COVID-SWIFT: Simple Whatsapp based Image interpretation at your Finger-Tips

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Abstract: COVID-SWIFT is a free Whatsapp based service to provide a swift diagnosis of potential COVID19 patients by analyzing Chest X-Ray images. Our state-of-the-art deep learning model generates a report containing predictions for COVID-19 and 14 other lung abnormalities with interpretable semantic markings on chest X-Ray. This can help doctors understand the severity of illness of their patients. We ran a small scale pilot for the last 10 months, where interested doctors within minutes, could receive a machine generated X-ray Report on sending us chest X-Ray of suspicious patients. Our model is trained using Multi-Task Learning on multiple chest X-Ray datasets by NIH, RSNA, etc.

COVID-SWIFT has now been launched as XraySetu in collaboration between IISc, Niramai, and ARTPARK. Xraysetu is quick and simple for busy doctors to use. XraySetu allows doctors in rural areas to plan early intervention for their patients by simply taking a picture of their Xray and sending it over via Whatsapp. We believe that this could be the model for the future of Indian healthcare, accessible to everyone wherever one might be.

Introduction

Covid-19 is currently one of the most life-threatening problems in the world. One of the primary methods of getting the Covid-19 pandemic under control is through massive testing and isolation. As the number of Covid-19 cases rises across the globe, massive testing faces the following challenges: 1) Duration of reliable pathology tests for the virus such as RT-PCR usually take 1-2 days which results in late diagnosis. 2) Testing centers are typically situated in cities which makes a timely diagnosis for rural patients difficult. 3) Testing centers have a limited capacity per day which can not be scaled quickly.

One of the most common symptoms of Covid-19 is dyspnea. On a closer analysis of Chest X-rays, radiologists have observed specific abnormalities in the lungs of patients diagnosed with Covid-19. Such an observation has motivated machine learning researchers all over the world to develop algorithms to detect Covid-19 specific characteristics in Chest X-rays and CT scans, and predict the presence of the disease. Our research study focuses on identifying Covid-19 using a patient's Chest X-ray. X-ray imaging is faster, cheaper, accessible and has a scope for portability. We have developed an end-to-end pipeline which in addition to screening Covid-19 can detect other common lung ailments among patients, generating comprehensive reports highlighting the affected regions in the lung.

A major focus area of our research is developing a model that is robust to variations in the quality of Chest X-ray images given as input to the model. The motivation behind this is the fact that most medical professionals prefer quickly sending mobile camera captured X-ray images via mediums such as WhatsApp for report generation. Towards this goal, we have successfully collected more than 700 Chest X-ray images of Indian patients sent to us via doctors over WhatsApp. Of these, we have generated

ground truths for more than 350 images based on the reliable RT-PCR test result. We call this novel collection of images as the *Niramai Covid-19 dataset*.

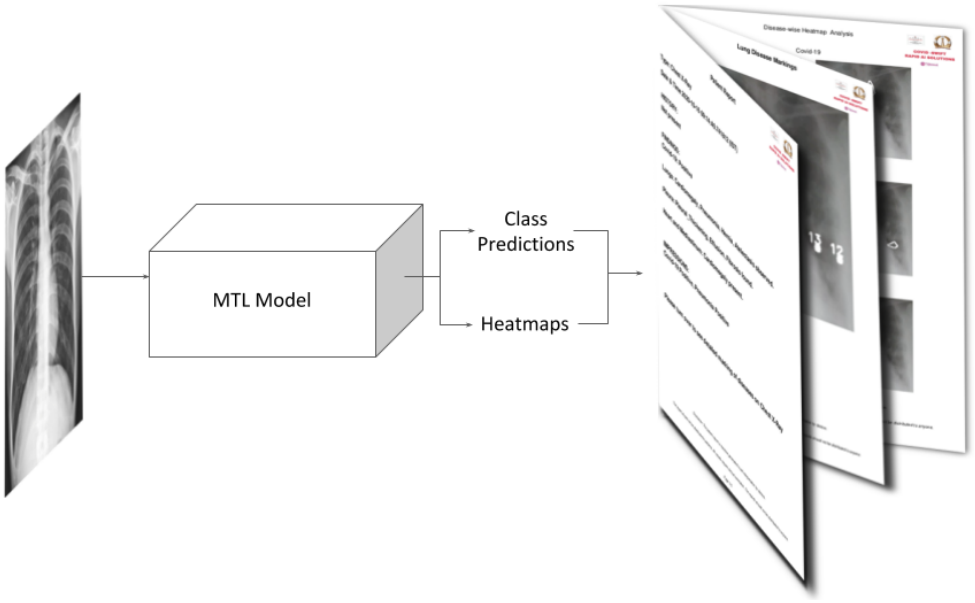


Fig. 1 : Report generation pipeline

Proposed deep learning model

We have devised a Multi-Task Learning (MTL) based deep learning model which is trained to identify a patient as being Covid-19 positive or negative from the Chest X-ray of the patient. In addition to Covid-19, our model can also identify the presence of fourteen other common lung ailments. Refer to Fig. 2 for the deep learning model architecture.

Multi-Task neural networks are known to learn similar and related tasks together based on the input data. As shown in Fig. 2 multi-task networks have a base network with multi-objective outputs (heads). Since the base network is shared across multiple related tasks, the weights are learned to be optimal for all functions jointly. The intuition behind using a multi-task learning model for Covid-19 detection is that the diagnosis of Covid-19 is typically associated with pneumonia-like symptoms. Hence, we have carefully assigned tasks to each of the heads. The three tasks assigned are as follows: (i) *Head 1*: Covid-19 vs 14 common lung ailments multi label classification and heatmap localization, (ii) *Head 2:* Pneumonia detection and bounding box localization and (iii) *Head 3:* Pneumonia type classification and heatmap localization.

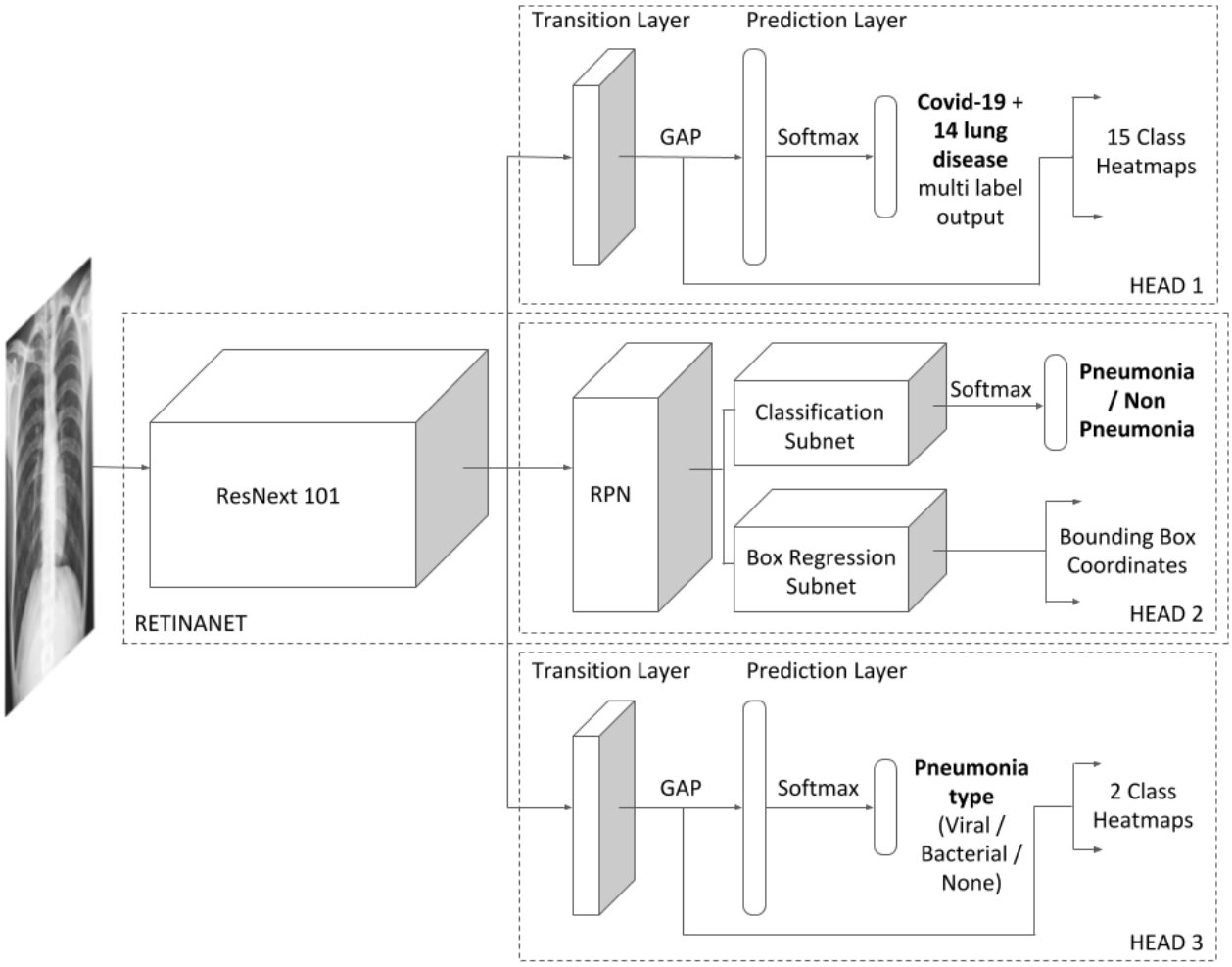


Fig. 2 : Multi Task Learning (MTL) model architecture

Experimental Results

We have evaluated the performance of the developed Multi-Task learning based deep learning model across various datasets used for training, validating and testing the model. Refer to Table 1. for Covid-19 detection performance across the validation sets used to gauge the best performing model across multiple experiments of training.

Dataset	Accuracy	Precision	Sensitivity	Specificity	AUROC
Niramai COVID-19 validation dataset	0.7482	0.7578	0.9463	0.2706	0.8299
Open source COVID-19 validation dataset	0.8634	0.7838	0.9886	0.7474	0.9316

We will soon be sharing our preprint paper with further details.

Table 1. Covid-19 performance metrics over various validation sets

Refer to Table 2. for Covid-19 detection performance on the Niramai Covid-19 test set. These metrics indicate the real world performance of the model and serve as a blind test for the model.

Dataset	Accuracy	Precision	Sensitivity	Specificity
Blind testing by Niramai (59 images)	0.7458	0.8367	0.8542	0.2727

Table 2. Covid-19 performance metrics over Niramai test set

Refer to Table 3. for the detection performance across the fourteen common lung ailments other than Covid-19.

Dataset	Mean Accuracy	Mean Sensitivity	Mean Specificity	Mean AUROC
Open source NIH validation dataset	0.7400	0.7537	0.7448	0.8095

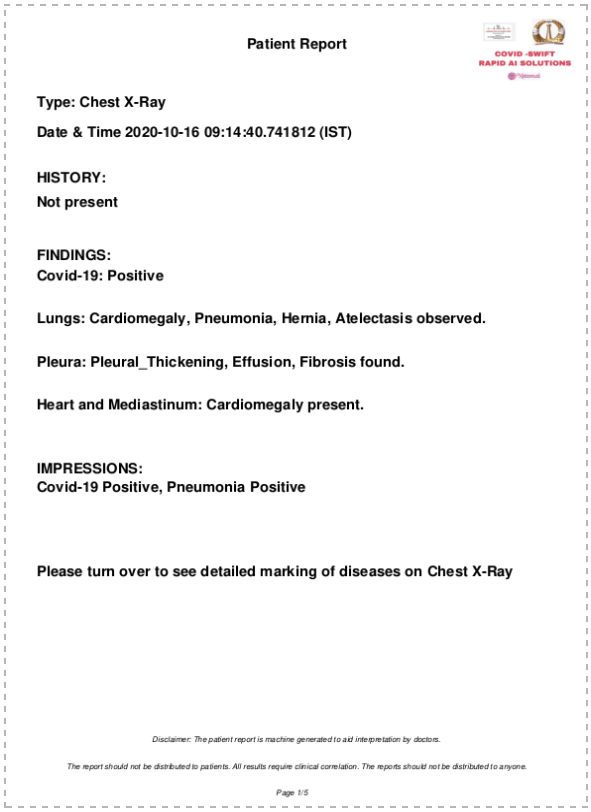
Table 3. Fourteen lung ailments performance metrics over NIH validation set

Covid-SWIFT Service

Using the pipeline discussed in the above sections, we have currently deployed a free WhatsApp based service called SWIFT (Simple Whatsapp based Image interpretation at your FingerTips) to provide a swift diagnosis of potential Covid-19 patients by analyzing Chest X-ray images. We are running a small scale pilot where interested doctors can receive an AI generated X-ray report in minutes on sending us Chest X-rays of suspicious patients. For this service we have collaborated with *Niramai*, a leading healthcare startup and *Cardiology At Doorsteps*, a whatsapp based radiology service.

Since the first day of deployment of SWIFT, we have been receiving an average of 5-10 patient X-rays per day from doctors via Whatsapp. We privately share the model generated report with the concerned doctors in less than 30 minutes. So far, more than 700 patient images have been sent to us by more than 200 doctors from different parts of India.

Using AI generated reports from SWIFT, doctors have claimed that they were better able to diagnose and decide the further course of action for the patients. Rural doctors in India do not have enough Covid-19 testing kits for testing their patients. Since X-ray machines are prevalent even in rural hospitals, using SWIFT's X-ray report, many doctors have been able to make decisions on whether the patients have to be transferred to urban hospitals for testing or care.



Patient Report

COVID -SWIFT RAPID AI SOLUTIONS

Type: Chest X-Ray

Date & Time 2020-10-16 09:14:40.741812 (IST)

HISTORY:
Not present

FINDINGS:
Covid-19: Positive

Lungs: Cardiomegaly, Pneumonia, Hernia, Atelectasis observed.

Pleura: Pleural_Thickening, Effusion, Fibrosis found.

Heart and Mediastinum: Cardiomegaly present.

IMPRESSIONS:
Covid-19 Positive, Pneumonia Positive

Please turn over to see detailed marking of diseases on Chest X-Ray

Disclaimer: The patient report is machine generated to aid interpretation by doctors.

The report should not be distributed to patients. All results require clinical correlation. The reports should not be distributed to anyone.

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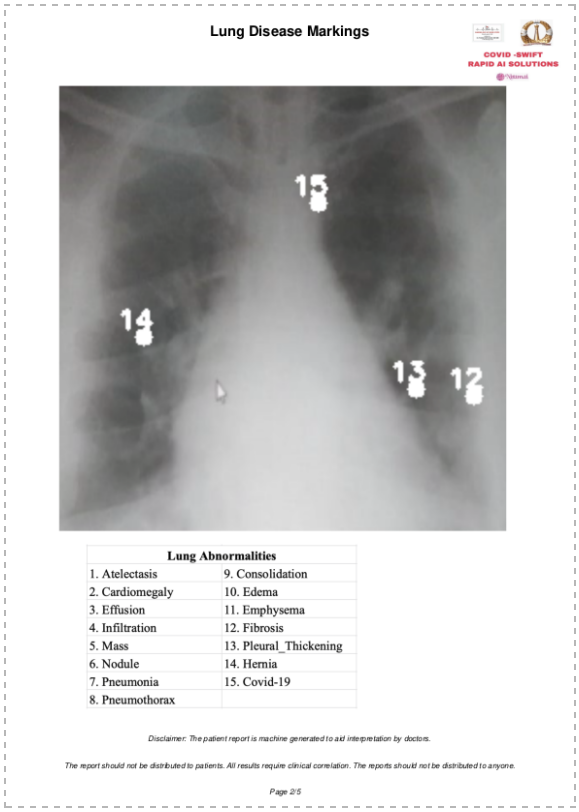

Lung Disease Markings

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Lung Abnormalities	
1. Atelectasis	9. Consolidation
2. Cardiomegaly	10. Edema
3. Effusion	11. Emphysema
4. Infiltration	12. Fibrosis
5. Mass	13. Pleural_Thickening
6. Nodule	14. Hernia
7. Pneumonia	15. Covid-19
8. Pneumothorax	

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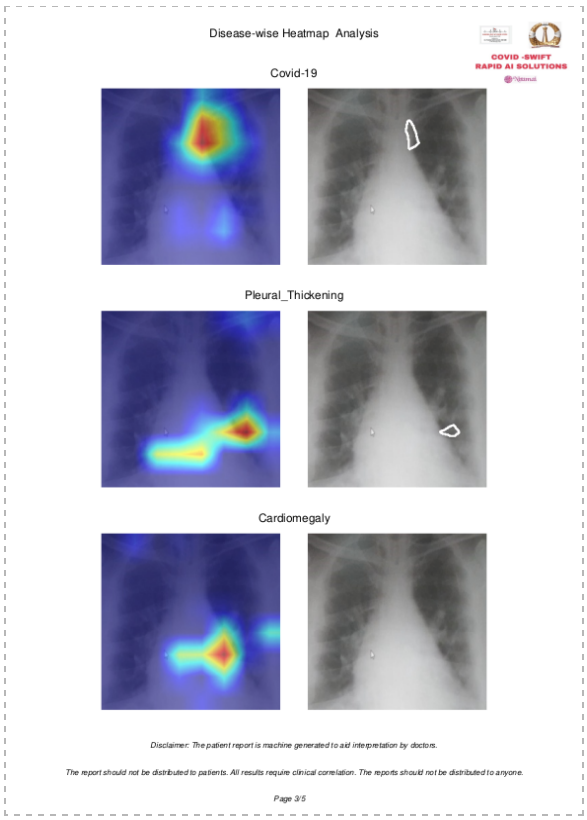

Disease-wise Heatmap Analysis

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Covid-19

Pleural_Thickening

Cardiomegaly

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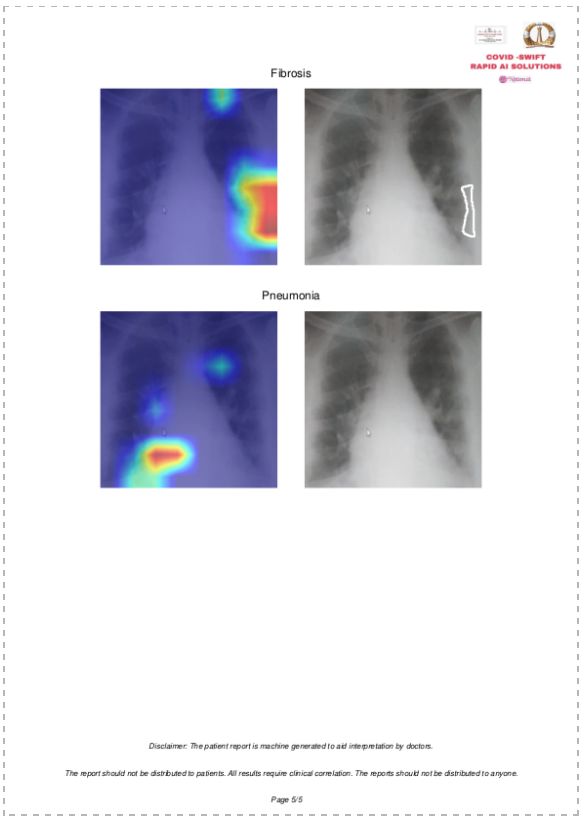

COVID -SWIFT RAPID AI SOLUTIONS

Fibrosis

Pneumonia

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Fig 3. Patient Report for actual Covid--19 positive patient with other lung ailments reported as well

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Report Analysis

Fig. 3 shows an anonymized real patient report generated by our model on one of the Chest X-ray images sent to us via doctors. The report format in its current form is a result of several iterations of feedback from the doctors involved with us. We have adopted a multi page report format to impart important information in a clear and concise manner. For a given Chest X-ray, we provide the following details in the report: (i) *Page 1:* An overview of the various lung ailments detected, categorized according to the lung region, (ii) *Page 2:* The Chest X-ray image with the detected diseases marked on the Chest X-ray for better interpretability and (iii) *Page 3 onwards:* Disease-wise heatmaps for all the reported diseases to exhibit the localized regions where the model has detected the presence of the disease.