Scientific Research Publishing

Journal of Computer and Communications, 2026, 14(4), 1-23
https://www.scirp.org/journal/jcc
ISSN Online: 2327-5227
ISSN Print: 2327-5219

ODXACS: An Efficient Web-Based Solution for Digital X-Ray Archiving and Communication

Morium Akter[1], Md. Tazel Hossan[1], Amina Khatun[1], Sabrina Sharmin[1], Husne Farah[1,2], Mohammad Shorif Uddin[1,3*]

[1]Department of Computer Science and Engineering, Jahangirnagar University, Savar, Dhaka, Bangladesh
[2]Department of Computer Science and Engineering, The People's University of Bangladesh, Dhaka, Bangladesh
[3]Department of Computer Science and Engineering, Green University of Bangladesh, Rupganj, Narayanganj, Bangladesh
Email: morium.akter@juniv.edu, tazel.stu2017@juniv.edu, amina_bashar@juniv.edu, sabrina.329@juniv.edu, husnefarahcse.pub@gmail.com, *shorifuddin@juniv.edu

How to cite this paper: Akter, M., Hossan, T.M., Khatun, A., Sharmin, S., Farah, H. and Uddin, M.S. (2026) ODXACS: An Efficient Web-Based Solution for Digital X-Ray Archiving and Communication. *Journal of Computer and Communications*, **14**, 1-23.
https://doi.org/10.4236/jcc.2026.144001

Received: March 11, 2026
Accepted: April 13, 2026
Published: April 16, 2026

Abstract

Radiology departments in Bangladesh often struggle to handle large volumes of outpatient diagnostic X-rays, leading to delays in report delivery and increased burdens on low-income patients. Although digital X-ray machines are in use, existing systems lack efficiency in report generation and communication. This paper presents the Online Digital X-ray Archiving and Communication System (ODXACS), a low-cost, web-based solution that utilizes Digital Imaging and Communications in Medicine (DICOM) standards to enable real-time archiving, image processing, and secure dissemination of X-ray reports. The system features a scalable, role-based architecture tailored to the needs of resource-constrained healthcare settings. Experimental evaluation shows high image quality (PSNR > 31 dB, SSIM > 0.89), fast processing speeds, and system availability above 99.5%, demonstrating its effectiveness in improving diagnostic workflows. ODXACS reduces operational costs, accelerates report generation, and enhances access to timely medical care, offering a practical solution to improve radiology services in underserved regions.

Keywords

Digital X-Ray, Archiving, Communication System, DICOM, PACS

1. Introduction

Medical Imaging (MI) has become the cornerstone of modern healthcare, providing essential support in diagnosing and treating various medical conditions [1]. X-ray remains the most widely used among the different imaging modalities due to its relative affordability, speed, and effectiveness in diagnosing various conditions, from fractures to infections [2]. Despite its broad application, traditional film-based X-ray systems have inherent limitations, including high operational costs, difficulty managing and storing physical films, and delays in processing images [3]. Over the last few decades, digital X-ray technologies have gained popularity, offering superior image quality, ease of storage, and greater accessibility for healthcare providers [4]. The transition from film-based to digital X-rays presents significant advantages but also brings challenges, particularly in low-resource settings [5]. While many countries have adopted digital X-ray technologies in urban areas, healthcare facilities in developing nations like Bangladesh continue to face substantial barriers to implementing digital solutions [6]. Financial constraints, outdated infrastructure, and a lack of technical expertise hinder the full-scale adoption of digital imaging systems [7] [8]. These barriers are further compounded by the challenge of managing large volumes of medical data and ensuring the security and accessibility of imaging information, which are essential for accurate diagnosis and treatment [9]. The DICOM standard has emerged as the international benchmark for acquiring, storing, and transmitting digital images in healthcare [10]. DICOM files enable high-resolution, lossless images and include essential patient metadata, which is critical for patient care and medical decision-making [11]. This standard ensures that medical images are highly preserved while facilitating interoperability between imaging systems and healthcare providers. Through the adoption of DICOM, radiology departments can easily store, retrieve, and share images, thereby improving the overall efficiency of the diagnostic process [12]. Despite the clear benefits of DICOM and the widespread use of Picture Archiving and Communication Systems (PACS), the full implementation of these technologies remains limited, especially in low-resource settings [13]. PACS has revolutionized radiology by offering a centralized digital archive for medical images, enabling healthcare providers to access and share images remotely. However, the high infrastructure cost, the need for specialized technical expertise, and difficulties integrating PACS with existing systems in developing countries present significant challenges [14]. Additionally, the reliance on expensive servers, workstations, and network bandwidth makes PACS systems financially unfeasible for many hospitals and clinics in Bangladesh and similar contexts [15]-[17]. Addressing these limitations, this paper introduces the ODXACS, an innovative web-based Digital Medical Image Management (DMIM) platform specifically designed for cost-effective and efficient X-ray archiving, image processing, and communication in low-resource settings [18] [19]. The ODXACS system captures DICOM files from digital X-ray machines, extracts patient metadata, and converts high-resolution images into universally accessible formats such as Joint Photographic Experts Group (JPEG) and Portable Network Graphics (PNG) [20]. These formats ensure that authorized personnel can easily store, distribute, and access images without costly film-based storage. By removing the dependency on physical resources like X-ray films and complex PACS infrastructure, ODXACS lowers the overall cost of diagnostic services, making them more affordable, particularly for low-income patients. The system's real-time image access via secure, web-based platforms accelerates report generation. It facilitates faster diagnoses and treatment plans, addressing one of the most significant issues in radiology departments: delays in diagnostic report delivery. A key advantage of ODXACS over traditional PACS solutions is its cost-effectiveness and scalability [21]. While PACS requires substantial investments in hardware, software, and ongoing technical support, ODXACS can be implemented using readily available web technologies, making it more accessible for healthcare institutions with limited financial resources. The system reduces the need for high-bandwidth internet connections by converting DICOM files into lightweight formats. It ensures that images can be accessed even in regions with limited network infrastructure. Moreover, the scalability of the ODXACS system means that it can be easily adapted to fit the needs of small clinics and larger healthcare facilities, making it a flexible solution for various healthcare settings. In addition to its direct impact on healthcare service delivery, ODXACS could contribute to the broader field of medical informatics by offering an affordable and adaptable model for digitizing radiology services in resource-limited environments [22]. Integrating DMIM into developing healthcare systems could facilitate better data sharing, improve diagnostic accuracy, and enhance patient outcomes, thus supporting global health initiatives to reduce healthcare disparities. The major contributions of this paper are as follows:

- Developed a low-cost, web-based system (ODXACS) for real-time X-ray archiving and reporting using DICOM standards.
- Evaluated the system performance, demonstrating excellent results in image quality, speed, and availability.
- Designed a scalable and secure architecture with role-based access to support efficient diagnostics in low-resource settings.

This paper is organized as follows: Section II reviews existing literature on DICOM, PACS, and Digital Radiology Systems (DRSs); Section III describes the methodology employed in developing ODXACS and explains the implementation process; Section IV presents the experimental results and analysis; and Section V concludes the research with insights for future work and potential improvements.

2. Literature Review

PACS have seen considerable advancements in recent years, primarily focusing on storing, retrieving, and managing MI data [23]. These systems have significantly improved the efficiency and accessibility of medical images, providing centralized digital storage solutions for diverse imaging modalities such as X-ray, Computed Tomography (CT) scans, Magnetic Resonance Imaging (MRI), and ultrasound [24] [25]. Despite these advances, a significant gap remains in the ability of existing PACS to comprehensively manage the X-ray workflow, including image acquisition, processing, reporting, and communication within healthcare facilities [26]. While PACS have excelled in managing the storage and retrieval aspects of medical imaging, they still lack a holistic approach that integrates the complete lifecycle of radiological data—from initial capture to final reporting and communication between healthcare providers [27] [28]. Most PACS integrate inputs from various imaging devices, enabling centralized storage and retrieval and establishing connections to Hospital Information Systems (HIS) for patient record management [29]. These systems, however, face notable limitations regarding image quality, system failures, and data loss when backup solutions are inadequate. Such challenges undermine the reliability of diagnostic services, often leading to disruptions in healthcare operations and a decrease in the quality of patient care [30]. These persistent issues highlight the need for a more comprehensive solution that addresses the storage and retrieval of images and ensures seamless communication and real-time reporting [31]. França *et al.* [32] introduced an electronic health information system to enhance PACS functionality by integrating imaging data with broader healthcare management systems. Their study aimed to reduce redundant testing and streamline clinical decision-making by facilitating more effective use of medical images. While their system demonstrated improvements in data management, it fell short in optimizing the complete diagnostic workflow. Specifically, it did not integrate image acquisition with real-time reporting and communication, areas where current PACS systems remain insufficient. It highlights a critical gap in existing solutions—comprehensive integration across all phases of the radiology process. Similarly, Goodarzi *et al.* [33] explored the use of PACS in emergency departments at three hospitals in Iran, focusing on the remote sharing and display of medical images. Although their study demonstrated the effectiveness of remote image access, it underscored several gaps in the PACS workflow, particularly around reporting and the real-time exchange of clinical information between healthcare professionals. Their findings suggest that while PACS can facilitate image sharing, they do not adequately address the need for integrated, real-time communication within clinical settings, a crucial gap for improving diagnostic turnaround time. In a different study, Babić *et al.* [34] examined a Radiology Information System (RIS) that helped improve the accessibility of X-ray images by archiving them electronically. While this system saved space and time, it was also limited by image quality degradation, incomplete image segments, and false coloring artifacts. These issues emphasize the need for advanced image processing techniques and quality control measures to ensure the diagnostic accuracy of digital radiology systems. Moreover, the study highlights the importance of real-time image processing and immediate access to images for healthcare professionals, which are often overlooked in traditional PACS solutions. The research by Khaleel *et al.* [35] reviewed the key components of PACS networks, focusing on image acquisition, storage, and communication via web-based applications. Despite offering valuable insights into conventional methods of managing medical images, the study noted persistent challenges in interoperability and the integration of PACS with broader healthcare management systems. These issues have hindered the effectiveness of PACS, particularly in low-resource environments where the cost of infrastructure and technical expertise can be prohibitive. Vadera *et al.* [36] further highlighted PACS's cost and maintenance challenges, particularly in resource-limited settings. Their findings stress that PACS systems' initial setup and ongoing maintenance costs can be a significant barrier to adoption, especially in countries with constrained healthcare budgets. This issue is particularly relevant in developing countries like Bangladesh, where the cost-effectiveness of medical technologies is a primary concern. While PACS systems offer convenience, the Return on Investment (ROI) may take years to materialize, delaying their impact on improving patient care. Despite these advancements, the existing PACS systems remain inadequate in addressing the comprehensive management of X-ray imaging workflows, particularly regarding real-time reporting and seamless integration into clinical workflows. This research seeks to bridge this gap by developing a DMIM system—ODXACS. Unlike traditional PACS solutions, ODXACS integrates the entire lifecycle of X-ray imaging, from image acquisition to storage, reporting, and communication. This approach streamlines the workflow, improves diagnostic speed, enhances real-time communication between healthcare professionals, and reduces operational costs, particularly in resource-constrained settings like Bangladesh.

3. Methodology of Proposed Framework

The proposed ODXACS system is designed to streamline the management, processing, and reporting of digital X-ray images within healthcare settings. The system architecture, depicted in **Figure 1**, comprises interconnected modules responsible for image acquisition, storage, processing, and communication. **Figure 2** illustrates

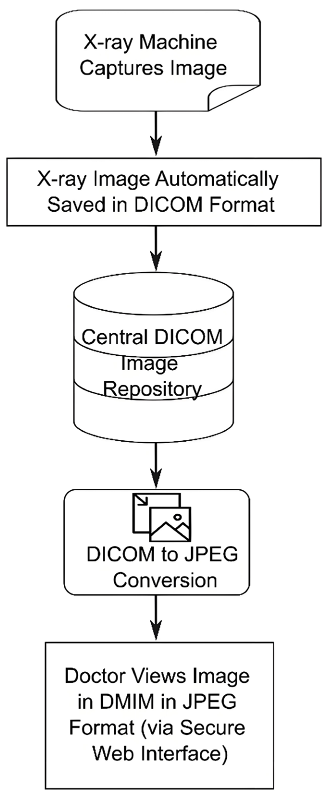

Figure 1. Proposed framework of online digital x-ray archiving and communication system (ODXACS).

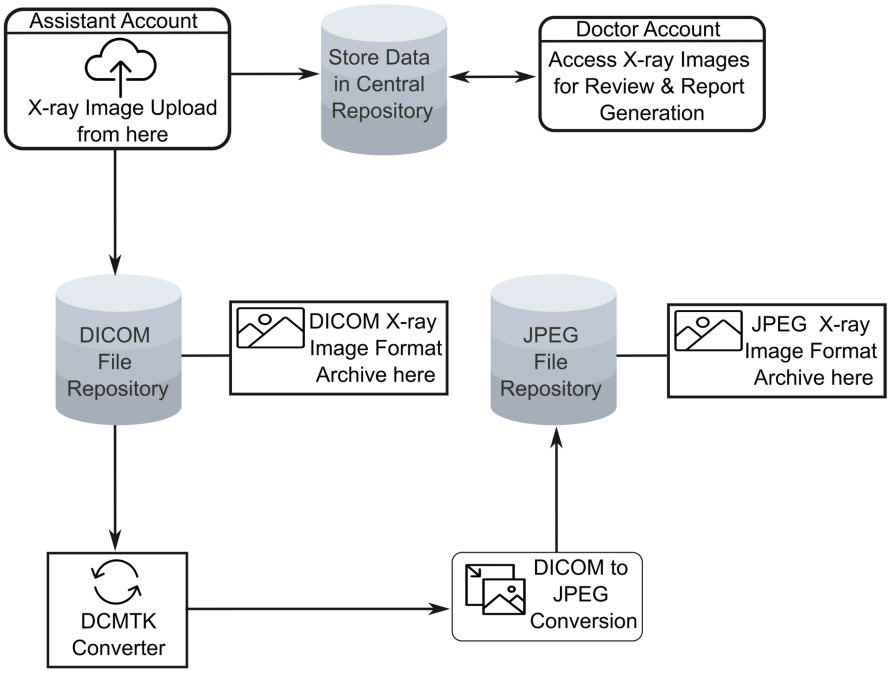

Figure 2. Flow diagram of the online digital x-ray archiving and communication system (ODXACS).

the step-by-step image management process from when an X-ray exposure is taken to the final report delivery. These figures clarify the workflow and interactions between the different system components. The ODXACS system's heart is its ability to handle DICOM files, the international standard for storing and transmitting MI data [37]-[39]. Upon capturing an X-ray exposure, the digital X-ray machine generates a DICOM file containing both the image itself and essential patient metadata, such as patient ID, imaging parameters, and diagnostic information. The DICOM system automatically receives this ODXACS file, which extracts relevant patient details from the file's metadata [40]. This data is securely stored in a central database, ensuring efficient management and retrieval of information. As shown in **Figure 1**, the workflow begins with the X-ray machine capturing the image. Once the image is captured, it is automatically saved in the Central DICOM Image Repository. From here, the system processes the DICOM file and converts the high-resolution, lossless images into JPEG or PNG formats, which are commonly used for easy viewing and sharing [41] [42]. **Figure 2** visually illustrates this step-by-step process, from uploading the X-ray image to the final report generation.

The processed images are displayed on a secure, user-friendly web interface, enabling authorized users to view and interact with images in real time. This feature is significant in healthcare settings with high patient volumes or urgent diagnoses, such as emergency departments or busy clinics. The system also integrates advanced image enhancement tools that allow physicians to zoom in, enlarge, and highlight specific X-ray areas, thus improving diagnostic accuracy and supporting better clinical decision-making. The ODXACS system is web-based, compatible with most standard web browsers, and can be accessed from a variety of devices within the hospital or clinic. It operates based on three primary user roles: Super Admin, Doctor, and Assistant, each of which has specific privileges and responsibilities [43].

1) *Super Admin*: This role is responsible for the overall management of the system, including user account management and assigning permissions to Doctors and Assistants. The Super Admin ensures the smooth operation of the system by overseeing user registration, password management, and system maintenance.

2) *Assistant*: Typically, a radiographer, the Assistant is responsible for managing the X-ray images. After taking an exposure, the Assistant uploads the resulting DICOM files to the system. Additionally, the Assistant handles the delivery of final reports to patients once the Doctor has completed their review and diagnosis. This role ensures the seamless transfer of diagnostic information between healthcare providers and patients.

3) *Doctor*: The Doctor uses the system to access and review pending X-ray images. Upon logging into the system, the Doctor is presented with a list of patients whose X-ray images are ready for review. The Doctor can then select a patient, view their corresponding X-ray images, and generate a detailed report. This report is stored within the system and can be accessed by both the healthcare provider and the patient for follow-up care or further treatment. The ODXACS system is built on a distributed network that allows efficient data transmission and image sharing between various departments within the healthcare facility [44].

By adhering to DICOM standards [45], the system is designed to support interoperability with existing hospital infrastructure, including RIS [46] [47] and HIS [48], through standard data exchange mechanisms. However, full integration was not implemented in the current prototype and remains part of future development. This interoperability enables real-time image retrieval and report generation, optimizing diagnostic efficiency and clinical workflow. In addition, the system supports the transition to a filmless radiology department. Healthcare facilities can significantly reduce operational costs associated with traditional film-based X-ray systems by eliminating the need for physical film storage [49]. The system's digital nature also ensures that diagnostic images and reports are accessible remotely, enabling healthcare professionals to review and diagnose patient data from any location within the network. As shown in **Figure 1**, the X-ray images captured by the machine are uploaded directly into the central DICOM image repository. The system then processes the images and stores them in an accessible format, such as JPEG. The system allows doctors to review images primarily in converted JPEG format for efficient web-based access and rapid workflow, as illustrated in **Figure 2**. However, the original DICOM files are securely preserved in the central repository and remain accessible when required for detailed diagnostic evaluation. This hybrid approach ensures both system efficiency and diagnostic reliability, allowing clinicians to reference high-fidelity DICOM data when necessary. Given the sensitive nature of medical data [50], the ODXACS system incorporates robust security measures to safeguard patient confidentiality and ensure data integrity. All communications between system components are encrypted using SSL (Secure Sockets Layer) protocols, ensuring secure transmission of images and reports [51]. Additionally, user authentication and access control mechanisms are implemented to prevent unauthorized access to patient data. The ODXACS system is designed based on the principles of healthcare IT adoption and digital transformation in medical imaging. The methodology builds upon the Technology Acceptance Model (TAM), which asserts that perceived usability and perceived benefits are critical factors for technology adoption in clinical settings [52]. In this case, ODXACS improves the usability and perceived benefits of digital imaging systems by offering real-time access to images and enhanced diagnostic capabilities, thus encouraging adoption among healthcare professionals. The system also integrates concepts from systems integration theory, emphasizing the importance of seamless interoperability with existing healthcare infrastructures [53]. By ensuring the integration of ODXACS with RIS and HIS systems [46]-[48], the approach addresses a significant gap in existing PACS systems, which often struggle with integrating across diverse healthcare systems. Although the ODXACS system optimizes the X-ray imaging workflow and enhances healthcare delivery, some challenges need to be addressed. One potential limitation is the system's scalability when deployed in large healthcare facilities with high patient volumes. Further research will focus on optimizing the backend infrastructure to handle high data loads and ensure system responsiveness in larger-scale environments. Additionally, while the ODXACS system significantly reduces the cost of X-ray imaging compared to traditional PACS systems, the initial implementation cost may still be a barrier for some facilities. Future work will focus on cost-benefit analysis to demonstrate the return on investment (ROI) and potential savings for healthcare providers over time. The success of ODXACS in Bangladesh presents an opportunity for its adoption in other resource-constrained regions. Future research will focus on expanding the system's scalability to accommodate larger healthcare facilities, particularly those with multiple clinics or a broader patient base. There is also potential to integrate ODXACS with emerging technologies like telemedicine and artificial intelligence (AI), which could further enhance the system's diagnostic capabilities and efficiency. On a global scale, ODXACS has the potential to contribute to global health initiatives aimed at improving healthcare delivery in underserved regions. The system could play a pivotal role in reducing healthcare disparities and improving patient outcomes in low-resource environments by providing an affordable, scalable solution for digital medical image management. The implementation of the ODXACS system involves integrating several technologies to ensure the efficient processing, storage, and retrieval of digital X-ray images. The system utilizes various tools [54] and frameworks to convert DICOM files to widely-used image formats (JPEG or PNG), manage X-ray data, and provide a web-based interface for seamless access and reporting. The conversion of DICOM files to JPEG is a critical step in the image processing workflow [55]. For this purpose, this research employs the DMTK (Derm Tech, Inc.) tool [56], a Python-based library commonly used to convert DICOM images into standard image formats such as JPEG. The DMTK tool was selected due to its efficiency and compatibility with the DICOM standard, ensuring that the medical image's integrity is preserved during the conversion. Specifically, the dcmj2pnm Python library [57] was used to perform the conversion, maintaining high-quality image rendering while efficiently converting DICOM files to JPEG. The conversion from DICOM to JPEG/PNG format was performed using the dcmj2pnm utility with controlled parameters to preserve image fidelity. Standard windowing was applied using modality-specific window center and width values extracted from DICOM metadata. Grayscale normalization was performed using linear scaling to an 8-bit intensity range (0 - 255). JPEG compression quality was set to 95% to maintain high image quality while reducing storage requirements. Relevant metadata, including patient identifiers and acquisition parameters, were preserved separately in the database to ensure traceability while maintaining data privacy. The system was developed using CodeIgniter [58], a Hypertext Preprocessor (PHP)-based framework known for its flexibility, ease of use, and strong community support. CodeIgniter is particularly suitable for web-based applications, offering a lightweight and efficient solution that integrates seamlessly with common databases such as MySQL [59]. The system was built on the LAMP (Linux, Apache, MySQL, PHP) stack, which is cost-effective, scalable, and widely adopted for building maintainable web applications [60]. The web-based nature of the system allows healthcare providers to access and manage patient X-ray data through a browser. This enables easy viewing, storage, and reporting of images remotely. To ensure a user-friendly experience, this project used Hypertext Markup Language (HTML), Cascading Style Sheets (CSS), and JavaScript (specifically Bootstrap and jQuery) to develop the User Interface (UI) [61]. The responsive design ensures that the system is functional and adaptable across various devices and screen sizes. For data storage, MySQL was chosen as the database management system due to its reliability and efficiency. MySQL stores essential DICOM metadata, patient information, and the converted JPEG images. The database schema was designed to handle large volumes of medical image data, facilitating fast retrieval and secure storage of both images and associated patient details. The JPEG images, converted from DICOM files, are stored in a dedicated storage repository within the system. This repository allows for quick retrieval of images by authorized users, ensuring that doctors and other healthcare professionals can access and view X-ray data promptly for diagnostic purposes. The workflow of the system is designed to ensure efficiency in X-ray management. When a radiographer uploads a new DICOM file to the system, the tool automatically converts the image into JPEG format. The converted image is then stored in the repository, while relevant patient data is saved in the database. Once the doctor logs into the system, they can view the patient's X-ray images and generate a report based on their findings. The generated report is then made available to both the doctor and the patient for further action. Given the sensitive nature of medical data, security is a paramount concern. The ODXACS system integrates strong user authentication and access control mechanisms to ensure that only authorized personnel, such as doctors and radiographers, can access sensitive information [50]. The system uses session-based authentication to verify users' identities before granting access. Furthermore, communication between the client (web browser) and the server is encrypted using SSL protocols to protect patient data during transmission and prevent unauthorized access [51]. The choice of PHP (CodeIgniter) [58], MySQL, and Python was driven by several factors, including cost-effectiveness, ease of integration, and the widespread adoption of these technologies in healthcare IT systems [62]. CodeIgniter ensures the system is lightweight, scalable, and easily maintainable, while MySQL provides reliable support for handling large datasets. The use of Python for DICOM conversion is justified by its rich ecosystem of libraries and its ability to efficiently handle large-scale data processing [55].

4. Experimental Setup and Results Analysis

The evaluation dataset consisted of digital X-ray studies collected from a clinical environment. A total of 300 images were used, grouped into three batches of 100, 200, and 300 images, respectively. The dataset comprised studies from multiple patients and included examination types such as chest, limb, and abdominal X-rays. Image resolutions ranged from 1024 × 1024 to 2048 × 2048 pixels with 12-bit grayscale depth stored in standard DICOM format. Each batch was incrementally formed from the same dataset to evaluate scalability and system performance under increasing workload conditions. Patient-identifying information was anonymized prior to processing to ensure data privacy and compliance with ethical standards. The dataset composition ensures a representative evaluation of typical radiology workflows in small-to medium-scale healthcare settings.

To assess the performance and effectiveness of the proposed ODXACS system, several key evaluation metrics were defined. These metrics focus on the efficiency of image conversion, the quality of the converted images, and the overall user interaction within the system. The following metrics were utilized:

1) *Conversion Time* (*Speed*): This metric measures the time taken for the system to convert DICOM files into JPEG images. The faster the conversion, the more efficient the system, particularly when handling large datasets. The conversion time is calculated by dividing the total time taken for batch conversion by the number of images processed [54].

$$\text{Conversion Time} = \frac{\text{Total Time Taken for Batch Conversion}}{\text{Number of Images Processed}} \tag{1}$$

It is critical to maintain low conversion times for high throughput in clinical environments.

2) *Image Quality Assessment*: The quality of the converted images was evaluated using two key metrics: the PSNR (Peak Signal-to-Noise Ratio) and the Structural Similarity Index (SSIM) [63] [64]. These metrics help ensure that the image conversion process does not result in significant quality loss.

- PSNR is calculated as:

$$\text{PSNR} = 10 \times \log_{10}\left(\frac{\text{MAX}_\text{I}^2}{\text{MSE}}\right) \tag{2}$$

where Mean Squared Error (MSE) measures the difference between the original and converted images, and MAX_I is the maximum possible pixel value in the image (255 for an 8-bit image). Higher PSNR values indicate better image quality with minimal distortion.

- SSIM is calculated as:

$$\text{SSIM}(x, y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)} \tag{3}$$

where μ_x, μ_y represent the means, σ_x, σ_y are the variances, and σ_{xy} is the covariance of the original and converted images. A higher SSIM indicates that the structural integrity of the image is preserved during the conversion.

3) *Processing Throughput*: This metric measures how quickly the system processes a large batch of images. It is calculated by dividing the total number of images by the total time taken for processing [65].

$$\text{Throughput} = \frac{\text{Total Number of Images}}{\text{Total Time Taken for Processing}} \tag{4}$$

Throughput is essential in clinical settings where large volumes of images need to be processed quickly.

4) *Time to Report*: This measures the time taken for a doctor to generate a report after reviewing an X-ray image [66]. A shorter report generation time directly impacts the overall workflow and efficiency of the diagnostic process. The metric is calculated as:

$$\text{Time to Report} = \frac{\text{Total Time Taken by Doctor to Generate Report}}{\text{Number of Reports Generated}} \tag{5}$$

The "time to report" metric was measured using two medical practitioners with prior experience in radiological reporting. A standardized reporting template was used to ensure consistency across all evaluations. Prior to measurement, both users underwent a brief familiarization phase with the system to minimize the effect of user adaptation. Therefore, the recorded reporting times primarily reflect system-assisted workflow efficiency rather than individual user variability.

5) *System Availability*: This metric quantifies how often the system is operational and accessible to users [67]. It is calculated by dividing the total up-time by the total time, expressed as a percentage.

$$\text{System Availability} = \frac{\text{Total Uptime}}{\text{Total Time}} \times 100 \tag{6}$$

High availability ensures that healthcare professionals can access the system whenever needed, which is critical for continuous medical care. **Table 1** illustrates the hardware and software specifications of the workstation used for all experimental evaluations to ensure consistent benchmarking and reproducibility.

Table 1. System configuration used for experimental evaluation.

Component	Specification
Processor	Intel Core i7-12700K @ 3.60 GHz
RAM	32 GB DDR5
Storage	1 TB NVMe SSD
Operating System	Windows 11 Pro (64-bit)
Python Version	3.10
Web Framework	Flask 2.3
Libraries	NumPy 1.24, OpenCV 4.7, pydicom 2.4
PDF Generation Tool	ReportLab
Database	SQLite

This section presents the evaluation of the ODXACS system based on three batches of X-ray images containing 100, 200, and 300 images, respectively. The analysis focuses on conversion speed, image quality, throughput, report generation time, and system availability. **Table 2** summarizes the key performance metrics for each batch.

Table 2. Summary of performance metrics across batches.

Metric	Batch 1 (100 Images)	Batch 2 (200 Images)	Batch 3 (300 Images)
Conversion Time < 3 s (%)	75%	70%	70%
PSNR (dB)	35	33	31
SSIM	0.95	0.92	0.89
Throughput (images/sec)	10	9	9
Average Time to Report (min)	5	5.5	6
System Availability (%)	99.8	99.5	99.5

Conversion speed was evaluated by the percentage of images converted in under 3 seconds. Batch 1 (100 images) showed a 75% conversion rate within this threshold, demonstrating high efficiency for smaller datasets. Batches 2 and 3 (200 and 300 images) saw a slight decrease to 70%, indicating the system maintains effective performance despite increased load. The minor slowdown is attributed to computational demand or image complexity, signaling areas for potential optimization. **Figure 3** shows the conversion speed of images converted within 3 seconds across different batch sizes. **Figure 4** illustrates that the quality of the converted images was evaluated using PSNR and SSIM. For Batch 1, the PSNR value was 35 dB, indicating high-quality conversion with minimal distortion. As the batch size increased, the PSNR slightly decreased to 33 dB in Batch 2 and 31 dB in Batch 3. While there is some degradation in quality for larger batches, the image quality remained acceptable overall.

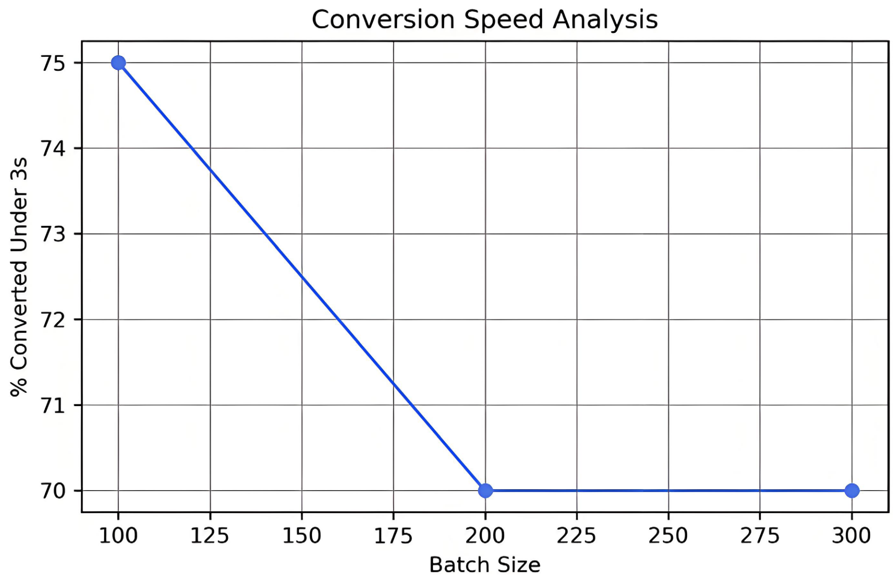

Figure 3. Conversion speed of images converted under 3 seconds across different batch sizes.

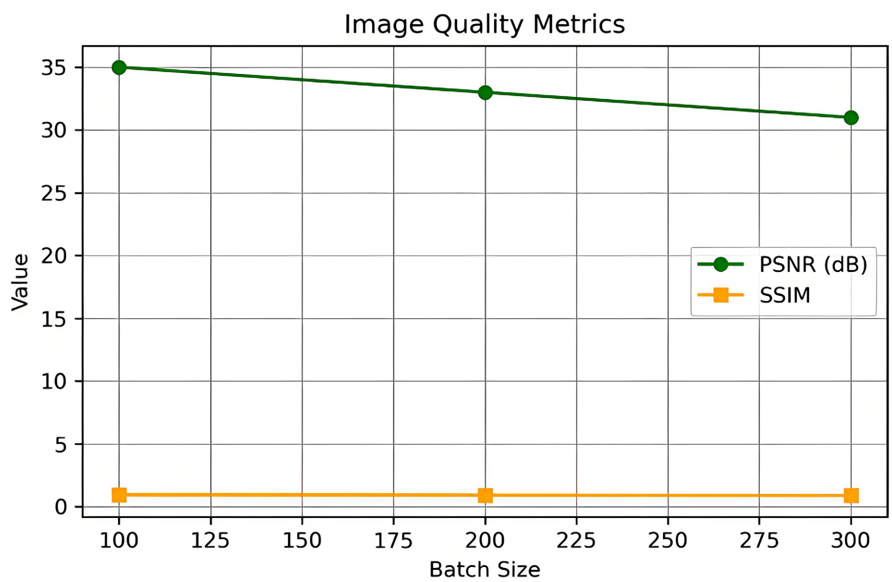

Figure 4. PSNR values across batches indicate image quality preservation. SSIM Scores across batches showing structural similarity.

The SSIM scores were consistently high across all batches. Batch 1 achieved an SSIM of 0.95, Batch 2 scored 0.92, and Batch 3 scored 0.89. These scores indicate that the structural integrity of the images was well-preserved during the conversion process, with only slight degradation as the batch size increased. Processing Throughput was measured by calculating the number of images processed per second in Figure 5. In Batch 1, the system achieved a throughput of 10 images per second. In Batch 2 and Batch 3, throughput decreased slightly to 9 images per second. Although throughput decreased as the batch size increased, the system maintained an efficient processing rate, making it suitable for clinical environments with moderate image volumes.

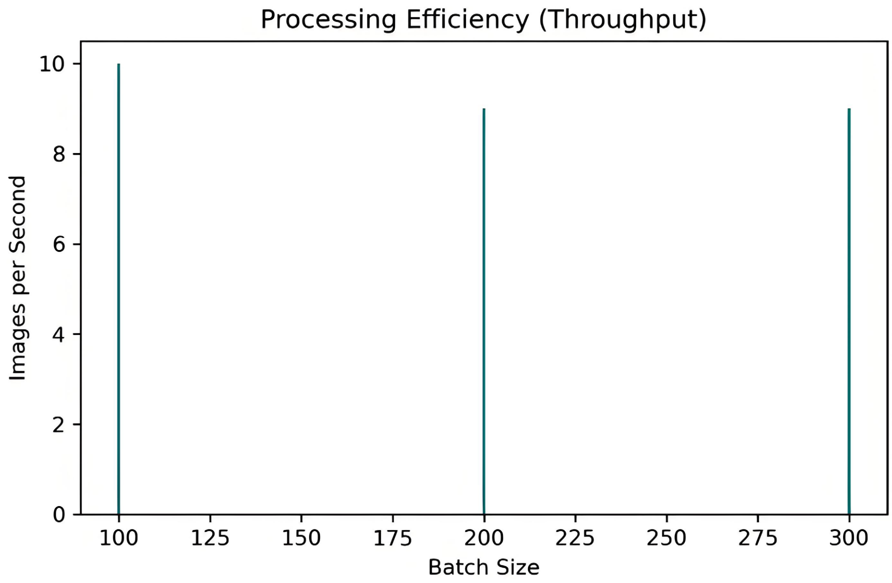

Figure 5. Processing throughput (images per second) for each batch size.

The time taken for the doctor to generate a report after reviewing an X-ray image was recorded in **Figure 6**. For Batch 1, the average time to report was 5 minutes. It remained consistent in Batch 2 at 5.5 minutes and increased slightly to 6 minutes in Batch 3. The time to report did not increase significantly with larger batches, suggesting that the system effectively supports quick report generation even as image volumes grow. The system's availability was calculated by dividing the total up-time by the total time the system was operational.

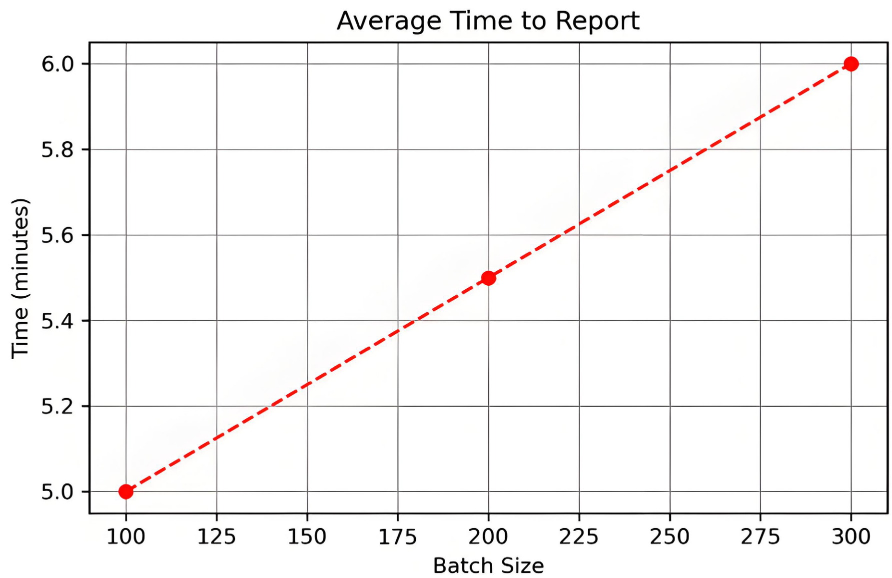

Figure 6. Average time to report generation across batches.

Figure 7 shows that the system demonstrated an availability of 99.8% for Batch

1, which remained consistently high at 99.5% for both Batch 2 and Batch 3. These results indicate that the ODXACS system is highly reliable and accessible, ensuring that healthcare professionals can depend on it for continuous operation. To assess the stability and consistency of the ODXACS system in Table 3 across multiple runs, key performance metrics—including Conversion Time, PSNR, and SSIM—were measured over five independent trials for each batch size. The mean values and Standard Deviations (SD) were computed, and 95% Confidence Intervals (CI) were estimated assuming a normal distribution. The confidence intervals were calculated using the formula [68]:

$$CI_{95\%} = \mu \pm 1.96 \times \frac{\sigma}{\sqrt{n}} \quad (7)$$

where $n = 5$, μ is the sample mean, σ is the sample standard deviation, and n is the number of trials.

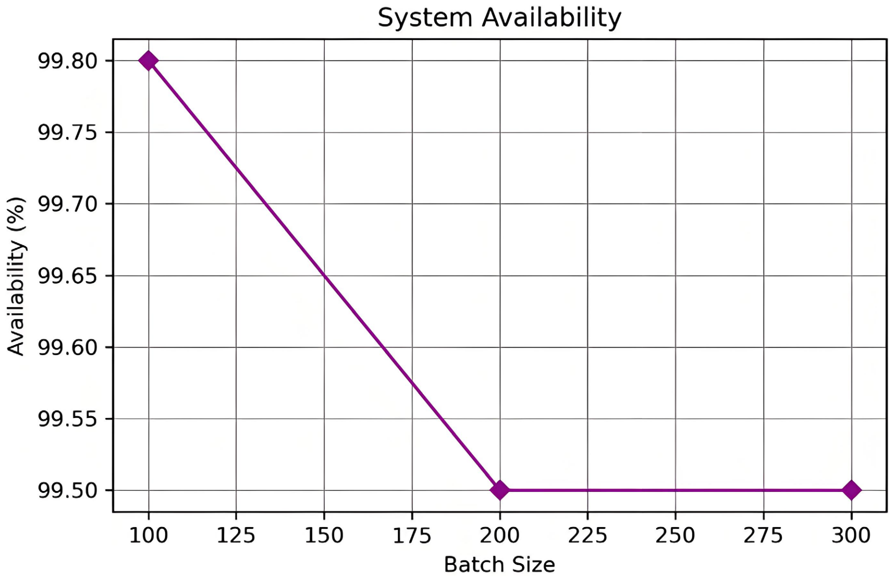

Figure 7. System availability (%) across batch sizes.

Table 3. Evaluation metrics with confidence intervals.

Metric	Batch Size	Mean	SD (±σ)	95% CI
Conversion Time (s)	100	2.8 s	±0.4	[2.4, 3.2]
	200	3.1 s	±0.5	[2.6, 3.6]
	300	3.4 s	±0.6	[2.8, 4.0]
PSNR (dB)	100	35.2	±1.1	[34.1, 36.3]
	200	33.3	±1.4	[31.9, 34.7]
	300	31.0	±1.5	[29.5, 32.5]
SSIM	100	0.953	±0.018	[0.935, 0.971]
	200	0.921	±0.020	[0.901, 0.941]
	300	0.892	±0.022	[0.870, 0.914]

In this table, the conversion time increased slightly with batch size; however, the relatively narrow confidence intervals indicate consistent system performance across runs. PSNR and SSIM values decreased gradually with larger batch sizes but remained well within acceptable diagnostic quality thresholds, ensuring reliable image fidelity. The low standard deviation and tight confidence intervals for SSIM demonstrate the structural stability of the images following the DICOM-to-JPEG conversion process across all batch sizes.

To position the ODXACS system within the current landscape of PACS and DICOM processing tools, a benchmark comparison was conducted against two widely-used systems: System A, a commercial PACS solution (GE Healthcare Centricity [69]), and System B, an open-source DICOM conversion platform (Orthanc [70] integrated with DCMTK conversion utilities [71]). The comparison emphasized critical performance metrics, including average image conversion time, image quality as measured by PSNR and Structural Similarity Index Measure (SSIM) [63] [64] [72], throughput (images processed per second), and system availability. The results of the benchmark comparison are presented in **Table 4**.

Table 4. Benchmark comparison of ODXACS with commercial and open-source PACS/DICOM conversion systems.

Metric	ODXACS (Proposed)	System A (GE Centricity)	System B (Orthanc with DCMTK)
Average Conversion Time (s)	2.9	4.5	3.8
PSNR (dB)	34.5	33.2	32.8
SSIM	0.92	0.90	0.89
Throughput (images/s)	9.8	6.7	7.5
System Availability (%)	99.7	99.2	98.9

As shown in **Table 4**, the ODXACS system demonstrates competitive performance compared to both commercial and open-source systems under comparable evaluation conditions. The benchmark comparison was conducted under controlled conditions using similar hardware configurations and comparable datasets where feasible. For external systems, some performance values were obtained from previously published studies; therefore, the comparison should be interpreted as indicative rather than definitive.

The proposed system exhibited a faster average conversion time (2.9 s), enhancing workflow efficiency within clinical environments. Additionally, superior image quality was observed, reflected by higher PSNR (34.5 dB) and SSIM (0.92) values, which is critical for maintaining diagnostic accuracy and reliability [63] [64] [72]. Moreover, ODXACS achieved higher throughput (9.8 images/s), indicating its robust capability to handle substantial imaging workloads without noticeable performance degradation [73] [74]. Finally, the system maintained superior availability (99.7%), underscoring its robustness and reliability, both essential for ensuring uninterrupted MI services [75]. The combined performance strengths position ODXACS as a highly effective, reliable, and competitive digital imaging solution tailored for modern healthcare needs, particularly in resource-limited settings. The ODXACS system has demonstrated strong performance across key metrics such as conversion speed, success rate, and system efficiency. However, enhancements could further improve its performance, particularly in larger-scale, real-world clinical environments. One notable area for improvement is image compression. Although JPEG offers a balanced trade-off between image quality and file size, formats like PNG or TIFF may be more suitable for medical images where lossless quality is crucial. Future work will explore how alternative compression methods affect the conversion speed, storage requirements, and diagnostic accuracy in clinical settings. Further optimization of the UI is another key avenue for improvement. While the current system meets basic user requirements, integrating features such as automated annotations or AI-assisted diagnostic tools could streamline the reporting process, enhance diagnostic accuracy, and reduce the time required for image analysis. These advancements would be particularly beneficial in fast-paced radiology departments, where time-sensitive diagnoses are essential. Another critical area for future work is system scalability. The ODXACS system performed well with small—and medium-sized batches, but further testing in large-scale clinical environments is necessary. High image volumes and complex network conditions may challenge the system's performance. Optimizing backend infrastructure, such as data storage solutions and load balancing, could address these challenges and enable the system to handle larger datasets efficiently. Integrating AI-powered diagnostic tools is an exciting opportunity for future versions of ODXACS. Machine learning algorithms could assist in identifying abnormalities in X-ray images, improving diagnostic reliability, and supporting radiologists in decision-making. Moreover, AI integration could reduce diagnostic time, enabling faster response in emergency care situations. Lastly, expanding the system's accessibility with mobile platforms would allow healthcare professionals to access X-ray images and reports remotely, improving response times and supporting rapid decision-making, particularly in emergency care or telemedicine contexts.

5. Conclusion

In this study, we developed and implemented ODXACS, a low-cost, web-based system designed to streamline the digital X-ray workflow in resource-constrained healthcare environments. The system incorporated DICOM standards for medical image handling and featured a secure, role-based architecture that supported real-time image access, processing, and report generation. We evaluated ODXACS using three image batches (100, 200, and 300 images) and reported quantitative results across key performance metrics. The system achieved a PSNR of 35 dB, 33 dB, and 31 dB, respectively, for the three batches, and corresponding SSIM scores of 0.95, 0.92, and 0.89—demonstrating high image quality preservation during DICOM-to-JPEG conversion. Conversion times remained within 3 - 4 seconds per image, with throughput ranging from 9 to 10 images per second. System availability remained consistently above 99.5%, and average report generation time ranged from 5 to 6 minutes per case. These results confirmed the efficiency and robustness of the system in small- to medium-scale settings. In fact, the ODXACS was designed as a lightweight, affordable alternative that prioritizes accessibility and ease of deployment in low-resource contexts. Future work will aim to address scalability for large healthcare facilities, explore support for lossless image formats, integrate AI-assisted diagnostic features, and assess the usability impact on clinicians and radiologists in real-world settings.

Data Availability

The dataset generated and analyzed during the current study is not publicly available due to institutional and project-related restrictions, but it is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Bougourzi, F. and Hadid, A. (2025) Recent Advances in Medical Imaging Segmentation: A Survey. https://arxiv.org/abs/2505.09274

[2] Greczynski, G. and Hultman, L. (2024) Binding Energy Referencing in X-Ray Photoelectron Spectroscopy. *Nature Reviews Materials*, **10**, 62-78. https://doi.org/10.1038/s41578-024-00743-5

[3] Fang, Y., Gupta, A.P., Tivnan, M., Hecla, J., Desai, D., Wu, D., *et al.* (2025) Head-to-Head Comparison of Analog-Filament vs a Digital-CNT X-Ray Sources: A Paradigm Shift in Radiology. *Proceedings of the SPIE*, **13405**, 134053G. https://doi.org/10.1117/12.3048833

[4] Pfeiffer, D., Pfeiffer, F. and Rummeny, E. (2020) Advanced X-Ray Imaging Technology. In: Schober, O., Kiessling, F. and Debus, J., Eds., *Molecular Imaging in Oncology*, *Volume* 216 of *Recent Results in Cancer Research*, Springer International Publishing, 3-30. https://doi.org/10.1007/978-3-030-42618-7_1

[5] Kanter, B.M., Artemiev, B.V., Vladimirov, L.V. and Artemyev, I.B. (2017) Challenges in X-Ray Medical Diagnosis. *Biomedical Engineering*, **50**, 410-415. https://doi.org/10.1007/s10527-017-9667-x

[6] Melingui, B.F., Basant, J., Taguebue, J.v., Massom, D.M., Leroy Terquem, E., Norval, P.Y., *et al.* (2024) Implementation of Digital Chest Radiography for Childhood Tuberculosis Diagnosis at District Hospital Level in Six High Tuberculosis Burden and Resources Limited Countries. *Tropical Medicine & International Health*, **29**, 979-989. https://doi.org/10.1111/tmi.14053

[7] Dalla Palma, L., Grisi, G., Cuttin, R. and Rimondini, A. (1999) Digital vs Conventional Radiography: Cost and Revenue Analysis. *European Radiology*, **9**, 1682-1692. https://doi.org/10.1007/s003300050910

[8] Zennaro, F., Oliveira Gomes, J.A., Casalino, A., Lonardi, M., Starc, M., Paoletti, P., *et al.* (2013) Digital Radiology to Improve the Quality of Care in Countries with Limited Resources: A Feasibility Study from Angola. *PLOS ONE*, **8**, e73939. https://doi.org/10.1371/journal.pone.0073939

[9] Dinov, I.D. (2016) Volume and Value of Big Healthcare Data. *Journal of Medical Statistics and Informatics*, **4**, Article No. 3. https://doi.org/10.7243/2053-7662-4-3

[10] Dreyer, K.J., Thrall, J.H., Hirschorn, D.S. and Mehta, A. (2006) PACS: A Guide to the

Digital Revolution. Springer.

[11] Herrmann, M.D., Clunie, D.A., Fedorov, A., Doyle, S.W., Pieper, S., Klepeis, V., *et al.* (2018) Implementing the DICOM Standard for Digital Pathology. *Journal of Pathology Informatics*, **9**, Article No. 37. https://doi.org/10.4103/jpi.jpi_42_18

[12] Larobina, M. (2023) Thirty Years of the DICOM Standard. *Tomography*, **9**, 1829-1838. https://doi.org/10.3390/tomography9050145

[13] Mansoori, B., Erhard, K.K. and Sunshine, J.L. (2012) Picture Archiving and Communication System (PACS) Implementation, Integration & Benefits in an Integrated Health System. *Academic Radiology*, **19**, 229-235. https://doi.org/10.1016/j.acra.2011.11.009

[14] Bauman, R.A., Gell, G. and Dwyer, S.J. (1996) Large Picture Archiving and Communication Systems of the World—Part 1. *Journal of Digital Imaging*, **9**, 99-103. https://doi.org/10.1007/bf03168603

[15] Choplin, R.H., Boehme, J.M. and Maynard, C.D. (1992) Picture Archiving and Communication Systems: An Overview. *RadioGraphics*, **12**, 127-129. https://doi.org/10.1148/radiographics.12.1.1734458

[16] Meyer-Ebrecht, D. (1994) Picture Archiving and Communication Systems (PACS) for Medical Application. *International Journal of Bio-Medical Computing*, **35**, 91-124. https://doi.org/10.1016/0020-7101(94)90061-2

[17] Abdekhoda, M. and Salih, K.M. (2017) Determinant Factors in Applying Picture Archiving and Communication Systems (PACS) in Healthcare. *Perspectives in Health Information Management*, **14**, 1c. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5559691/

[18] Suapang, P., Yimmun, S. and Puditkanawat, A. (2011) Web-Based Medical Image Archiving and Communication System for Teleimaging. 2011 11*th International Conference on Control, Automation and Systems*, Gyeonggi-do, 26-29 October 2011, 172-177. https://ieeexplore.ieee.org/document/6106400

[19] Acuña, C.J., Marcos, E., de Castro, V. and Hernández, J.A. (2004) A Web Information System for Medical Image Management. In: Barreiro, J.M., *et al.*, Eds., *Biological and Medical Data Analysis*, Springer, 59-66.

[20] Yee, D., Soltaninejad, S., Hazarika, D., Mbuyi, G., Barnwal, R. and Basu, A. (2017) Medical Image Compression Based on Region of Interest Using Better Portable Graphics (BPG). 2017 *IEEE International Conference on Systems, Man, and Cybernetics* (*SMC*), Banff, 5-8 October 2017, 216-221. https://doi.org/10.1109/smc.2017.8122605

[21] Bick, U. and Lenzen, H. (1999) PACS: The Silent Revolution. *European Radiology*, **9**, 1152-1160. https://doi.org/10.1007/s003300050811

[22] Li, K.C., Marcovici, P., Phelps, A., Potter, C., Tillack, A., Tomich, J., *et al.* (2013) Digitization of Medicine: How Radiology Can Take Advantage of the Digital Revolution. *Academic Radiology*, **20**, 1479-1494. https://doi.org/10.1016/j.acra.2013.09.008

[23] Alhajeri, M., Aldosari, H. and Aldosari, B. (2017) Evaluating Latest Developments in PACS and Their Impact on Radiology Practices: A Systematic Literature Review. *Informatics in Medicine Unlocked*, **9**, 181-190. https://doi.org/10.1016/j.imu.2017.08.005

[24] Huang, H.K. (2011) Short History of PACS. Part I: Usa. *European Journal of Radiology*, **78**, 163-176. https://doi.org/10.1016/j.ejrad.2010.05.007

[25] You, J.J., Yun, L. and Tu, J.V. (2008) Impact of Picture Archiving Communication Systems on Rates of Duplicate Imaging: A Before-After Study. *BMC Health Services Research*, **8**, Article No. 234. https://doi.org/10.1186/1472-6963-8-234

[26] Pérez-Sanpablo, A.I., Quinzaños-Fresnedo, J., Gutiérrez-Martínez, J., Lozano-Rodríguez, I.G. and Roldan-Valadez, E. (2025) Transforming Medical Imaging: The Role of Artificial Intelligence Integration in PACS for Enhanced Diagnostic Accuracy and Workflow Efficiency. *Current Medical Imaging Formerly Current Medical Imaging Reviews*, **21**, e15734056370620. https://doi.org/10.2174/0115734056370620250403030638

[27] Alhajeri, M. and Shah, S.G.S. (2018) Limitations in and Solutions for Improving the Functionality of Picture Archiving and Communication System: An Exploratory Study of PACS Professionals' Perspectives. *Journal of Digital Imaging*, **32**, 54-67. https://doi.org/10.1007/s10278-018-0127-2

[28] Souto, M., Correa, J., Tahoces, P.G., Carrascal, F., Méndez, A., Lado, M.J., *et al*. (1996) A Limited PACS Dedicated to a Research Environment. Nine Years' Experience in Santiago De Compostela. *Medical Informatics*, **21**, 123-132. https://doi.org/10.3109/14639239608995014

[29] Samei, E., Seibert, J.A., Andriole, K., Badano, A., Crawford, J., Reiner, B., *et al*. (2004) AAPM/RSNA Tutorial on Equipment Selection: PACS Equipment Overview. *RadioGraphics*, **24**, 313-334. https://doi.org/10.1148/rg.241035137

[30] Ratib, O., Swiernik, M. and McCoy, J.M. (2003) From PACS to Integrated EMR. *Computerized Medical Imaging and Graphics*, **27**, 207-215. https://doi.org/10.1016/s0895-6111(02)00075-7

[31] Raman, B., Raman, R., Raman, L. and Beaulieu, C.F. (2004) Radiology on Handheld Devices: Image Display, Manipulation, and PACS Integration Issues. *RadioGraphics*, **24**, 299-310. https://doi.org/10.1148/rg.241035127

[32] França, R.P., Monteiro, A.C.B., Arthur, R. and Iano, Y. (2022) An Overview of the Impact of PACS as Health Informatics and Technology E-Health in Healthcare Management. In: Zhang, Y.-D. and Sangaiah, A.K., Eds., *Cognitive Data Science in Sustainable Computing*, Elsevier, 101-128. https://doi.org/10.1016/b978-0-12-824410-4.00007-6

[33] Goodarzi, H., Khatami, S., Javadzadeh, H., Mahmoudi, S., Khajehpour, H., Heidari, S., *et al*. (2016) User Acceptance of Picture Archiving and Communication System in the Emergency Department. *Iranian Journal of Radiology*, **13**, e20102. https://doi.org/10.5812/iranjradiol.20102

[34] R. Babić, R., Milošević, Z., Đinđić, B. and Stanković-Babić, G. (2012) Radiology Information System. *Acta Medica Medianae*, **51**, 39-46. https://doi.org/10.5633/amm.2012.0406

[35] Khaleel, H.H., Rahmat, R.O.K. and Zamrin, D.M. (2021) Components and Implementation of a Picture Archiving and Communication System in a Prototype Application. *Reports in Medical Imaging*, **12**, 1-8. https://www.dovepress.com/components-and-implementation-of-a-picture-archiving-and-communication-peer-reviewed-fulltext-article-RMI

[36] Vadera, S., Jha, P., *et al*. (2023) Picture Archiving and Communication System. https://radiopaedia.org/articles/picture-archiving-and-communication-system

[37] Mustra, M., Delac, K. and Grgic, M. (2008) Overview of the DICOM Standard. 2008 50*th International Symposium ELMAR*, Borik Zadar, 10-12 September 2008, 39-44. https://ieeexplore.ieee.org/document/4747434

[38] Mildenberger, P., Eichelberg, M. and Martin, E. (2002) Introduction to the DICOM Standard. *European Radiology*, **12**, 920-927. https://doi.org/10.1007/s003300101100

[39] Gibaud, B. (2008) The DICOM Standard: A Brief Overview. In: Lemoigne, Y. and Caner, A., Eds., *Molecular Imaging*: *Computer Reconstruction and Practice*, Springer, 229-238. https://doi.org/10.1007/978-1-4020-8752-3_13

[40] Riddle, W.R. and Pickens, D.R. (2005) Extracting Data from a DICOM File. *Medical Physics*, **32**, 1537-1541. https://doi.org/10.1118/1.1916183

[41] Putra, Y.D., Sigit, R. and Yuniarti, H. (2021) Portable Device-Based Medical Service System for DICOM to PNG Conversion. 2021 *International Electronics Symposium* (*IES*), Surabaya, 29-30 September 2021, 451-457. https://doi.org/10.1109/ies53407.2021.9593962

[42] Moreno-Torres, O.H., Ballesteros-Ricaurte, J.A. and Gonzalez Sanabria, J.S. (2015) Transformación de Archivos Dicom a Formatos XML, JPEG y PNG. *Revista Científica*, **1**, 71-80. https://doi.org/10.14483/udistrital.jour.rc.2015.21.a7

[43] Puri, I. (2020) A Study on Role of Front Office Administration in Max Super Speciality Hospital Bathinda. *Journal of Ayurveda and Integrated Medical Sciences*, **5**, 321-329. https://www.jaims.in/jaims/article/view/1628

[44] Genereaux, B.W., Dennison, D.K., Ho, K., Horn, R., Silver, E.L., O'Donnell, K., *et al.* (2018) Dicomweb™: Background and Application of the Web Standard for Medical Imaging. *Journal of Digital Imaging*, **31**, 321-326. https://doi.org/10.1007/s10278-018-0073-z

[45] Kahn, C.E., Carrino, J.A., Flynn, M.J., Peck, D.J. and Horii, S.C. (2007) DICOM and Radiology: Past, Present, and Future. *Journal of the American College of Radiology*, **4**, 652-657. https://doi.org/10.1016/j.jacr.2007.06.004

[46] Zhang, J., Lu, X., Nie, H., Huang, Z. and van der Aalst, W.M.P. (2009) Radiology Information System: A Workflow-Based Approach. *International Journal of Computer Assisted Radiology and Surgery*, **4**, 509-516. https://doi.org/10.1007/s11548-009-0362-6

[47] Nance Jr, J.W., Meenan, C. and Nagy, P.G. (2013) The Future of the Radiology Information System. *American Journal of Roentgenology*, **200**, 1064-1070. https://doi.org/10.2214/ajr.12.10326

[48] Reichertz, P.L. (2006) Hospital Information Systems—Past, Present, Future. *International Journal of Medical Informatics*, **75**, 282-299. https://doi.org/10.1016/j.ijmedinf.2005.10.001

[49] Muto, H., Tani, Y., Suzuki, S., Yokooka, Y., Abe, T., Sase, Y., *et al.* (2011) Filmless versus Film-Based Systems in Radiographic Examination Costs: An Activity-Based Costing Method. *BMC Health Services Research*, **11**, Article No. 246. https://doi.org/10.1186/1472-6963-11-246

[50] Beyan, O., Choudhury, A., van Soest, J., Kohlbacher, O., Zimmermann, L., Stenzhorn, H., *et al.* (2020) Distributed Analytics on Sensitive Medical Data: The Personal Health Train. *Data Intelligence*, **2**, 96-107. https://doi.org/10.1162/dint_a_00032

[51] Oida, T., Okuyama, T. and Finley, M.R. (2005) A Security Gateway System for Medical Communication Networks Inter-Hospital Use of the Secure Socket Layer. *Joint International Conference on Autonomic and Autonomous Systems and International Conference on Networking and Services*—(*icas-isns*'05), Papeete, 23-28 October 2005, 35. https://doi.org/10.1109/icas-icns.2005.9

[52] Silva, P. (2015) Davis' Technology Acceptance Model (TAM) (1989). In: Al-Suqri, M.N. and Al-Oufi, A.S., Eds., *Information Seeking Behavior and Technology Adoption*: *Theories and Trends*, IGI Global, 205-219. https://doi.org/10.4018/978-1-4666-8156-9.ch013

[53] Rajabalinejad, M., van Dongen, L. and Ramtahalsing, M. (2020) Systems Integration Theory and Fundamentals. *Safety and Reliability*, **39**, 83-113. https://doi.org/10.1080/09617353.2020.1712918

[54] Liu, B., Zhu, M., Zhang, Z., Yin, C., Liu, Z. and Gu, J. (2007) Medical Image Conver-

sion with DICOM. 2007 *Canadian Conference on Electrical and Computer Engineering*, Vancouver, 22-26 April 2007, 36-39. https://doi.org/10.1109/ccece.2007.16

[55] Mayer, R.S., Fliedner, F., Mathisen, I.F., Laib, A., Bein, J., Eichelberg, M., *et al.* (2025) Lossy DICOM Conversion May Affect AI Performance. *Scientific Reports*, **15**, Article No. 24470. https://doi.org/10.1038/s41598-025-02851-w

[56] Woda, M. and Torbiarczyk, M. (2018) Use of Distributed Machine Learning Toolkit for Searching Content Promoting Hate Speech on the Web. In: Zamojski, W., Mazurkiewicz, J., Sugier, J., Walkowiak, T. and Kacprzyk, J., Eds., *Contemporary Complex Systems and Their Dependability*, *DepCoS-RELCOMEX* 2018, Springer International Publishing, 536-544. https://doi.org/10.1007/978-3-319-91446-6_50

[57] Taylor, A.G., Mielke, C. and Mongan, J. (2018) Automated Detection of Moderate and Large Pneumothorax on Frontal Chest X-Rays Using Deep Convolutional Neural Networks: A Retrospective Study. *PLOS Medicine*, **15**, e1002697. https://doi.org/10.1371/journal.pmed.1002697

[58] Hustinawati, H., Kurnia Himawan, A. and Latifah, L. (2014) Performance Analysis Framework Codeigniter and Cakephp in Website Creation. *International Journal of Computer Applications*, **94**, 6-11. https://doi.org/10.5120/16549-5946

[59] Zhang, C., Sun, F., Zhang, M., Liu, W., Yu, Q., Babyn, P., *et al.* (2017) Design and Implementation of a Medical Image Knowledge Base for Pulmonary Nodules Diagnosis. 2017 3*rd IEEE International Conference on Computer and Communications* (*ICCC*), Chengdu, 13-16 December 2017, 2071-2075. https://doi.org/10.1109/compcomm.2017.8322901

[60] Zhu, W., Zhao, C., Li, W., Roth, H., Xu, Z. and Xu, D. (2020) LAMP: Large Deep Nets with Automated Model Parallelism for Image Segmentation. In: Martel, A.L., *et al.*, Eds., *Medical Image Computing and Computer Assisted Intervention—MICCAI* 2020, Springer International Publishing, 374-384. https://doi.org/10.1007/978-3-030-59719-1_37

[61] Ogiela, M.R. and Hachaj, T. (2014) Natural User Interfaces in Medical Image Analysis: Cognitive Analysis of Brain and Carotid Artery Images, Volume 1 of Advances in Computer Vision and Pattern Recognition. Springer.

[62] Pai, F.-Y. and Huang, K.-I. (2011) Applying the Technology Acceptance Model to the Introduction of Healthcare Information Systems. *Technological Forecasting and Social Change*, **78**, 650-660. https://doi.org/10.1016/j.techfore.2010.11.007

[63] Wang, Z. and Bovik, A.C. (2022) Modern Image Quality Assessment. Synthesis Lectures on Image, Video, and Multimedia Processing. Springer.

[64] Sara, U., Akter, M. and Uddin, M.S. (2019) Image Quality Assessment through FSIM, SSIM, MSE and PSNR—A Comparative Study. *Journal of Computer and Communications*, **7**, 8-18. https://doi.org/10.4236/jcc.2019.73002

[65] Scholl, I., Aach, T., Deserno, T.M. and Kuhlen, T. (2011) Challenges of Medical Image Processing. *Computer Science—Research and Development*, **26**, 5-13. https://doi.org/10.1007/s00450-010-0146-9

[66] Reiner, B.I. (2009) The Challenges, Opportunities, and Imperative of Structured Reporting in Medical Imaging. *Journal of Digital Imaging*, **22**, 562-568. https://doi.org/10.1007/s10278-009-9239-z

[67] Kasban, H., El-Bendary, M.A.M. and Salama, D.H. (2015) A Comparative Study of Medical Imaging Techniques. *International Journal of Information Science and Intelligent System*, **4**, 37-58. https://ilearn.th-deg.de/pluginfile.php/480243/mod_book/chapter/8248/updated_JXIJSIS2015.pdf

[68] Bland, J.M. and Altman, D.G. (1996) Statistics Notes: Transformations, Means, and Confidence Intervals. *BMJ*, **312**, Article No. 1079. https://doi.org/10.1136/bmj.312.7038.1079

[69] GE Healthcare (2023) Ge Healthcare Centricity PACS. https://www.gehealthcare.com

[70] Jodogne, S., Bernard, C., Devillers, M., Lenaerts, E. and Coucke, P. (2013) ORTHANC—A Lightweight, Restful DICOM Server for Healthcare and Medical Research. 2013 *IEEE* 10*th International Symposium on Biomedical Imaging*, San Francisco, 7-11 April 2013, 190-193.

[71] OFFIS e.V. Dcmtk: DICOM Toolkit (2023). https://dicom.offis.de/dcmtk.php.en

[72] Hore, A. and Ziou, D. (2010) Image Quality Metrics: PSNR vs. SSIM. 2010 20*th International Conference on Pattern Recognition*, Istanbul, 23-26 August 2010, 2366-2369. https://doi.org/10.1109/icpr.2010.579

[73] Larobina, M. and Murino, L. (2014) Medical Image File Formats. *Journal of Digital Imaging*, **27**, 200-206. https://doi.org/10.1007/s10278-013-9657-9

[74] Bahga, A. and Madisetti, V.K. (2013) A Cloud-Based Approach for Interoperable Electronic Health Records (EHRs). *IEEE Journal of Biomedical and Health Informatics*, **17**, 894-906. https://doi.org/10.1109/JBHI.2013.2257818

[75] Mollura, D.J., Shah, N., and Mazal, J. (2014) White Paper Report of the 2013 RAD-AID Conference: Improving Radiology in Resource-Limited Regions and Developing Countries. *Journal of the American College of Radiology*, **11**, 913-919. https://doi.org/10.1016/j.jacr.2014.03.026