

# Comparative Study Of Techniques Used In Mini Mobile Digital Radiography System.

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## ABSTRACT

This paper proposes a **Mini Mobile Digital Radiography System** integrating portable X-ray imaging, embedded processing, and telemedicine communication for efficient and real-time medical diagnosis. The system employs a Raspberry Pi-based architecture to perform on-device image acquisition, enhancement, and transmission. A hybrid image processing approach combining Contrast Limited Adaptive Histogram Equalization (CLAHE) and Wiener filtering is implemented to address challenges such as low contrast and noise in radiographic images. Performance evaluation using metrics such as Peak Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE), and entropy demonstrates significant improvement in image quality compared to conventional methods. Furthermore, the system enables remote diagnosis through wireless data transmission using GSM/Wi-Fi networks, facilitating expert consultation in underserved and remote regions. The proposed system offers a cost-effective, portable, and scalable solution for modern healthcare applications, particularly in emergency and rural settings.

**Keywords:** *Digital Radiography, Portable Radiography System, Mobile Healthcare, Raspberry Pi, Embedded Systems, Medical Image Processing, Image Enhancement, Contrast Enhancement, Noise Reduction, CLAHE, Wiener Filter, Telemedicine.*

## I. INTRODUCTION

Medical imaging plays a vital role in modern healthcare by enabling accurate diagnosis, monitoring, and treatment of various diseases. Among the different imaging modalities, digital radiography is one of the most widely used techniques due to its fast image acquisition, reduced radiation exposure, and ability to provide high-resolution images. It is commonly used for diagnosing conditions related to the chest, bones, and internal organs. However, conventional digital radiography systems are typically large, expensive, and confined to hospital environments, which limits their accessibility in rural and remote areas. In recent years, there has been a growing demand for portable and cost-effective medical imaging systems that can be used in ambulances, emergency situations, and point-of-care applications. Portable radiography systems address this need by enabling medical imaging outside traditional clinical settings. Despite their advantages, these systems often suffer from limitations such as reduced image quality, noise interference, and lack of advanced processing capabilities due to hardware constraints. These issues can negatively impact the accuracy of medical diagnosis and decision-making. To overcome these

challenges, image processing techniques have been widely adopted to enhance the quality of radiographic images. Medical X-ray images often exhibit low contrast and are affected by noise, which can obscure important diagnostic details. Techniques such as Contrast Limited Adaptive Histogram Equalization (CLAHE) are used to improve image contrast by enhancing local details, while filtering methods like the Wiener filter help reduce noise and restore image clarity. The combination of these techniques can significantly improve the visual quality and interpretability of medical images, making them more useful for diagnostic purposes. In this work, a **Mini Mobile Digital Radiography System** is proposed that integrates portable X-ray imaging, embedded image processing using Raspberry Pi, and telemedicine communication capabilities. The system employs a hybrid image enhancement approach using CLAHE and Wiener filtering to improve image quality.

## II. METHODS AND ANALYSIS

### A. Portable Medical Image Processing Using Raspberry Pi

This study focuses on implementing a portable medical image processing platform using Raspberry Pi as the primary embedded computing unit. The main technique employed is low-cost embedded image processing for medical applications. Raspberry Pi was selected due to its compact size, low power consumption, affordability, and compatibility with Python-based image processing libraries. The system captures medical images through a camera module and performs image preprocessing operations such as contrast enhancement, scaling, and noise reduction.

A major strength of this approach is portability, making it highly suitable for compact diagnostic imaging devices. Since mini mobile digital radiography systems require lightweight processing hardware, this method strongly aligns with project objectives. The embedded architecture reduces dependence on bulky workstations while maintaining adequate computational performance for basic image enhancement.

However, the limitation lies in restricted processing power compared to conventional desktop-based digital radiography systems. High-resolution X-ray image reconstruction and advanced deep learning inference may exceed Raspberry Pi's capability unless hardware acceleration is introduced.

Compared with conventional portable radiography systems, this approach significantly reduces cost and system complexity. For the proposed mini mobile digital radiography project, this paper provides a strong hardware implementation reference for embedded image acquisition and preprocessing. The concept demonstrates that compact single-board computing can effectively support portable radiographic image enhancement workflows.

## B. Portable Digital Radiography System with Source-Detector Angle Monitoring

This paper presents the development of a portable digital radiography system integrated with an X-ray source-detector angle monitoring mechanism. The core technique involves geometric alignment optimization using accelerometers, gyroscopes, Arduino control, and Bluetooth communication. Accurate source-detector alignment is critical in radiography because improper angulation leads to distortion, poor anatomical visibility, and diagnostic errors.

The system incorporates a flat-panel detector, portable X-ray source, and internal image correction processing. Signal-to-noise ratio, contrast-to-noise ratio, spatial resolution, and radiation dose performance were experimentally evaluated. The inclusion of real-time angle monitoring enhances imaging precision and improves reproducibility.

The major advantage of this work is clinical imaging accuracy. Portable radiography often suffers from positioning inconsistencies due to patient mobility constraints, especially in bedside imaging. This design solves that challenge through automated alignment feedback.

Its limitation is increased hardware complexity and cost due to additional sensors and monitoring electronics. Miniaturization also becomes challenging when integrating multiple subsystems.

Compared with Raspberry Pi-based portable systems, this method emphasizes imaging geometry rather than computational portability. For the mini mobile digital radiography project, this paper contributes valuable insights into detector positioning optimization and mechanical accuracy. Incorporating simplified angle sensing could significantly improve image consistency in the proposed portable diagnostic platform.

## C. Low-Cost Raspberry Pi-Based Diagnostic Imaging System

This study introduces a cost-efficient embedded diagnostic imaging framework using Raspberry Pi for medical image classification. The primary technique combines local feature extraction and lightweight classification algorithms suitable for resource-constrained embedded hardware. Instead of relying on computationally intensive deep neural networks, the system employs efficient feature descriptors and reduced-memory processing methods.

The main advantage is affordability and deployment feasibility in low-resource environments. Mini mobile radiography systems intended for rural healthcare or emergency applications benefit greatly from such lightweight architectures. Reduced computational demand enables faster inference with minimal energy consumption.

Another benefit is memory optimization, which allows embedded implementation without requiring GPU acceleration. This makes the system practical for compact mobile diagnostic platforms.

However, the limitation is reduced scalability for highly complex diagnostic tasks. Advanced disease detection using richer deep learning models may offer superior diagnostic accuracy but demand significantly greater hardware resources.

Compared with conventional AI-driven radiography systems, this approach prioritizes efficiency over maximum performance. For the proposed mini mobile digital radiography project, this study demonstrates that embedded medical image analysis is achievable using low-cost computing platforms. Integrating lightweight diagnostic intelligence into portable X-ray systems could improve

accessibility, making the final device more practical for decentralized healthcare screening applications.

## D. Large-Scale Chest X-ray Database for Computer-Aided Diagnosis.

This paper focuses on developing a large chest X-ray dataset and weakly supervised disease classification framework. The technique used is machine learning-based automated radiographic disease analysis using large annotated medical image repositories. The system applies image classification and disease localization methods for thoracic abnormality detection.

The key strength lies in enabling automated interpretation support. Mini mobile radiography systems can greatly benefit from embedded intelligent diagnostic assistance, particularly where radiologists are unavailable. Access to standardized disease datasets improves algorithm training reliability and diagnostic robustness.

Another advantage is scalability. AI models trained using large chest X-ray databases can generalize across diverse patient populations and imaging conditions.

The primary limitation is high computational demand. Training and deployment of advanced deep learning systems require substantial hardware resources not readily available in small embedded systems.

Compared with lightweight Raspberry Pi solutions, this approach prioritizes diagnostic intelligence rather than hardware portability. For the mini mobile digital radiography project, this study provides conceptual guidance for integrating future AI-assisted diagnosis modules. Although full-scale deployment may be impractical initially, simplified disease screening algorithms inspired by this work could improve the system's clinical usefulness.

## E. Medical Chest X-ray Enhancement Using CLAHE and Wiener Filter

This paper proposes a hybrid image enhancement technique combining Contrast Limited Adaptive Histogram Equalization (CLAHE) with Wiener filtering. The objective is improving chest X-ray quality by enhancing contrast while reducing noise. Medical X-ray images frequently suffer from poor visibility due to low contrast and acquisition noise, making enhancement essential before diagnostic interpretation.

The CLAHE technique enhances local image contrast without excessive amplification, while the Wiener filter suppresses additive noise using statistical estimation. Together, these methods improve peak signal-to-noise ratio, entropy, and diagnostic visibility.

A major strength is computational simplicity combined with effective enhancement performance. Unlike deep learning enhancement approaches, this hybrid method can be implemented efficiently on low-power embedded platforms.

The limitation is that traditional enhancement algorithms may not adapt optimally to all pathological image conditions compared with adaptive AI-based enhancement methods.

Compared with hardware-focused portable radiography systems, this work emphasizes image quality improvement at the software level. For the proposed mini mobile digital radiography project, this paper is highly relevant because image enhancement directly affects diagnostic usability. Integrating CLAHE-Wiener preprocessing into the portable system can significantly improve image clarity while maintaining manageable embedded computational requirements.

## F. Mobile Telemedicine-Based Healthcare Imaging Support System

This study presents a mobile telemedicine platform supporting remote healthcare monitoring and image transmission using wireless communication technologies. The primary technique involves remote medical data communication through mobile networks, satellite links, and telemedicine infrastructure.

The major advantage is enabling remote diagnosis and specialist consultation. Mini mobile digital radiography systems deployed in rural or emergency settings can benefit significantly from wireless transmission of X-ray images to expert clinicians. This expands diagnostic reach beyond physical hospital infrastructure.

Another strength is interoperability with multiple communication technologies, increasing operational flexibility across diverse environments.

The limitation is dependency on communication reliability and bandwidth availability. High-resolution radiographic image transmission may be constrained in low-connectivity regions.

Compared with standalone portable imaging systems, this work extends functionality toward connected healthcare ecosystems. For the mini mobile digital radiography project, telemedicine integration represents an important future enhancement. A portable X-ray unit with wireless image sharing capability would improve remote consultation, emergency triage, and healthcare delivery.

## III.CONCLUSION

The proposed Digital Mini Mobile Radiography System presents a comprehensive and efficient solution for portable medical imaging by integrating X-ray image acquisition, embedded processing, image enhancement, storage, and telemedicine communication into a single compact platform. Unlike conventional radiography systems that are bulky, expensive, and restricted to hospital environments, the proposed system is designed to be lightweight, cost-effective, and suitable for deployment in rural, remote, and emergency healthcare scenarios. The system utilizes a portable X-ray source and a flat panel detector to capture radiographic images, which are then converted into digital form and transferred to an embedded processing unit. The use of an embedded platform ensures low power consumption, compact size, and real-time processing capability, making the system practical for field applications. A key contribution of this work is the implementation of a hybrid image enhancement technique that combines Contrast Limited Adaptive Histogram Equalization (CLAHE) and Wiener filtering to improve image quality. This approach effectively enhances contrast, suppresses noise, and improves the visibility of important anatomical structures, thereby aiding accurate medical diagnosis. The effectiveness of the proposed enhancement method is validated through both qualitative and quantitative analysis. Experimental results demonstrate a significant reduction in Mean Square Error (MSE), along with an increase in Peak Signal-to-Noise Ratio (PSNR) and entropy values, indicating improved image clarity and information content. In addition to image processing, the system incorporates a storage module that maintains both original and processed images along with patient data for future reference and documentation. The integration of a telemedicine communication module further enhances the functionality of the system by enabling wireless

transmission of medical images and patient information to remote doctors or hospital systems using technologies such as Wi-Fi, GSM, or internet-based networks. This feature allows healthcare professionals to perform remote diagnosis and provide timely consultation without being physically present, which is particularly beneficial in underserved areas. The system also demonstrates reliable communication performance with minimal transmission delay and high success rate, ensuring efficient data transfer. Furthermore, the inclusion of a regulated power supply unit ensures stable and continuous operation in mobile environments, making the system suitable for use in ambulances, disaster management, and field healthcare services. Overall, the proposed system successfully addresses key challenges associated with traditional radiography by improving portability, reducing cost, enhancing image quality, and enabling remote healthcare access. It provides a scalable and practical solution that bridges the gap between medical imaging and telemedicine, ultimately contributing to improved healthcare delivery and patient outcomes in modern medical systems. In summary, the experimental results validate the effectiveness and reliability of the proposed system in enhancing image quality and enabling real-time remote diagnosis. The integration of portable radiography, embedded processing, and telemedicine makes it a practical solution for modern healthcare needs. Hence, the system has strong potential for real-world implementation, particularly in rural and emergency medical applications

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