among underserved and remote populations. The AI system learns to identify heat pattern anomalies in breast tissue and classify likely risks. The study reflects the possibility of using mobile-based thermographic screening as a low-cost, accessible alternative to traditional mammography. This article also argues about the ethical implications, strength, and future viability of combining AI-based thermography with telemedicine services to provide real-time diagnosis and referral service for high-risk cases.

III. OBJECTIVES

1) **Early Breast Cancer Detection:** The primary objective of this project is to develop an early detection system for breast cancer using AI and infrared thermography to improve diagnosis through non-invasive techniques.
2) **Non-Radiation and Non-Invasive Screening:** The project aims to provide a safer alternative to traditional mammography through the utilization of thermal imaging, thereby increasing accessibility and comfort in screening.
3) **AI-Powered Image Analysis for Increased Accuracy:** Based on deep learning techniques, the platform augments accuracy by reducing false negatives and false positives in the diagnosis of breast cancer, thus contributing early action

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IV. METHODOLOGY

The implementation of the "ThermoScan AI: Infrared-Based Breast Cancer Detection System" is a task that must be fulfilled with a very well-planned and structured framework. The overall goal is to provide a non-invasive, AI-based diagnostic system that enables early detection and accessibility. Along those lines, the following comprehensive and step-by-step methodology provides a clear picture of the project's intricate inner mechanisms:

A. System Design and Architecture

1) System Planning and Requirement Analysis

a) We start with a rigorous analysis to determine the project's objectives, scope, and functional requirements at the beginning.
This includes identifying the target users, i.e., healthcare professionals and those in search of early detection of breast cancer, and determining their respective needs. We also evaluate the feasibility of implementing AI-based thermographic analysis in an easy-to-use mobile and web application.
b) Technologies: Tools for requirement analysis (e.g., Jira, Notion), collaboration tools, and documentation tools.

2) Technology Stack Choice

a) Based on well-defined project goals, we selectively choose the most appropriate technologies for system implementation. This involves selection of web and mobile development frameworks, deployment of AI models on the cloud, and secure database management to achieve performance and scalability.
b) Technologies: Java (backend), React Native (mobile app), Firebase/AWS (cloud storage), TensorFlow/Keras (AI model implementation), and PostgreSQL/MongoDB (database management).

3) Architecture Design

a) The " ThermoScan AI " system architecture is conceived for modularity, scalability, and unobtrusive integration. It supports thermal imaging data transfer, analysis driven by AI, and user communication combined with cloud storage, healthcare databases, and geolocation services. The modularity guarantees easy updates and future developments.

B. Data Collection and Risk Assessment

1) Breast Cancer Awareness and Education Materials:

I. The system offers extensive educational material regarding the prevention of breast cancer, its early detection, and its respective treatment options. This comprises risk factors, signs, and self-examination methods in order to raise awareness among users.
b) Technologies: Content management systems (CMS), online educational platforms, and digital publication tools.

2) Hospital and Diagnostic Centre Database:

a) A systematic database of hospitals and diagnostic centres providing thermal imaging for breast cancer screening is stored. Information about facilities in the vicinity, contact information, services provided, and availability of the screening facility is accessible to users.
b) Technologies: Google Maps API, healthcare databases, and protected data management systems.

3) AI-Based Risk Analysis and Screening Recommendations:

a) The system includes AI-based risk assessment to process thermal imaging information and forecast probable risks. It gives users screening suggestions depending on medical history, identified anomalies, and AI-forecasted risk scores.
b) Technologies: AI models for thermal analysis, machine learning environments, and statistical data processing software.

4) Report Generation and Notification System:

a) Following thermal imaging analysis, the system produces detailed reports synthesizing results, risk levels, and recommendations. Users are notified of screening results, follow-up sessions, and reminders for regular check-ups.
b) Technologies: Automated report generation software, cloud notification services, and secure messaging services

5) Healthcare Centres and Screening Facilities Integration:

a) AI-Based Thermal Image Processing
b) The system uses AI-based image processing algorithms to scan thermal images and identify possible anomalies related to breast cancer. The AI algorithm is trained on a database of thermal images to identify patterns of abnormal heat signatures.

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c) Technologies: Deep learning libraries (e.g., TensorFlow, PyTorch), image processing libraries (e.g., OpenCV), and medical imaging datasets.

6) Integration with Nearby Screening Centres:

a) The system is connected to a hospital and diagnostic centre database, allowing users to find the closest facility for further diagnosis. The AI model can also provide recommendations on the most appropriate healthcare providers based on user history and risk level.

b) Technologies: Google Maps API, cloud healthcare databases, and location tracking.

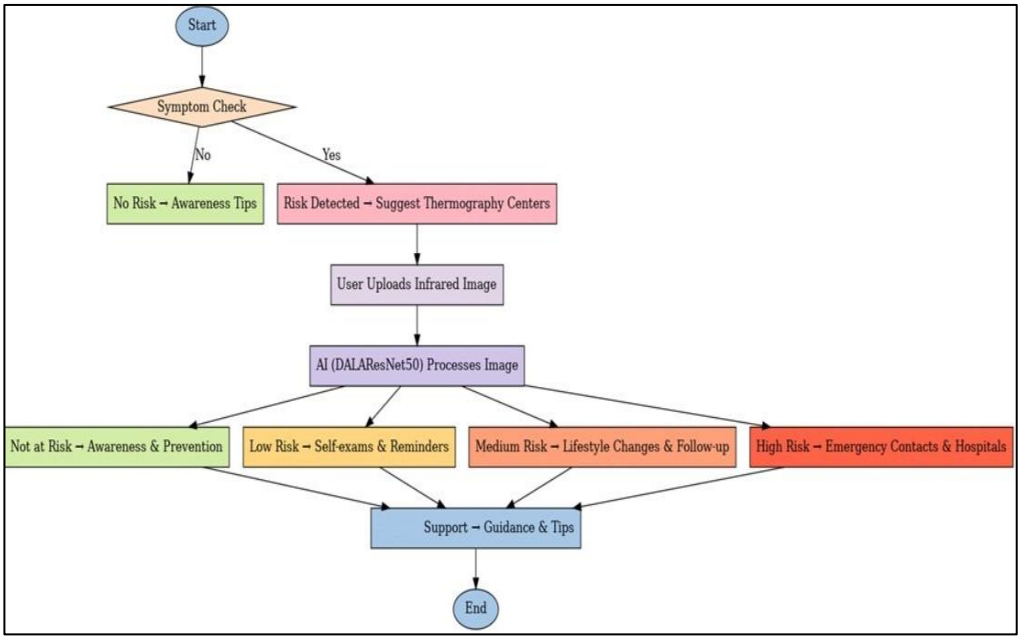

Fig.1 Architecture Design

V. APPLICATION REQUIREMENTS

The following hardware requirements must be fulfilled in order to operate our integrated system optimally:

A. Hardware

1. Ordinary PC or Server

a) Processor: Multicore processor (e.g., Intel Core i5/i7 or AMD Ryzen 5/7) for processing user requests and database queries.

b) RAM: 8GB minimum is recommended, with 16GB being preferable for performance tuning.

c) Storage: SSD (256GB or more) for best data access and storage of user reports.

2. GPU (Graphics Processing Unit)

a) Required to train and tune the DALAResNet50 model for breast cancer detection.

b) NVIDIA CUDA-enabled GPUs (e.g., RTX 3060, 3080, A100, Tesla V100) for speeding up AI models.

c) If cloud-based processing of AI is utilized, GPU specifications can be handled by AWS, Google Cloud, or Azure ML services

3. Internet Connectivity

a) Reliable internet for accessing AI models, cloud-based inference, and fetching screening center recommendations.

b) Required for Google Maps API integration to find the nearest thermography centers.

B. Software. Development Tools

1. Development Tools:

a) Programming Language: Python for the development of AI models and Java for the backend services.

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b) Integrated Development Environment (IDE): VSCode, PyCharm, Jupyter Notebook. Used for coding and debugging purposes.

2. AI and Backend. Frameworks:

a) TensorFlow & PyTorch – Used for training and fine-tuning DALAResNet50 to differentiate between breast cancer.

b) OpenCV – If image preprocessing or image enhancement is to be performed prior to supplying data as an input to the AI model.

3. Web & Mobile Application Development:

a) MERN Stack (MongoDB, Express.js, React, Node.js) – For creating the web interface of ThermoScan AI.

b) Android & iOS Frameworks (Flutter/React Native) – If to be implemented with a mobile interface.

4. Database & Cloud Services:

a) MongoDB, MySQL – To save user information, reports, and screening center details.

b) Google Firebase – For real-time database support & authentication.

c) AWS/Azure/GCP – Cloud hosting of AI model if online inference is employed.

5. Geolocation & Screening Center Suggestions

a) Google Maps API – To locate & suggest nearby thermography centers around the user location.

b) Healthcare Database APIs – For retrieving legitimate screening center listings.

6. Security & User Authentication

a) Auth 2.0 / Firebase Authentication – Secure login system for users.

b) Role-Based Access Control (RBAC) – Restrict access for multiple user groups (patients, doctors, and admin).

7. Version Control & Project Management:

a) Git & GitHub/GitLab – For version control and collaboration

b) Trello / Notion – For team collaboration and task tracking of projects.

8. User Interface:

a) Clean and intuitive design with straightforward navigation.

b) Customized user accounts and downloadable reports

c) Integration of Google Maps for locating screening centers.

d) AI-generated risk assessment dashboard with data visualizations.

e) Notifications, learning content, and accessibility.

VI. CONCLUSION AND FUTURE SCOPE

The launch of ThermoScan AI is a huge leap towards harnessing the potential of AI-based thermal imaging in the early detection of breast cancer. By incorporating DALAResNet50, the product ensures proper and precise thermal image classification and offers a viable means for early diagnosis. Moreover, with geolocation capability, users can find nearby screening centers with ease, thus facilitating easy access to timely healthcare. The system is built to merge machine learning with advanced imaging methodologies to develop a comprehensive and interactive solution. Machine learning facilitates autonomous improvements in diagnostic precision, so the system becomes a learner that offers more correct results as time progresses. The paired approach ensures that ThermoScan AI shall continue being responsive and operational in response to changing healthcare needs.

The well-structured methodology adopted in this project, starting from requirement analysis and culminating in system deployment, is a guarantee of scalability, performance, and readability. The system has an intuitive interface, complete with features like personal accounts, downloadable reports, and quick results retrieval, making it an easy platform for both doctors and patients. It is centered on risk assessment and preventive medicine. By providing access to live health information and regular check-up reminders, ThermoScan AI encourages proactive care and involves users in ownership of their wellbeing. Secure cloud storage of medical records enables convenient and secure access to health information. In the coming times, ThermoScan AI offers a lot of scope for growth. Adding real-time risk assessment and recommendation based on AI would further add to the strength of the system, providing individuals with personalized insights and medical professionals with well-informed choices. Growing screening partnerships with hospitals and diagnostic facilities can further widen the reach of the platform, facilitating timely screenings for larger populations.

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This would go a long way in adding to the global efforts of early detection and cancer prevention. To extend its reach even further, subsequent releases of ThermoScan AI can include wearable device connectivity, support for multiple languages, and mobile health analytics, so that it is appropriate for heterogeneous populations across a variety of geographical areas. Electronic health record (EHR) system and national health database integrations may also enable smooth data transfer and longitudinal health monitoring. Such developments would make ThermoScan AI a globally scalable, adaptable solution in the area of smart and inclusive health technologies.

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