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Detection Of Covid-19 Using ResCapsNet and YOLOv5 From Pulmonary X-ray Images

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Abstract: This study introduces novel deep learning networks, COVID19-ResCapsNet and yolov5, for the classification and detection of COVID-19 using chest X-ray images respectively. These networks address limitations of existing methods and achieve high accuracy, showcasing its potential as a valuable tool for automated diagnosis. Additionally, a user-friendly interface was developed for easy access by both healthcare professionals and the general public. Users can upload their chest X-rays (or those of a concerned individual) after signing up for the secure website and receive a predicted diagnosis.

This deep learning system analyzes the uploaded chest X-ray images for COVID-19 using two methods: classification and detection. the user has the flexibility to choose either classification or detection based on their needs. The uploaded image undergoes preprocessing (resizing, normalization, etc.) for consistency. For classification, the preprocessed image is fed into ResCapsNet, a model combining improved residual modules for feature extraction and capsule networks for classification, to predict the presence or absence of COVID-19. Alternatively, detection utilizes YOLOv5, which excels at identifying potential regions of interest (ROIs) suggestive of COVID-19 within the preprocessed image. The system then highlights these ROIs and will provide confidence scores for the detection.

I. INTRODUCTION

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, has thrown the world into a state of flux. As of April 13, 2024, the reported global Case Fatality Rate (CFR) was around 1.4%. Even though COVID-19 cases have subsided in many parts of the world, the threat of new and potentially variants is always imminent. They can be much more transmissible and deadlier.

The virus has the characteristic of long incubation period and causes several illnesses. According to the report of the World Health Organization (WHO), the main symptoms are cold, dry cough, fever, and so on. Moreover, there are 40%～50% asymptomatic patients, who are also infectious. The infection of COVID-19 is transmitted through the droplets of carriers, such as coughing and sneezing. Above all, there are no available drugs to prevent or control this virus. While RT-PCR tests have been most commonly used tool in diagnosing COVID-19, results can take hours or even days, which can further delay isolation and tracing the source of the spread.

Therefore, Rapid and accurate diagnosis of COVID-19 is very crucial due to its asymptomatic spread and limitations of existing methods like of RT-PCR tests and then the subsequent quarantine and isolation are best way to stop the COVID-19 community transmission. We are using novel deep learning models, COVID19-ResCapsNet, for COVID-19 classification and using YOLOv5 for detection of COVID-19 from chest X-rays. The proposed networks address limitations of existing methods and achieve high accuracy, outperforming other approaches. We are integrating those two models into a user-friendly interface with easy access for not only healthcare professionals but also general public.

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II. LITERATURE SURVEY

Recently, deep learning-based CAD techniques have shown that they could identify numerous disorders on chest radio-graphs with accuracy comparable to expert radiologists. These approaches make use of unstructured data as input and attempt to extract more significant features from the input. With the extracted features, more accurate results are generated than classic diagnosis methods. Nowadays, CNN-based detection methods always classify and assess COVID-19-infected chest X-ray images or chest CT scans, which is treated as one of the most efficient ways. There are usually two categories; one is to take advantages of the medical imaging technology, such as the CT scans and CXRs. The other one utilizes the RT-PCR technology to detect COVID-19 disease. Compared with the methods with RT-PCR, chest X-ray and CT scan images are more efficient and convenient. Moreover, these images could be used to diagnose the location and shape of lung inflammation. Hence, Chest X-ray images and CT scans are being used primarily for COVID-19 disease detection.

Many researches have given precise results using these medical images. H. Nasiri et al [1]proposed an efficient COVID-19 detection method employing DenseNet169 for feature extraction achieving a accuracy of 98.23% . Hamid Nasiri Naeem et al[2] proposed CovidDetNet, a ten-layer deep learning model with ReLu and Leaky ReLu activation functions, batch normalization, and cross-channel normalization. Achieving an accuracy of 98.40% Afshar et al. [3] proposed the COVID-19 detection capsulenet work withCXRsimages, called COVID-CAPS network. They achieved 95.7% accu racy in the COVID-19 and non-COVID-19 classification Apostolopoulos et al. [4] made use of the CXRs image datasets to classify COVID-19 positive, common pneumo nia and normal, in order to evaluate the performance of convolution neural network algorithm proposed in recent years for medical image classification. Their accuracy could reach 96.78% with the V2 Mobile-Net Song et al. [5] pro posed the deep learning-based diagnosis network, named as DRE-Net. They categorized the CT scan samples into different classes and achieved 86% sensitivity and 94% specificity on the datasets Wang et al. [6] have used trans fer learning on a pre-trained convolutional neural network to categorize the input CXRs images and achieved 93.3%. Nigam et al. [7] designed the COVID-19 diagnostic sys tem with the deep-learning framework, and achieved the classification of COVID-19 positive, pneumonia and nor mal and they obtained the 93.48% accuracy Hassantabar, et al.[8] Develped diagnosis and detection of infected tissue of COVID-19 patients based on lung x-ray image using convolutional neural network approaches . it can almost detect infected regions with high accuracy of 83.84% .Altan, et al. [9]Made recognition of COVID-19 disease from X-ray images by hybrid model consisting of 2D curvelet transform, chaotic salp swarm algorithm and deep learning technique Tuncer et al. [10] proposed an automated Residual Exemplar Local Binary Pattern and iterative Relief based COVID-19 detection method using chest Xray image, Chemometrics and Intelligent Laboratory Systems end got an accuracy of 90.5%. Yoo, S.H, et al.[11] Designed deep Learning-Based Decision-Tree Classifier for COVID-19 Diagnosis from Chest X-ray Imaging., has accuracies of the first and second decision trees are 98 and 80%, respectively, whereas the average accuracy of the third decision tree is 95% .

Hemdan, et al. [12]COVIDX Net: A Framework of Deep Learning Classifiers to Diagnose COVID-19 in X-Ray Images with f1-scores of 0.89 and 0.91 for normal and COVID-19, respectively. Shibly, K.H et al.[13] COVID faster R–CNN: A novel framework to Diagnose Novel Coronavirus Disease (COVID-19) in X-Ray images, classification accuracy of 97.36%, 97.65% of sensitivity, and a precision of 99.28%. Ozturk,T., et al.[14] Automated detection of COVID-19 cases using deep neural networks with X-ray images, Computers in Biology and Medicines with an classification accuracy of 98.08% for binary classes and 87.02% for multi-class cases Narin, A., et al.[15] Automatic Detection of Coronavirus Disease (COVID-19) Using X-ray Images and Deep Convolutional Neural Networks with an 96.1% accuracy for Dataset-1 Das, N.N., et al.[16]Automated Deep Transfer Learning-Based Approach for Detection of COVID-19 Infection

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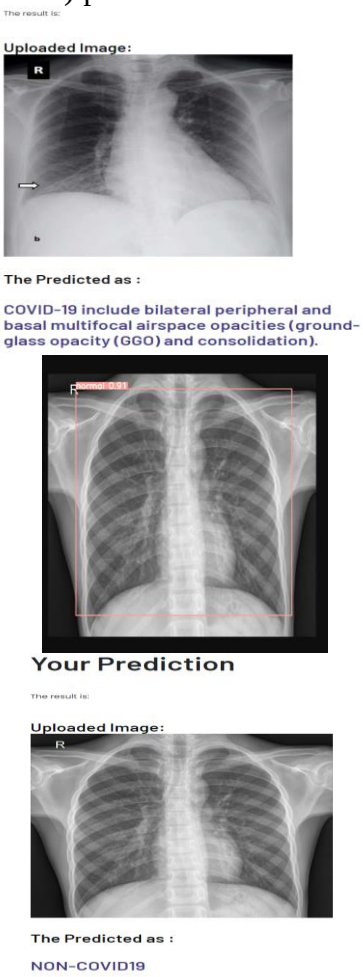

Fig: Predicted Outcome From The User Interface

III. PROPOSED SYSTEM

This deep learning system tackles COVID-19 analysis from chest X-ray images using deep learning models, offering two distinct functionalities. They are classification and detection. The uploaded images undergo preprocessing for consistency and improved analysis. Preprocessing is an important step in preparing images for deep learning analysis. It provides consistency and improves performance of the model. The common techniques used in preprocessing include resizing images to a standard size, adjusting pixel values for normalization and removing unwanted variations or artifacts from the image.

The preprocessed image is fed into a powerful deep learning model, ResCapsNet, for classification. This model has a very high accuracy in classification tasks. It is the integration of improved residual modules which are used for feature extraction and improved capsule networks which is specialized for classification. This system predicts the presence or absence of COVID-19 and then displays the predicted outcome on the display

For detection, the system utilizes YOLOv5, a model which excels at identifying relevant regions within images. YOLOv5 analyzes the preprocessed X-ray and pinpoints potential regions of interest (ROIs) that might be indicative of COVID-19. These ROIs are believed to contain abnormalities associated with the virus. The system then highlights these identified regions on the original image, aiding in visual analysis. Additionally, it provide supplemental information like confidence scores, indicating the model's certainty in the detection.

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A user-friendly web interface is developed to ensure accessibility for both healthcare professionals and the general public. After signing up for the secure website, users can select either classification or detection based on their needs. Then users have to upload their chest X-rays (or those of a concerned individual). Once an image is uploaded, the system will initiate deep learning analysis using COVID19-ResCapsNet model for classification or YOLOv5 for detection. Finally, the user will receive a predicted diagnosis or risk assessment based on the model's output.

IV. EXPERIMENTAL SETTINGS

The core of this project relies on Python, a versatile programming language known for its scientific computing and deep learning abilities. All the libraries we are using are built on top of Python. To determine the most suitable models for classification and detection tasks, we conducted extensive comparisons using Keras, a popular deep learning framework.

We compared the performance of our proposed ResCapsNet model against established deep learning architectures like VGG19, ResNet101, DenseNet121, and Xception. All models were trained and evaluated on the same chest X-ray datasets for COVID-19 classification. For the detection task, we compared various YOLO family object detection frameworks, including YOLOv5, YOLOv6, YOLOv7, and YOLOv8. All models were trained and evaluated on chest X-ray datasets to identify potential regions indicative of COVID-19 or ROI's.

For image preprocessing during both classification and detection, we used OpenCV or scikit-image libraries for handling various image manipulation tasks which include resizing, normalization, and data augmentation techniques. Pandas imaging data management library is used for data loading, manipulation, and exploration.

Finally, to construct the user interface for the web application, Flask, web framework in Python, is used. Flask allows users to interact with the trained models by uploading chest X-ray images and receiving the predicted results. A simple and lightweight database, SQLite, is used within the web application for implementing user authentication functionalities i.e. Sign up and sign in.

Accuracy=(TP+TN)/(TP + TN + FN + FP)

Precision=(TP)/(TP+FP)

Recall=(TP)/(TP+FN)

F1-score=(2*Precision*Recall)/(Precision+Recall)

where True Positive (TP): indicates a correct test. Positive class was detected as positive class. Taking COVID-19 or Normal experiment as an example, COVID-19 patients are detected as COVID-19 positive.

True Negative (TN): indicates a correct test. Negative class is detected as detected as negative class. False Positive (FP): indicates a false positive test where the negative class is detected as the positive class. Taking COVID-19 or Normal experiment as an example, people without disabilities are detected as positive for COVID-19. False Negative (FN): indicates wrong detection. positive class is detected as negative class. In the case of the COVID-19 or Normal result, patients with COVID-19 are detected as normal

V. RESULT AND CONCLUSION

To determine the most suitable models for classification and detection tasks, we conducted extensive experiment comparing various deep learning models for COVID-19 classification and detection from chest X-ray images.

In the extensive comparison conducted on deep learning models for classification task. This comparison involved training and testing a few diversely known models on our chosen dataset. The evaluation metrics focused on accuracy, precision, recall, and F1-score to provide a well-rounded

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assessment of each model's effectiveness as shown in the table. this comprehensive evaluation revealed that ResCapsNet model achieved the highest accuracy of 99.09% among all other models.

	ML Model	Accuracy	Precision	Recall	F1_score
0	ResCapsNet	99.090	99.160	99.160	99.160
1	CNN	91.324	91.364	91.364	91.364
2	VGG19	45.662	45.455	45.455	45.455
3	ResNet101	80.365	80.000	80.000	80.000
4	DenseNet121	91.781	91.818	91.818	91.818
5	Xception	94.977	95.000	95.000	95.000

Table1: Comparisons of ML Models

An exhaustive comparison was also conducted to select the optimal deep learning model for object detection. This evaluation process compared various models in the YOLO family, as shown in the figure. The table depicts their performance on key metrics such as precision, recall, and mean Average Precision (mAP@502). YOLOv5 remained the best option, achieving the best metrics. While YOLOv8 achieved slightly higher precision compared to YOLOv5, as evident in the table, YOLOv5 emerged as the frontrunner when considering overall performance.

	Detection Model	*Precision*	*Recall*	*mAP502*
0	YoloV5	95.7	96.2	98.4
1	YoloV6	67.4	77.9	92.56
2	YoloV7	33.6	80.6	53.0
3	YoloV8	96.8	90.4	98.4

Table 2: Comparisons of Detection Models

In conclusion, our project has prioritized the selection of high-performing models for both classification and detection tasks within the user interface. As discussed earlier, the meticulous evaluation identified ResCapsNet as the optimal choice for classification, achieving an impressive accuracy of 99.09%. Similarly, for object detection, YOLOv5 remained the optimal choice with well-rounded performance across all metrics. By integrating these best-in-class models, our user interface is equipped to deliver exceptional accuracy and reliability for our users.

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