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AI-Enabled Deep Learning Model for COVID-19 Identification Leveraging Internet of Things

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ABSTRACT: Since the COVID-19 epidemic was first addressed in December 2019, the importance of accurate and speedy patient identification has been highlighted. Automated COVID-19 identification on CXRs provided by deep TL is crucial for fighting the outbreak. To facilitate early identification of COVID-19 afflicted persons, this study suggested a real-time IoT system leveraging ensemble deep TL. The method enables the instantaneous transmission and identification of persons suspected of carrying the COVID-19 virus. Several deep learning (DL) models, such as InceptionResNetV2, VGG16, ResNet152V2, and DenseNet201, are incorporated into the proposed IoT model. In order to diagnose infections using chest X-ray data, medical sensors work in tandem with these models, which are stored on a cloud server. The deep ensemble model is evaluated against six transfer learning techniques on a chest X-ray dataset. The comparative investigation demonstrates that the suggested approach facilitates swift and effective diagnosis of COVID-19 suspicious patients, providing valuable support to radiologists. This work highlights the significance of leveraging deep transfer learning and IoT in achieving early identification of suspected COVID-19 patients. The proposed system, incorporating a deep ensemble model, offers a practical solution for assisting radiologists in efficiently diagnosing COVID-19 cases.

Keywords: IoT, COVID-19, deep transfer learning, medical treatment and Artificial Intelligent.

1. INTRODUCTION

IoT devices have found broad use in a variety of industries in recent years including manufacturing, medical care, smart cities, and home automation [1]. Sensors in these gadgets acquire data about the physical environment. The COVID-19 epidemic has now swamped the healthcare system. As of the 19th of December, 2020, there were over 21 million active infections, 55 million recovered cases, and 1.6 million documented deaths across 185 nations. The rapid identification of those affected with the coronavirus is critical to containing the epidemic. For this reason, IoT devices are utilized to remotely collect information from COVID-19 individuals. This data is shared with medical practitioners to help them diagnose coronavirus [2]. These gadgets not only diminish the load on medical professionals, but also allow for the detection of unfamiliar patterns in sensor data. The usage of it-enabled devices, healthcare personnel can supply higher remedy for coronavirus-infected human beings extra speedy. There may be a need to construct an automated categorization technique that makes use of information from IoT devices. Deep gaining knowledge of fashions has recently been utilized by a number of researchers to aid a spread of healthcare packages [3].

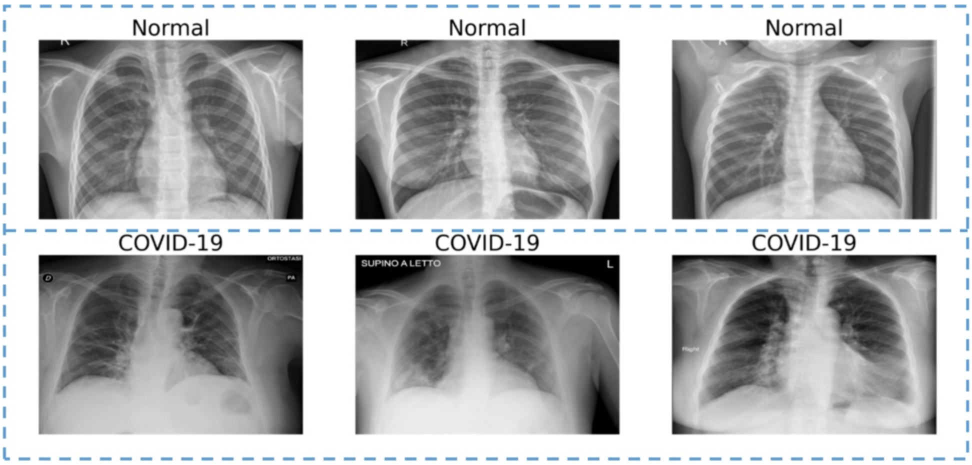

FIGURE 1. - COVID-19 Chest Xray (CXR) Images [4]

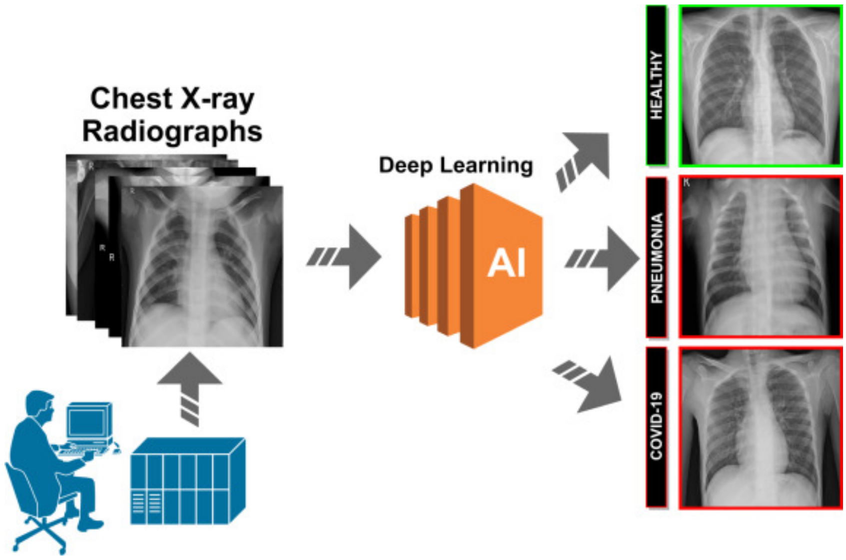

FIGURE 2. – Conventional Block diagram of COVID-19 identification [5]

According to existing literature, the CXR modality can be utilized to identify individuals as COVID-19 active, pneumonia, healthy or tuberculosis. CXR are preferred over other imaging modalities due to their low cost and low radiation exposure risk. CXR modality evaluation for evaluating coronavirus infected patients is shown in Figure 1. This job, however, is difficult and time-consuming. Radiologists examine the presence of white patches on the CXR, which indicate infection. Yet, X-ray images may also contain pus and fluids, making the detection of infection more difficult and time-consuming. Figure 1 depicts the IoT and DL-enabled framework for coronavirus detection. Radiologists can employ the deep ensemble model to swiftly diagnose positive individuals.

The remainder of this work is structured as follows: The 2nd portion analyzes the most recent relevant papers, and the third section outlines the suggested strategy. Section 4 presents and compares the trials carried out to assess our system against other methodologies. The article concludes in the fifth section.

2. LITERATURE SURVEY

For the purpose of early coronavirus diagnosis, an IoT-enabled system has been created.. Researchers have utilized a CNN with ResNet101 to diagnose coronavirus suspected cases, achieving a 98% accuracy [4]. A deep 3D multiple instance learning approach has been developed for automatic identification of coronavirus from CXR images [5]. To build upon the success of DL models in automated coronavirus diagnosis, an IoT-enabled ensemble DL method has been constructed. This recommended ensemble model assists radiologists and medical staff in identifying COVID-19 (+),tuberculosis, pneumonia, or healthy individuals. The framework incorporates InceptionResNetV2, ResNet152V2, VGG16, and DenseNet201 in a deep ensemble model. The ensemble deep TL approach is used to identify the infection after clinical sensors collect CXR modalities and save them to a cloud server. CXR images are categorized into four groups (healthy, COVID-19 (+), TB, and pneumonia).

In a comparative analysis, the proposed approach demonstrates its effectiveness in accurately and swiftly diagnosing COVID-19 suspicious individuals. AD3D-MIL method trained and evaluated on 460 CT pictures, is used for screening individuals for coronavirus infection using CT scans [6]. Another system, M3 Lung-sys, a multitask multislice DL model, is developed for the same purpose [6]. CovidGAN, a GAN-based model, is used to differentiate coronavirus from other pneumonias using CXR scans [7]. Deep learning models utilizing ultrasound, CT scans, and CXR are utilized to identify coronavirus suspicious cases [8]. A CNN-based TL architecture with eight pretrained CNN models is utilized for the identification of COVID-19 suspicious cases [9]. In order to differentiate COVID-19 infection from other illnesses, a 3DCNN is also constructed [10]. DL-CRC uses a GAN and data augmentation to categorize individuals with coronavirus infection from CXR images [11].

Despite the fact that medical IoT devices have considerably aided in the coronavirus epidemic, DL models based on the Internet of Things lack robustness against adversarial attacks [12]. Various DL methods and screening strategies have been proposed for detecting coronavirus suspicious patients [13-15]. However, overfitting remains a challenge in existing models [16, 17]. Ensemble models, which combine multiple learning methodologies, offer improved classification performance compared to individual methods [18]. The diversity among DL models ensures that ensembling produces superior results. Ensemble modeling techniques, such as stacking, boosting, and bagging, have been used to enhance predictions and reduce bias and variation [18].

3. PROPOSED METHODOLOGY

The layered design of the IoT-enabled coronavirus detection method is shown in Fig. 3. The perception layer, network layer, data storage, processing layer, and application layer are the four layers that make up the system. Medical IoT devices capture many scan types, including CT, ultrasound, and CXR scans, at the perception layer. After getting these scans, the network layer sends them to the data store layer. The network layer facilitates the communication of the collected scans through means such as telecommunications, internet, or other network protocols.

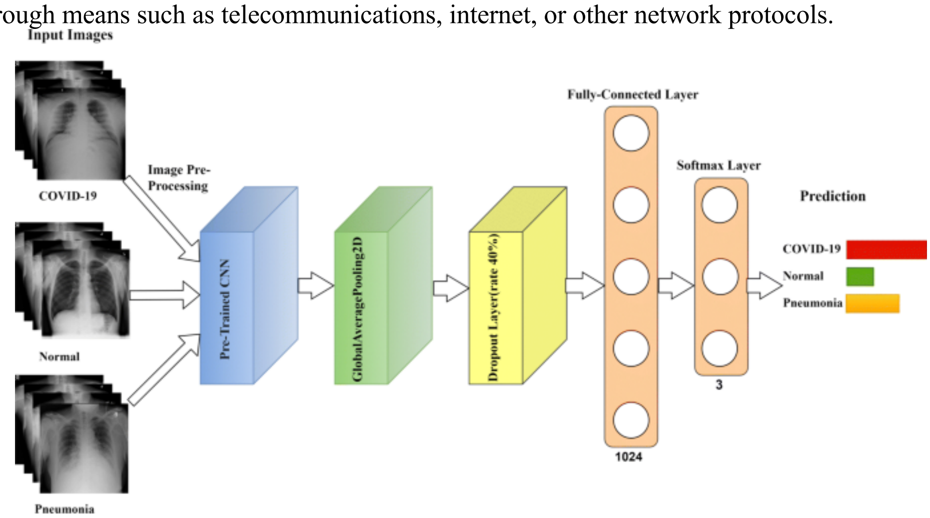

FIGURE 3. – The proposed architecture model

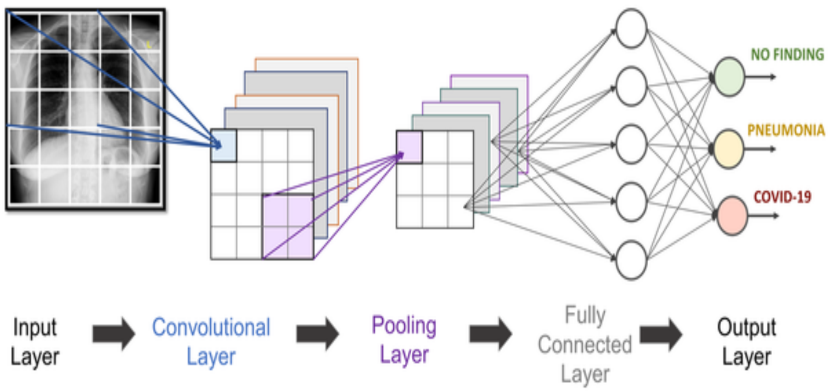

FIGURE 4. – The proposed AI-based DL model

The IoT network's storage layer applies DL models to categorize people as healthy or diseased and records the findings. Customers at the application layer, such as patients, doctors, and other medical personnel, may utilize the diagnostic results for further treatment or activities. A possible ensemble method for diagnosing coronavirus is shown in

Fig. 3, and it consists of four well-known TL models: ResNet152V2 [9], VGG16 [19], InceptionResNetV2 [20], and DenseNet201 [9]. These models were selected based on their good accuracy and diversity when tested on the provided dataset.

According to research, ensemble models outperform individual models in terms of efficiency. The ensemble technique makes the most of each model's advantages to extricate the best features and increase classification precision. Fig. 3 depicts the suggested ensemble method for coronavirus identification, which begins with a thick layer made up of 64 neurons. To extricate features, a multiple-layered, fine-tuned TL method is used. The softmax activation function has been applied to the problem of 4-class categorization. The models received training using a 10-person batch size over 100 iterations. To prevent overfitting, we employ fully connected layers of 64 neurons with dropout rates of 0.3 and 0.2 during the first feature tuning. To avoid overfitting, regularization strategies like early stopping are also used.

4. RESULTS AND DISCUSSION

4.1 Experimental Design

The four-class CXR dataset is utilized to evaluate the suggested DenseNet methodology. The suggested ensemble model's performance is compared to that of current deep TL methods. The trials are carried out on a MATLAB 2020b PC with a core i7 CPU, and 32 GB RAM. A 20-fold cross-validation approach is used to solve overfitting problems. For training purposes, 70% of the complete data is utilized, ensuring a comprehensive evaluation of the model's capabilities.

4.2 Database

The facts were gathered by means of combining 4 separate datasets. (The primary set of facts comes from hospitals in So Paulo, Brazil.) There are 1262 COVID-19 (+) and 1230 healthful contributors some of the 2492 CXR scans [21]. Furthermore, two publicity to be had tuberculosis datasets from Shenzhen, China, and 1st viscount montgomery of alamein County, u.s.a., have been obtained from the national Institutes of health's country wide Library of medicine (NIH). The Shenzhen dataset incorporates 326 healthful sufferers and 336 tuberculosis (+) sufferers. There are 80 normal CXR pictures and fifty eight CXR photos of tuberculosis (+) sufferers in Montgomery County, u.s.. a complete of 1663 COVID-19 (+), 394 tuberculosis, 401 pneumonia (bacterial and viral pneumonia), and 2039 healthful individual photos have been employed within the take a look at. , Random cropping, rotation and blurring also are utilized to supplement records.

The suggested framework reveals its superior performance, unaffected by overfitting issues. The pneumonia class has a 99.4% accuracy rate. The coronavirus class achieves an impressive accuracy of 99.6%. The recommended deep ensemble methodology has a high accuracy of 99.2% for healthy patients. Furthermore, the tuberculosis class has a 99.1% accuracy rate. Overall, the recommended method achieves an exceptional accuracy of 99.3% across all classes, demonstrating its robust categorization capabilities. Moreover, the proposed model exhibits minimal impact from overfitting. In terms of performance, the findings clearly show that the suggested architecture outperforms current deep learning models. The suggested approach surpasses previous models in accuracy, sensitivity, specificity, F-measure, and other key metrics, reaffirming its superior performance.

Table 1. - Comparing COVID-19 Diagnostic Detection Performance Evaluation Using an AI-DL Model Combined with IoT

Model	Accuracy	Sensitivity	Specificity	F-score
VGG16	96.3	96.5	95.4	96.6
ResNetV2	97.1	97.3	96.2	97.9
DenseNet201	97.2	97.1	98.7	96.9
Inception V4 network	97.7	97.4	98.5	98.2
ResNet152V2	98.4	98.2	98.7	98.9
Proposed Model	99.5	99.2	99.7	99.4

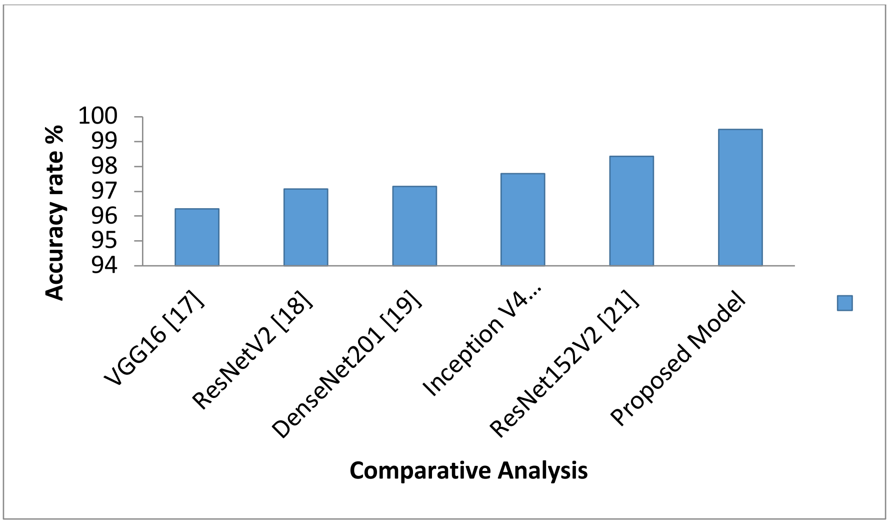

FIGURE 5. - **Comparison of Accuracy with respect to various models**

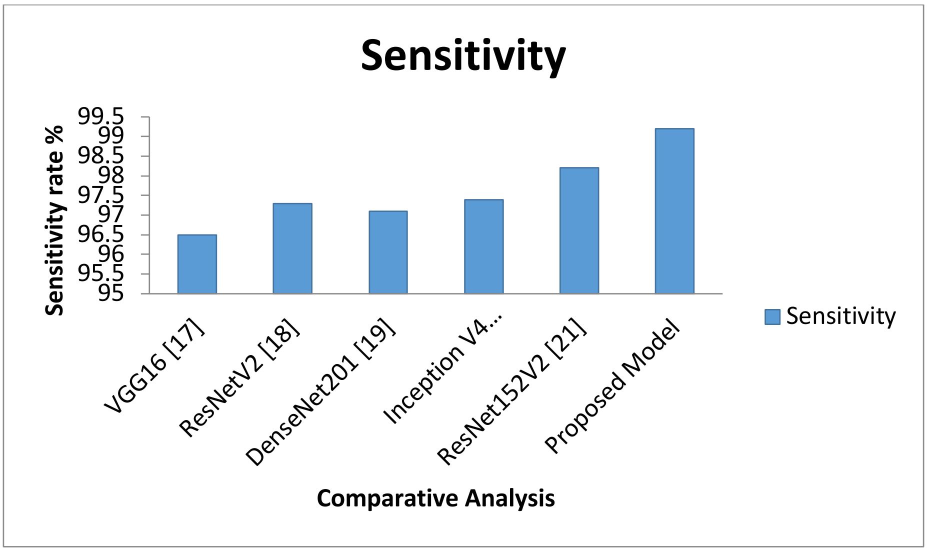

FIGURE6. - **Comparison of Sensitivity with respect to various models**

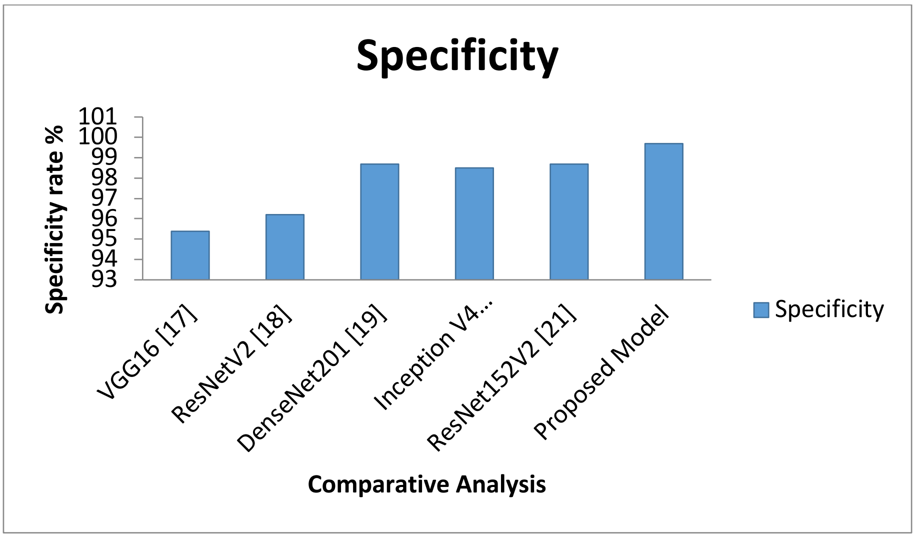

FIGURE7. - **Comparison of Specificity with respect to various models**

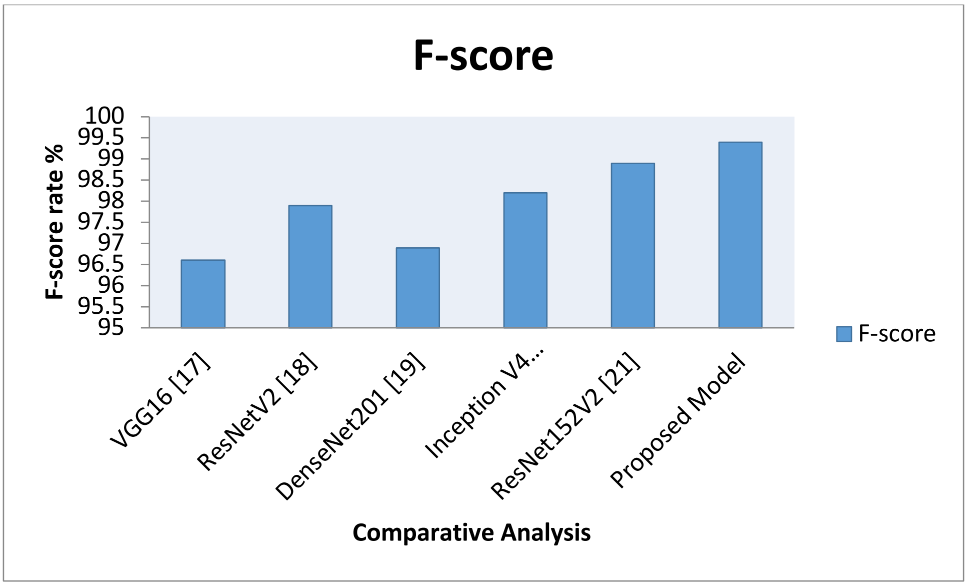

FIGURE8. - Comparison of F-score with respect to various models

The issue of hyperparameter tuning in deep transfer learning models remains unresolved. Effective adjustment of hyperparameters can significantly improve the performance of the above models. Additionally, it is necessary to extend the suggested methodology to identify CXR and ultrasound pictures. The approach can be utilized to develop a multidisease classification model across different domains. Further research and exploration are required in these areas to address these challenges and expand the scope of the proposed approach.

5. Conclusion

This research paper introduces a real-time diagnosis system for suspected COVID-19 patients. The system utilizes ensemble deep learning and is integrated with the Internet of Things (IoT) to create an automated coronavirus detection tool. The framework combines various DL methods, including InceptionResNetV2, VGG16, ResNet152V2 and DenseNet201. The performance of the suggested methodology is estimated utilizing a 4-class CXR dataset. A comparative investigation demonstrates that the suggested approach enables radiologists to identify COVID-19 suspicious individuals quickly and effectively. The suggested architecture outperforms previous methods in terms of performance, highlighting its potential in enhancing COVID-19 diagnostic capabilities.

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CONFLICTS OF INTEREST

The author declares no conflict of interest.

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