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Pneumonia Detection Using X-Ray Images Based on Machine Learning and Deep Learning Techniques – A Survey

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ABSTRACT

Artificial intelligence has proven to be an effective way in the detection of many diseases. This study presents a survey of artificial intelligence techniques used in the detection, classification, and visualization of pneumonia disease in lungs using radiographs of the chest. In this survey, different reliable databases were searched including research gate, Applied sciences, and IEEE. Pneumonia is a fatal sort of malady on the off chance that truly couldn't care less. If diagnose cannot be done in its early stages can be responsible for 50000 deaths every year. There are two kinds of pneumonia: viral and bacterial. Many researchers have done their research for the identification of pneumonia using machine learning and deep learning methods. This study gives you an overview of the machine learning methods proposed previously for pneumonia detection. The review is structured based on machine learning methods using chest x-ray images for the early identification of pneumonia.

1. INTRODUCTION

Pneumonia is a lung infection mainly caused due to variety of organisms like viruses' bacteria etc. This infection causes inflammation of wind pipes (air sacs) and also results in filling of air sacs by pus. In the entire world pneumonia is at the top of those diseases which are causing death over the world. Every year more than 50000 people mostly old age become die due to pneumonia. Many other techniques apart of X-ray exist for early detection of Pneumonia [1].

Artificial Intelligence (AI) is a vast field of machines equipped for performing a task that commonly provides human knowledge. It is the pledge to reproduce or generate human knowledge in machines. With mechanized location, radiologists see pictures dependent on perusing need which velocities detail and improve persistent results. With the expansion of recovery benefits, the AI pulls comparable pictures from a database for a survey when it experiences strange or complex cases Mostly the chest X-Ray is being used all over the world for the detection of infection by applying various techniques. In this paper presented a review of the all-AI methods and techniques used in the detection of pneumonia. AI is a vast field and all the methods related to AI are

working on medical imaging are giving amazingly good results. For example, digital image processing is a very efficient and reliable method in the classification and identification of diseases. Mask-RCNN, Deep learning, neural network, Transfer learning, CNN are being discussed in this paper. If we look at these techniques deep learning is used more extensively than other ones and its accuracy rate is also higher. Convolutional neural network that inputs a chest X-beam picture, gets the probability of pneumonia beside a heat map restricting the zones of the picture [13]. In addition, there is a lot of computer software that helps in automating the detection of pneumonia and robotization on the way to get the most accurate analysis using computerized calculations in the field of AI, which can reduce the chances of errors and misdiagnosis which can reduce unwanted incidents [14].

Symptoms of pneumonia were first portrayed by the Greek doctor Hippocrates around 460 BC. Despite the reality that it conveyed numerous names and was frequently distinguished as an abnormal illness, in the 19th-century scholars identified by their research that it is not only infection but a disease itself. It is a lung disease. It causes the air sacs of the lungs to top off with liquid or discharge. It can go from mellow to serious, contingent upon the sort of germ causing the disease, your age, and your general wellbeing. The most commonly used data for the detection of pneumonia is X-ray. Despite these CT images being also used CT images take more time C-XT and there are not enough CT scanners available in underdeveloped countries. That's why CXT is the cheapest way of detecting pneumonia. There are mostly two types of pneumonia bacterial pneumonia and viral pneumonia. The difference between normal and infected X-rays is shown below respectively. The difference between normal and infected X-rays is shown below respectively.

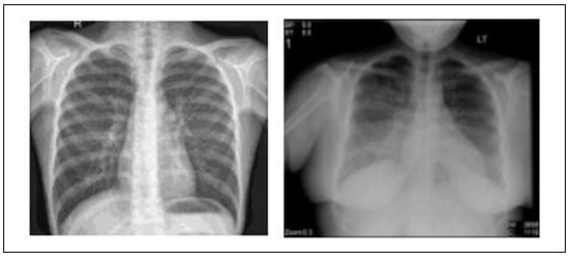

Figure 1: Normal X-rays Figure 2: Infected X-rays

A. Bacterial Pneumonia

In the bacterial type of pneumonia lungs, inflammation occurs due to bacterial infection and it could be in one lung, both lungs, or could be in a section of the lung. In the viral type of pneumonia, air sacs are infected and the patient feels difficulty in his windpipe.

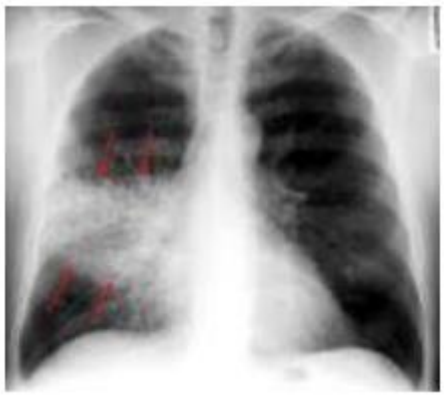

Figure 3: Bacterial Pneumonia

B. Viral Pneumonia

Infection that is caused by a virus is called viral infection and pneumonia is caused by a virus called viral pneumonia. Viral type of pneumonia is commonly caused by flu or even cold. Viral pneumonia spreads in three parts viruses caught the upper part of the repertory system first and then enter into your lungs and then affects the victim's lung.

Figure 4: Viral Pneumonia

Symptoms: Muscle pain, fever, dry cough, loss of appetite, throat get sore and headache are the early symptoms of pneumonia. Always in these types of conditions, we should don't get panic and take normal medicine which is our first mistake.

C. Datasets

The dataset that is used and processed by previous works had their worth as discussed below.

Kaggle dataset: Kaggle is a website that allows user to use their dataset work on it and explore it

for future research. In this dataset, there are three folders named train, test, and val as well and their subfolders contain two normal types and pneumonia images [14].5216 images were included for training and 624 images were included for training. Grayscale images 64x64 dimensions are given [15].

Indiana kit: In [16] dataset was used collected through Indiana university and medicine school and that dataset contains 7470 X-Rays.

Kit dataset: In that dataset from the total of 10484 images there were 3828 were abnormal cases and 7020 image data was normal images data.

Kermany dataset: For the evaluation and testing of the proposed methods dataset of kermany was used [24]. That was a scanned dataset of pediatric patients. 5856 total images were used. This dataset included its own test sets of 234 normal and 390 infected images.

2. LITERATURE REVIEW

This survey is categorized into two major AI divisions machine learning and deep learning. Further methods of machine learning and deep learning are explained below. Machine learning is a subfield of artificial intelligence (AI). The goal of machine learning generally is to understand the structure of data and fit data into models that can be seen and utilized by people. In machine learning tasks are by and large characterized as supervised and unsupervised. These classifications depend on how learning is gotten or how criticism on the learning is given to the framework created [21].
There are two main machine learning methods

A. Supervised Learning Methods

Supervised learning method trains algorithm which is based on examples and labelled data the unsupervised method come up with no labelled data [21].

There are the following supervised learning methods which we have discussed:

Support Vector Machine: It is a classification method. In this algorithm, we plot each data item as a point in n-dimensional space (where n is number of features you have) with the value of each feature being the value of a particular coordinate.

Linear Regression: Linear Regression is mainly of two types: Simple Linear Regression and Multiple Linear Regression. Simple Linear Regression is characterized by one independent variable. And, Multiple Linear Regression (as the name suggests) is characterized by multiple (more than 1) independent variables. While finding the best fit line, you can fit a polynomial or curvilinear regression. And these are known as polynomial or curvilinear regression.

Logistic Regression: It is used to estimate discrete values (Binary values like 0/1, yes/no, true/false) based on given set of independent variables(s). In simple words, it predicts the probability of occurrence of an event by fitting data to a logit function. Hence, it is also known as logit regression. Since, it predicts the probability, its output values lie between 0 and 1 (as expected).
Naïve Bayes: It is a classification technique based on Bayes' theorem with an assumption of independence between predictors. In simple terms, a Naive Bayes classifier assumes that the presence of a particular feature in a class is unrelated to the presence of any other feature. For example, a fruit may be considered to be an apple if it is red, round, and about 3 inches in diameter. Even if these features depend on each other or upon the existence of the other features, a naive Bayes classifier.

Linear Discriminant Analysis: Linear Discriminant Analysis or Normal Discriminant Analysis or Discriminant Function Analysis is a dimensionality reduction technique that is commonly used for supervised classification problems. It is used for modelling differences in groups i.e., separating two or more classes. It is used to project the features in higher dimension space into a lower dimension space.

Decision Tree: It is a type of supervised learning algorithm that is mostly used for classification problems. Surprisingly, it works for both categorical and continuous dependent variables. In this algorithm, we split the population into two or more homogeneous sets. This is done based on most significant attributes/ independent variables to make as distinct groups as possible.

K-Nearest Neighbor Algorithm: It can be used for both classification and regression problems. However, it is more widely used in classification problems in the industry. K nearest neighbors is a simple algorithm that stores all available cases and classifies new cases by a majority vote of its k neighbors. The case being assigned to the class is most common amongst its K nearest neighbors measured by a distance function.
Similarity learning: Similarity is a machine learning method that uses a nearest neighbor approach to identify the similarity of two or more objects to each other based on algorithmic distance functions. In order for similarity to operate at the speed and scale of machine learning standards,

two critical capabilities are required – high-speed indexing and metric and non-metric distance functions.

B. Unsupervised Learning Method

Following are the form of the unsupervised method which we have discussed some in our survey:

- K-means for clustering problems
- Apriori algorithm for association rule learning problem
- Principle component Analysis
- Singular Value Decomposition
- Independent component analysis

Deep learning is a subset of machine learning where artificial neural networks, calculations motivated by the human brain, gain from a lot of information. Additionally, to how we gain for a reality, deep learning count would play out a task on and on each time tweaking it a little to improve the outcome so that teaches the computers to do what falls into place without any issues for people. Learning from the Deep Learning perspective is a technique for developing activities dependent on information and experience. Deep Learning is an artificial intelligence and machine learning subgroup which grows the yield of innumerable machine learning applications like AI.

There are the following deep learning methods used in different researches:

Convolutional Neural Network (CNN): CNNs have wide usage in identifying the image of the satellites, medical image processing, series forecasting, and anomaly detection. CNNs process the data by passing it through multiple layers and extracting features to exhibit convolutional operations. The Convolutional Layer consists of Rectified Linear Unit (ReLU) that outlasts to rectify the feature map. The Pooling layer is used to rectify these feature maps into the next feed. Pooling is generally a sampling algorithm that is down-sampled and it reduces the dimensions of the feature map. Later, the result generated consists of 2-D arrays consisting of single, long, continuous, and linear vector flattened in the map. The next layer i.e., called Fully Connected Layer which forms the flattened matrix or 2-D array fetched from the Pooling Layer as input and identifies the image by classifying it.

Recurrent Neural Network (RNN): Recurrent Neural Networks or RNNs consist of some directed connections that form a cycle that allow the input provided from the LSTMs to be used as input in the current phase of RNNs. These inputs are deeply embedded as inputs and enforce the memorization ability of LSTMs lets these inputs get absorbed for a period in the internal memory. RNNs are therefore dependent on the inputs that are preserved by LSTMs and work under the synchronization phenomenon of LSTMs. RNNs are mostly used in captioning the image, time series analysis, recognizing handwritten data, and translating data to machines.

De-noising Auto Encoder (DAE): A Denoising Autoencoder is a modification on the autoencoder to prevent the network learning the identity function. Specifically, if the autoencoder is too big, then it can just learn the data, so the output equals the input, and does not perform any useful representation learning or dimensionality reduction. Denoising autoencoders solve this problem by corrupting the input data on purpose, adding noise or masking some of the input values.
Deep belief networks (DBN's): DBNs are called generative models because they have various layers of latent as well as stochastic variables. The latent variable is called a hidden unit because they have binary values. DBNs are also called Boltzmann Machines because the RGM layers are stacked over each other to establish communication with previous and consecutive layers. DBNs are used in applications like video and image recognition as well as capturing motional objects.
DBNs are powered by Greedy algorithms. The layer-to-layer approach by leaning through a top-down approach to generate weights is the most common way DBNs function. DBNs use step by step approach of Gibbs sampling on the hidden two-layer at the top. Then, these stages draw a sample from the visible units using a model that follows the ancestral sampling method. DBNs learn from the values present in the latent value from every layer following the bottom-up pass approach.

Long Short-Term Memory (LSTM): LSTMs can be defined as Recurrent Neural Networks (RNN) that are programmed to learn and adapt for dependencies for the long term. It can memorize and recall past data for a greater period and by default, it is its sole behavior. LSTMs are designed to retain over time and henceforth they are majorly used in time series predictions because they can restrain memory or previous inputs. This analogy comes from their chain-like structure consisting of four interacting layers that communicate with each other differently. Besides applications of time series prediction, they can be used to construct speech recognizers, development in pharmaceuticals, and composition of music loops as well.
LSTM work in a sequence of events. First, they don't tend to remember irrelevant details attained

in the previous state. Next, they update certain cell-state values selectively and finally generate certain parts of the cell-state as output. Below is the diagram of their operation.

C. Machine Learning

By extracting some specific features from images, we can find out several things like disease detection, etc. Cosmin et al used this feature selection technique to detect pneumonia with the help of a natural language processing system. In this research author used statistical feature selection because that is just the most informative highlights from the feature space significantly improves the performance over a gauge that utilizes all the highlights from a similar component space. Extricating the statement esteem for pneumonia articulations further improves the framework execution.

The presented model is a machine learning model which can detect pneumonia. Machine learning methods are also used in [2]-[3]-[6]-[8]. The author describes that only a small informative part of an image feature can give you better results [58]. This research aimed to compare the machine learning methods including Naive Bayes, K-Nearest Neighbor (KNN), and Support Vector Machines (SVM). Rafael et al used 3 different methods on the Pneumonia CAD dataset including feature testing, robustness testing, and feature selection.

After all these experiments and tests according to the author, SVM shows better results than the other two methods. In conclusion, the SVM classifier created the most exact outcomes and has demonstrated to be steadier with preparing information variety.

In addition, it beats the best outcome from past work and even outperforms the analysis precision of clinical inhabitants.

Table 1: Summary of Related Work in Pneumonia Detection in Machine Learning

Sr. No	Author	Technique/Algorithm	Dataset	Finding	Limitation
1	Nghia Duong et. al. 2019	Transfer learning	Guangzhou Women and Children's Medical Center Guangzhou.	98.0% accuracy, improved and efficient.	A specific focus on the binary of pneumonia and normal can develop the model.
2	Ara Abigail E. et. al. 2020	SVM	chest x-ray images	Accuracy 98%	including GPU and other machine learning techniques accuracy can be increased.
3	Rafael T. Sousa, et. al.	SVM, Naive Bayes	Digital camera images	Accuracy 68%	--
4	Sagar Kora Venu 2020	Transfer learning	Radiograph images	98% accuracy	Time complexity is more
5	Inderpreet Singh Walia, 2020	Transfer learning, CNN	Radiograph images	98.5% accuracy	By freezing, transfer learning algorithm layers and use of different algorithm work can be extended
6	Cosmin Adrian et. al. 2012	Machine learning, feature selection	narrative reports for 426 patients	Extract information from narrative reports	The performance will be improved if a feature is added which can extract the assertion value of all pneumonia expression
7	Gaurav Labhane, 2020	Transfer learning, CNN	Guangzhou Women and Children's Medical Center.	97% accuracy	---

D. Deep learning

As we know deep learning is a very well-known method used in AI. Many researchers in [1]-[5]-[7]-[9]-[10] work for pneumonia detection using deep learning methods. Jae Hyun Kim et al takes advantage and used commercial deep learning in their research. An exploration on Clinical approval of a deep learning calculation for identification of pneumonia on chest radiographs in crisis division patients with intense febrile respiratory disease was proposed by Jae Hyun Kim et al (2020). Deep learning calculation is being utilized in this exploration to identify pneumonia in crisis office patients. 377 sequential patients' datasets were gathered and the calculation was applied on their X-beam to recognize pneumonia. This examination results that the proposed calculation working productively and getting pneumonia obvious on the chest x-beams.

Table 2: Summary of Related Work in Pneumonia Detection in Deep Learning

Sr. No	Author	Technique/Algorithm	Dataset	Finding	Limitation
1	Bing Chuan Li, 2019	CNN	8,964 pneumonia labelled CXR images	End to end detection of pneumonia	More validation. labels identify false-positive samples.
2	Sabyasachi Et. al. 2019	CNN	5856 chest X-ray	Spatial detection of pneumonia	Adam can also be used to rain the data of other subjects and multiple X-Rays.
3	Sheikh Rafiul Et. al.	Compressed Sensing (CS) based deep learning framework/ CNN	Kaggle	97.34% accuracy.	The method can be further used to localize the area of interest like tumor cells.
4	Heewon Ko et al. 2019	Mask R-CNN and RetinaNet	Subset of NIH	Detection of pneumonia	--
5	Ansh Mittal, Et. al. 2020	CapsNet	Mendeley CXR image	97.34% accuracy.	It can be extended by a general automatic computerized system by localizing the region of interest
6	Naseem Ansari, Et. al. 2020	Deep convolutional neural network	RSNA, Kermany	96.76%	Accuracy can be improved using ResNet-101 or ResNet-15
7	Jason R. Andrews, et. al. 2020	Commercial deep learning (DL) algorithm	377 patients dataset	DL algorithm showed fair diagnostic performance for detecting pneumonia	Needs to validate the results by multiple observers

CONCLUSION

We conclude that chest radiography can plays a crucial role in testing and diagnosis of related Pneumonia diseases. Various algorithms are available nowadays using different techniques. The paper presents the survey of pneumonia classification by using chest x-ray that is currently accessible. It surveys the topic and analyse present algorithms in various aspects like usability, goodness, and complexity in computation associated with different techniques. Many datasets are available, but we observed that most of them are imbalanced, also only a few researchers are following balancing techniques. In most of the cases, authors concluded results using very few images in dataset, most of them used under sampling. Therefore, we conclude that their results are unreliable, and suggest that their work should not be exploited on an industrial scale, because doing so will lead to danger to life of patients. Massive-scale data which is balanced and having a million pneumonia images should be used. Much research in using Machine Learning and Deep Learnings in the Medical industry is going on worldwide. Different versions of CNN's show promising results in detecting Pneumonia. We all know the shortage of expert radiologists, even when imaging machines are available. The automatic detection of Pneumonia will assist the expert radiologist, and this technique will be advantageous for developing countries which don't have proper medical facilities. If detection of Pneumonia is done timely, then it will save many lives. Studying and understanding the research work, we have found some limitations that are there.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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