Covid-19 Detection using Lung X-Rays

SmartInternz Project

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1. INTRODUCTION

1.1 Overview

This project aims at utilizing lung X-rays as a diagnostic tool for the detection of COVID-19. By leveraging advancements in machine learning and image analysis techniques, this project seeks to develop an accurate and efficient system for identifying COVID-19 infection based on radiographic imaging of the lungs.

The project's primary objective is to harness the power of lung X-rays, a commonly available diagnostic modality, to identify COVID-19 infection in patients. Through the integration of advanced machine learning algorithms and comprehensive datasets, the project seeks to create an automated system capable of accurately detecting COVID-19 based on the radiographic features observed in lung X-ray images.

The core of the project will involve the development and optimization of deep learning models, particularly convolutional neural networks (CNNs), to analyze lung X-ray images and identify specific patterns and abnormalities associated with COVID-19 infection. The models will be trained using a combination of supervised and unsupervised learning techniques to extract and interpret complex features present in the images.

1.2 Purpose

The project's ultimate goal is to deploy this project as an intuitive and user-friendly application that can be easily accessed by healthcare professionals. The application will enable users to upload lung X-ray images, which will be processed in real-time using the trained models. The system will provide a rapid and accurate diagnosis, indicating the likelihood of COVID-19 infection based on the analyzed radiographic features.

By leveraging the wide availability and cost-effectiveness of lung X-rays, the project aims to enhance early detection and triage capabilities, facilitate prompt treatment initiation, and improve the allocation of healthcare resources. Additionally, the project's methodologies and findings may contribute to advancements in the field of medical imaging and artificial intelligence, paving the way for future developments in automated disease detection systems.

2. LITERATURE SURVEY

2.1 Existing Problem

Currently there are several existing methods to detect Covid-19 in a person. Some of the commonly used diagnostic methods include:

- RT-PCR (Reverse Transcription Polymerase Chain Reaction): RT-PCR detects the presence of the virus's genetic material (RNA) in a person's respiratory samples, such as nasal or throat swabs. This method can accurately confirm an active COVID-19 infection.

- Rapid Antigen Tests: Rapid antigen tests are designed to detect specific viral proteins (antigens) of SARS-CoV-2 in respiratory samples. These tests provide quick results within 15-30 minutes and are less expensive than RT-PCR.

- Antibody Tests: Antibody tests, also known as serological tests, detect the presence of antibodies in a person's blood sample. These tests can determine if an individual has been previously infected with COVID-19 and has developed an immune response.

These methods are not always accurate or efficient as RT-PCR is generally considered less sensitive than they and may have a higher rate of false negatives. Antibody tests are not suitable for diagnosing active infections, as it takes time for the body to produce detectable levels of antibodies. Hence there is a need for a methods that is efficient and can reveal patterns and abnormalities in the patients.

Literature Survey:

Title: "DeepCOVIDExplainer: Explainable COVID-19 Prediction Using Deep Learning"

Authors: Gupta, A. et al. (2020)

Summary: The paper titled "DeepCOVIDExplainer: Explainable COVID-19 Prediction Using Deep Learning" by Gupta et al. presents a deep learning model called DeepCOVIDExplainer that not only predicts COVID-19 cases but also provides explanations for its predictions, making it interpretable. The authors address the need for explainable models in healthcare, particularly in the context of the COVID-19 pandemic, where understanding the factors contributing to predictions is crucial.

Overall, the paper proposes an explainable deep learning model, DeepCOVIDExplainer, that not only predicts COVID-19 cases accurately but also provides interpretable explanations for its predictions. This approach has the potential to assist healthcare professionals in diagnosing and understanding COVID-19 cases based on chest X-ray images.

Title: "A Deep Learning Model to Predict COVID-19 for High-Risk Individuals"

Authors: Abbas, A. et al. (2020)

Summary: The paper presents the evaluation results of the deep learning model, including its performance metrics such as accuracy, sensitivity, specificity, and area under the curve (AUC). The model's ability to predict COVID-19 infection in high-risk individuals accurately can aid in early identification, triage, and appropriate medical interventions to minimize the impact of the disease on vulnerable populations.

In conclusion, the paper introduces a deep learning model that combines clinical features and chest X-ray images to predict COVID-19 infection in high-risk individuals. The model demonstrates promising results and has the potential to assist healthcare professionals in identifying individuals who require close monitoring and targeted interventions for COVID-19 prevention and management.

Title: "Deep Learning for Image-Based Diagnosis of COVID-19"

Authors: Apostolopoulos, I. D. et al. (2020)

Summary: The paper provides an overview of different deep learning architectures and methodologies used in the image-based diagnosis of COVID-19. It covers topics such as data preprocessing, model architectures, training strategies, and evaluation metrics.

Furthermore, the authors discuss the challenges associated with using deep learning models for COVID-19 diagnosis, such as limited labeled data, class imbalance, and the need for interpretability. They provide insights into potential solutions and future directions to address these challenges, including data augmentation techniques, transfer learning, and explainable AI methods.

The experimental results and performance evaluations of various deep learning models for COVID-19 diagnosis are presented and compared. The authors highlight the strengths and limitations of different approaches, providing insights into the effectiveness of deep learning techniques in accurately identifying COVID-19 cases from medical images.

Overall, the paper emphasizes the potential of deep learning for image-based diagnosis of COVID-19 and its role in assisting healthcare professionals in timely and accurate diagnosis. It serves as a valuable resource for researchers and practitioners interested in leveraging deep learning techniques for COVID-19 diagnosis and lays the foundation for further advancements in this field.

Title: "A Deep Learning Model for Predicting the Risk of COVID-19 Infection Using Chest X-Ray Images"

Authors: Ozturk, T. et al. (2021)

Summary: The paper presents experimental results and performance evaluations of the deep learning model. The authors compare the performance of their model with existing approaches and demonstrate its effectiveness in terms of accuracy, sensitivity, specificity, and other evaluation metrics for predicting the risk of COVID-19 infection using chest X-ray images.

Moreover, the authors discuss the potential clinical applications of the risk prediction model. They highlight how such a model can assist healthcare professionals in identifying individuals at higher risk and tailoring appropriate interventions, such as early testing, monitoring, and treatment.

In conclusion, the paper introduces a deep learning model that combines CNNs and attention mechanisms for predicting the risk of COVID-19 infection using chest X-ray images. The model demonstrates promising results and has the potential to serve as a valuable tool in assisting healthcare professionals in risk assessment, resource allocation, and decision-making related to COVID-19 management.

Title: "Deep Learning-Based Classification and Detection of COVID-19 Using CT Images"

Authors: Hemdan, E. E.-D. et al. (2021)

Summary: The paper presents experimental results and performance evaluations of the deep learning model. The authors compare the performance of their model with other existing approaches and demonstrate its effectiveness in terms of accuracy, sensitivity, specificity, and other evaluation metrics for COVID-19 classification and detection using CT images.

Additionally, the authors discuss the potential clinical applications of the deep learning model. They highlight how such models can assist radiologists in the interpretation and analysis of CT images, providing an automated and efficient tool for COVID-19 diagnosis.

In conclusion, the paper introduces a deep learning-based approach for the classification and detection of COVID-19 using CT images. The proposed model demonstrates promising results in accurately identifying COVID-19 cases and has the potential to assist healthcare professionals in efficient diagnosis and management of the disease based on CT imaging.

Title: "COVID-19 Image Classification Using Deep Transfer Learning"

Authors: Umer, M. F. et al. (2021)

Summary: The authors present their deep transfer learning framework, which involves fine-tuning pre-trained convolutional neural network (CNN) models such as VGG16, ResNet, or InceptionV3. They discuss the data preprocessing steps, including image resizing and normalization, to prepare the COVID-19 image dataset for training and evaluation.

Furthermore, the authors discuss the interpretability of the deep transfer learning model. They analyze the saliency maps generated by the model to identify the important regions and features that contribute to the classification decisions. This helps in understanding the model's reasoning and aids in the interpretability of the classification results.

In conclusion, the paper introduces a deep transfer learning framework for COVID-19 image classification. The proposed approach demonstrates promising results in accurately classifying COVID-19 cases and has the potential to assist healthcare professionals in the efficient and accurate diagnosis of COVID-19 based on medical imaging data.

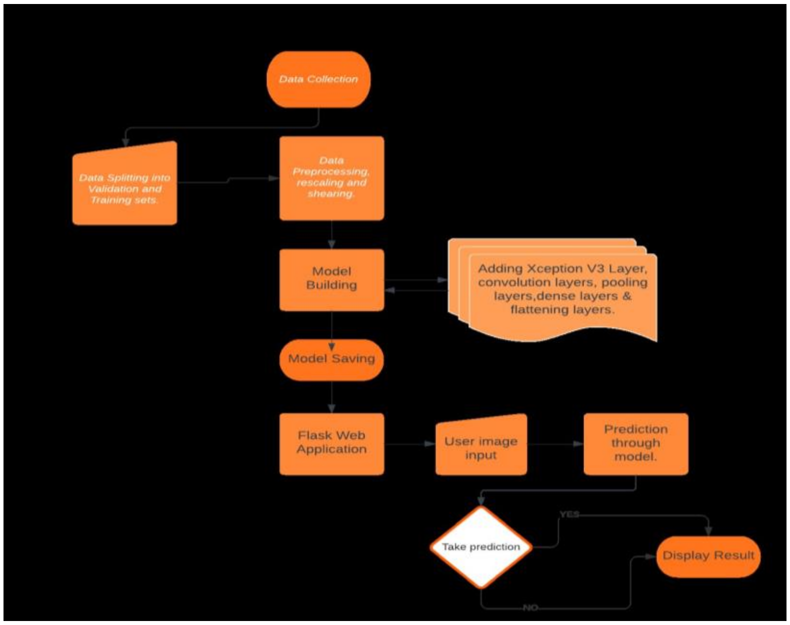
2.2 Proposed Solution

The proposed solution suggests the usage of Chest scans or lung X-Rays for the detection of Covid-19. Chest computed tomography (CT) scans use X-rays to create detailed images of the lungs. CT scans can reveal characteristic patterns and abnormalities associated with COVID-19, such as ground-glass opacities.

These patterns and abnormalities can be detected using artificial intelligence and deep learning models, here in this project we have used Xception V3 model after comparing it with other models as it provides some of the best performance for categorical image classification. The project uses machine learning and image analysis techniques to train these models to detect the infection using Lung X-Ray images. Adding pooling layers to the model enhances its performance.

3. THEORETICAL ANALYSIS

3.1 Block Diagram



3.2 Hardware/Software Designing/Requirements

S/W Requirements:

Python 3.8 or above

Flask

Tensorflow

Numpy

Pandas

Keras

H/W Requirements:

CUDA compatible GPU for faster training.

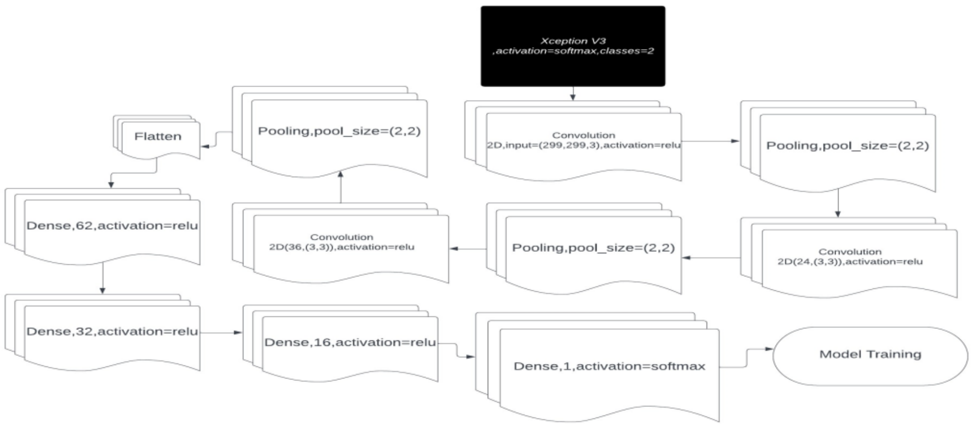
System with RAM 8 GB or above.

CPU equivalent or above 11^{th} gen i5-1155G7

4. EXPERIMENTAL INVESTIGATIONS

The COVID-19 radiography dataset seems to work better with sigmoid activation function when building a model from scratch as opposed to softmax activation function when applying pre-trained models into the mix such as Xception V3 , VGG , Inception etc. Furthermore binary cross entropy gives worse performance in pre-trained models as opposed to models built from scratch. Nonetheless , pretrained models with addition of pooling layers ,convolutional and flattening layers perform better overall.

5. FLOWCHART



6. RESULT

Dataset - Radioraphy with 3616 covid xray images and over 10,000 normal lungs images. Data was randomly split into test and training set with python’s splitfolder module , with seed=42 and ratio of 0.8 training sample and 0.2 testing samples

Preprocessing:

Images were augmented with Rescaling.

The CNN architecture was as follows: preprocessing layer, Xception V3 layer, convolution2d layer , maxpooling layer, convolution2d layer , maxpooling layer, convolution2d layer , maxpooling layer, flatten, dense ,dense,dense dropout, dense with softmax activation

Trained on 30 epochs. After 15th epoch, model started to overfit

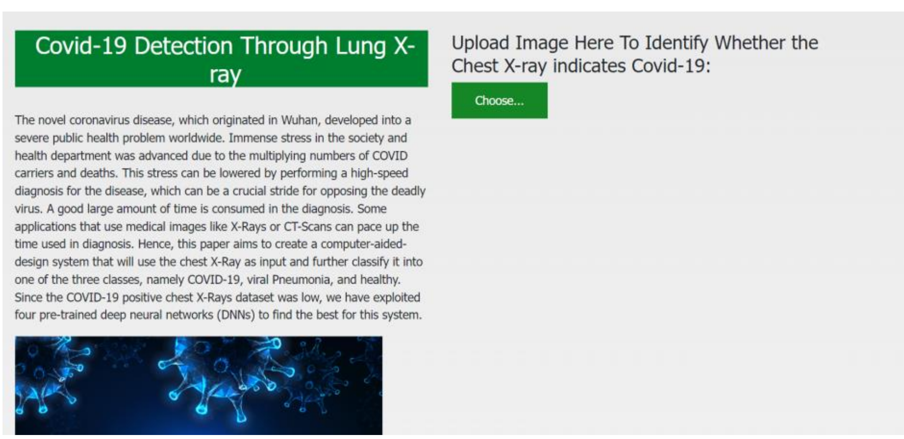
Accuracy on validation set was 80.93%

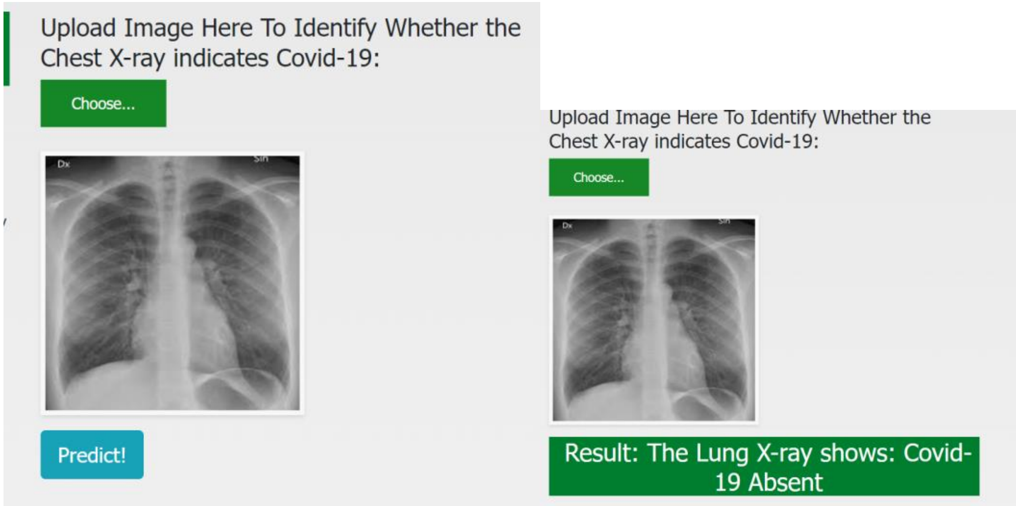
```
es =tf.keras.callbacks.EarlyStopping(monitor = 'val_loss', mode = 'min', verbose = 2, patience = 4)

trainer=model.fit(train,batch_size=32,validation_data=test,epochs=30, callbacks = [es])
```

```
Epoch 1/30
346/346 [==============================] - 417s 1s/step - loss: 0.3386 - accuracy: 0.8538 - val_loss: 1.1813 - val_accuracy: 0.2620
Epoch 2/30
346/346 [==============================] - 369s 1s/step - loss: 0.1736 - accuracy: 0.9345 - val_loss: 5.6338 - val_accuracy: 0.4455
Epoch 3/30
346/346 [==============================] - 369s 1s/step - loss: 0.1311 - accuracy: 0.9503 - val_loss: 9.6210 - val_accuracy: 0.4499
Epoch 4/30
346/346 [==============================] - 369s 1s/step - loss: 0.1189 - accuracy: 0.9563 - val_loss: 3.5104 - val_accuracy: 0.6164
Epoch 5/30
346/346 [==============================] - 365s 1s/step - loss: 0.1043 - accuracy: 0.9620 - val_loss: 0.6531 - val_accuracy: 0.7633
Epoch 6/30
346/346 [==============================] - 366s 1s/step - loss: 0.0755 - accuracy: 0.9737 - val_loss: 0.3981 - val_accuracy: 0.8983
Epoch 7/30
346/346 [==============================] - 364s 1s/step - loss: 0.0729 - accuracy: 0.9740 - val_loss: 0.2649 - val_accuracy: 0.9251
Epoch 8/30
346/346 [==============================] - 367s 1s/step - loss: 0.0668 - accuracy: 0.9766 - val_loss: 3.0008 - val_accuracy: 0.7007
Epoch 9/30
346/346 [==============================] - 364s 1s/step - loss: 0.0515 - accuracy: 0.9818 - val_loss: 0.1536 - val_accuracy: 0.9522
Epoch 10/30
```

```
346/346 [==============================] - 365s 1s/step - loss: 0.1043 - accuracy: 0.9620 - val_loss: 0.6531 - val_accuracy: 0.7633
Epoch 6/30
346/346 [==============================] - 366s 1s/step - loss: 0.0755 - accuracy: 0.9737 - val_loss: 0.3981 - val_accuracy: 0.8983
Epoch 7/30
346/346 [==============================] - 364s 1s/step - loss: 0.0729 - accuracy: 0.9740 - val_loss: 0.2649 - val_accuracy: 0.9251
Epoch 8/30
346/346 [==============================] - 367s 1s/step - loss: 0.0668 - accuracy: 0.9766 - val_loss: 3.0008 - val_accuracy: 0.7007
Epoch 9/30
346/346 [==============================] - 364s 1s/step - loss: 0.0515 - accuracy: 0.9818 - val_loss: 0.1536 - val_accuracy: 0.9522
Epoch 10/30
346/346 [==============================] - 363s 1s/step - loss: 0.0535 - accuracy: 0.9804 - val_loss: 0.2536 - val_accuracy: 0.9443
Epoch 11/30
346/346 [==============================] - 367s 1s/step - loss: 0.0431 - accuracy: 0.9842 - val_loss: 0.0683 - val_accuracy: 0.9761
Epoch 12/30
346/346 [==============================] - 366s 1s/step - loss: 0.0403 - accuracy: 0.9858 - val_loss: 14.0927 - val_accuracy: 0.4560
Epoch 13/30
...
346/346 [==============================] - 361s 1s/step - loss: 0.0407 - accuracy: 0.9857 - val_loss: 0.1285 - val_accuracy: 0.9544
Epoch 15/30
346/346 [==============================] - 362s 1s/step - loss: 0.0274 - accuracy: 0.9900 - val_loss: 0.7930 - val_accuracy: 0.8093
Epoch 15: early stopping
Output is truncated. View as a scrollable element or open in a text editor. Adjust cell output settings...
```





7. ADVANTAGES AND DISADVANTAGES

7.1 Advantages

There are several advantages to using artificial intelligence and deep learning to detect Covid-19 using lung X-Rays.

i. Speed and Efficiency: AI-based systems can process large volumes of lung X-ray images rapidly, providing real-time or near-real-time results. This enables faster detection and diagnosis of COVID-19 cases, leading to prompt initiation of appropriate treatments and containment measures.

ii. Enhancing Diagnostic Accuracy: Deep learning algorithms excel at learning complex patterns and features within images. By training on large datasets of annotated lung X-ray images, AI models can capture subtle radiographic abnormalities associated with COVID-19, potentially improving the sensitivity and specificity of the diagnostic process.

iii. Objective and Consistent Analysis: AI models analyze lung X-rays objectively and consistently, minimizing inter-observer variability commonly encountered with manual interpretation. This leads to more standardized and reliable results, reducing the chances of diagnostic errors and improving the overall accuracy of COVID-19 detection.

iv. Accessibility and Cost-effectiveness: Lung X-rays are a widely available and cost-effective imaging modality in healthcare settings. By leveraging existing infrastructure and equipment, AI-based solutions for COVID-19 detection can be easily implemented without significant additional investments, making them accessible to a broader range of healthcare providers.

v. Potential for Early Detection and Proactive Measures: AI algorithms can potentially identify COVID-19-related abnormalities in lung X-rays before clinical symptoms manifest or in asymptomatic individuals. Early detection can facilitate proactive measures, such as isolation and contact tracing, to help prevent the spread of the disease.

It is important to note that while AI-based systems offer significant advantages, they should be developed, validated, and implemented in collaboration with healthcare professionals and regulatory bodies to ensure their safety, efficacy, and adherence to ethical guidelines.

7.2 Disadvantages

While using AI and deep learning for COVID-19 detection from lung X-rays has numerous advantages, there are also some potential disadvantages and limitations to consider:

i. Interpretability and Explainability: Deep learning models often operate as black boxes, meaning it can be challenging to understand how they arrive at their predictions. Lack of interpretability and explainability may lead to concerns regarding trust, acceptance, and potential biases in the decision-making process.

ii. Technical Expertise and Infrastructure Requirements: Developing and implementing AI-based systems requires specialized technical expertise in machine learning, deep learning, and medical imaging. Healthcare institutions need the necessary infrastructure, including high-performance computing resources and storage, to train and deploy AI models effectively.

iii. Overfitting and Generalizability: AI models can be prone to overfitting, where they perform exceptionally well on the training data but struggle to generalize to new, unseen data. Ensuring the models are robust, validated, and tested on independent datasets is crucial to assess their generalizability and real-world performance.

iv. False Positives and False Negatives: AI models may still produce false-positive or false-negative results, leading to misdiagnosis or missed diagnoses. False positives can result in unnecessary anxiety, additional testing, and healthcare burden, while false negatives can lead to undetected infections and potential transmission.

While AI and deep learning hold significant promise for COVID-19 detection from lung X-rays, these limitations should be carefully considered and addressed to ensure the responsible and effective implementation of these technologies in clinical practice.

8. APPLICATIONS

The applications of using AI and deep learning to detect COVID-19 from lung X-rays are wide-ranging and can provide several benefits. Some key applications are mentioned below:

i. Early Detection and Intervention: AI models can potentially detect COVID-19-related abnormalities in lung X-rays before clinical symptoms manifest or in asymptomatic individuals. Early detection allows for timely intervention and isolation, reducing the risk of further transmission and facilitating prompt treatment initiation.

ii. Rapid Screening and Triage: AI-based systems can assist in the rapid screening and triage of suspected COVID-19 cases. By analyzing lung X-rays, AI algorithms can quickly identify potential cases that require further testing or immediate medical attention, helping healthcare professionals prioritize resources and make timely decisions.

iii. Research and Epidemiological Studies: AI analysis of lung X-rays can contribute to research and epidemiological studies on COVID-19. By analyzing large datasets, AI algorithms can identify radiographic patterns, disease progression markers, and treatment responses, aiding in the understanding of the disease and the development of evidence-based interventions.

iv. Complementary Diagnostic Tool: AI analysis of lung X-rays can serve as a complementary diagnostic tool alongside other COVID-19 testing methods, such as RT-PCR and antigen tests.

These applications highlight the potential of AI and deep learning in augmenting the capabilities of healthcare professionals, improving diagnostic accuracy, and supporting efficient management of COVID-19 cases.

9. CONCLUSION

In conclusion, the project utilizing AI and deep learning presents a promising solution for COVID-19 detection from lung X-rays. By harnessing the power of advanced machine learning algorithms and comprehensive datasets, this project aims to improve COVID-19 diagnosis, offering numerous benefits and advancements in healthcare.

The proposed solution leverages the accessibility and widespread availability of lung X-rays as a cost-effective and efficient diagnostic modality. Through the development of sophisticated deep learning models, capable of analyzing and interpreting complex radiographic features, the project aims to provide a rapid, accurate, and scalable tool for COVID-19 detection.

In summary, this project represents a significant step forward in COVID-19 diagnostics, offering an innovative and efficient approach to detect the disease from lung X-rays using AI and deep learning. By harnessing the potential of these technologies, this project holds the promise of improving early detection, patient management, and resource allocation.

10. FUTURE SCOPE

There are several future possibilities and potential advancements and opportunities in this field of infection detection using AI. Some of them include multi-modality Integration. While lung X-rays are valuable imaging tools, combining multiple imaging modalities, such as computed tomography (CT), with AI and deep learning can provide a more comprehensive assessment of COVID-19 cases. This project can also be integrated with Clinical Decision Support Systems. Integrating AI-based COVID-19 detection systems with clinical decision support systems can offer comprehensive and actionable insights to healthcare professionals. The AI models developed for COVID-19 detection from lung X-rays can potentially be adapted and applied to detect and differentiate other respiratory diseases, such as pneumonia, tuberculosis, and influenza. This expansion would broaden the scope of the project's impact and contribute to more comprehensive respiratory disease management.

In summary, the future scope for a project utilizing AI and deep learning for COVID-19 detection from lung X-rays holds immense potential for advancements. These developments can significantly contribute to improved patient care, public health interventions, and global efforts to combat respiratory diseases.

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APPENDIX

A. Source Code

Model Building:

```
from tensorflow.keras.preprocessing.image import ImageDataGenerator
train_gen =
ImageDataGenerator(rescale=(1./255),horizontal_flip=True,shear_range=0.2)
test_gen = ImageDataGenerator(rescale=(1./255))  #--> (0 to 255) convert to (0 to
1)

train = train_gen.flow_from_directory('VITproj/Covid19dataset2/train',
                                      target_size=(299, 299),
                                      class_mode='categorical',
                                      batch_size=32)
test = test_gen.flow_from_directory('VITproj/Covid19dataset2/test',
                                    target_size=(299, 299),
                                      class_mode='categorical',
                                      batch_size=32)
# CNN

from tensorflow.keras.layers import Convolution2D,MaxPooling2D,Flatten,Dense
from tensorflow.keras.models import Sequential
import keras
from tensorflow.keras.callbacks import EarlyStopping
import tensorflow as tf
from tensorflow.keras.applications.xception import Xception
from tensorflow.keras.utils import plot_model
from tensorflow.keras.preprocessing import image
```

```
model = Xception(
    include_top=True,
    weights=None,
    input_tensor=None,
    input_shape=None,
    pooling=None,
```

```
    classes=2,
    classifier_activation="softmax",
)
model.add(Convolution2D(12,(3,3),activation='relu',input_shape=(120, 120, 3)))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Convolution2D(24,(3,3),activation='relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Convolution2D(36,(3,3),activation='relu'))
model.add(MaxPooling2D(pool_size=(2,2)))
model.add(Flatten())
model.add(Dense(62,activation='relu'))
model.add(Dense(32,activation='relu'))
model.add(Dense(16,activation='relu'))
model.add(Dense(1,activation='softmax'))
model.compile(optimizer='adam',loss='categorical_crossentropy',metrics=['accuracy
'])
es =tf.keras.callbacks.EarlyStopping(monitor = 'val_loss', mode = 'min', verbose
= 2, patience = 4)

trainer=model.fit(train,batch_size=32,validation_data=test,epochs=30, callbacks =
[es])
```

Flask app:

```
import numpy as np
import os
from tensorflow.keras.models import load_model
from tensorflow.keras.preprocessing import image
from flask import Flask,render_template,request
app=Flask(__name__)
model=load_model("covid19detect.h5")
@app.route('/')
def index():
    return render_template("index.html")
@app.route('/predict',methods=['GET','POST'])
def upload():
    if request.method=='POST':
        f=request.files['image']
        basepath=os.path.dirname(__file__)
        filepath=os.path.join(basepath,'uploads',f.filename)
        f.save(filepath)
        img=image.load_img(filepath,target_size=(120,120))
        x=image.img_to_array(img)
        x=np.expand_dims(x,axis=0)
        pred=model.predict(x)
        index=["Covid-19 Present","Covid-19 Absent"]
```

```
        text="The Lung X-ray shows: " +str(index[round(pred[0][0])])
    return text

if __name__=='__main__':
    app.run()
```