CovidVision: Advanced COVID-19 Detection From Lung X-Rays With Machine Learning Or Deep Learnings

Team Members

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1. **INTRODUCTION**

1.1 Project Overview

COVID-19 (coronavirus disease 2019) is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which is a strain of coronavirus. The disease was officially announced as a pandemic by the World Health Organization(WHO) on 11 March 2020. Given spikes in new COVID-19 cases and the re-opening of daily activities around the world, the demand for curbing the pandemic is to be more emphasized. Medical images and artificial intelligence (AI) have been found useful for rapid assessment to provide treatment of COVID-19 infected patients. The PCR test may take several hours to become available, information revealed from the chest X-ray plays an important role for a rapid clinical assessment. This means if the clinical condition and the chest X-ray are normal, the patient is sent home while awaiting the results of the etiological test. But if the X-ray shows pathological findings, the suspected patient will be admitted to the hospital for close monitoring. Chest X-ray data have been found to be very promising for assessing COVID-19 patients, especially for resolving emergency-department and urgent-care-center overcapacity. Deep-learning (DL) methods in artificial intelligence (AI) play a dominant role as high-performance classifiers in the detection of the disease using chest X-rays.

One of the biggest challenges following the Covid-19 pandemic is the detection of the disease in patients. To address this challenge we have been using the Deep Learning Algorithm to build an image recognition model that can detect the presence of Covid-19 from an X-Ray or CT-Scan image of a patient's lungs.

Transfer learning has become one of the most common techniques that has achieved better performance in many areas, especially in medical image analysis and classification. We used Transfer Learning techniques like Inception V3,Resnet50,Xception V3 that are more widely used as a transfer learning method in medical image analysis and they are highly effective.

1.2 Purpose

The purpose of the project "CovidVision: Advanced COVID-19 Detection from Lung X-rays with Machine Learning or Deep Learning" is to develop an automated system that can accurately detect COVID-19 cases by analyzing lung X-ray images. The project aims to leverage machine learning or deep learning algorithms to create a robust and efficient diagnostic tool.

The primary objective is to build a system that can effectively identify COVID-19 cases from lung X-ray images with a high level of accuracy. This tool can assist healthcare professionals in quickly and accurately diagnosing COVID-19 patients, enabling timely treatment and management of the disease. By automating the analysis of lung X-rays, the system can help healthcare providers quickly identify potential COVID-19 cases, allowing for timely isolation and testing.

The project seeks to support healthcare systems by providing an additional diagnostic tool. The automated system can help alleviate the burden on healthcare professionals, especially in situations where the number of cases overwhelms their capacity to analyze X-ray images manually. Additionally, early detection of COVID-19 is crucial for effective disease management. By leveraging machine learning or deep learning techniques, the project aims to identify subtle patterns and indicators in lung X-rays that might not be easily recognizable to the human eye, thus enabling prompt intervention.

The project also contributes to research and development in the field of medical imaging analysis and disease detection using artificial intelligence. It can advance the state-of-the-art in machine learning or deep learning algorithms specifically tailored for COVID-19 detection from lung X-rays.

Overall, the purpose of the "CovidVision" project is to utilize machine learning or deep learning techniques to create an automated and accurate system for COVID-19 detection from lung X-ray images. This can significantly improve diagnostic capabilities, aid healthcare professionals, and help control and manage the spread of the disease.

3. REQUIREMENT ANALYSIS

3.1 Functional requirements

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	User Registration	Registration through Form Registration through Gmail
FR-2	User Confirmation	Confirmation via Email Confirmation via OTP
FR-3	Feature extraction	The system should be able to extract relevant features from the preprocessed images that are indicative of COVID-19 infection.
FR-4	Real-time prediction	The system should be able to process X-ray images in real-time and provide a prediction of COVID-19 infection probability within a reasonable time frame.

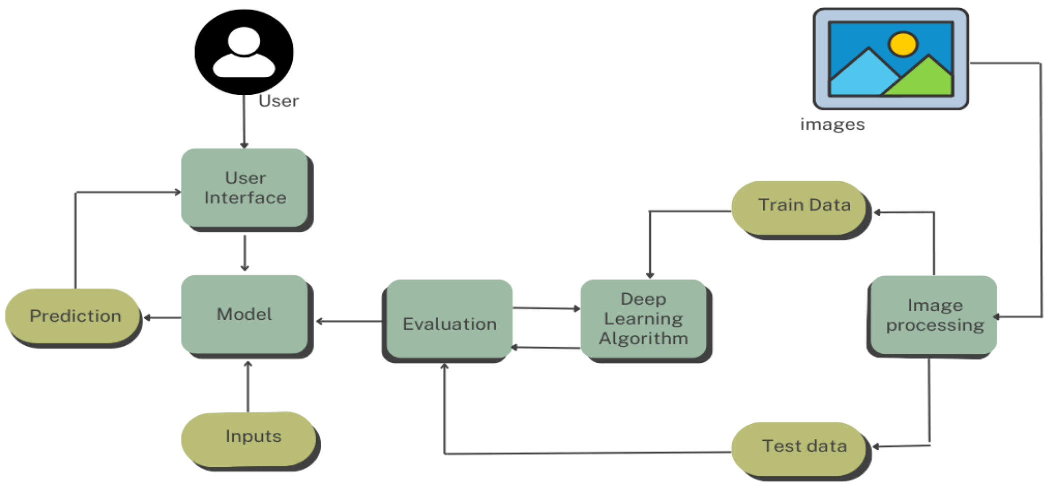
3.2 Non-Functional requirements

FR No.	Non-Functional Requirement	Description
NFR-1	**Usability**	The system should be easy to use, with a user-friendly interface that requires minimal training for healthcare professionals.
NFR-2	**Security**	The system should be secure, with robust measures in place to protect patient data and prevent unauthorized access.

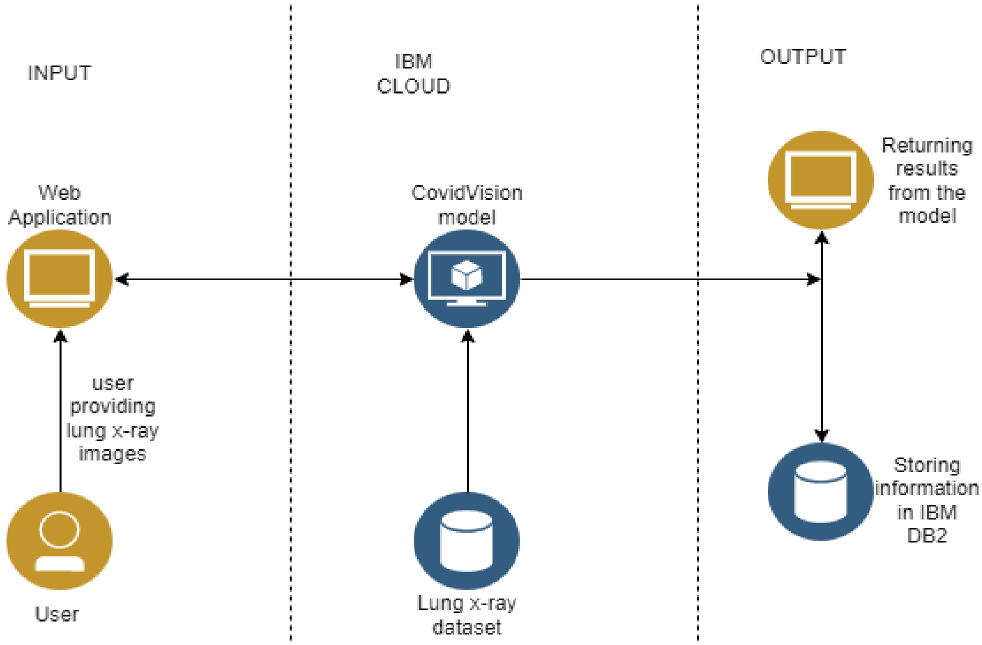
NFR-3	**Reliability**	The system should be reliable and available at all times, with minimal downtime for maintenance or upgrades.
NFR-4	**Performance**	The system should be able to process X-ray images quickly and efficiently to provide a timely prediction of COVID-19 infection probability.
NFR-5	**Availability**	The system should be highly available to ensure that healthcare professionals can access the system and make critical decisions based on its predictions. The system should also have a disaster recovery plan.
NFR-6	**Scalability**	The system should be scalable to handle large amounts of X-ray images and users without compromising performance.

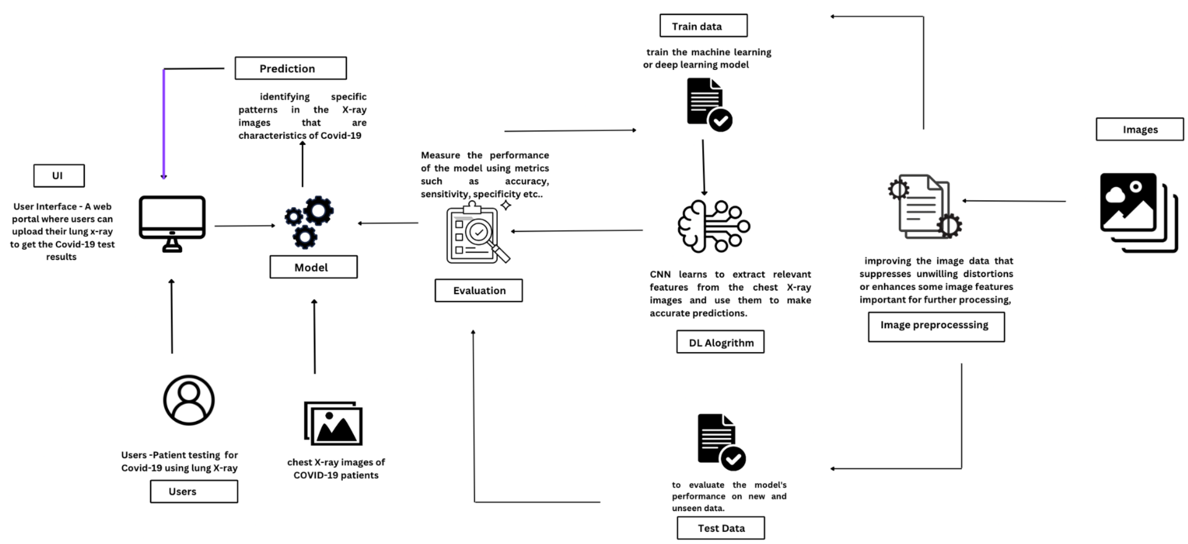
4. PROJECT DESIGN

4.1 Data Flow Diagrams



4.2 Solution & Technical Architecture





4.3 User Stories

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria	Priority	Team Member
Customer (Web user)	Registration	USN-1	As a user, I can register for the application by entering my email, password, and confirming my password.	I can access my account / dashboard	High	Team Member
		USN-2	As a user, I will receive confirmation email once I have registered for the application	I can receive confirmation email & click confirm	High	Team Member
	Login	USN-3	As a user, I can log into the	I can login to the	High	Team Member

			application by entering email & password	application.		
	Dashboard	USN-4	As a user, I will be able to see my status on the dashboard	I can notice my status.	Medium	Team Member
	Data Collection	USN-5	As a user, I will upload X-ray images to the system for analysis.	The system should be able to accept X-ray images in various formats, and the images should be securely stored in the system.	High	Team Member
	Image Pre-processing	USN-6	As a user, I want to pre-process X-ray images to enhance their quality and remove noise.	The system should be able to standardize the format of the images and make it ready for processing.	Medium	Team Member

	Model Building	USN-7	As a user, I want to evaluate and compare the performance of different machine learning or deep learning models for COVID-19 detection.	The system should provide metrics such as precision, recall, F1 score, and area under the ROC curve, and should allow comparison of different models.	High	Team Member
	Application Building	USN-8	As a user, I want to access the results of COVID-19 detection from lung X-ray images through a web or mobile application.	The application should provide a user-friendly interface for uploading X- ray images and viewing the results, and should ensure the security and privacy of patient data.	High	Team Member

5. CODING & SOLUTIONS

5.1 Automated COVID-19 detection:

CovidVision utilizes advanced machine learning or deep learning algorithms to automate the detection of COVID-19 from lung X-ray images. By analyzing patterns and features in the images, the system can provide an automated assessment of whether a patient's X-ray shows signs of COVID-19 infection. This can potentially help streamline the diagnostic process and provide a preliminary screening tool, particularly in situations where radiologists or healthcare professionals are overloaded or resources are limited.

```python
base_model = VGG16(weights='imagenet', include_top=False, input_shape=(128,128, 3))


for layer in base_model.layers:
    layer.trainable = False

model = Sequential()
model.add(base_model)
model.add(Flatten())
model.add(Dense(1024))
model.add(Activation("relu"))
model.add(Dense(512))
model.add(Activation("relu"))
model.add(Dense(1))
model.add(Activation("sigmoid"))
model.summary()
```

Python

```python
learning_rate = 0.0001
decay_steps = 10
decay_rate = 1


lr_scheduler = tf.keras.optimizers.schedules.ExponentialDecay(learning_rate, decay_steps, decay_rate)
optimizer1 = tf.keras.optimizers.Adam(learning_rate = lr_scheduler)
model.compile(optimizer = optimizer1, loss = 'binary_crossentropy',metrics =['accuracy'])

history = model.fit(X_train,y_train,batch_size = 16, epochs =30,validation_data =(X_val, y_val))
```

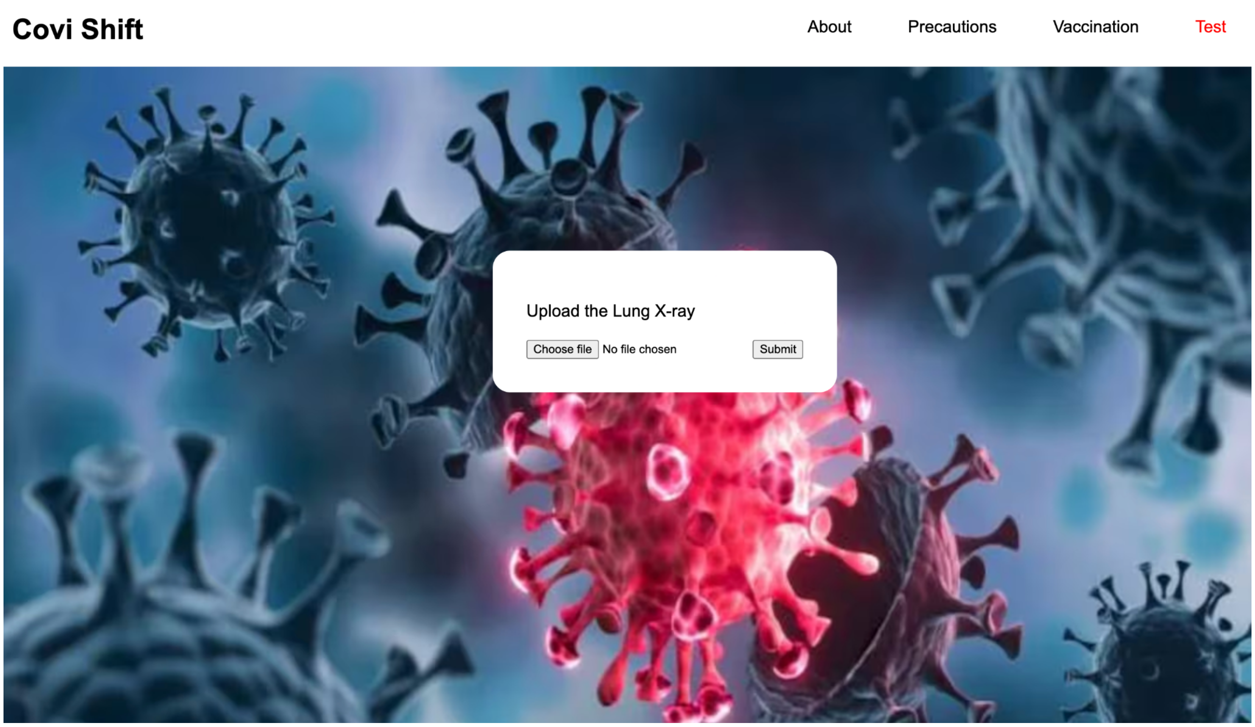
Python

5.2 Assistive decision support:

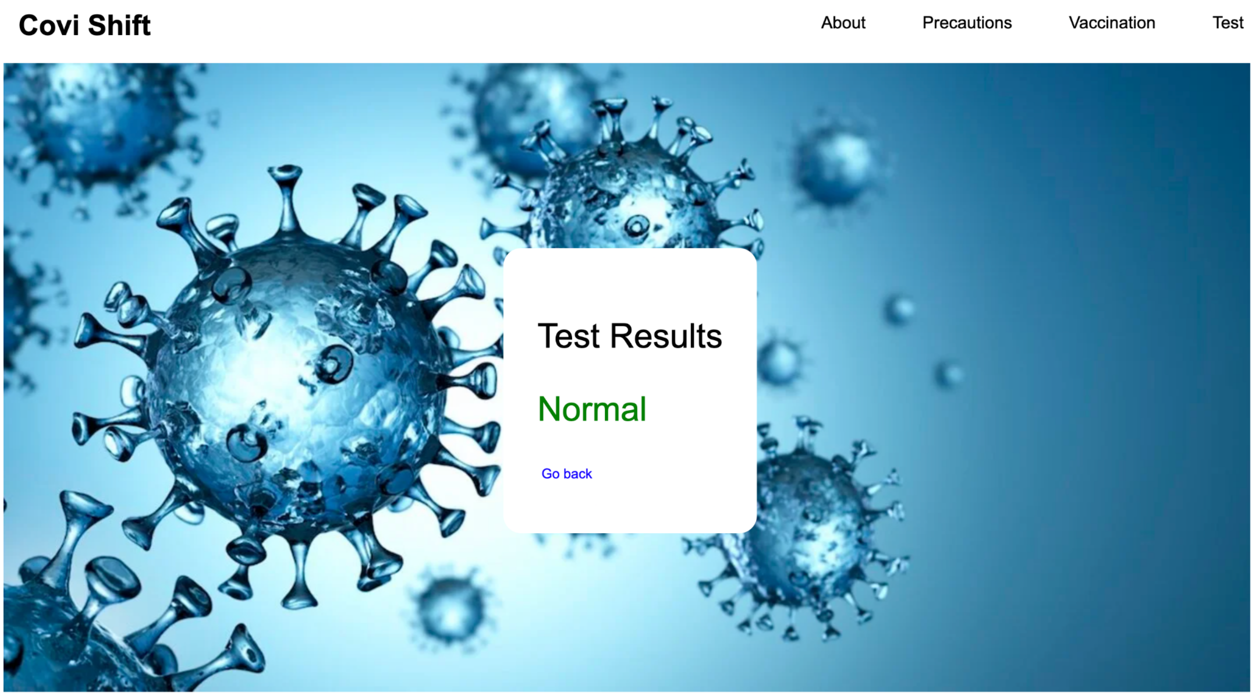
CovidVision is designed to serve as a decision support tool for healthcare professionals rather than a standalone diagnostic system. It can provide additional insights and assist radiologists in their evaluation by highlighting regions of interest, indicating potential COVID-19 indicators, and providing a confidence score for the presence of the disease. This collaborative approach between AI and human experts can lead to more accurate and efficient diagnoses, helping healthcare professionals make informed decisions and improving patient care.

5.3 User-friendly Interface :

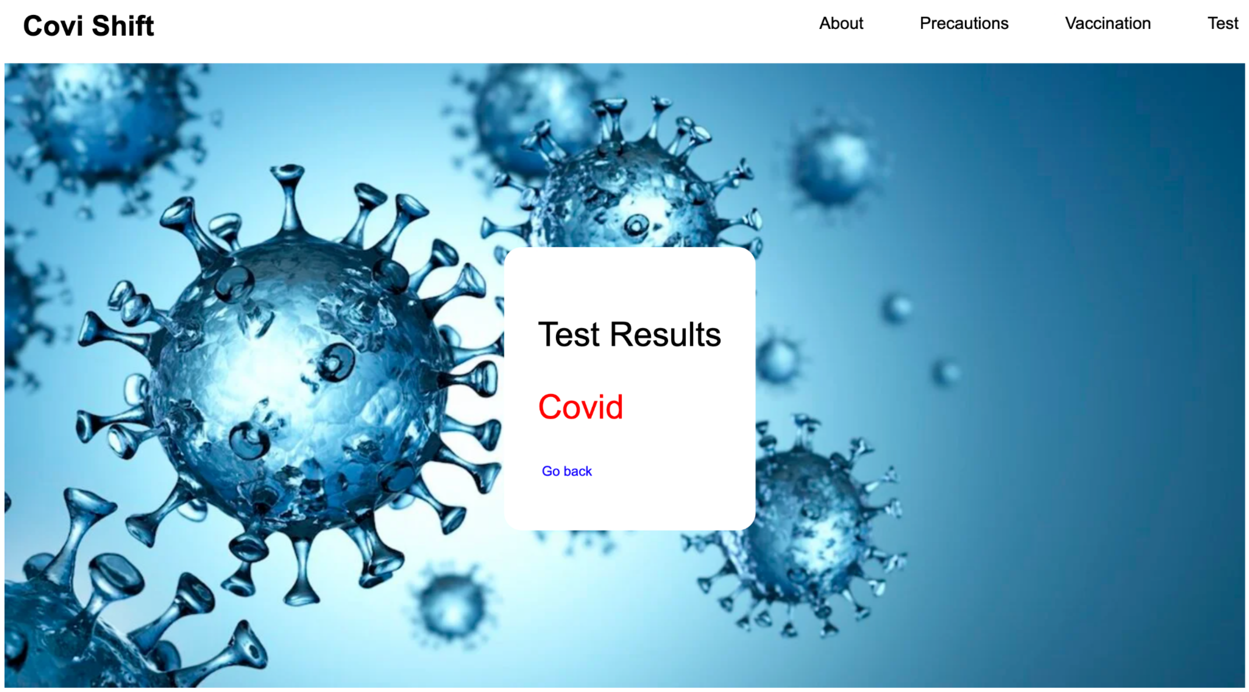
For uploading Lung X-ray:

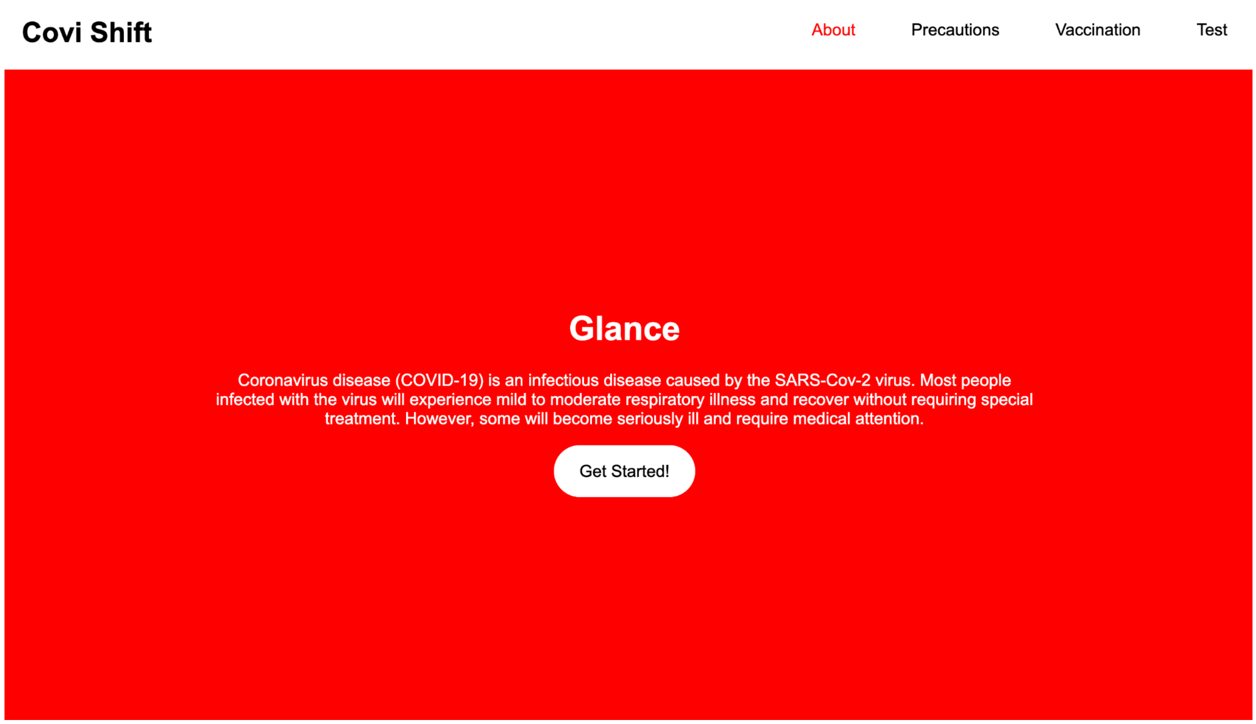


For Normal:


Covi Shift
About
Precautions
Vaccination
Test
Test Results
Normal
Go back

For covid :

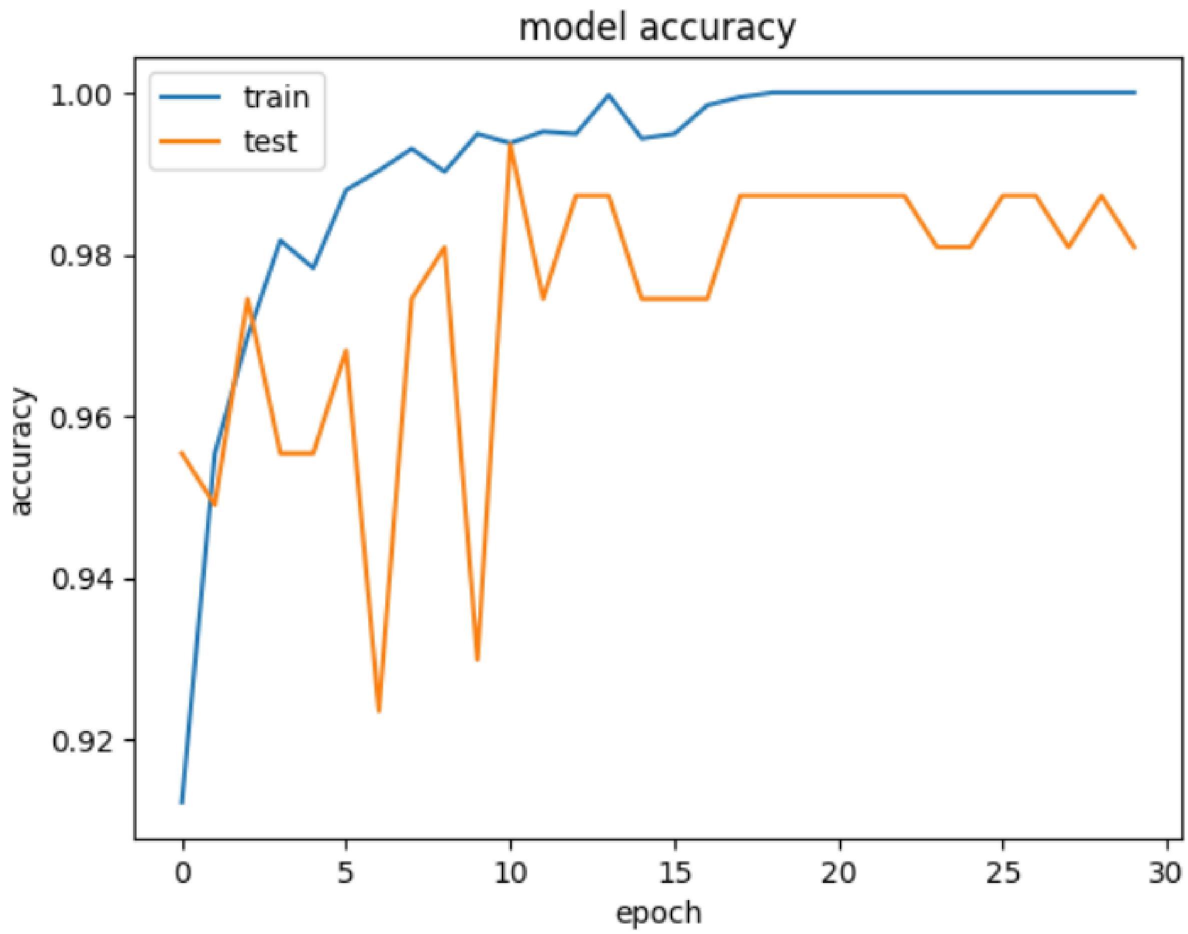

Covi Shift
About
Precautions
Vaccination
Test
Test Results
Covid
Go back


Covi Shift
About
Precautions
Vaccination
Test
Glance
Coronavirus disease (COVID-19) is an infectious disease caused by the SARS-Cov-2 virus. Most people infected with the virus will experience mild to moderate respiratory illness and recover without requiring special treatment. However, some will become seriously ill and require medical attention.
Get Started!

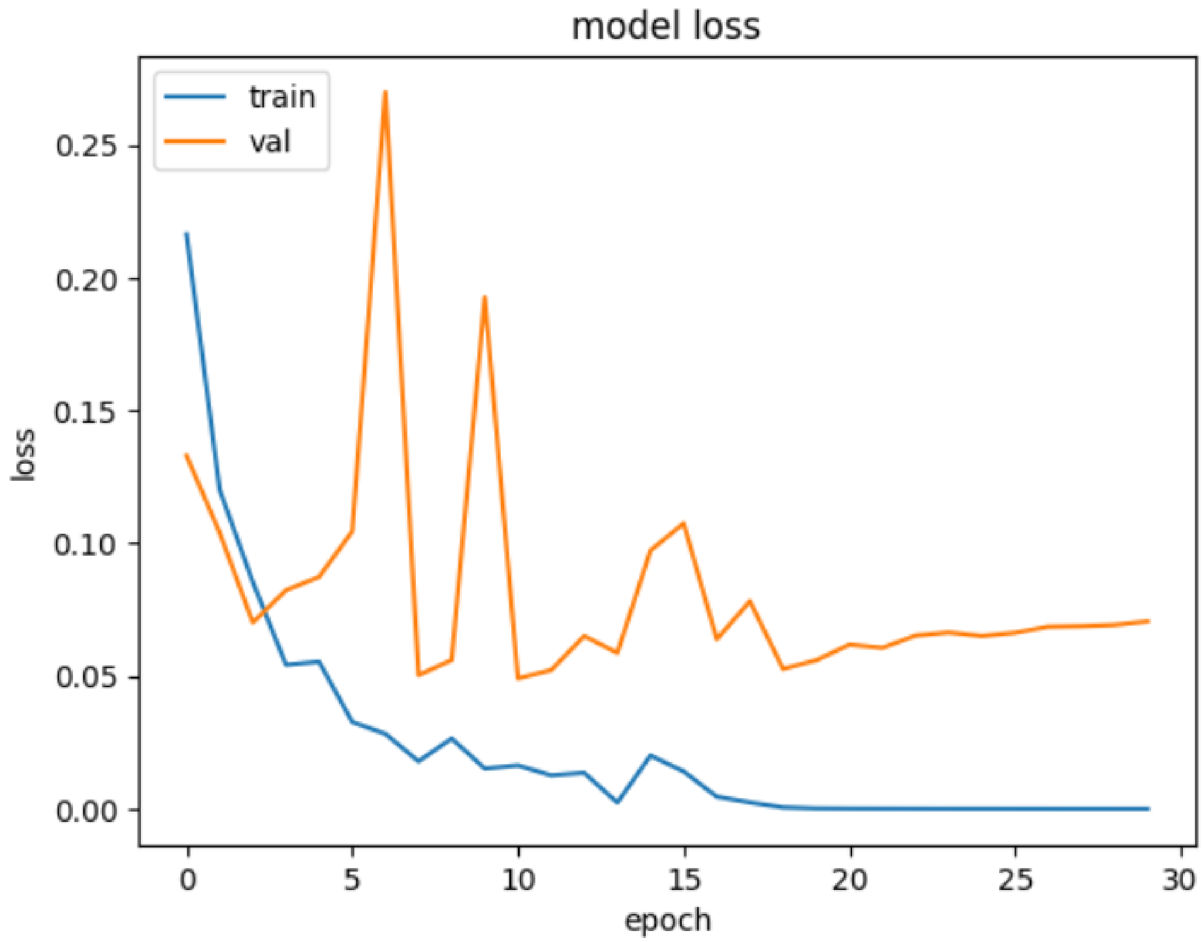
6. RESULTS

6.1 Performance Metrics

Accuracy



Model loss

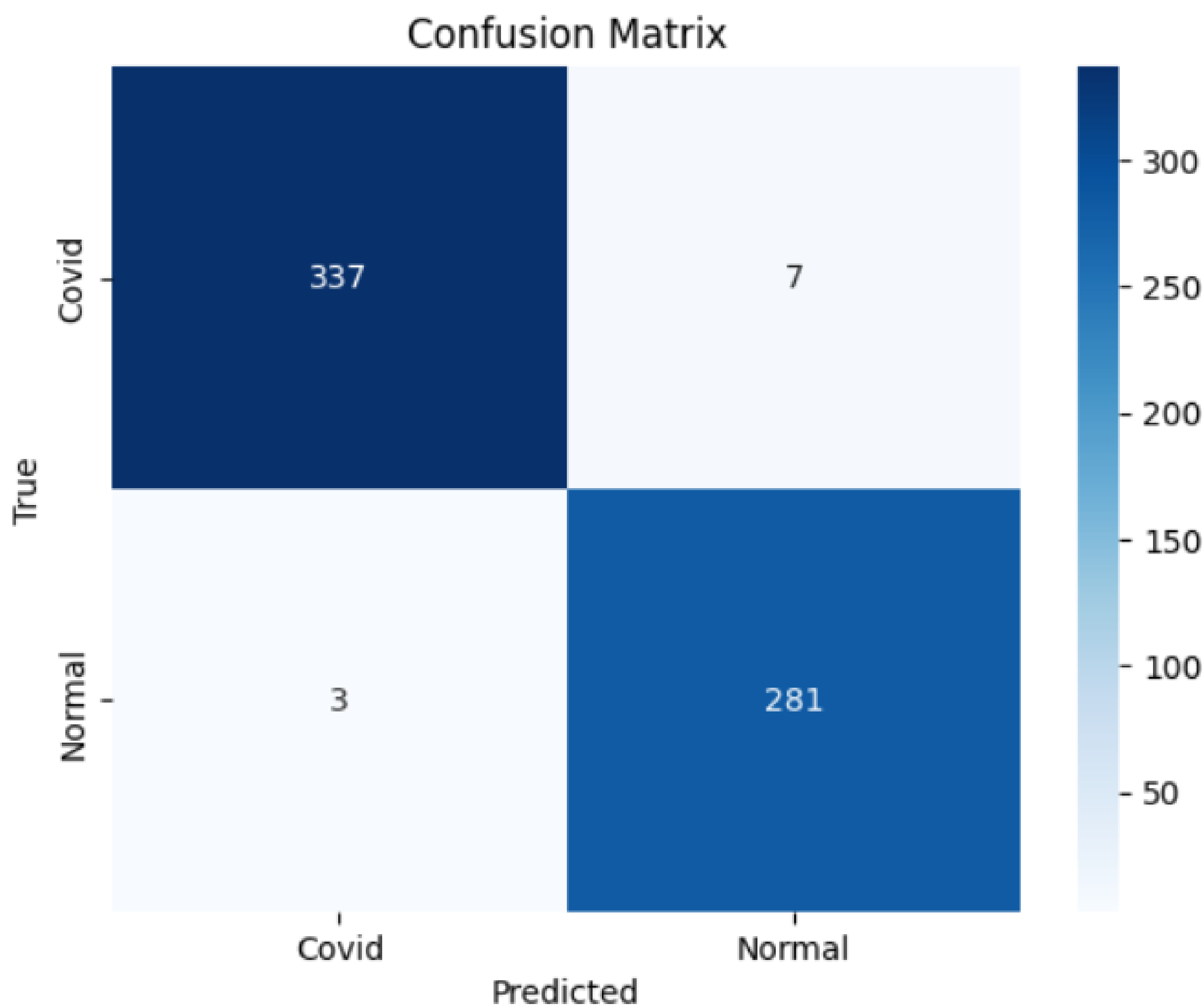


Precision , recall, f1-score and accuracy

	precision	recall	f1-score	support
Covid	0.99	0.98	0.99	344
Normal	0.98	0.99	0.98	284
accuracy			0.98	628
macro avg	0.98	0.98	0.98	628
weighted avg	0.98	0.98	0.98	628

Accuracy: 0.9840764331210191

Confusion matrix



7. ADVANTAGES & DISADVANTAGES

Advantages of using deep learning and transfer learning for COVID-19 detection from lung X-rays:

1. **High accuracy:** Deep learning algorithms, when properly trained and validated, have shown high accuracy in various image analysis tasks, including medical image classification. This can help improve the reliability of COVID-19 detection from lung X-rays.

2. **Efficient feature extraction:** Deep learning models automatically learn relevant features from raw data, eliminating the need for manual feature engineering. This can save time and effort in the development process.

3. **Transferability of knowledge:** Transfer learning allows leveraging pre-trained models, trained on large and diverse datasets, to extract generic image features. This knowledge can be transferred to the COVID-19 detection task, even with limited labeled data, resulting in better performance.

4. **Scalability:** Deep learning algorithms can handle large-scale datasets efficiently. As more COVID-19 cases are reported, the availability of a large amount of data can be leveraged to improve the performance of the detection model.

5. **Rapid assessment:** Deep learning-based COVID-19 detection from lung X-rays can provide rapid assessment, helping prioritize cases and allocate medical resources effectively, especially in emergency situations.

Disadvantages and challenges of using deep learning and transfer learning for COVID-19 detection from lung X-rays:

1. **Data availability and quality:** Deep learning models require large amounts of labeled data for training, but obtaining well-annotated COVID-19 datasets may be challenging.

Additionally, the quality and consistency of the data can vary, which may affect model performance.

2. **Bias and generalization:** Deep learning models may suffer from bias if the training data is not representative of the diverse population. The model's generalization ability should be carefully evaluated to ensure its effectiveness across different demographics and imaging setups.

3. **Interpretability and explainability:** Deep learning models are often considered as black boxes, making it challenging to interpret their decisions and provide explanations. In the medical field, interpretability is crucial to gain trust and confidence from healthcare professionals.

4. **Overfitting and model complexity**: Deep learning models with a large number of parameters can be prone to overfitting, especially when the training data is limited. Regularization techniques and careful model selection are required to mitigate this issue.

5. **Hardware and computational requirements:** Training deep learning models can be computationally intensive and require substantial computational resources, including powerful GPUs. This can pose challenges in resource-constrained settings or for researchers with limited access to high-performance computing infrastructure.

8. CONCLUSION

In conclusion, the use of deep learning and transfer learning techniques for COVID-19 detection from lung X-rays offers several advantages, including high accuracy, efficient feature extraction, transferability of knowledge, scalability, and rapid assessment. These techniques have the potential to assist healthcare professionals in making timely and informed decisions, especially in emergency situations and when there is a need to alleviate overcapacity in medical facilities.

However, there are challenges and considerations to keep in mind. Data availability and quality, potential bias and generalization issues, interpretability and explainability limitations, overfitting and model complexity, and hardware and computational requirements are among the factors that need careful attention during the development and deployment of such models.

It is crucial to approach the development of deep learning models for COVID-19 detection with caution, ensuring robust validation, rigorous evaluation, and collaboration with healthcare professionals. These models should be seen as complementary tools that support clinical expertise rather than replace it.

Continued research, refinement, and validation of deep learning algorithms, along with the collection of diverse and representative datasets, can further enhance their performance and reliability. By addressing the challenges and maximizing the benefits, deep learning and transfer learning have the potential to contribute significantly to the fight against the COVID-19 pandemic, aiding in the rapid and accurate assessment of patients and the efficient allocation of healthcare resources.

9. FUTURE SCOPE

Improved accuracy: Ongoing research and development can lead to further improvements in the accuracy of deep learning models for COVID-19 detection. Fine-tuning existing models and exploring new architectures specifically tailored for this task can help achieve higher sensitivity and specificity.

Robustness to variations: Ensuring the robustness and generalizability of deep learning models across different populations, imaging modalities, and variations in disease manifestation is crucial. Future research can focus on addressing biases, reducing false positives and false negatives, and accounting for diverse patient demographics and imaging protocols.

Integration with clinical workflows: Efforts can be made to seamlessly integrate deep learning models into clinical workflows. Developing user-friendly interfaces, establishing standardized protocols for data collection and model deployment, and ensuring interoperability with existing healthcare systems can facilitate the practical implementation and adoption of these technologies.

Explainability and interpretability: Enhancing the explainability and interpretability of deep learning models is an ongoing research area. Techniques such as attention mechanisms, saliency maps, and model visualization can help healthcare professionals understand and trust the decisions made by these models, leading to increased acceptance and adoption.

Multi-modal approaches: Combining information from multiple imaging modalities, such as X-rays, CT scans, and other clinical data, can provide a more comprehensive and accurate assessment of COVID-19. Future research can explore the integration of different modalities to leverage complementary information and improve overall diagnostic performance.

Detection of new variants and complications: As new variants of SARS-CoV-2 emerge and our understanding of COVID-19 evolves, deep learning models can be adapted to detect and characterize these variants from imaging data. Additionally, these models can be expanded to identify and assess complications associated with COVID-19, aiding in early detection and management.

Real-time monitoring and prediction: Deep learning models can be further developed to enable real-time monitoring and prediction of disease progression based on sequential imaging data. This can support timely intervention and personalized treatment planning for COVID-19 patients.

Collaboration and data sharing: Collaboration among researchers, healthcare institutions, and policymakers is vital for the development and validation of deep learning models. Sharing anonymized and standardized datasets can facilitate advancements in the field and enable benchmarking and comparison studies.

Source Code:

Video Link:

https://drive.google.com/drive/folders/1uY4p0M30JeGbY08Gnk0ZxIRQO-dl3fBb?usp=sharing

Github :

https://github.com/naanmudhalvan-SI/PBL-NT-GP-16783-1682926846/tree/222052c46e79bf8ace2453d1b40aac1d0b661d05/Final%20Deliverables

Model.h5 link:

https://drive.google.com/file/d/1pO6BqIcByIXXm_e3Y-fyNLBMPUgdqpZR/view?usp=share_link