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A Survey of Artificial Intelligence and Internet of Things (IoT) based approaches against Covid-19

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***Abstract*—Artificial Intelligence (AI) has proven to be a great instrument in the application of technology in different real life situations. In most cases, the application of AI is followed by an improvement in the living conditions and well-being for humanity. Currently, the world is facing the pandemic of Covid-19. Application of artificial intelligence (AI) can be of great significance in the fight against Covid-19 combined with other forms of technology like the Internet of Things (IoT). This paper focuses on the survey of different AI applications and methods to aid our fight against Covid-19 and winning this battle. Different application subdomains of artificial intelligence include computer vision, speech recognition, natural language processing and data analytics etc. The survey highlights areas where artificial intelligence (AI) works in tandem with internet of things (IoT) to provide efficient ways to prevent, diagnose and reduce Covid-19. The paper also presents a survey of research work and approaches on applications of technology against Covid-19 and data sources related to them. We also propose a novel approach for preliminary indication of Covid-19, which makes use of AI enabled IoT sensors, along with conversational capabilities.**

***Index Terms*—Covid-19, Artificial Intelligence, Internet of Things, Pandemic, Survey**

I. Introduction

Covid-19 virus also known as SARS-COV-2 was first reported towards the end of 2019. Covid-19 outbreak started in Wuhan, a city in central China. Initial reports indicated that bats were the original carriers of this virus; and due to human consumption of bats as food items, it was introduced in the society. Since this virus was new, researchers and government alike could not understand its nature soon enough to stop its spread on a global scale. As a result, it culminated into a pandemic of worldwide scale as illustrated in Figure 1. Globally, as of 12:45 PM GMT on 22nd October, 2020, there have been over 41,000,000 diagnosed cases of Covid-19 including 1,128,325 deaths, reported to WHO. When it comes to prevention of Covid-19 spread and prevalence in society, the only known method currently is to enforce and execute SOPs (Standard Operating Procedures). This fact is evident by the current situation where the countries that implemented SOPs effectively have been successful in recovering from economic and social impacts of Covid-19.

However, technology can play a crucial role in implementing SOPs and diagnosing Covid-19 in patients that may or may not have developed symptoms and indications of Covid-19 presence. This paper emphasizes on approaches that use Artificial Intelligence (AI), and focuses on research work on the subject of using technology against Covid-19 in the past or currently under progress. This research work revolves around the topic of detecting and preventing Covid-19 using technologies like deep learning, internet of things, natural language processing etc. Artificial intelligence is powerful tool and it can not only help us mitigate effects of Covid-19 but it can also help us come up with vaccines and medicines to stop Covid-19 using simulation and computer models. Thus, reducing human collateral in the research and experimentation process and saving human lives from unnecessary risk.

In short, this paper focuses on answering one fundamental question using previous and current research. The remainder of this paper is organized as follows. Section II-A provides an overview of Covid-19 diagnosis approaches using AI. Section II-B describes research in the domain of pandemic forecasting using data science. Section II-C explains IoT enabled approaches. In Section III, we propose our novel IoT and AI based approach for preliminary Covid-19 diagnosis. Finally, a conclusion is given in Section IV.

II. AI IN ACTION AGAINST COVID-19

We have divided reference papers into groups like artificial intelligence algorithms for Covid-19 diagnosis, AI and data science methods for pandemic forecasting, use of AI and IoT in prevention of Covid-19 spread.

A. *Artificial Intelligence in Covid-19 Diagnosis*

Artificial Intelligence (AI) has proved to be a powerful tool in the field of medicine. AI can be used to automate the process of Covid-19 diagnosis from medical imagery like the CT scan; X-Ray etc. The work [1] applies AI to detect Covid-19 using CT scan imagery. In this study, 618 CT scan samples corresponding to 11,871 image patches is acquired and used. Out of 618, 528 samples corresponding to 10,681 images including Covid-19, influenza-A-viral-pneumonia and non-Infected images are used as training and validation sets. While the remaining 90 samples equivalent to 1,710 images are used as the test dataset.

The process followed in this paper has three steps:

1. Images are preprocessed to extract pulmonary regions.

2. These images are segmented using a 3D convolutional neural network (CNN) model.

3. An image classification model is used to classify images into three types: Covid-19, influenza-A-viral-pneumonia and non-infected images.

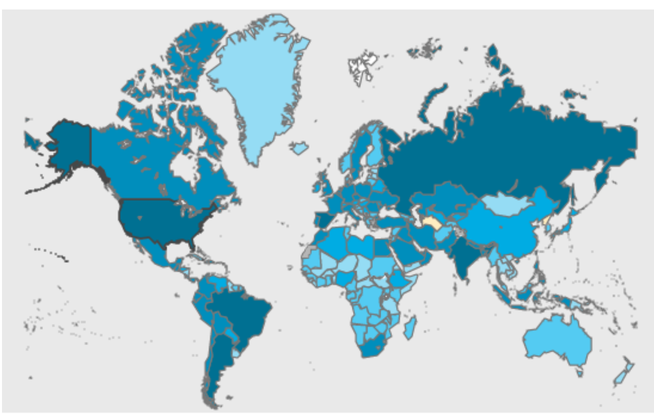

Fig. 1. Map of COVID-19 infected people worldwide [2] as of 22nd October 2020. Darker shades of blue represent higher number of cases per capita.

The overall accuracy turns out to be 86.7% for classifying images into three group: Covid-19, Influenza-A Viral pneumonia and healthy cases.

Another system for detection of Covid-19 known as Covid-19 detection neural network (COVNet) is presented in [3]. The COVNet architecture consists of ResNet50 that uses a series of CT slices for classification of CT images as output. The architecture of COVNet is illustrated in Figure 2. The extracted features by ResNet50 have max pooling operation performed on them to combine features. These features are then processed to calculate probabilities for the three cases given above. The class with highest probability is the predicted result.

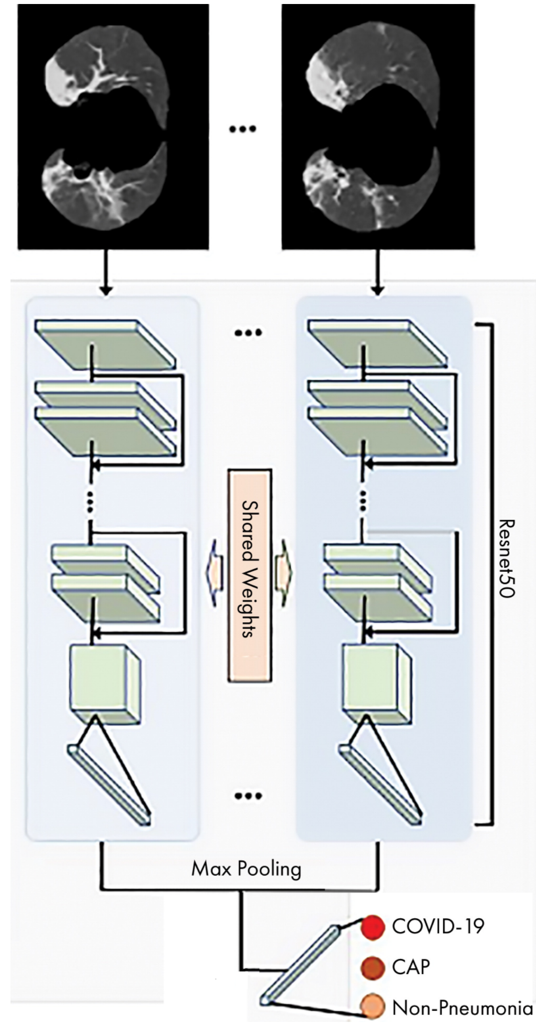

Fig. 2. COVNet architecture [3]

The dataset used by COVNet has 4,356 3D volumetric CT exams data from 3,322 patients. This dataset has three kinds of CT images that included Covid-19, community acquired pneumonia (CAP) and non-pneumonia cases collected from 6 different hospitals. Flow diagram for the dataset is shown in Figure 3. COVNet has produced an AUC value of 0.96, which solidifies the efficiency of COVNet in detecting Covid-19 cases. The results of COVNet are illustrated in Table I.

In order to make Covid-19 diagnosis easier, another custom network is proposed in [4] known as SCOAT-Net. SCOAT-Net is based on UNET++ that is an excellent network with high performance in Image Segmentation. SCOAT-Net modifies the structure of UNET++ by adding an encoder and a decoder. The encoder is used to extract semantic level information of the image. The decoder uses this semantic level extraction to reconstruct the segmentation template. This reduces the calculation cost and parameters significantly and performances is enhanced.

Deep Neural Networks (DNNs) have also shown great promise in image segmentation and a lot of research work

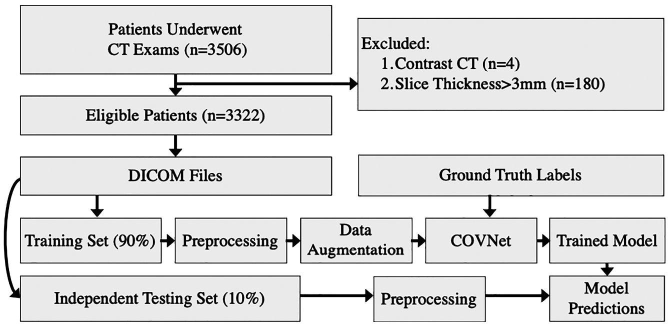

Fig. 3. COVNet data collection flow diagram [3]

has focused on using DNNs for computer vision tasks. We can understand the usefulness of DNNs with a few examples.

- Zhao et al. [5] have proposed a custom DNN for scene parsing named as pyramid scene parsing network (PSP-Net).
- Cao et al. [6] and Huang et al [7] have come up with a model using CNNs as basis for CT image prediction.
- The research work from [8] is focused on using CT imagery to develop segmentation models to detect abnormalities and lung diseases.

Shan et al [9] introduces a deep learning (DL) based system using CT Scans for automatic segmentation and quantification of infected regions in lungs. This system uses CT scans from 249 Covid-19 patients for training and CT scans from 300 Covid-19 patients for validation of VB-Net Neural Network for segmentation of infected lung regions. VB-Net is a 3D CNN and is much faster than its component i.e. V-Net. This system had accuracy of 91.6% with estimation error of 0.3%.

TABLE I
COVNet performance on the independent testing set [3].

	AUC	P-value
COVID-19	0.96 [0.94, 0.99]	$<$0.001
CAP	0.95 [0.93, 0.97]	$<$0.001
Non-Pneumonia	0.98 [0.97, 0.99]	$<$0.001

B. Pandemic Forecasting using AI and Data Science

A number of organizations made publicly available datasets and dashboards for Covid-19 statistics as given in Table II.

A number of different Covid-19 forecasting models have been developed by the data science community. A modified auto-encoder (MAE) is used by [10] for modeling the transmission dynamics and forecasting the number of confirmed cases of Covid-19 across China. Unlike the normal auto-encoder in which number of nodes decreases from input to output layer, the number of nodes in the input, first latent, second latent and output layer were 8, 32, 4, 1. The back-propagation

TABLE II
Publicly available and updated Covid-19 datasets used for forecasting.

Dataset	Link
WHO Coronavirus Disease Dashboard	https://covid19.who.int
Centers for Disease Control and Prevention (CDC), USA	https://www.cdc.gov
Johns Hopkins University	https://coronavirus.jhu.edu

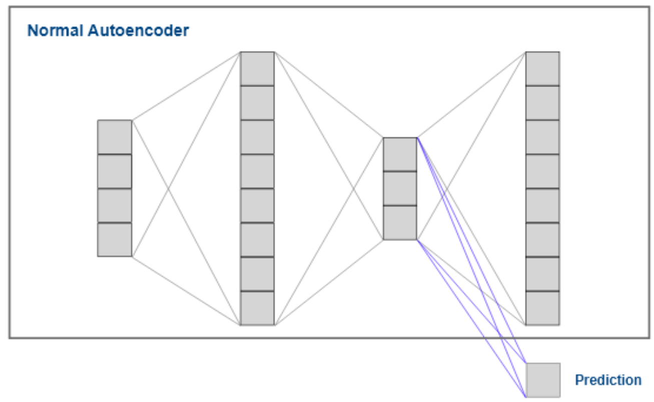

Fig. 4. Architecture of modified auto-encoder (MAE) [10].

algorithm is used to estimate the weights and bias of modified auto-encoder. The authors extract the values of second latent layer of modified auto-encoder for each province/city, and is later processed by single value decomposition to obtain the largest single value of latent matrix. Later, K-means algorithms is used to group provinces/cities into clusters to model the transmission dynamics of the pandemic. The results obtained have high accuracy, hinting that data driven AI models can be used to estimate the trajectory of epidemics and even assist health workers and governments to make timely decisions.

LSTM networks are used for forecasting of Covid-19 transmission in Canada [11]. The dataset is checked for stationarity using augmented Dickey Fuller (ADF) test. A series is said to stationary, if it does not depend on trend, seasonality and external factors. The input data is then passed to RNNs with LSTM blocks, which is by far the most effective algorithm for forecasting time series data. Each LSTM block consists of 3 gates: an input gate, forget gate and an output gate.

The self-loops in LSTM blocks prevent the vanishing gradient problem in deep neural networks. The model used in this paper is shown in Figure 5. The model gave the RMSE error of 34.83 with an accuracy of 93.4% on short term predictions in Canada, while a testing accuracy of 92.67% for long term predictions suggesting that the predictive outcomes can provide help in possible elimination of Covid-19 from the region.

C. AI with IoT against Covid-19

In the recent years, Internet of Things (IoT) has been a trending topic when it comes to integrating technology in

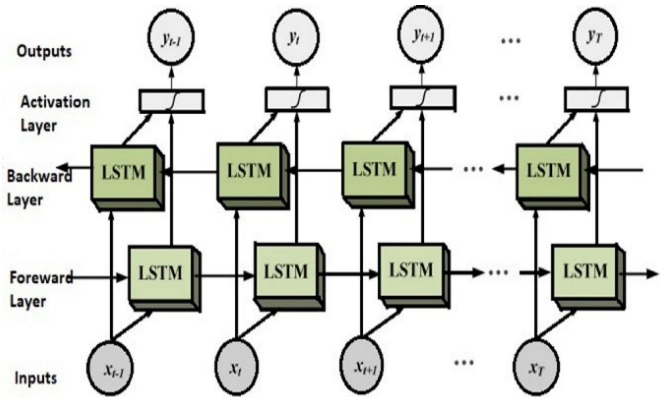

Fig. 5. Architecture of an LSTM network [11].

human society to make life standards modern and convenient. [12] has defined Internet of Things (IoT) as a system of interconnected digital and mechanical devices possessing the capability of data transmission over a defined network. [12] focuses on how Internet of Things (IoT) can act as a means against Covid-19. It has emphasized on the use of mobile devices-based applications to collect information about Covid-19 patients such as the symptoms, locations and movement. This information can then be shared using IoT in real time to enable effective communications about Covid-19. IoT can help enable remote communications between Covid-19 patients and other stakeholders like the healthcare workers, relatives etc. to reduce man-to-man contact which can greatly reduce the risk of Covid-19 transmission through human contact. The captured data is shared to all relevant channels through IoT, and can be used for analysis to come up with strategies against Covid-19. These strategies can be used for decision making by health care workers, governments and other institutions.

[13] introduces another approach that makes use of phone-based survey as a means of collecting travel history of individuals and by asking them a set of questions to estimate the chances of Covid-19 presence and infection around them. The individuals responses are then fed to an AI Algorithm to identify possible cases and alert nearest health care facility along with alerting the respondent for an immediate health check.

Allam and Jones [14] have proposed a new strategy to tackle Covid-19 by using AI and data sharing protocols to manage health care during Covid-19. Installing thermal cameras, monitoring CCTV footage to ensure social distancing and using mobile care devices to monitor breathing etc. can be integrated in the system to monitor health conditions in the society without exhausting human resources and exposure to avoidable risks.

In the above Section II, a number of techniques and application scenarios have been presented, which use technology for treatment and mitigation of Covid-19. Table III provides a tabular overview of all the discussed approaches, with their salient features.

TABLE III
A SUMMARY OF APPROACHES AGAINST COVID-19

Ref.	Goal	Data source	Results
[1]	disease classification	CT scan	86.7 accuracy%
[3]	Covid-19 diagnosis	CT scan	0.96 AUC
[4], [8]	lung image segmentation	CT scan	qualitative
[6], [7]	lung disease prediction	CT scan	qualitative
[9]	lung infection segmentation	CT scan	91.6% accuracy
[10]	transmission forecasting	confirmed cases	0.73% avg. error
[11]	transmission forecasting	confirmed cases	93.4% accuracy
[12]	suspect monitoring	IoT (mobile devices)	defining roadmap
[13]	suspect monitoring	mobile survey	data collected
[14]	Covid-19 monitoring	CCTV, mobile care devices	data collected

III. PROPOSED SOLUTION

Based on the discussion in previous sections, it can be seen that there is still much room for work. This is especially true in case of developing countries, where the Government has limited finances and healthcare capacity; therefore cost-effective solutions for screening are required. To remedy this problem, we present a novel walkthrough scanner for initial screening of Covid-19. This scanner would be installed at entry points of hospitals, banks, grocery stores and other public installations. This scanner is completely hands-free, to avoid contamination. It automatically scans each person one-by-one, checking for face mask, taking his temperature, listening to his cough, and asking verbal questions about Covid-19 symptoms such as chest pain, difficulty in breathing etc. If a person with Corona virus symptoms is detected, he is given relevant advice. If the person is clear, preventive advice is provided. Figure 6 shows the construction and operation of this system.

This product would be effective for large scale initial screening of the general public. Its cost is also quite low, since its hardware consists only of a computer CPU and some sensing devices. Potential customers for this machine include the government and private sector institutions like banks, hospitals, grocery stores and railway stations.

IV. CONCLUSION

Unlike the 1918 Spanish flu that killed more than 50 million people worldwide [15], we are fortunately in an advanced scientific era. Every individual, organization is doing its utmost efforts to counter Covid-19. AI has proven to be an extremely valuable asset in domains ranging from robotics to medical diagnosis to even assisting the treatment of many diseases. In this paper, we have surveyed recent efforts of research community for Covid-19 treatment and control. AI based diagnosis methods are discussed, as well as data analytics for controlling the disease spread. IoT based solutions for

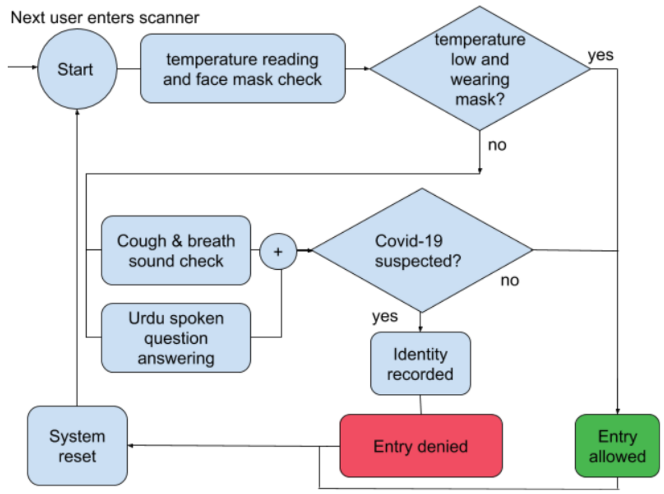

Fig. 6. Proposed system architecture

data collection and monitoring are also discussed. Finally, we have proposed a low cost method for preliminary Covid-19 screening of general public for developing countries. It is time for the AI community to come forward and utilize the power of AI to counter the disease, and hence prevent the loss of any more lives.

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