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Analysis of Deep Learning Techniques for COVID-19 Detection

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***Abstract*—Recent findings in the area of Coronavirus detection using deep learning techniques made it possible to develop AI based tool for analyzing coronavirus with good accuracy. In this paper we present systematic study of publicly available datasets and deep learning techniques suitable for COVID-19 detection.**
Keywords: *Coronavirus, deep learning, CNN, ResNet and VGG16.*

I. INTRODUCTION

Coronavirus is a specific type of virus and as per inherited property replicates and expands. Seriousness of this virus is due to Its nature of expanding with very fast pace. Figure1 shows the basic structure of coronavirus. Mammals and birds are attacking points of this virus. This disease cause variety of infections related to respiratory system.

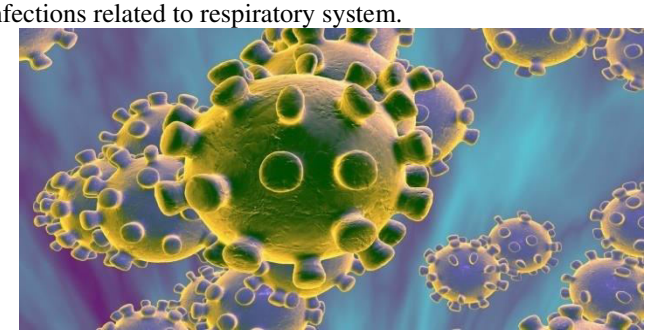

Figure1: Coronavirus

Coronavirus origination started from china and expanded in different parts of world. Most of the countries declared it as medical emergency. Till March 2020 around 16000 deaths are confirmed due to this. Figure2 depicts the coronavirus spread.

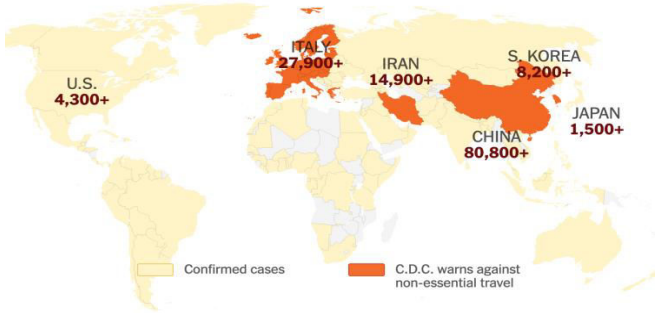

Figure2: Coronavirus spread [1]

Governments developed various isolation centers to take care infected patients. Sanitization procedures are taken at wide scale to mitigate the effect of this epidemic. Figure3 shows the efforts made by government agencies to tackle the situation.

Figure3: Coronavirus Prevention [2]

Government efforts are not sufficient to tackle the situation alone. Without efforts of common men it's not possible to control the disaster. Figure4 shows some common precautions required by everyone in this situation. In case of any symptoms, medical checkup is necessary. Common questions &answers related to COVID-19 are released by WHO: https://www.who.int/news-room/q-a-detail/q-a-coronaviruses. Advice for common public released by WHO can be found at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public.

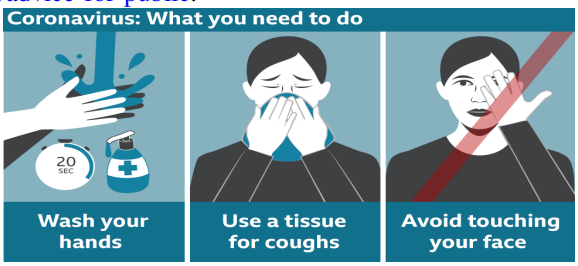

Figure4: Preventive Measures

AI can be used to tackle this situation:

1. By analyzing Chest X-Ray, CT-Scans and other clinical symptoms to detect COVID-19
2. By doing drug or vaccine discovery for Covid-19 virus
3. By analyzing the effect of existing medicines on Covid-19 virus
4. By analyzing the remedies for current and future attacks of same type

In this paper we are focusing on point 1. To demonstrate the capability of deep learning for COVID-19 prediction, we collected chest X-Ray dataset and evaluated accuracy metric over VGG16, ResNet50 and MobileNetV2. An overview of the rest of the paper is as follows: in section 2 we present

related work and datasets in this area; section 3 defines AI in Healthcare; section4 present deep learning architectures for coronavirus; section 5 present conclusions and future work.

II. RELATED WORK & DATASETS

Datasets are very crucial to derive any kind of inference. When use case belongs to healthcare domain then proper availability of data points with deep learning technique will be helpful to build real world application. Various research organization and labs are coming out with dataset of COVID-19. Dataset is also available on kaggle platform:https://www.kaggle.com/sudalairajkumar/novel-corona-virus-2019-dataset. This dataset have various features like patient location, age, symptoms etc. Different notebooks are also available based on this dataset. Researchers of Johns Hopkins University prepared the dataset and made it available for research: https://github.com/ieee8023/covid-chestxray-dataset/blob/master/README.md?fbclid=IwAR30yTGBr55WXdCngCoICDENHycmdL2bGwlvl1ckdZMucjGH10Uakz7khk. Other recent important repositories are as follows: https://github.com/mattroconnor/deep_learning_coronavirus_cure , https://github.com/tmacdou4/2019-nCov etc. Research papers are popping out to give direction in this domain. Authors [3] in paper used deep learning based segmentation method to identify region of interest in CT Images of lungs for quantifying COVID-19. Authors [4] in paper used 2D and 3D deep learning techniques and obtained 99.6% accuracy in context of COVID-19. Authors in paper [5] used GRU neural network with bidirectional and attentional mechanisms and seeking to scale proposed approach on large datasets in context of COVID-19. Authors in paper [6] come out with 86.7% accuracy on benchmark datasets using deep learning in context of coronavirus. Author [7] in his blog used VGG16 for detecting COVID-19 in X-Ray images. Literature is growing and various efforts are going on in scientific community to mitigate the negative effects of coronavirus.

III. ARTIFICIAL INTELLIGENCE IN HEALTHCARE

AI technologies are used in healthcare due to technical stability in this domain. Machine learning, Deep Learning, Natural Language Processing & Robotics are integrated as per need of application. Role of artificial intelligence in healthcare:

1. Disease prediction under different medical domains
   - 1.1 Radiology (Ct-Scan, X-Ray, MRI Analysis)
   - 1.2 Pathology
   - 1.3 Dermatology(Skin disease prediction)
   - 1.4 Ophthalmology (Glaucoma or Diabetic Retinopathy Analysis etc.)
2. Drug discovery
3. Healthcare monitoring
4. Robot Assisted Surgery
5. Insurance Fraud detection
6. Dosage Error detection
7. Personalized Medicine

Benefits of AI enabled Healthcare

- Advancements in healthcare treatments
- More accurate prediction of disease in less time frame
- NLP based assistants to help patients
- Human error reduction
- Processing volumes of data and texts in seconds

From leading companies of world to startups are jumping in AI enabled healthcare sector. Efforts of different research groups created health related datasets. AI research is going on the top of that data. Some important healthcare datasets are as follows:

1. Breast Cancer Dataset: https://www.kaggle.com/uciml/breast-cancer-wisconsin-data
2. Diabetes Dataset: https://www.kaggle.com/uciml/pima-indians-diabetes-database
3. Skin Cancer Dataset: https://www.kaggle.com/kmader/skin-cancer-mnist-ham10000
4. Glucoma Dataset: https://www.kaggle.com/andrewgrey/glaucoma-dataset-for-machine-learning
5. Diabetic Retinopathy: https://www.kaggle.com/c/diabetic-retinopathy-detection
6. Personalized Medicine: Cancer Treatment: https://www.kaggle.com/c/msk-redefining-cancer-treatment
7. Liver Patent Dataset: https://www.kaggle.com/uciml/indian-liver-patient-records
8. Chronic Kidney Disease Dataset: https://www.kaggle.com/mansoordaku/ckdisease
9. Brain MRI Dataset: https://www.kaggle.com/navoneel/brain-mri-images-for-brain-tumor-detection
10. Bone Defects: https://www.kaggle.com/chzpan/bone-lab/version/9
11. Swine Flu Dataset: https://www.kaggle.com/celcius/swine-flu/version/1

IV. DEEP LEARNING ARCHITECTURES FOR CORONAVIRUS

Deep Learning is extension of machine learning where multiple layers are present and high level features are selected from input data. Figure5 shows the architecture of deep neural network. Literature of deep learning techniques is expanding,

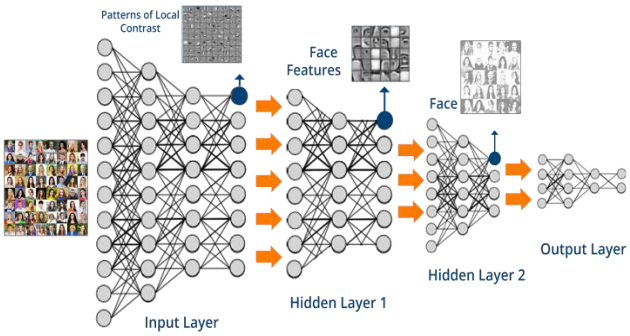

Figure5: Deep Neural Network [8]

due to their wide scale use in sectors like finance, healthcare, identity etc. The real impact of deep learning on different sectors is yet to come. There are various popular deep learning architectures.

1. Convolutional Neural Network
2. Recurrent Neural Network
3. Deep Belief Network
4. Long short-term Memory
5. Restricted Boltzmann Machine

Role of deep learning in healthcare sector is well established and above mentioned deep learning techniques have been used to analyze various diseases in literature. As per current study, Chest X-ray and CT-Scan images can be used to predict COVID-19. Figure6 shows the observation recorded by researchers of an old man suffering from fever under different time frame. Figure7 shows the CT image in similar context. As discussed in previous section research communities are releasing dataset for research in this domain.

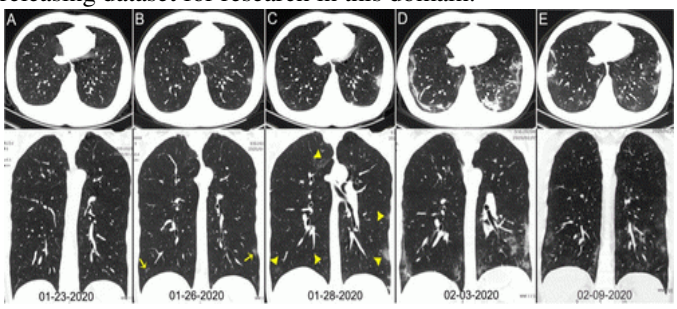

Figure6: CT Scan images at different time frame under fever [9]

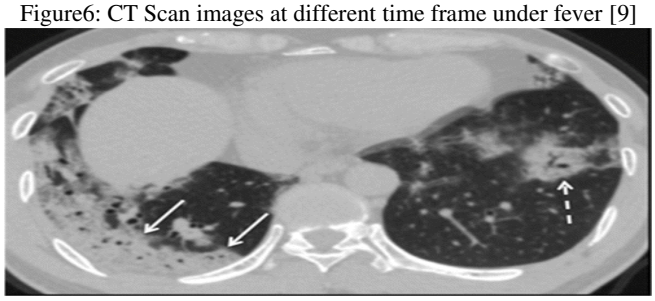

Figure7: Male patient CT image for analysis [10]

Research societies guidelines regarding CT Scan based predictions:

- CT should not be taken as primary check to assure COVID-19.
- CT should be taken carefully and kept for deriving future inference. Suitable infection control methods should be taken before scanning next patients.
- Facilities may think of using transportable radiography while identifying the current need of Chest X-ray. These machines must be kept clean to avoid infections.
- Radiologists should make continuous observation based on X-ray samples. They should also focus on other parameters from where detection can be made with ease and fast pace.

Deep learning researchers are giving proof of concept on standard datasets. While understanding the nature of problem, we found that it is closer to problems like Pneumonia Classification using deep learning. Past literature will be helpful to select well established algorithms and data pre-processing techniques. Figure8 shows the patterns of chest X-ray (normal & infected) by Pneumonia.

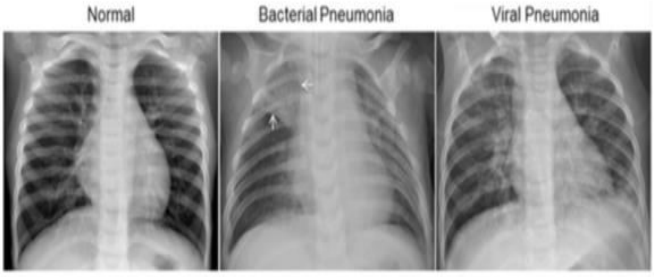

Figure8: Chest X-Ray pattern (Normal & Infected) [11]

Authors in past literature analyzed Pneumonia in Chest X-Ray by Deep Convolutional Neural Network, ImageNet, Inception, Mask-RCNN etc. Some important repository regarding the same is as follows:

1.https://github.com/amitkumarj441/identify_pneumonia
2.https://github.com/anjanatiha/Pneumonia-Detection-from-Chest-X-Ray-Images-with-Deep-Learning
3.https://github.com/suvhradipghosh07/Chest-Pneumonia-Detection-using-Deep-Learning-Various-Architecture
4.https://github.com/ferhatkkochan/pneumonia_classifier
5.https://github.com/gregwchase/nih-chest-xray

Proposed AI model for COVID-19 prediction

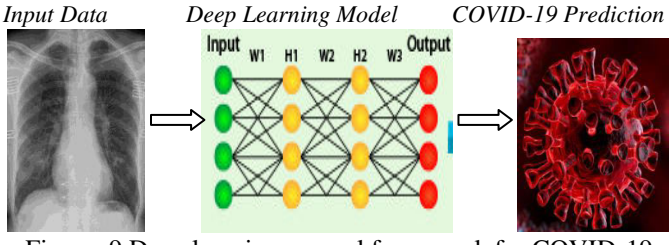

Figure: 9 Deep learning general framework for COVID-19 prediction

To present a proof of concept, we collected Chest X-Ray dataset for COVID-19 & Normal from different openly available sources as mentioned in section2 of paper. To evaluate effectiveness of deep learning techniques on collected datasets, we used VGG16, ResNet50 and MobileNetV2. Basic architectures of these models is shown in Figure10, Figure11

and Figure12.

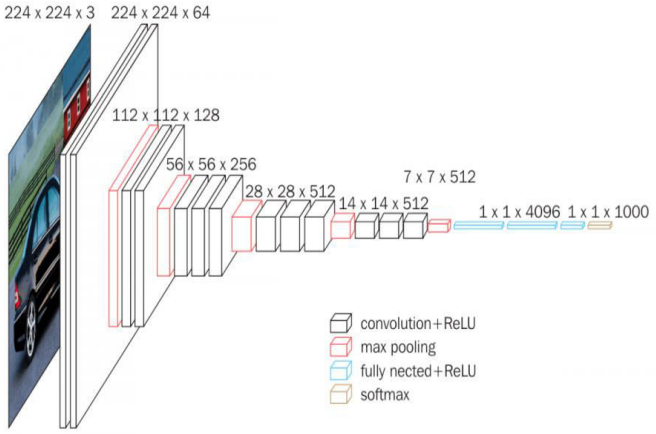

Figure10:VGG16 basic architecture[13]

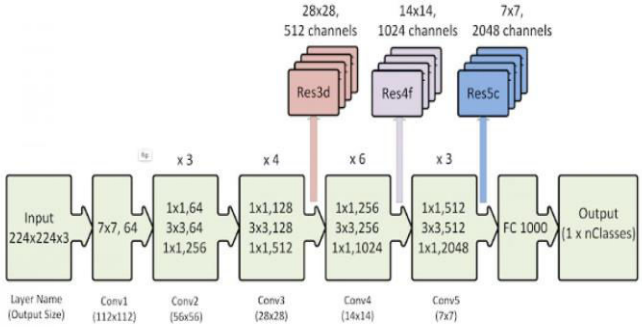

Figure11: ResNet50 basic architecture [14]

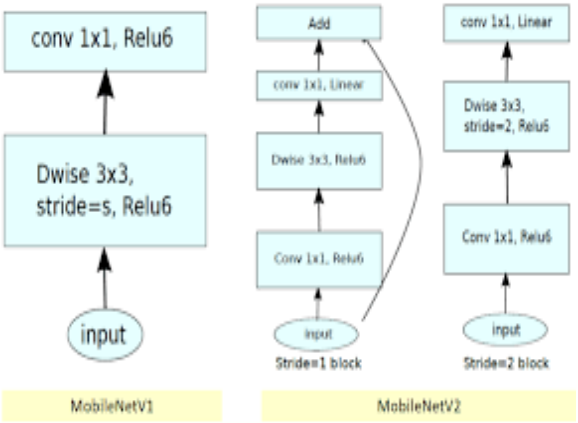

Figure12: MobileNetV1 and MobileNetV2 basic architecture[15]

We used the concept of transfer learning with fine tuning of input data, selecting loss function, Adam optimizer and learning rate10^{-4}. Figure13 reflects the utility of transfer learning.

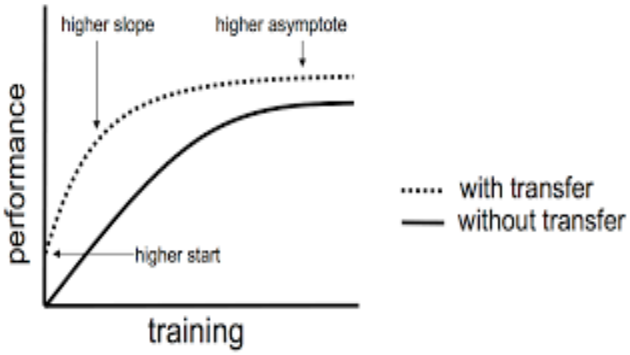

Figure13: Transfer Learning in deep learning models[16]

Same process is applied on three different deep learning techniques. Pre-trained models can be taken from, https://github.com/Cadene/pretrained-models.pytorch. Only top layer of these models are modified and fine tuning is done for 25 epochs. Experimental results are shown in Figure14. VGG16 model is giving good results but still there is issue of proper data points as well as understanding of medical domain in terms of data selection. In this paper we are focusing more on open dataset and code resources to make this write-up simple and useful for peer group.

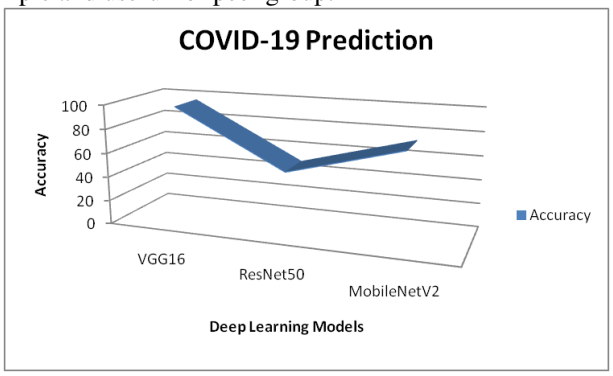

Figure14: Comparative analysis of Deep Learning Techniques for COVID-19

To demonstrate the utility of available data we performed the experiments. More data in future will reflect the real potential of deep learning models. Some techniques suggested in recent literature must be integrated with existing models. Authors in[17] discussed the role of data selection and active learning for designing AI based framework for COVID-19 detection.

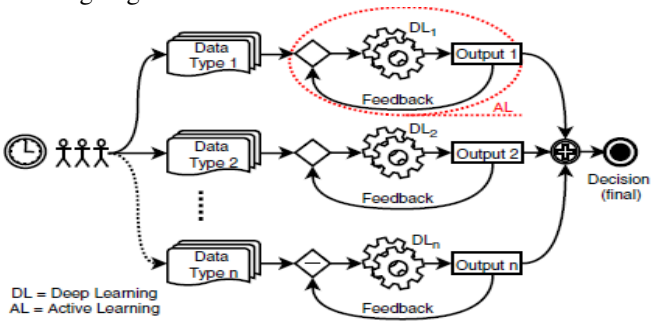

Figure15: Active Learning approach in COVID-19 prediction [17]

Beyond this, researchers are developing medicines/vaccines to tackle the situation. As per latest report published in nature

[12], there are serious questions on clinical trials just like safety, immunity sustainment etc. In near future, we can think about proper vaccine/ medicine for COVID-19.

V. CONCLUSION AND FUTURE WORK

In this paper we summarized the current scenario of COVID-19. Role of AI is going to be crucial for predicting the outcome based on symptoms, CT-Scan, X-Ray reports etc. We discussed recently available datasets with various techniques in current literature to tackle same or related diseases. VGG16, ResNet50 and MobileNetV2 have been presented as proof of concept on collected dataset taken from different sources. Deep learning architectures are evolving with very fast pace, that will be helpful for designing robust system. Current work will be very useful for industrial or academic purpose.

Acknowledgement

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Appendix

Some important projects related to COVID-19 are listed as follows:

1. https://github.com/lindawangg/COVID-Net
2. https://github.com/BlankerL/DXY-COVID-19-Crawler
3. https://github.com/NovelCOVID/API
4. https://github.com/mathdroid/covid-19-api
5. https://github.com/mattroconnor/deep_learning_coronavirus_cure

Some important research papers and books related to COVID-19 are listed as follows:

BOOKS

1. Wuhan Coronavirus (COVID-19)
2. The 2020 Coronavirus Recession Economic Crisis Series Bundle

Research Articles

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