

IoT-Enabled Medical Image Management: A Framework for Real-Time Analysis, Secure Archiving, and Distributed Diagnostics

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Abstract – The use of Internet of Things (IoT) devices in the healthcare industry, such as handheld imaging sensors to linked in-hospital devices, is creating medical image data in volumes and speeds never seen before. This data flood is a challenge to the traditional Picture Archiving and Communication Systems (PACS) and it is an opportunity of advanced analytics. The given paper suggests a complex model of applying IoT to the medical image processing with the support of the ideas of radiomics, edge computing, and secure distributed systems. We discuss how IoT allows to receive the pictures of remote or point-of-care devices, process and triage in cases of real-time, and transfer data safely to cloud or fog nodes to process it with the intensive radiomics analysis with the help of machine learning (ML) models. Continuing on innovations to predictive analytics through supervised learning, image retrieval via deep learning, and data augmentation via generative models, we present a system that would serve such purposes as remote diagnostics, ongoing observation over such chronic diseases, outbreak tracking of epidemic outbreaks. Of the interest to this framework are the solutions to the inherent issue of IoT in healthcare, which are: data security, privacy, interoperability and missing or noisy data. The paper ends with the transformation potential of such integration of global health equity, telemedicine and personal individual and proactive care.

Keywords – Internet of Things (IoT), Medical Imaging, Edge Computing, Radiomics, Remote Diagnostics, Secure Data Transmission, Real-Time Analytics, Telemedicine.

I. INTRODUCTION

Internet of Things (IoT) enables the integration of medical imaging and the convergence of the field is driving an age of connected healthcare technologies. IoT involves a network of physical objects, including high-end MRI machines that include physiological sensors and cheap portable ultrasound probes and dermatology cameras that are armed with software and connection to and transmit data. This in medical imaging means decentralized acquisition of images, records of patients, and production of large volumes and the heterogeneous image-data volume.

Conventional, centralized imaging processes in the hospital do not usually adapt well to this arrival, especially where remote treatment is required, emergency reaction is needed, or massive screening frameworks are implemented. A framework based on the IoT fills these gaps through the distribution of intelligence throughout the network: at the edge (the imaging device or a local gateway) to the fog (local network nodes) and the cloud. The pictorial triage in real time, effective management of collected data, and the implementation of advanced radiomics and machine learning models can be observed with the use of this paradigm, as it is demonstrated in the recent literature about predictive analytics (Ghule et al., 2024; Saha et al., 2025).

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This paper ultimately combines the ideas of the IoT architecture, secure communication (following the studies related to the VANETs), image processing, and ML to make a suggestion on the strong framework of the IoT in medical imaging directly based on the offered citations.

II. IOT-ENABLED MEDICAL IMAGING ARCHITECTURE

An offered three-level architecture makes it convenient to process and send data:

Tier 1: Edge Layer (Acquisition & Preliminary Processing)

- **Devices:** Portable X-ray equipment, connected ophthalmoscopes with smartphones, wearable biosensors with imaging, and even sophisticated equipment such as airborne Synthetic Aperture Radar (SAR) used to map health conditions of the population (Kavitha et al., 2017), modified to serve the needs of the public health.
- **Function:** Image capture and fast-weight real-time processing. This includes:
 - **Preprocessing:** Simple noise reduction, format standardization and compression.
 - **Triage:** Executing a lightweight ML model (e.g. pruned CNN) that signals the presence of a critical case (e.g. identified fracture, large opacity) that can receive a high priority upload, like the hand gesture recognition system that processes sensor data immediately to act on it (Sheela et al., 2022).
 - **Anonymization & Secure Packaging:** Adding metadata and patient privacy.

Tier 2: Fog/Cloud Layer (Storage, Analytics, & Archiving)

- **Nodes:** Local servers or cloud providers (e.g. in a clinic or in a regional hospital) or cloud(s) (e.g. AWS, Google Cloud).
- **Function:** This is the central processing unit, executing the resource demanding functions:

- **Secure Archiving:** Removing or enhancing conventional PACS using distributed storage solutions that are scaled.
- **Advanced Radiomics Analysis:** Entails running the entire workflow of radiomics, i. e. segmentation, feature extraction (with more advanced transforms such as QWT to analyze texture such as in EEG processing (Sardesai, 2025)). In this case, Bayesian Optimized SVM (BO-SVM) or Gradient Boosting (CatBoost) are supervised ML models used to identify COPD progression in a patient scan through the use of chest CT or cardiac risk in diabetic patients (Amudala Puchakayala et al., 2024; Sheela et al., 2022).
- **Content-Based Image Retrieval (CBIR):** A similarity in historical cases is located in a distributed database with CNN-like reverse search engines (Marathe et al., 2022) to assist in the determination and treatment regimen.
- **Dealing with Imperfect Data:** Adopting the most cutting-edge imputation methods, such as Spatio-Convolutional GAIN (SCGAIN) to address lacking or spoiled data associated with the use of unreliable IoT transmissions, which will also offer a solid model performance (Bansal et al., 2025).

Tier 3: Application & Visualization Layer (Decision Support)

- **Interfaces:** Clinician mobile apps, patient portals, and Web dashboards.
- **Function:** Delivers an analyzed data, explainable AI (XAI) insights, and alerts to the end-users and supports clinical decision-making.

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III. KEY IOT APPLICATIONS IN MEDICAL

IMAGING

1. **Remote Diagnostics and Tele-Radiology:** IoT is used to allow specialists to analyze pictures in the rural or underserved regions in real-time. A CT scanner in a remote clinic can post pictures to be immediately analyzed using a centralized AI model to identify tuberculosis or a haemorrhagic stroke (e.g., with results sent to an available radiologist).
2. **Chronic Disease Monitoring:** In the case of such a disease as COPD, patients might be allowed to make use of approved, connected spirometers with simple imaging sensors in their home. Combined with clinical levels, time-series imaging data may be analyzed using predictive models (Saha et al., 2025) to control the progression and cause early interventions before acute exacerbations.
3. **Point-of-Care Ultrasound (POCUS) Networks:** General practicing doctors or emergency room doctors performing with handheld ultrasound units are able to take pictures. IoT allows the immediate upload, automated initial assessment (e.g., suspicions of cardiac tamponade), and consultations, which significantly shorten the time-to-diagnosis.
4. **AI-Enhanced Screening Programs:** Mobile screening vans/Mobile screening vans with IoT-connected cameras/Mobile screening vans with mammography cameras can travel around the communities. Pictures are checked on-board or sent to the AI so that they could be screened of breast cancer or diabetic retinopathy and a positive result will attract a follow-up. That is consistent with the vision of large-scale, proactive health management with the use of AI (Ghori, 2021).
5. **Surgical and Interventional Guidance:** IoT-enabled an imaging machine (e.g. real-time MRI, optical cameras) in the operating room can provide

input to an augmented reality (AR) application or a robot assistant, whose AI models will process the input and locate important structures and boundaries of the surgery.

IV. CRITICAL CHALLENGES AND MITIGATION STRATEGIES

Possible integration of IoT into medical imaging is not entirely devoid of challenges, most of which are outlined in the wider analysis of AI/ML literature:

1. Data Security, Privacy, and Integrity:

- **Challenge:** IoT devices are prone to entry points. When sending sensitive medical pictures, there are serious issues of privacy on the network.
- **Mitigation:** Use end to end encryption, blockchain based access logs in audit trails (as proposed in smart farming (Kumar et al., 2023)) and regulations such as HIPAA/GDPR are strictly followed. The most significant methods of responsible and ethical AIs use are at the forefront (Puchakayala, 2022).

2. Interoperability and Standardization:

- **Challenge:** There are dozens of gadgets by various manufacturers that employ some proprietary protocols and data formats.
- **Mitigation:** Implement imaging standards such as DICOM, health data exchange standards such as HL7/FHIR, and device-specific protocols such as MQTT or the SDC standards of HL7.

3. Network Reliability and Resource Allocation:

- **Challenge:** Data flow may be disrupted by bandwidth, latency, and unstable connectivity particularly in far off locations.
- **Mitigation:** Adaptive compression and edge computing are futile to reduce data transfer. Schemata Adopt smart resource

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allocation techniques following the investigations in Vehicle Ad-Hoc Networks (VANETs) in order to minimize the network traffic and attain Quality of Service (QoS) to the essential information (Sheela et al., 2022).

4. Algorithmic Bias and Fairness:

- **Challenge:** ML models which are trained with non-representative data can be ineffective when acting upon groups of people with different IoT devices, contributing to health inequity.
- **Mitigation:** Train a variety of training datasets. Use XAI to check what the model has decided to do and whether it is fair or not, and this is also a significant consideration in behavioral economics AI implementation (Ghule, 2025).

5. Data Volume and Management:

- **Challenge:** Due to their continuous streams of images, IoTs have the potential to overwhelm storage and analysis.
- **Mitigation:** Ensure the existence of smart data lifecycle management, i.e. archiving raw data when possible, retaining salient features or model outputs where possible. Apache Spark (Ghori, 2021) is a distributed processor of image-derived feature sets with big data analysis tools.

V. CONCLUSION

The key to creation of more resilient, accessible, and personalized healthcare worldwide concerns the IoT-enabled medical imaging ecosystem that will be created on the basis of the concepts of secure communication, distributed intelligence, and enhanced AI (which will be based on the principles described in the given literature). The interconnected technical, ethical, and regulatory

issues will be overcome by interdisciplinary cooperation to achieve success.

Integration of IoT and medical imaging with the help of powerful ML analytics will make advanced diagnostics more democratic and allow transforming the very nature of medical care, as well as to make preventive and prioritizing healthcare. The further development will probably be concerned with:

- **Multimodal IoT Fusion:** These methods provide insights into multimodal analysis (imaging data with other types of IoT data, such as vital signs, genomics, environmental sensors, etc.), which requires holistic analysis, and research on Multimodal Machine Learning (MML) has supported this view (Sardesai et al., 2025).
- **Advanced Edge AI:** Cutting-edge models based on more efficient models on devices to operate independently.
- **Federated Learning:** Optimization Federated learning to generate ML models when training multiple, decentralized IoT devices or hospitals, without treating raw images data, with enhanced model performance without invading privacy.
- **Generative AI in Synthetic Data:** Training Synthetic images with IoT devices via GAN in creating the synthetic medical images that are real, to train powerful models and not to worry about privacy, as a solution to data scarcity.

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