International Journal of Academic Information Systems Research (IJAISR)
ISSN: 2643-9026
Vol. 10 Issue 7 July - 2026, Pages: 79-83

Artificial Intelligence for Intelligent Medical Image Sorting and Diagnostic Workflow Optimization

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Abstract*: Medical imaging departments worldwide are experiencing an unprecedented increase in diagnostic imaging volume due to the widespread adoption of digital radiology, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound technologies. Conventional Picture Archiving and Communication Systems (PACS) generally process examinations using First-In, First-Out (FIFO) scheduling, which does not account for the clinical severity of individual cases. Consequently, patients with life-threatening conditions may experience unnecessary delays before radiological review. This paper proposes an intelligent image-sorting framework that combines deep learning–based medical image analysis with a Max-Heap Priority Queue to dynamically prioritize examinations according to predicted clinical urgency. A lightweight Convolutional Neural Network (CNN) assigns each incoming image an urgency score reflecting the probability of critical pathology. The assigned score serves as the priority key for insertion into a heap-based scheduling structure, enabling efficient retrieval of the most urgent examination in logarithmic time complexity. The proposed framework is analytically compared with traditional FIFO queues, unsorted lists, and fully sorted lists in terms of computational complexity and scalability. Complexity analysis demonstrates that the proposed approach reduces retrieval operations from* ***O(n)*** *to* ***O(log n)*** *while maintaining efficient insertion performance suitable for high-volume imaging environments. Theoretical workload evaluation indicates that the number of comparisons required to retrieve the highest-priority examination decreases by more than* ***99%*** *for large imaging queues. The proposed framework illustrates how integrating artificial intelligence with classical data structures can improve diagnostic workflow efficiency, reduce waiting times for critically ill patients, and provide a scalable foundation for intelligent medical imaging pipelines.*

Keywords *Artificial Intelligence, Medical Imaging, Sorting Algorithms, Priority Queues, Heaps, Diagnostic Pipelines, Big-O Complexity.*

I. INTRODUCTION

Medical imaging has become one of the most important diagnostic tools in modern healthcare. Advances in digital imaging technologies, including computed tomography (CT), magnetic resonance imaging (MRI), X-ray radiography, ultrasound, and positron emission tomography (PET), have dramatically increased the quantity of medical images generated every day. Large tertiary hospitals routinely produce tens of thousands of imaging studies daily, creating significant pressure on radiologists and imaging infrastructures.

Although Picture Archiving and Communication Systems (PACS) have significantly improved image storage and accessibility, most current systems continue to schedule image interpretation using chronological ordering or manually assigned examination priorities. These scheduling strategies fail to exploit the diagnostic information already contained within the images themselves. Consequently, patients presenting with critical conditions such as intracranial hemorrhage, pulmonary embolism, or malignant tumors may experience unnecessary delays before receiving specialist attention.

Recent advances in artificial intelligence, particularly deep learning and convolutional neural networks (CNNs), have demonstrated remarkable success in automatically detecting abnormalities across multiple imaging modalities. AI systems can now identify fractures, intracranial bleeding, lung nodules, breast cancer, and other pathologies with high diagnostic accuracy. However, the majority of existing research focuses primarily on disease detection rather than optimizing diagnostic workflow scheduling.

This paper proposes an AI-assisted scheduling framework that integrates automated image classification with a Max-Heap Priority Queue. Instead of replacing radiologists, the proposed system assists workflow management by automatically assigning urgency scores to incoming examinations and dynamically prioritizing image review according to predicted clinical severity. By combining deep learning with efficient data structures, the proposed framework seeks to reduce diagnostic delays while maintaining computational scalability suitable for modern healthcare environments.

The primary contributions of this work are:

- Development of an AI-driven image prioritization framework based on CNN-generated urgency scores.
- Integration of machine learning with a Max-Heap Priority Queue for efficient scheduling.

- Analytical comparison between traditional scheduling methods and the proposed architecture.
- Complexity analysis demonstrating scalability for large-scale medical imaging systems.

II. OBJECTIVES

The objectives of this research are:

1. To investigate existing scheduling and sorting techniques used in medical imaging systems.
2. To develop an intelligent framework capable of assigning clinical priority scores to medical images using deep learning.
3. To integrate AI-generated urgency scores with a Max-Heap Priority Queue for dynamic image scheduling.
4. To evaluate the computational complexity and scalability of the proposed framework compared with conventional scheduling methods.
5. To demonstrate the potential clinical impact of AI-assisted image prioritization on reducing diagnostic delays in emergency radiology.

III. PROBLEM STATEMENT

The rapid growth of digital medical imaging has significantly increased radiologists' workloads. Conventional scheduling mechanisms process imaging studies according to acquisition time rather than predicted clinical urgency. Consequently, examinations containing life-threatening abnormalities may remain buried within large imaging queues until manually reviewed.

While artificial intelligence has substantially improved automated disease detection, relatively little research has explored integrating AI predictions directly into scheduling algorithms. Existing PACS infrastructures rarely utilize AI-generated diagnostic information for workflow optimization.

Therefore, there is a need for an intelligent scheduling framework capable of automatically identifying high-risk examinations and dynamically prioritizing them using computationally efficient data structures. Such a framework should improve diagnostic responsiveness without introducing significant computational overhead.

IV. LITERATURE REVIEW

Sorting algorithms have long served as fundamental components of computer science, supporting efficient organization, retrieval, and scheduling of data. Classical algorithms such as Merge Sort, Heap Sort, and Quick Sort achieve average computational complexity of **O(n log n)** and remain widely used for static datasets. However, continuously arriving medical imaging studies require dynamic scheduling structures capable of supporting frequent insertions and priority updates.

Priority Queues implemented using binary heaps provide an attractive solution for dynamic scheduling because insertion and deletion operations require only **O(log n)** time while preserving efficient access to the highest-priority element. Heap-based scheduling has been extensively adopted in operating systems, cloud computing, and network traffic management due to its scalability.

Meanwhile, deep learning has revolutionized medical image analysis. Convolutional Neural Networks have achieved state-of-the-art performance across numerous diagnostic applications including breast cancer detection, pulmonary disease classification, retinal disease diagnosis, and neurological imaging. Comprehensive surveys by Litjens et al. demonstrated the widespread adoption of CNNs across nearly every medical imaging modality.

More recent studies have shifted attention from disease detection toward workflow optimization. Verburg et al. proposed automated triage for breast MRI examinations using deep learning, significantly reducing review time for suspicious cases. Carriero et al. argued that AI should support entire clinical workflows rather than isolated diagnostic tasks. Similarly, Berghout emphasized workflow-aware AI deployment within radiology departments.

Research in emergency medicine has also investigated AI-assisted patient prioritization. Tyler et al. demonstrated reductions in emergency department waiting times using machine learning–based triage systems, while Antczak et al. explored complexity-aware admission prediction for emergency care.

Despite these advances, relatively few studies integrate AI-generated urgency predictions directly with efficient scheduling data structures. Most existing systems continue to rely on rule-based prioritization or static scheduling mechanisms. The proposed framework addresses this research gap by combining deep learning with heap-based priority scheduling for real-time management of medical imaging workflows.

V. METHODOLOGY

Figure 1 illustrates the architecture of the proposed framework.

The workflow consists of five sequential stages:

Stage 1: Image Acquisition

Medical images are acquired from imaging modalities including CT, MRI, X-ray, and ultrasound before being transmitted to the PACS server.

Stage 2: Image Preprocessing

Images undergo resizing, normalization, and noise reduction to produce standardized inputs suitable for CNN inference.

Stage 3: AI-Based Urgency Prediction

A lightweight CNN analyzes each incoming image and predicts an urgency probability ranging between 0 and 1.

The urgency score is defined as

Priority=P(Critical|Image)Priority = P(Critical|Image)Priority=P(Critical|Image)

where

- 0 indicates routine examination
- 1 indicates life-threatening abnormality

Stage 4: Heap-Based Scheduling

Each image is inserted into a Max-Heap using the predicted urgency score as its key.

Insertion complexity:

O(log⁡n)O(\log n)O(logn)

Retrieval complexity:

O(log⁡n)O(\log n)O(logn)

Stage 5: Radiologist Review

Whenever a radiologist requests the next examination, the root node of the heap is removed and presented first, ensuring that the most clinically urgent examination receives immediate attention.

To prevent starvation of low-priority examinations, an aging mechanism periodically increases priority values according to waiting time:

Prioritynew=PriorityAI+λ×WaitingTimePriority_{new}=Priority_{AI}+\lambda\times WaitingTimePrioritynew=PriorityAI+λ×WaitingTime

where λ controls the aging rate.

VI. RESULTS

The proposed framework was evaluated analytically through computational complexity analysis and workload estimation. Unlike conventional FIFO scheduling, the proposed system dynamically reorganizes examinations after each insertion while maintaining logarithmic computational complexity.

Table I compares insertion and retrieval complexities.

Structure	Insert	Retrieve Highest Priority
FIFO Queue	O(1)	O(n)
Unsorted List	O(1)	O(n)
Sorted List	O(n)	O(1)
Max-Heap (Proposed)	O(log n)	O(log n)

To estimate scalability, workload analysis was conducted for queue sizes ranging from 100 to 100,000 imaging examinations.

Queue Size	FIFO Scan	Max-Heap	Reduction
100	100	7	93%
1,000	1,000	10	99%
10,000	10,000	14	99.86%
100,000	100,000	17	99.98%

The results demonstrate that the computational advantage increases as queue size grows. While conventional scanning requires linear traversal of the queue, the proposed heap maintains logarithmic retrieval complexity regardless of imaging volume.

VII. DISCUSSION

The proposed framework illustrates how artificial intelligence and classical algorithm design can complement one another in healthcare workflow optimization. CNNs provide clinically meaningful urgency estimates, whereas the Max-Heap efficiently organizes examinations according to these predictions.

Unlike previous studies focusing solely on disease classification accuracy, this research emphasizes workflow efficiency and scheduling optimization. The computational complexity analysis indicates that logarithmic retrieval scales effectively even for very large imaging repositories.

Nevertheless, several practical challenges remain. First, diagnostic accuracy depends heavily on CNN performance; inaccurate urgency predictions could affect scheduling quality. Second, inference latency should remain sufficiently low to avoid offsetting scheduling gains. Third, fairness mechanisms such as aging are essential to prevent prolonged delays for routine examinations. Finally, future implementations should support continuous learning from radiologist feedback, allowing urgency predictions to improve over time.

VIII. CONCLUSION

This paper presented an AI-assisted framework for intelligent scheduling of medical imaging examinations by integrating deep learning with a Max-Heap Priority Queue. The proposed approach dynamically assigns urgency scores to medical images and organizes diagnostic workflows according to predicted clinical severity rather than acquisition time. Complexity analysis demonstrated substantial computational advantages over conventional FIFO and list-based scheduling methods, reducing retrieval complexity from linear to logarithmic time while maintaining scalability for large imaging repositories.

Although the current work provides analytical validation rather than experimental evaluation on clinical datasets, it establishes a promising framework for future intelligent PACS systems. Future research should implement the proposed architecture using publicly available datasets such as NIH ChestX-ray14, RSNA Intracranial Hemorrhage Detection, or CheXpert, evaluate CNN performance using metrics including accuracy, precision, recall, F1-score, and AUC, and assess workflow improvements through simulation or deployment in real clinical environments. Such validation would further demonstrate the feasibility of AI-driven image prioritization for improving patient outcomes and radiology efficiency.

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