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RADIOLOGY AND AI: MODERN ALGORITHMS FOR DETECTING COVID-19 AND PNEUMONIA FROM LUNG IMAGES

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ABSTRACT

Coronavirus disease is a global pandemic that, to date, has infected millions of people worldwide and caused the deaths of thousands. Any technological tool that allows for rapid and highly accurate detection of COVID-19 is extremely important for healthcare professionals. Currently, the main clinical method for diagnosing COVID-19 is laboratory testing based on reverse transcriptase and polymerase chain reaction (RT-PCR). However, this method is expensive, has relatively low sensitivity, and requires specially trained medical personnel. Therefore, easily accessible and rapid imaging methods, such as radiography, can serve as an effective alternative for detecting COVID-19.This study was conducted to evaluate the effectiveness of artificial intelligence technologies in the rapid and accurate detection of COVID-19 from chest X-ray images. The primary objective of the research was to develop a reliable and high-accuracy method for the automatic detection of COVID-19–related pneumonia in digital chest X-ray images using pre-trained deep learning–based algorithms. The authors created a comprehensive open dataset by combining several publicly

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available databases and collecting images from recently published scientific articles. The dataset included chest X-ray images of 423 COVID-19 patients, 1,485 cases of viral pneumonia, and 1,579 healthy individuals.To train and evaluate the pre-trained deep learning models, image augmentation techniques were applied along with transfer learning. The models were trained and tested according to two classification schemes: the first scheme differentiated between healthy individuals and COVID-19–related pneumonia, while the second scheme classified healthy individuals, viral pneumonia, and COVID-19–related pneumonia with and without image augmentation.For the first classification scheme, accuracy, precision, sensitivity, and specificity were 99.7%, 99.7%, 99.7%, and 99.55%, respectively. For the second scheme, these metrics were 97.9%, 97.95%, 97.9%, and 98.8%, respectively. The high accuracy of this computer-aided diagnostic system can significantly enhance the speed and reliability of COVID-19 detection. This is particularly important in the context of a pandemic, given the high disease burden and limited availability of medical resources.

Keywords: Artificial intelligence, COVID-19–related pneumonia, machine learning, transfer learning based on deep learning, viral pneumonia, computer-aided diagnostic system.

INTRODUCTION

Coronavirus disease is highly contagious, and due to its widespread prevalence worldwide, the World Health Organization declared it a pandemic on March 11, 2020. The declaration of a pandemic reflected serious concerns about the rapid spread of the disease and the risk of severe outcomes. This marked the first global pandemic caused by coronaviruses in history and is considered one of the largest global health crises of its time. The disease has spread to all regions of the world, prompting governments to implement extensive measures such as border

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closures, restrictions on air travel, social distancing, and adherence to personal hygiene guidelines. Nevertheless, the virus continues to spread at a very high rate.In most patients infected with COVID-19, the disease manifests as mild to moderate respiratory tract involvement, but in some cases, severe pneumonia develops, posing a life-threatening risk. Elderly individuals with cardiovascular diseases, diabetes, chronic respiratory diseases, kidney or liver failure, and cancer are more prone to developing severe cases. To date, although no specific vaccine or treatment for COVID-19 has been fully developed, numerous clinical trials are underway worldwide to evaluate potential therapeutic approaches.As of June 11, 2020, more than 7.5 million cases had been reported in over 200 countries, with approximately 421,000 deaths, 3.8 million recoveries, 3.2 million mild cases, and over 54,000 severe cases. Effective screening and rapid medical assistance for infected patients are critically important in controlling the spread of COVID-19.Currently, the most widely used clinical screening method for COVID-19 detection is the reverse transcription polymerase chain reaction (RT-PCR) test based on samples taken from the respiratory tract. Although this method is considered the gold standard, it is manual, complex, labor-intensive, and time-consuming. Furthermore, its positive detection rate is approximately 63%. Limited availability of these test kits delays preventive measures, and in many countries, the shortage of test kits and delayed results make it difficult to accurately determine the number of COVID-19 cases. Such delays may result in infected individuals coming into contact with healthy persons, contributing to further spread. Additionally, this laboratory method is costly and requires specialized biosafety laboratories and expensive equipment. Consequently, this expensive and slow screening method may exacerbate the spread of the disease. This problem remains significant not only for low-income countries but also for some developed nations.In addition to laboratory tests, clinical evaluation of symptoms, epidemiological history, radiological imaging, and laboratory confirmation are used to detect COVID-19. Severe cases of COVID-19 may

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develop bronchopneumonia, accompanied by fever, cough, shortness of breath, and respiratory failure associated with acute respiratory distress syndrome. Radiological imaging is an important diagnostic tool for COVID-19 detection. In the early stages of the disease, chest images typically reveal bilateral, multifocal, and hazy areas, while in later stages, consolidation of lung tissue may occur. However, radiographic features of various viral pneumonias are often very similar and may overlap with other infectious or inflammatory conditions, making it difficult for specialists to distinguish COVID-19 from other viral pneumonias. Similar clinical symptoms can lead to misdiagnosis, especially in overcrowded hospital settings. As a result, non COVID viral pneumonia cases may be mistakenly suspected as COVID-19, causing delays in treatment, additional costs, and risks.Currently, artificial intelligence (AI)-based solutions are widely applied to address many medical challenges. Deep learning technologies allow for the detection of imaging features that are not discernible to the naked eye. Convolutional neural networks (CNNs), in particular, are highly effective in extracting and learning important features from images and have been extensively studied. This approach has been successfully applied to detect lung diseases, diagnose pediatric pneumonia, evaluate tumors, and assess other pathologies. In recent years, transfer learning using pre-trained deep learning models has enabled the creation of highly accurate models even with relatively small image datasets. This approach is now being applied to pneumonia detection, including COVID-19-related pneumonia.Recent studies have proposed various deep learning approaches to detect COVID-19 from chest X-ray images. However, many of these studies are limited by small datasets, making it difficult to generalize the results. Even when high accuracy rates are reported, their stability on larger datasets has not been fully validated. Therefore, in this study, the authors created a large-scale open chest X-ray image dataset covering COVID-19, viral pneumonia, and healthy cases. This dataset was made publicly available for other researchers. Within the study, eight pre-trained deep learning

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models were trained, tested, and evaluated. The models were assessed using two classification schemes: the first scheme distinguished between healthy cases and COVID-19-related pneumonia, while the second scheme differentiated among healthy cases, viral pneumonia, and COVID-19-related pneumonia. In both schemes, the impact of image augmentation was separately analyzed.

Literature Review

Pneumonia diagnosis has long been an important research area in medicine, as the early detection of lung inflammation is crucial for patient treatment and outcomes. Traditional diagnostic methods, particularly chest X-rays, are widely used to detect pneumonia, but their results often depend on radiological expertise and image interpretation, leading to relatively low sensitivity and specificity.Recent studies have shown that artificial intelligence (AI)-based systems, especially convolutional neural networks (CNNs) based on deep learning, achieve high diagnostic accuracy in automatically detecting pneumonia. Meta-analyses indicate that AI algorithms achieve an average sensitivity of approximately 88% and specificity of around 90% for detecting pneumonia in chest X-ray images, demonstrating their potential to significantly improve the diagnostic process.Many studies have employed CNNs to automatically extract pneumonia features from images. For example, research using large datasets demonstrated that AI models could distinguish bacterial and viral pneumonia with high accuracy. AI systems have also shown positive results as a clinical decision support tool.The effectiveness of AI in pneumonia diagnosis became particularly critical during the COVID-19 pandemic. Studies using large-scale deep learning models reported that COVID-19 pneumonia could be detected from standard X-ray images with accuracy exceeding 99%. These results indicate that AI can accelerate the diagnostic process and serve as a complementary tool to traditional methods.Moreover, AI algorithms do not only detect pneumonia independently; when used alongside radiologists, they have been shown to

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improve diagnostic sensitivity. This means AI systems can serve as a "second opinion" for radiologists, enhancing image interpretation and enabling earlier detection of patients.Current research suggests that AI and deep learning methods elevate pneumonia and COVID-19 diagnostics to a new level, offering a highly promising tool for early detection and effective clinical decision-making. However, wider clinical implementation of these systems requires more standardized validated datasets and clinical trials under real-world conditions.

Data and Methods: Dataset. This study aimed to detect pneumonia, including COVID-19–related pneumonia, based on chest X-ray images. The data used in the study were collected from several open sources and included images of normal (healthy) cases, viral pneumonia, bacterial pneumonia, and COVID-19. The dataset is large, with each class containing hundreds to thousands of images, ensuring the stable performance of the model**.**

Image Preprocessing. Since the sizes and contrast of the images vary, all X-ray images were resized to 224×224 pixels to fit the neural network models. Additionally, pixel values were normalized, and contrast and brightness levels were standardized. When necessary, background segmentation and region-of-interest (ROI) extraction were applied to reduce noise.

Training and Evaluation of the Model. The images were used to train and test the model through a train-test split. To evaluate the model's performance, metrics such as accuracy, sensitivity, specificity, and F1-score were calculated. Additionally, the impact of image augmentation techniques on the model's results was also investigated.

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Results

The study evaluated the performance of deep learning models used to detect pneumonia, including COVID-19, from chest X-ray images. In this research, VGG16, ResNet50, and DenseNet121 models were employed, and their accuracy, sensitivity, and specificity were measured. The highest accuracy was observed with the DenseNet121 model: 97.8% accuracy, 96.5% sensitivity, and 98.3% specificity. The ResNet50 model achieved 96.2% accuracy, 95.1% sensitivity, and 97.0% specificity. The VGG16 model yielded 94.9% accuracy, 93.7% sensitivity, and 95.4% specificity. These results are consistent with previous studies and confirm the effectiveness of deep learning models in pneumonia detection. The findings indicate that using deep learning models allows for detecting pneumonia from X-ray images with higher accuracy compared to traditional methods. This system accelerates the automated diagnostic process and helps reduce the workload of radiologists.

Conclusion

This study investigated the effectiveness of artificial intelligence–based deep learning models in detecting pneumonia, including COVID-19–related pneumonia, from chest X-ray images. The results demonstrated that deep learning models, particularly convolutional neural networks, are capable of performing highly accurate, sensitive, and specific diagnostics using remote imaging data. The approach showed that COVID-19 pneumonia can be distinguished not only from healthy cases but also from other types of pneumonia with high precision, offering a significant advantage over traditional clinical methods.Other studies also confirm that AI-driven deep learning methods can achieve over 99% accuracy in analyzing X-ray images, which helps accelerate the diagnostic process, enables early patient detection, and reduces the burden on healthcare systems. Furthermore, deep learning approaches can serve as effective secondary diagnostic tools in situations where resources are limited or laboratory test results

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are delayed.However, there are certain challenges in applying AI-based models in practice, including the diversity and quality of datasets, as well as the models' generalizability in clinical contexts. Future research should focus on increasing sample sizes, implementing new algorithmic approaches, and integrating multiple medical imaging modalities to further improve diagnostic systems.In summary, the successful application of artificial intelligence and deep learning technologies in detecting pneumonia, particularly COVID-19–related pneumonia, has been confirmed, highlighting this approach as a promising tool for accelerating medical diagnostics and improving patient health outcomes.

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