Pneumonia Classification Using Deep Learning VGG19 Model

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***Abstract*— Pneumonia is a fatal disease that primarily affects the elderly and can be fatal. The earlier diagnosis of pneumonia saves lives. Deep learning is utilized in medical imaging. This paper develops the detection and classification of pneumonia patients according to their chest X-rays. This system was developed for the detection and classification of pneumonia using a deep learning model. In this system, the VGG-19 deep learning approach is used for solving the problem of pneumonia classification. The chest X-ray images (pneumonia) dataset at Kaggle is used for training with the VGG-19. The system implementation is done for the chest X-ray image dataset's balanced and unbalanced nature. This proposed system achieves an accuracy of 86% in an unbalanced dataset and 94% in a balanced dataset.**

Keywords—*Pneumonia Classification; VGG19; Deep Learning; Undersampling*

I. INTRODUCTION

Pneumonia is one of the infection diseases occurred by germs, bacteria, viruses, and fungi. The inflammation of air sacs in the lungs are occurred that may be very dangerous when there is no identification at the earlier steps. The infection of the lungs causes the pulmonary alveoli that results the deterioration in the health conditions in people. There are various kinds of pneumonia including bacterial pneumonia, mycoplasma pneumonia, and viral pneumonia. Bacterial pneumonia is occurred by fungi or bacteria. Various viruses like flu causes viral pneumonia and is noticeable to one-third in the causes of all pneumonia. Atypical pneumonia or mycoplasma pneumonia is occurred from a bacterium and usually causes the infection in people at all ages and this is more serious to alcoholics, asthma, people with frail immune system, smokers, surgical patients, and viral infected.

The consideration of viral pneumonia is very serious and it is more risk with owning pneumonia than if the attacking with viral pneumonia. The various symptoms of pneumonia are fever, heavy sweating, chest pain, loss of appetite, turning in the color of lips and nails blue, cough, tiredness, squatness of breath, shivering, and confusion. The pneumonia is suggested as the serious disease which may occur death worldwide.

Today, medical imaging approaches are applied for the identification of various diseases such as tumors through MRI cardiomegaly at Echo chest diseases through chest X-rays. The largest data science platform, Kaggle supports data scientists with various medical imaging jobs and data for training algorithms and everyone performs the competition for providing outputs. Many hospitals make the investment on the intelligent smart health appliances and the hiring more medical doctors that aid for the work in effectively and efficiently to support most accurate outputs. Moreover, medical image classification systems aid medical doctors for the earlier identification of diseases at the specific fields deciding that surgeries are essential and this enhances the placement of patients at relevant areas like ICU.

Machine learning acts as an important part for the identification of different diseases. Various researches have been performed in the diagnosis in the disorders of chest and lungs utilizing these machine learning techniques. Machine learning fails in the achievement of low error rate, low computing power, and high accuracy although these techniques achieved the good performance. Deep learning provides the enhancement in accuracy and is utilized to different aims as classification of image, segmentation of objects, classification of text, detection of objects and so on. Moreover, deep learning has the capability in the segmentation and recognition at medical imaging like analysis of radiology image for the analysis in the abnormal or biological characteristics at the human body. Deep learning algorithms and methods provide more accurate outputs than traditional state-of-the-art machine learning approaches and algorithms.

In this paper, the pneumonia classification is developed with VGG19 deep learning model in order to provide the most accurate results to medical doctors. NSL – KDD dataset is used to train the data with VGG19 deep learning model. The system implementation is performed for balanced and unbalanced nature of NSL – KDD dataset. The rest of this paper is organized as follows. Section 2 describes related works and background theory is showed in section 3 Section 4 presents proposed system design. Experimental evaluation is described in section 5 and finally, section 6 concludes the conclusion and future work.

II. RELATED WORKS

The authors developed a computer-aided diagnosis system utilizing chest X-ray images for the diagnosis of pneumonia [1]. The extraction and integration of local binary patterns and the combined scale-invariant fourier transform features was performed through incoming training images, and the features were put into machine learning approaches like artificial neural networks, decision trees, and random forests. Then, the building of the classification model was done, and this model was tested with the test images set. In the evaluation, random forest achieved an accuracy of 91.29% for the classification of all patients who had pneumonia.

According to the development of deep learning approaches for the analysis of medical images, convolutional neural networks have improved the classification of diseases.

2023 IEEE Conference on Computer Applications (ICCA) | 978-1-6654-3599-4/23/$31.00 ©2023 IEEE | DOI: 10.1109/ICCA51723.2023.10181954

Moreover, features extracted through pre-trained convolutional neural network models for larger datasets are more applicable in the classification of images. The authors validated the functionality of pre-trained convolutional neural network models used as feature extraction with various classifiers in the classification of normal and abnormal chest X-rays [2]. The demonstration of statistical outputs presented shows that pretrained models utilized through supervised classifier methods can be very effective in the analysis of chest X-ray images for the detection of pneumonia.

The authors proposed a convolutional neural network model for supporting effective and more accurate outputs in the detection of pneumonia employing X-ray images. It included the use of a dropout layer on the network's convolutional layers [3]. The training and testing of the introduced approach were performed with a set of 5856 labeled images from Kaggle. The selection of chest X-ray images was done through retrospective cohorts of pediatric patients, aged between one and five years, in China. The experimental evaluation found that this approach achieved more accurate results than current state-of-the-art solutions with accuracy and efficiency, providing recall and precision above 97% by predictions provided in only 122 ms.

Chest X-ray images were utilized in the detection of medical imaging. Various factors, like the inspiration depth and the situation of the patient, may cause changes in the formation of the chest X-ray. The deep learning-based method for the identification and localization of pneumonia in chest X-ray images was developed using Mask-RCNN [4]. That deep model integrated local and global features for pixel-wise segmentation. This technique provided robustness with alterations in the training and post-processing that combined bounding boxes through many methods. The developed specification method provided more accurate results with the chest radiograph dataset.

The detection and classification of pneumonia were developed according to chest X-rays using a convolutional neural network [5]. The classification happened after the input image was processed with a series of max pooling and convolutional layers, which were activated using the activation function of ReLU, which is continuously applied to the neurons at dense layers, and after the output neurons were activated using the sigmoidal function. The model training achieved a simultaneous improvement in accuracy and a decrease in loss. The implementation of data augmentation prevented overfitting before model fitting. As a result, the proposed method effectively classified the chest X-rays for the identification of pneumonia.

The authors deployed the convolutional neural networks, transfer learning and deep learning approaches for the identification of covid-19 induced pneumonia diseases through the images of chest X-rays [6]. This paper performed the successful detection of regular pneumonia, normal situations, and covid-19 induced pneumonia by using transfer learning with fine tuning. VGG19, Xception, and VGG16 were applied for the consideration of transfer learning. The experimental evaluation was performed with recall, specificity, false negative rate, false discovery rate, precision, F1 score, false omission rate, false positive rate by the classification accuracy of covid-19 induced pneumonia by 98%. This system did not need the larger dataset as the usage of transfer learning for providing more accurate detection outputs. This system performed the successful classification of covid-19 and observed the difference between regular pneumonia and covid-19 induced pneumonia.

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III. BACKGROUND THEORY AND METHODOLOGY

This section gives random sampling, undersampling, deep learning, VGG19 and transfer learning.

A. Random Sampling

Random sampling is one kind of probability sampling in that every instance possesses the equality in probability for the selection. A random selected instance is an unbiased description for the total population. If the instance does not represent the population, the variation becomes a sampling error. Random sampling is a method for choosing each participant or a subset of the population for providing the statistical inferences from them and estimation the characteristics of the whole population. It can be utilized as a data reduction method as it allows a large data set to be represented by a much smaller random data instance (or subset).

B. Undersampling

Undersampling is a balancing approach for asymmetric datasets that involves maintaining all of the data in the minority class and reducing the size of the majority class. In other words, samples from the majority class are deleted, which can result in the loss of valuable information in the model. Majority classes are classes that provide a larger proportion of the dataset [7]. Minority classes are classes that provide a smaller proportion of the dataset. Assume that D is a large data set and that it contains the number of instances, N. Simple random sample without replacement (SRSWOR) of size s: This creation is done by deleting s from the N instances at D ($s < N$), where the deletion probability of any instance in D is $1 = N$, i.e., all instances are equally likely to be sampled. This sampling is appropriate in such conditions as there is plenty of data for an accurate analysis. All rare instances are utilized, but the number of abundant instances is reduced due to the creation of two equally sized classes.

C. Deep Learning

Deep learning is a kind of artificial intelligence and machine learning that imitates the path humans take to achieve specific kinds of knowledge [8]. This learning is a potential thing in data science that contains modeling of predictive and statistical methods. This is more efficient for data scientists who are tasked with the analysis, translation, and collection of a huge volume of data; this learning makes this procedure easier and faster. Operational models are permitted by incorporating many operation layers for learning descriptions in the data at many abstraction levels. This learning model contains many fully connected hidden layers, so such models are called "deep learning models" in comparison with models with only two hidden layers, which are called "shallow learning models." The classification of deep neural networks is done according to the flow of information. When the flow of information from the input layer to the output layer is performed without feedback, this network is known as a feedforward deep learning neural network.

Learning descriptions from raw datasets is one of the primary activities of deep learning neural networks. The

neural network model has the ability to automatically discover the descriptions in data needed to detect features and classify them; this is called feature learning or description. A deep learning neural network may be specified with a class of machine learning methods that apply many layers of operational elements for continuous learning and extract features from a raw dataset. As the movement from the lower end to the higher end of the layers is done, the extracted features start resulting in more and more pronounced results in the learning model for inferring desired results for the given classification or forecasting job.

D. Transfer Learning

Transfer learning is the machine learning approach and at which a pre-trained model is reused as the beginning point for a model on an incoming job [9]. For the improvement in generalization with other, what has been observed at a job is exploited by using transfer learning. The weight at a network observed task "X" to a new task "Y" is transferred. The initial and middle layers are utilized and the latter layers are retrained at transfer learning. The labelling data of the job that was early trained is leveraged. Transfer learning provides the best outcomes and the computing effectiveness utilizing small dataset. The knowledge obtained through the previous pretrained model such as features and weights is utilized for continuing the job. Moreover, this transfer learning approaches provide the best and faster performance results than traditional machine learning approaches.

E. VGG19

VGG19 is a convolutional neural network architecture that was used to win the 2014 ILSVR (ImageNet) competition; it is a variation of the VGG model with 19 layers [10]. The VGG19 sets the input image size to 224 x 224. In preprocessing, the subtraction is done with the mean RGB value from each pixel by computing over the whole training set. The convolutional layers of VGG19 contain 16 convolutional layers of 3x3. For the preservation of the spatial resolution of the image, spatial padding was applied. The rectified linear unit (ReLU) activation function is applied. The maximum pooling was done among two 2-pixel windows by stride 2. By applying kernels of (3 * 3) size to a stride size of 1 pixel, it enabled them to cover the whole notion of the image. You have three layers of fully connected with the VGG-19. Among the three layers, the first two own 4096 nodes each, and the last owns 1000 nodes; that is the total number of classes the imagenet dataset has. In this VGG-19 architecture, the convolutional layer has 16 layers, the pooling layer has 5 layers, and the fully connected layer has 3 layers. The architecture of VGG19 is described in Fig 1.

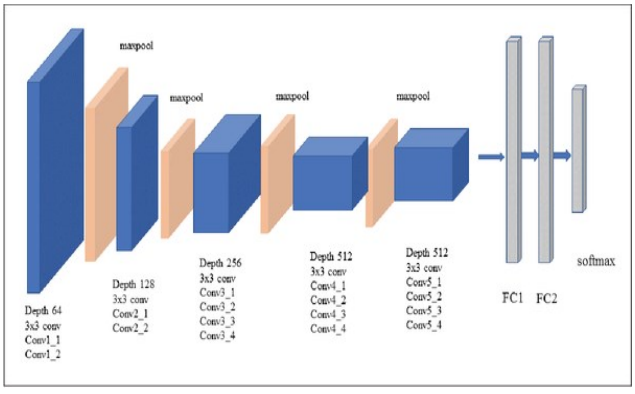

Figure 1. VGG19 Model Architecture

F. Pneumonia

Pneumonia is the infection disease which disorders the sacs of air at both lungs. The filling of air sacs by fluid occurring cough by phlegm, chills, the difficulties in breathing and fever. Various organisms such as viruses, fungi, and bacteria may happen the pneumonia. The serious range of pneumonia occurs among mild to life issues. The pneumonia disease is the most dangerous and serious to people older than the age of 65, people with weakened immune systems or health issues, and young children and infants. The variation in the symptoms and signs of pneumonia happens through mild to severe according to the facts like the age, the kind of germ occurring the infection, and overall health conditions. The flu or cold is the mild symptom and sign of pneumonia however it may occur longer time.

The symptoms and signs of pneumonia contains:

- The changes or confusion at the awareness of mental
- The fatigue
- The lower temperature than normal body temperature
- The shortness in breathing
- The pains of chest as the cough of breathing
- The phlegm coughs
- The shaking chills, fever, and sweating
- The diarrhea, nausea, and vomiting

The sign and symptom may not occur at infants and newborns. If they may infect, they occur cough and fever, the difficulty in eating and breathing, and happen tired no energy. The medical history, the testing of physical, and chest x-ray diagnosis images will be reviewed by the healthcare provider for the diagnosis of pneumonia. Which type of pneumonia may occurring can be decided with the aid of this information. The medicines made with fungi, viral, and antibiotics may treat pneumonia. However, this may take many weeks for recovering over pneumonia. If there is the worse symptoms of pneumonia, the earlier treatment to hospital is required through antibiotics provided by oxygen therapy and line of intravenous.

IV. PROPOSED SYSTEM ARCHITECTURE

The proposed system flow diagram is shown in Fig 2. This system's goal is to classify pneumonia using an unbalanced and balanced dataset. This pre-processing step generally involves balancing a dataset from an unbalanced dataset using undersampling, resizing, changing data types and normalization, cleaning, and scaling in order to achieve a more accurate deep learning model. Then the splitting of training and testing is performed. To extract optimized features from images, we used the VGG19 convolutional neural network architecture with the Adam and stochastic gradient descent optimizers. All the convolutional and separable convolution layers are followed by batch normalization.

To extract features from this pretrained VGG-19, fine-tuning is conducted using chest X-ray images to obtain higher-quality features from the images. The new fully connected layer is added by removing the old fully connected layer from this architecture. In this system, the Chest X-Ray Images (Pneumonia) dataset [11] at Kaggle is employed. This

collection includes 5,863 images of normal and pneumonia diseases. The testing phase is shown in Fig 3.

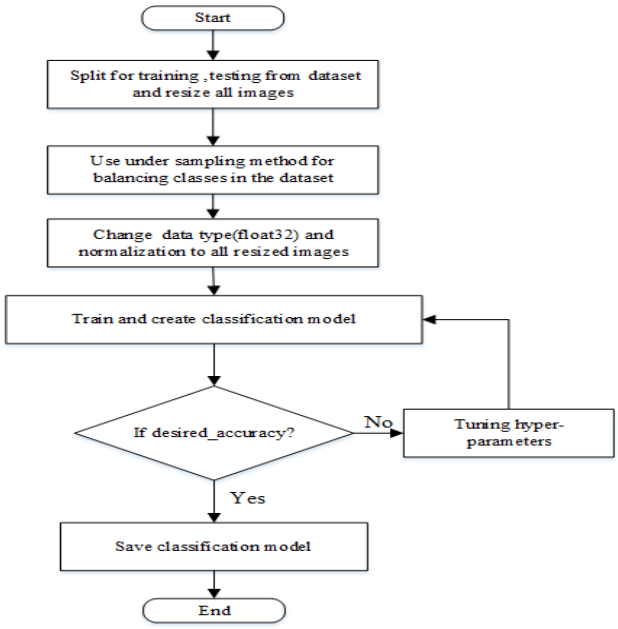

Figure 2. Proposed System Flow Diagram

V. PERFORMANCE EVALUATION

In this system, the Chest X-Ray Images (Pneumonia) dataset at Kaggle is utilized. The chest X-ray images are divided into pneumonia and normal images. This system is first tested against the unbalanced nature of the original dataset. The system is then tested with balanced nature using undersampling.

The key metrics of performance measures (accuracy, recall, f-measure, and precision) are evaluated for this proposed system analysis. The accuracy is computed using equation 1, the precision is calculated with equation 2, the recall is computed with equation 3, and the f-measure is computed according to equation 4.

$$Accuracy\ (\%) = \frac{\text{Exactly predicted sample}}{\text{Total number of samples}} \times 100 \quad (1)$$

$$\text{Precision} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Positive}} \quad (2)$$

$$\text{Recall} = \frac{\text{True Positive}}{\text{True Positive} + \text{False Negative}} \quad (3)$$

$$\text{F} - \text{measure} = \frac{2 * \text{Precision} * \text{Recall}}{\text{Precision} + \text{Recall}} \quad (4)$$

Table 1 shows the comparative results for the performance of VGG19 model on unbalanced, balanced by undersampling. Fig 4 shows the comparative of accuracy of proposed model on unbalanced, balanced by undersampling. According to the evaluation results, the improvement of accuracy of VGG19 is achieved by applying random sampling technique: undersampling.

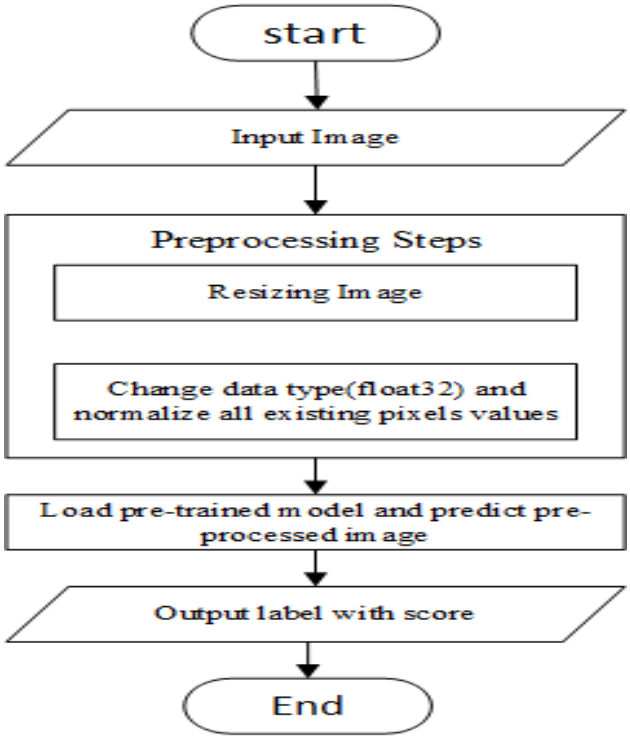

Figure 3. Testing Phase

TABLE I PERFORMANCE RESULTS FOR VGG19

	Pneumonia			Normal		
	Precision	Recall	F-measure	Precision	Recall	F-measure
Unbalanced	0.89	0.83	0.81	0.8	0.39	0.55
Undersampling	0.96	0.97	0.89	0.87	0.9	0.88

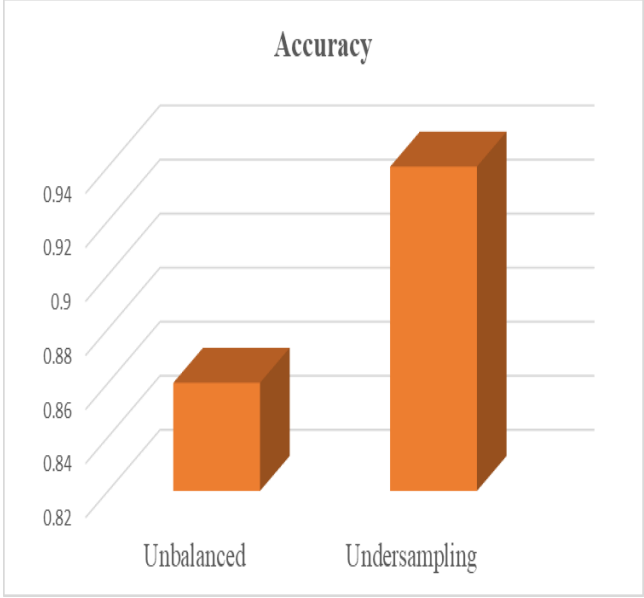

Figure 4. Accuracy for Unbalanced and Balanced Dataset

VI. CONCLUSION

Pneumonia is a respiratory infection disease caused by viruses that typically occurs in underdeveloped and developing countries with unsanitary living conditions,

overcrowding, and higher pollution levels, as well as insufficient medical infrastructure. In this system, a deep learning model for pneumonia classification is proposed. This system utilizes a deep learning approach (VGG-19). This proposed system will provide the most accurate results for pneumonia classification. This proposed system implements a deep learning model to train the model VGG19 with chest X-ray images (pneumonia) from the Kaggle dataset. This system classifies X-ray images into normal and pneumonia-type diseases. This system achieves an accuracy of 86% in an unbalanced dataset and 94% in a balanced dataset. In future work, this pneumonia classification system will be implemented using the ensemble model of deep learning methods.

REFERENCES

1. D. S. Rao, S. A. H. Nair, T. V. N. Rao, K. P. S. Kumar, "Classification of Pneumonia from Chest X-ray Image using Machine Learning Models," International Journal of Intelligent Systems and Applications in Engineering, IJISAE, 2022, 10(1s), pp. 399–408.
2. D. Varshni, K. Thakral, L. Agarwal, R. Nijhawan, and A. Mittal, "Pneumonia Detection Using CNN based Feature Extraction", 2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT), IEEE, Coimbatore, India, 20-22 February 2019, pp. 1-7.
3. P. Szepesi, and L. Szilagyi, "Detection of pneumonia using convolutional neural networks and deep learning", Biocybernetics and Biomedical Engineering, Volume 42, Issue 3, Elsevier, July–September 2022, pp. 1012-1022.
4. A. K. Jaiswal, P. Tiwari, S. Kumar, D. Gupta, and A. Khanna, "Identifying pneumonia in chest X-rays: A deep learning approach", Measurement, Volume 145, Elsevier, October 2019, pp. 511-518.
5. S. Shah, H. Mehta, and P. Sonawane, "Pneumonia Detection Using Convolutional Neural Networks", 2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT), IEEE, Tirunelveli, India, 20-22 August 2020, pp. 933-939.
6. D. K. Jain, T. Singh, P. Saurabh, D. Bisen, N. Sahu, J. Mishra, and H. Rahman, "Deep Learning-Aided Automated Pneumonia Detection and Classification Using CXR Scans," Journal of Computational D. S. Rao, S. A. H. Nair, T. V. N. Rao, K. P. S. Kumar, "Classification of Pneumonia from Chest X-ray Image using Machine Learning Models," International Journal of Intelligent Systems and Applications in Engineering, IJISAE, 2022, 10(1s), pp. 399–408.
7. J. Han, M. Kamber, and J. Pei, "Data Mining: Concepts and Techniques (The Morgan Kaufmann Series in Data Management Systems) 3rd Edition", Elsevier Science Ltd, USA, 22 June, 2011, pp. 1-703.
8. https://www.techtarget.com/searchenterpriseai/definition/deep-learning-deep-neural-network
9. J. Brownlee, "A Gentle Introduction to Transfer Learning for Deep Learning", September 16, 2019.
10. https://blog.techcraft.org/vgg-19-convolutional-neural-network/
11. https://www.kaggle.com/datasets/paultimothymooney/chest-xray-pneumonia