JOURNAL MEDICAL INFORMATICS TECHNOLOGY
medinftech.org ISSN 2988-7003 (online)

Implementation of Image Processing Techniques for Viral Pneumonia Diagnosis Using Chest X-Ray Images

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ARTICLE HISTORY
Received: 29 December 24
Final Revision: 30 November 25
Accepted: 26 December 25
Online Publication: 31 December 25

KEYWORDS
Chest X-ray, Edge Detection, Image Processing, Morphological Operations, Viral Pneumonia

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DOI
10.37034/medinftech.v3i4.52

A B S T R A C T

The COVID-19 pandemic has increased the need for rapid and accurate diagnostic methods for viral pneumonia diseases. This study employs an experimental approach to analyze the application of image processing techniques for viral pneumonia diagnosis using chest X-ray images. The dataset consists of 100 chest X-ray images obtained from a public Kaggle repository, including normal and viral pneumonia cases. The proposed methodology involves several main stages. Image preprocessing is performed through image enlargement using bilinear interpolation and noise reduction using a median filter to improve image quality. Morphological operations, including erosion and dilation, are applied to enhance lung structures and clarify anatomical contours. Image enhancement is conducted using histogram equalization to improve contrast between healthy and infected regions. Finally, convolution-based edge detection using the Sobel operator is applied to highlight structural boundaries relevant to diagnostic interpretation. This processing framework aims to enhance image clarity and feature visibility, thereby supporting more efficient and consistent analysis of chest X-ray images for viral pneumonia diagnosis.

1. Introduction

Pneumonia is an infectious disease of the lungs that can be caused by various pathogenic agents, including bacteria, viruses, and fungi [1], [2]. In the last decade, viral pneumonia has emerged as a major global health concern, particularly following the outbreak of Coronavirus Disease 2019 (COVID-19) caused by the SARS-CoV-2 virus [3], [4]. Since its initial detection in Wuhan, China, in December 2019, COVID-19 has rapidly spread worldwide. As of July 31, 2020, the World Health Organization (WHO) reported 17,106,007 confirmed cases and 668,910 deaths globally (WHO Situation Report-193). The pandemic has significantly burdened healthcare systems, especially due to the sharp increase in patients requiring rapid and accurate respiratory diagnosis [5], [6].

During the COVID-19 pandemic, the diagnosis of pneumonia has become more challenging due to overlapping clinical symptoms, high patient volumes, and limited medical resources. COVID-19 patients commonly present with symptoms such as cough and fever exceeding 38°C, which may progress to dyspnea and severe respiratory distress [1], [7]. In many cases, pneumonia develops rapidly, and by the second week of illness, patients may require mechanical ventilation due to acute respiratory failure [8], [9]. Viral pneumonia is one of the most serious complications of COVID-19, as it can cause extensive lung damage and increase mortality risk [10]. These conditions emphasize the urgent need for efficient diagnostic methods that can support clinicians in identifying pneumonia accurately and promptly.

Chest X-ray imaging is one of the most widely used diagnostic modalities for pneumonia detection due to its low cost, minimal radiation exposure, and widespread availability [11], [12]. Chest X-ray images offer simplicity, low cost, low radiation, a wealth of information, and worldwide availability. The purpose of using a chest X-ray is to prove the doctor's perception in identifying lung diseases [13], [14], [15]. X-ray images provide a detailed picture of the condition of the lungs and can help identify infiltrates, consolidations, and other changes associated with pneumonia [16], [17]. However, during the COVID-19 pandemic, the reliance on manual interpretation has proven to be challenging, as radiologists and clinicians must analyze large volumes of images in a limited time. This situation increases the risk of diagnostic errors and delays, highlighting the importance of automated and computer-assisted image analysis approaches [18], [19].

This study aims to enhance the diagnostic quality of viral pneumonia detection by applying image processing techniques to chest X-ray images. Specifically, this research focuses on improving image clarity and feature visibility through a series of image processing stages, including image enlargement, noise reduction using median filtering, contrast enhancement, and convolution-based feature extraction [20], [21], [22]. Image enlargement aims to increase the resolution and make it easier to analyze the details in the X-ray image. Preprocessing using a median filter aims to reduce noise in the image and retain important details [23], [24], [25], [26]. Quality enhancement was performed using contrast adjustment techniques to clarify the structure in the image [27]. Convolution is used to detect edges and other important features in X-ray images.

By improving image quality and feature representation, the proposed approach is expected to support more accurate and consistent interpretation of chest X-ray images. This enhancement can assist clinicians in distinguishing between normal and pneumonia-affected lungs more effectively, particularly in high-demand pandemic situations. Ultimately, this research contributes to the development of medical decision support systems by providing processed X-ray images that facilitate faster, more reliable, and objective diagnostic decision-making in the management of viral pneumonia, especially in the context of the COVID-19 pandemic.This study is expected to improve the accuracy of viral pneumonia diagnosis by providing clearer and more informative images, and the results of this study may contribute to the development of a more effective medical decision support system in the diagnosis and management of patients with viral pneumonia, particularly in the context of the COVID-19 pandemic.

2. Research Method

This study uses an experimental approach with the main stages including image data collection, image preprocessing, application of image morphology techniques, image quality enhancement, and convolution for edge detection in the diagnosis of viral pneumonia can be seen in Figure 1. The following is a detailed explanation of each of these stages:

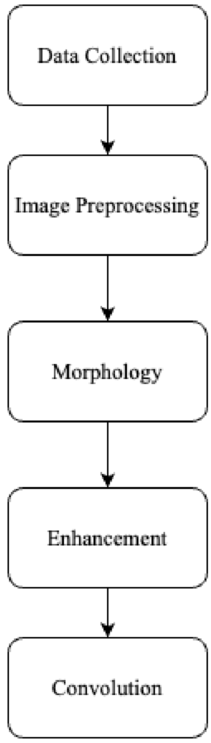

Figure 1. Research Methodology

2.1. Data Collection

The dataset used in this study consists of chest X-ray images categorized into two classes: viral pneumonia images and normal chest images. The data were obtained from a publicly available medical imaging repository on Kaggle, which provides high-quality datasets commonly used for research purposes. Representative images from both categories were selected to ensure variation in lung conditions and image characteristics, supporting a comprehensive evaluation of the proposed image processing approach.

2.2. Image Preprocessing

The The preprocessing stage aims to prepare the X-ray images for subsequent analysis by improving their basic quality. This stage includes image enlargement to increase spatial resolution and median filtering to reduce noise while preserving important structural information. These preprocessing steps are essential to enhance image clarity and ensure that relevant lung features can be effectively analyzed in the following stages.

2.3. Morphology

At this stage, image morphology techniques are applied to clarify structures and contours in the X-ray image. Morphological operations such as erosion, dilation and others are used to improve the image representation, helping in the identification of small details relevant to the diagnosi Morphological image processing techniques are applied to emphasize lung structures and improve contour visibility in the X-ray images. Operations such as erosion and dilation are utilized to refine image shapes and enhance structural details. This stage helps in highlighting anatomical regions that are potentially affected by viral pneumonia, facilitating better feature representation for diagnostic purposes.

2.4. Enhancement

Following morphological processing, image enhancement techniques are applied to further improve visual quality. Contrast enhancement methods, including histogram equalization, are employed to increase the distinction between healthy lung tissue and infected regions. This enhancement stage aims to make diagnostically relevant features more prominent and easier to interpret.

2.5. Convolution

Following morphological processing, image enhancement techniques are applied to further improve visual quality. Contrast enhancement methods, including histogram equalization, are employed to increase the distinction between healthy lung tissue and infected regions. This enhancement stage aims to make diagnostically relevant features more prominent and easier to interpret.

3. Result and Discussion

This study presents the results obtained from each stage of the proposed image processing framework for viral pneumonia diagnosis using chest X-ray images. The effectiveness of each processing stage is discussed based on its contribution to image clarity, feature enhancement, and diagnostic interpretability.

3.1. Data Collection Results

The dataset used consists of 100 chest X-ray images classified into two groups: normal images and images with viral pneumonia. Each image was randomly selected from a public dataset available on Kaggle to ensure variation in severity and visual characteristics. Figure 2 presents sample images from the dataset used in this research.

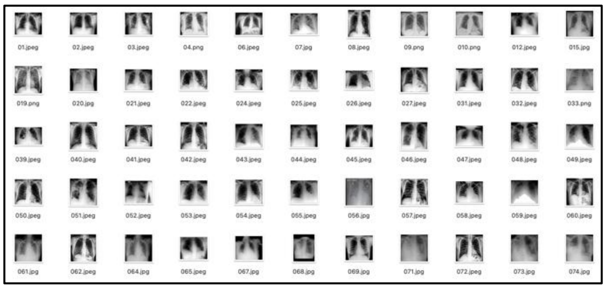

Figure 2. Chest X-ray Dataset

Each X-ray image underwent a series of processing stages aimed at improving visual quality and highlighting diagnostically relevant features. An example of a viral pneumonia chest X-ray image prior to processing is shown in Figure 3.

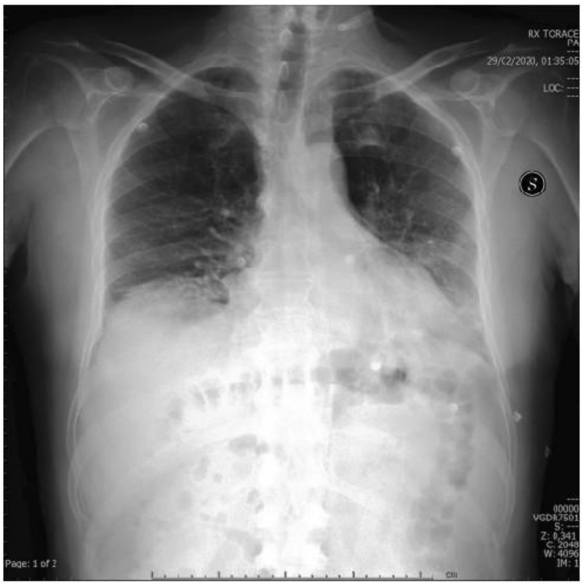

Figure 3. Pneumonia Viral Chest X-ray Figure

3.2. Pre-Processing Results

In the preprocessing stage, image enlargement was performed using bilinear interpolation to increase spatial resolution. This process resulted in improved visibility of lung structures that previously appeared blurred or unclear. Subsequently, a median filter was applied to reduce noise while preserving essential structural details. The results of the image enlargement process are illustrated in Figure 4.

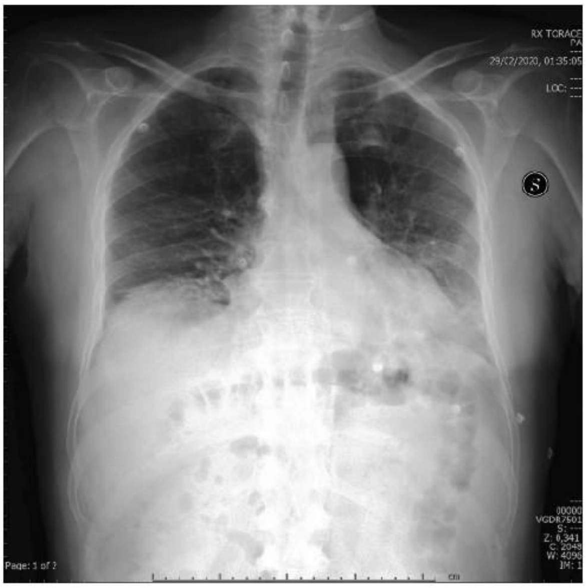

Figure 4. Result of Image Enlarge

The preprocessing stage produced cleaner and clearer images, providing a more reliable foundation for subsequent morphological processing and feature enhancement.

3.3. Morphological Processing Results

Morphological operations, including erosion and dilation, were applied to enhance structural representation and clarify contours within the lung regions. These operations effectively refined the boundaries of lung tissue and emphasized regions potentially affected by viral infection, as shown in Figure 5.

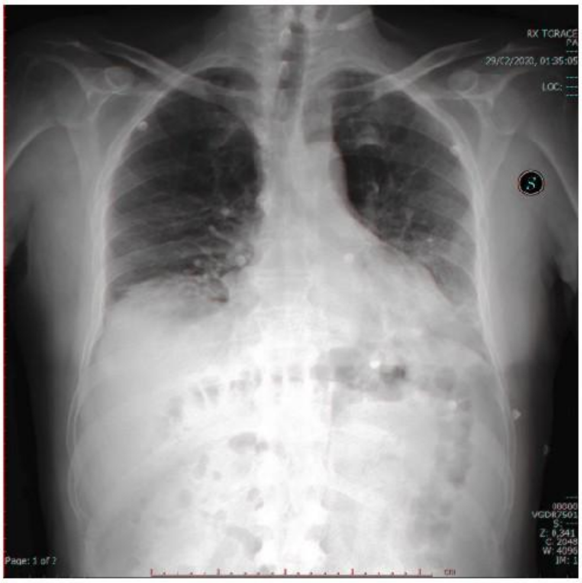

Figure 5. Result of Morphological Processing

The results indicate that morphological processing improves the visibility of small but important structural details, which are essential for distinguishing abnormal patterns associated with viral pneumonia.

3.4. Image Enhancement Results

Contrast adjustment was performed using histogram equalization. The results show a significant increase in contrast, making the difference between healthy and infected tissue clearer. The results of the Enhancement Process are shown in figure Image enhancement was carried out using histogram equalization to improve contrast levels.

As shown in Figure 6, this technique significantly enhanced the contrast between healthy lung tissue and infected areas, making pathological features more distinguishable. The improved contrast enhances the interpretability of chest X-ray images and supports more consistent identification of regions affected by viral pneumonia.

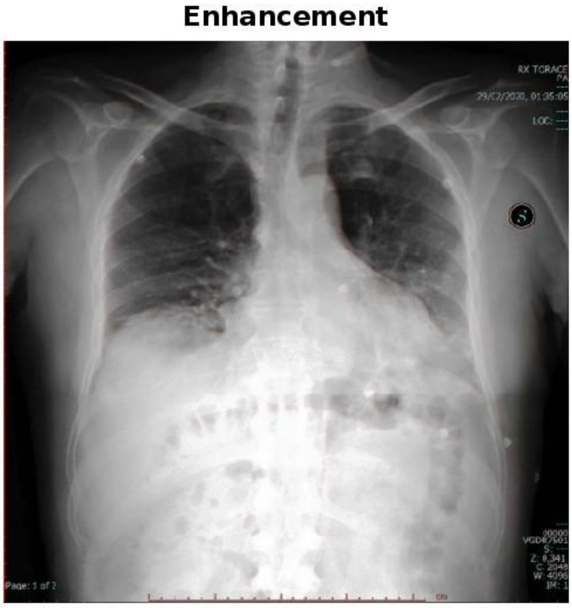

Figure 6. Result of Image Enhancement

3.5. Convolution Results

In the final stage, convolution-based edge detection was applied using the Sobel operator. The resulting edge-detected images, shown in Figure 7, clearly highlight lung boundaries and structural patterns associated with infection.

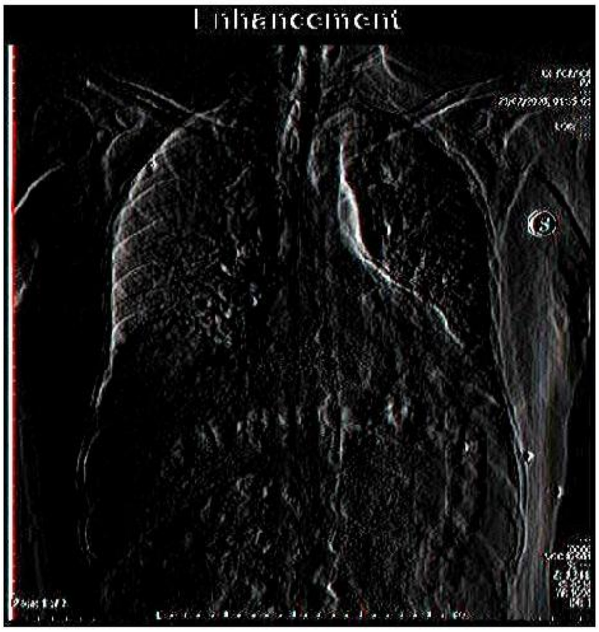

Figure 7. Result of Image Convolution

Edge detection using convolution helps emphasize regions that require further diagnostic attention, thereby supporting a more precise and systematic analysis of chest X-ray images.

4. Conclusion

This study demonstrates that a structured combination of image processing techniques can effectively enhance the quality and interpretability of chest X-ray images for viral pneumonia analysis. Each processing stage contributes a specific role in supporting diagnostic accuracy and efficiency. The preprocessing stage, which includes image enlargement and median filtering, improves spatial resolution and suppresses noise, thereby reducing visual ambiguity and facilitating faster image interpretation. Morphological operations enhance structural continuity and emphasize lung contours, helping to clarify anatomical regions that may be affected by infection. Image enhancement using contrast adjustment further improves the visibility of pathological patterns, while convolution-based edge detection using the Sobel operator highlights structural boundaries, supporting clearer identification of abnormal lung regions.

Although this study does not incorporate machine learning-based classification, the applied image processing framework provides an essential foundation for diagnostic analysis. The absence of automated learning models may limit direct improvements in diagnostic accuracy; however, the enhanced image quality produced by the proposed methods can reduce misinterpretation and serve as a critical preprocessing step for future intelligent diagnostic systems. The integration of machine learning models, such as Convolutional Neural Networks (CNNs), is expected to further improve diagnostic performance by enabling automated feature learning and classification based on the enhanced images.

The main contribution of this research lies in the systematic integration of multiple image processing stages into a unified framework aimed at supporting viral pneumonia diagnosis. Unlike many previous studies that focus on individual techniques or directly apply machine learning models, this study emphasizes the role of image quality optimization as a decision-support mechanism. The results demonstrate that combining preprocessing, morphology, enhancement, and convolution can provide added value by producing clearer, more interpretable chest X-ray images that are suitable for both human interpretation and future automated analysis.

Despite these contributions, several limitations remain. The dataset was obtained from a single public source and may not represent the full diversity of viral pneumonia cases. In addition, evaluation was primarily based on visual analysis rather than quantitative clinical metrics. Future research should therefore expand the dataset across multiple sources and patient demographics, integrate machine learning models for automated diagnosis, and involve radiologists for clinical validation. Further studies may also explore comparative evaluations with alternative image processing techniques and assess the impact of the proposed framework on diagnostic efficiency in real clinical settings.

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