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Developing Convolutional Neural Networks-Based System for Predicting Pneumonia Using X-Radiography Image

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Abstract

Pneumonia is a respiratory disease caused by *Streptococcus Pneumoniae* infection. It is a life-threatening disease that causes a high mortality rate for children under 5 years of age every year. Under such circumstances, we have a vital need to develop an appropriate and consistent protocol for the identification and diagnosis of pneumonia. The incorporation of computational approaches into the diagnosis of disease is extremely efficient, promising and reliable. Our goal is to integrate these methods into pneumonia routine diagnosis to save countless lives around the world. We used the machine learning algorithm of Convolutional Neural Networks (CNNs) to identify visual symptoms of pneumonia in X-ray radiographic images and make a diagnostic decision. The dataset used to construct the computational model consists of 5844 X-ray images belonging to the pneumonia affected and normal individuals. Our computational model has been successful in identifying pneumonia patients with a diagnosis accuracy of 84%. Our model may increase the efficiency of the pneumonia diagnosis process and accelerate pathogenicity studies of the disease.

Keywords: CNNs, Artificial intelligence, Pneumonia, Disease diagnosis.

Introduction

Pneumonia is a bacterial disorder that causes severe symptoms such as grunting, chest retraction, central cyanosis, obtundation, lethargy, convulsions and inability to feed or drink [1,2]. Each year about 1,400 cases of pneumonia occur in 100,000 children with around 1 in 71 babies. According to a recent study, pneumonia claimed the lives of over 800,000 children under the age of five last year, or one child every 39 seconds [3].

According to the American Lung Association, pneumonia can be diagnosed in various ways, including a blood examination, pulse oximetry, sputum analysis on a sample of mucus, arterial blood gas examination, pleural fluid culture, or bronchoscopy [4]. Despite the many methods available to diagnose pneumonia, chest radiography remains the main method used for diagnosis. Although x-rays are commonly used, it is difficult to diagnose them based solely on these images. Perusing these images is a bottleneck problem because the area or areas of increased opacity are usually determined by pneumonia [5,6].

In fact, accuracy of the diagnosis of pneumonia is very limited due to certain causes of opacity which are difficult to account for. In this regard, many advances have been achieved by the application of machine learning (ML) techniques in medical diagnosis. The development of an artificial intelligence pneumonia diagnostic framework has recently become a hot topic in medical bioinformatics. Such frameworks may help radiologists interpret medical images using additional perspectives developed by computer systems [7].

Continuous improvement of such frameworks using new ML algorithms and techniques could provide more accuracy and ease of use of computer platforms. In this regard, Python programming language provides a hundreds of library. Sci-kit learn [8], Tensorflow [9], and Keras [10] are the most popular libraries ML programming. These ML libraries have been shown to have an impact on the integration of ML programming in biological data analysis [11,12]. In addition, AlexNet is the name of a convolutional neural network (CNN) algorithm designed for large-scale visual recognition. AlexNet has been successfully used for pathological brain detection [13–15].

In this research, we are trying to use highly specialized ML subtype for image classification to resolve many complications of routine pneumonia diagnosis. Using x-images this tool may be used for diagnosis of pneumonia. This tool will also be available as user-friendly applications which can be used with the minimum programming skills. In addition, we aim to develop a diagnostic software that could be easily updated, modified and integrated into different medical diagnostic systems.

Materials and Methods

Data collection

The dataset is composed of 5844 X-rays images belonging to normal and pneumonia patients. The dataset consists of images with high resolutions and satisfied statistical variance (Figure 1). The dataset was retrieved from kaggle database [16,17]. This data was collected from retrospective samples of one to five year-old pediatric patients.

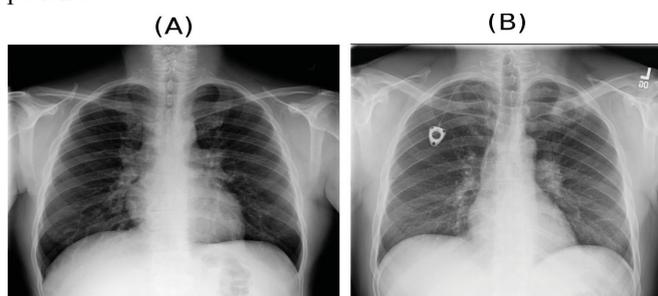


Figure 1 : Sample X-ray image of normal (A) and lung pneumonia (B).

Model construction and validation

The dataset of X-rays images have been used for ML model training (5216 image) and validation (624 images). The AlexNet architecture yielded 37% accuracy at the beginning of the design. Our ML model design is inspired by AlexNet structure, where the architecture consists of eight constitutional layers (Figure 2 and Table 1).

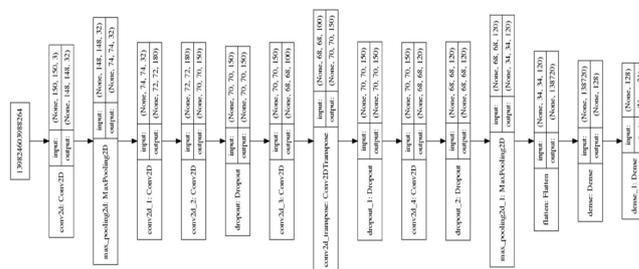


Figure 2 : The architecture of the ML neural network used to diagnose pneumonia from X-rays images.

Table 1: Description of the structure of the neural network architecture.

Layers	Feature Map	Size	Strides	Dilation Rate	Activation
Input	Image	1	(150, 150, 3)	1	relu
1	Convolutional	3	(150, 150, 3)	1	relu
	Max Pooling	32	(148, 148, 32)	1	relu
2	Convolutional	32	(74, 74, 32)	1	relu
3	Convolutional	180	(72, 72, 180)	1	relu
4	Convolutional	150	(70, 70, 150)	1	relu
5	Convolutional Transpose	100	(68, 68, 100)	1	relu
6	Convolutional	150	(70, 70, 150)	1	relu
	Max Pooling	120	(68, 68, 120)	1	relu
7	FC	-	138720	-	softmax
Output	FC	-	1000	-	softmax

Results and Discussion

Diagnosis of pneumonia is very difficult due to hidden factors causing opacity such as pulmonary edema, bleeding, atelectasis or lung cancer. When examining an area of increased opacity in the chest radiography, it is critical to determine where increased opacity occurs [18,19]. Computational analysis integration could accelerate pneumonia and enhance the routine medical diagnosis system.

A highly specialized sub-type of machine learning for image classification called deep learning networks has been used in current research to detect lung pneumonia from X-ray images (Figure 2). We analyzed a dataset of 5844 images of chest X-ray film to diagnose pneumonia using ML pipeline. AlexNet's neural network architecture has produced an ML model accuracy of 84%.

Conclusion

Deep learning is expected to lead to a revolutionary progression in the efficacy of medical diagnosis using radiological methods around the world. We ML models and novel diagnostic approaches for various x-ray abnormalities to detect pneumonia. Our pipeline may trigger the impact of artificial intelligence, which will

defiantly lead to an enormous improvement in the visual diagnosis of many diseases.

Availability

The Python source code we have used is freely available at : <https://github.com/peterhabib/PneumoniaAI> . This code can be executed interactively in a Python command line.

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