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Role of Artificial Intelligence and Machine Learning against COVID-19 Pandemic

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Abstract

There is a record of 170 plus million cases found of COVID-19 in the current scenario with its mortality rate being close to 4%, causing a major burden on health care systems and in some countries, there is total collapse of health care infrastructure like in India where daily COVID-19 cases crossed more than 400000. In the current scenario there is an urgent need of more advanced diagnostic method to for early detection of COVID-19. Artificial intelligence (AI) is one such tool which is highly promising and can be used for the development of an automated diagnosis system for COVID-19. The currently used diagnostic method "reverse transcription polymerase chain reaction (RT-PCR)" tests have some drawbacks and limitations and it is not 100% accurate. Using AI augmented devices or diagnostic systems will save time and cost and moreover it will reduce the burden of physicians as well during the pandemic period. This review paper examines the emerging AI based tools for early detection of COVID-19. It also provides insights into how AI and machine learning tools can be very usefull in predicting the stats of the COVID -19. This paper helps to promote

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future R&D in artificial intelligence and how it can be used to produce advanced diagnostic tools for managing COVID-19 pandemic and also future pandemics.

Keywords: Deep Learning, Machine Learning, Artificial Intelligence, COVID-19

1. INTRODUCTION

The first cases of COVID-19 were reported in late December 2019. The Chinese government started conducting investigations to ascertain the epidemiology of COVID-19 and its original source of outbreak. Most of the initial cases had direct link to the Huanan Wholesale Seafood Market in Wuhan City. This market is famous for its variety of seafood, wild and farmed animals. The samples taken from this market in December 2019 tested positive for COVID-19 virus such as SARS-CoV-2; the tests confirmed that the Huanan Wholesale Seafood Market was the epicenter of the outbreak and played a significant role in spreading the COVID-19 virus [1], [2]. Immediately after the samples had tested positive the Market was closed and lockdown was imposed to contain the outbreak. After sample collection and identification, it was found that COVID-19 ailment is majorly instigated by severe respiratory syndrome coronavirus 2 (SARS-CoV-2) [3] [4]. Since the outbreak of COVID-19 disease, it has become an unprecedented public health crisis which forced WHO to declare this disease a pandemic on March 11, 2020 [5]. Globally, as of 30th May 2021, the confirmed COVID-19 cases are 169,118,995 out of that 3, 519,175 have been reported dead and a number of 1,546,316,352 vaccine doses have given [6]. Figure 1 shows the Day wise Rise in new COVID 19 Cases being reported globally. With the growing crisis, World Health Organization called for the collaborative research wherein the federal governments, pharma companies and researchers would work together to tackle and mitigate the spread of COVID-19 virus and also find effective cure for the same.

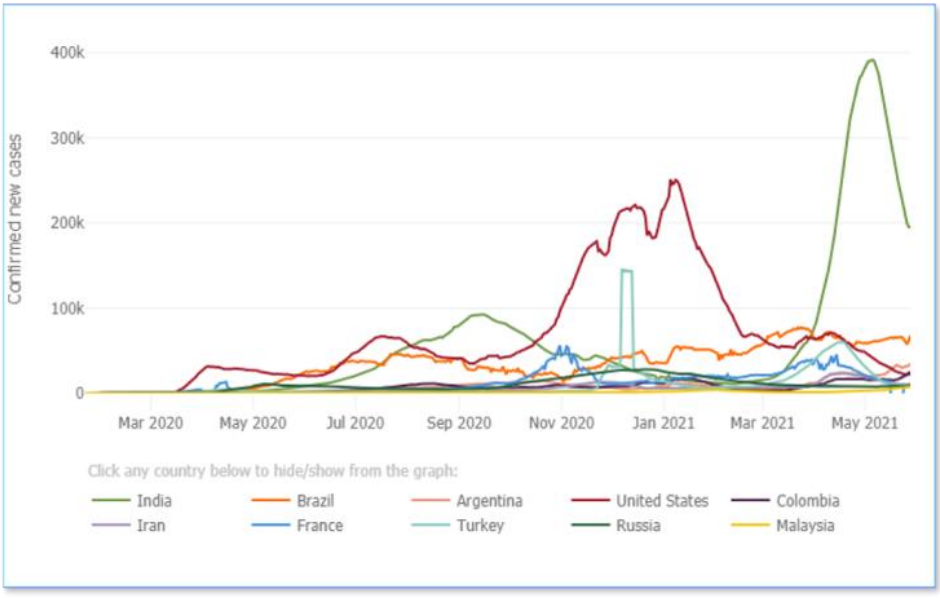

Figure 1 Daily new confirmed COVID-19 cases

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Chinese government was the first federal government to use artificial intelligence (AI), when COVID-19 cases started spreading in Wuhan city by using AI augmented cameras for facial recognition to identify healthy and infected persons, artificially intelligent robots to deliver food and medicine and drones to sterilization and disinfection of public places, transports and trains [7], [8] .

On the onset of COVID-19 and as the number of cases started increasing exponentially many AI companies partnered with federal governments and other leading research groups to share weekly updates of COVID-19 research datasets to accelerate better research using real time data. The large-scale database of COVID-19 patients can easily be integrated, processed and analyzed by exploiting computational intelligence and advanced machine learning algorithms enabling the researchers to understand the patterns of COVID-19 spread, improving the speed and accuracy of diagnosis, develop novel and effective vaccines and drugs, identify susceptible and infected population based on their genetic and physiological characteristics.

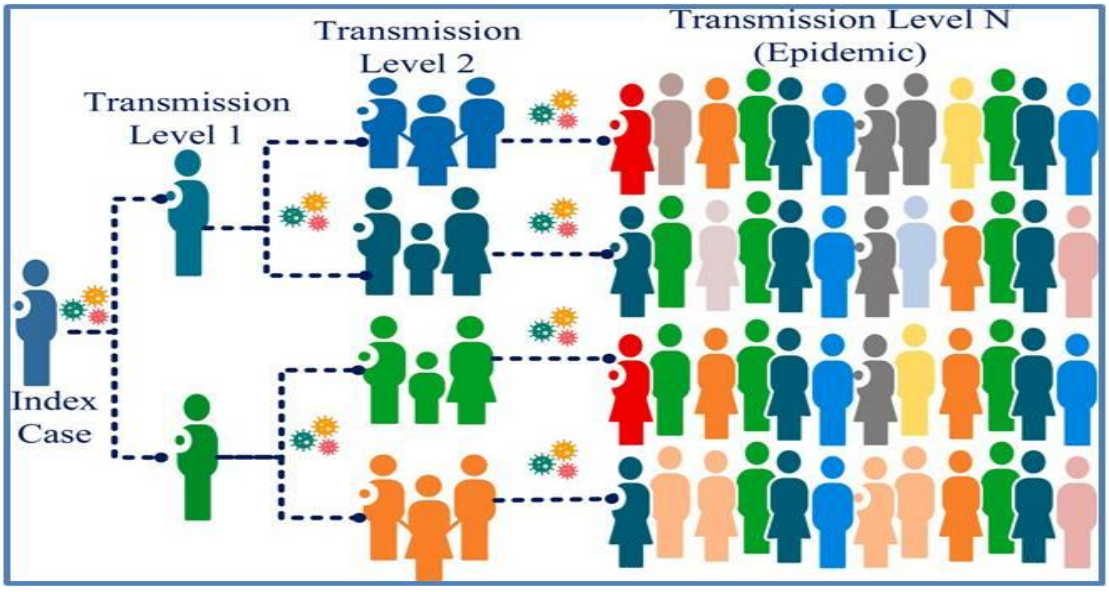

Figure 2 Transmission of COVID-19

AI and machine learning techniques are being employed for the digital image processing on medical field of X-rays and CT scans to detect and identify susceptible and infected population [9] [10], [11]. AI augmented monitoring bracelets and wrist watches are being used that helps in identification of people breaching the quarantine code of conduct. AI enabled thermal cameras which can be used for temperature measurement and COVID-19 patient identification [12], [13].

The present review focuses on the use of computational intelligence and AI /ML methods to tackle COVID-19 pandemic. Through this review paper we have tried to explain how AI and ML can be used effectively to subdue the impact of pandemics including COVID-19, Zika virus or SARS.

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2. Role of AI and ML to mitigate COVID

Artificial Intelligence can be defined as "the science and engineering making intelligent machines, moreover making intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable."

So, AI refers to the technologies that make it possible that the human knowledge can be reenacted by machines enabling them to think like human beings and also copy and replace their activities. AI enables the machines to perform cognitive functions such as identifying, learning, reasoning and cracking complex problems. AI has human level concerning in terms of many traits which are not only limited to reasoning, speech and vision.

Enabling the machines to learn without programming them is known as machine learning that are comprised of four different methods such as supervised, unsupervised, semi-supervised and reinforcement learning. It enables machines to predict, perform, identify and make decisions using a given dataset. ML is a subset of artificial intelligence wherein intelligent algorithms are used to enable the machines to perform their tasks exceptionally well. Intelligence in machines is developed by using intelligent software that are designed using statistical learning methods based on available datasets.

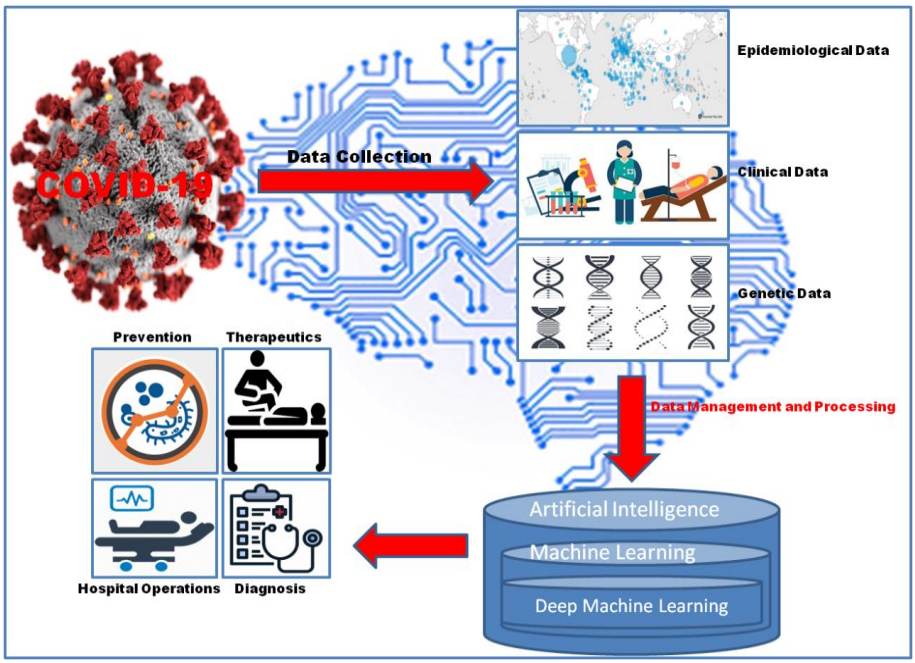

Figure 3 AI , ML & Deep learning tackling COVID-19

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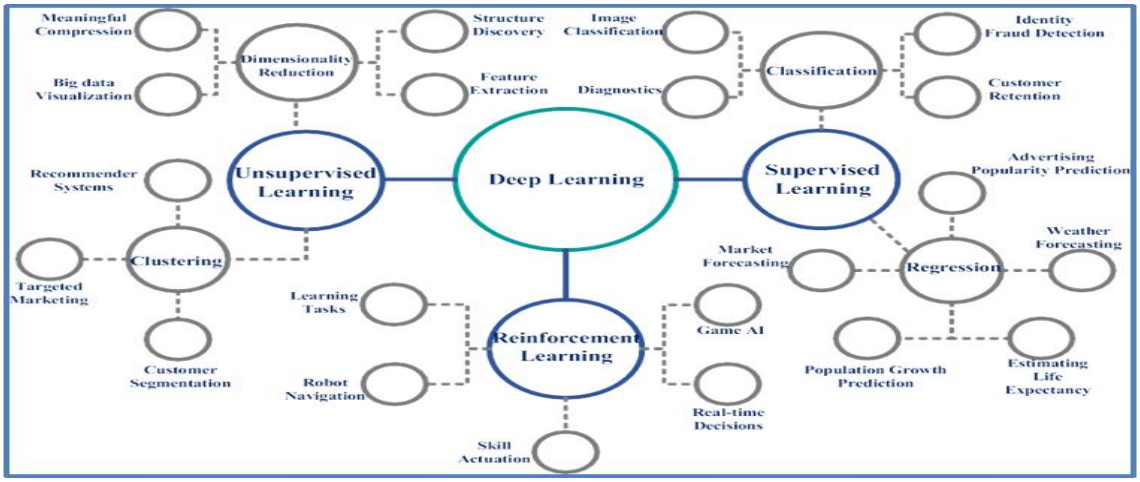

Figure 4 Different techniques and applications of Deep Learning

3. Simulation and Modeling based on AI/ML : Toolkit for Predicting COVID-19 Spread

Researchers had worked a lot to figure out the extent of COVID-19 in a population, such as how much faster a susceptible or exposed person will develop COVID-19 symptoms and the average number of individuals that will contract the disease after contact with an exposed person. Scientists and other researchers have been working to build epidemiology simulators and models based on available datasets gathered from different institutions, federal governments and World Health Organization (WHO). Previous dataset from similar ailments such as SARS, MERS, ZIKA, NIPA etc. is also being used to better understand the spread of COVID-19 in a population. Robust models can be built that include learning parameters that influence variations in COVID-19 spread across countries and communities, combining different intervention approaches and employing what-if scenarios by assimilating previous pandemic trends.

A toolset for modeling; simulating have been designed by Tomal Deb and co-workers [14] and better understand the spread of COVID-19 in a population. Figure 5 explains COVID-19 simulator and machine learning toolkit for prior predicting COVID-19 spread. The toolset is composed of a disease progression simulator and various machine learning models to test the impact of varied interventions. Firstly, the machine learning models help bootstrap the toolset through estimation of disease progression and thereby comparing the outcome with that of the historical data. Afterwards, the simulator is run using learned parameters to analyze what-if scenarios for various interventions.

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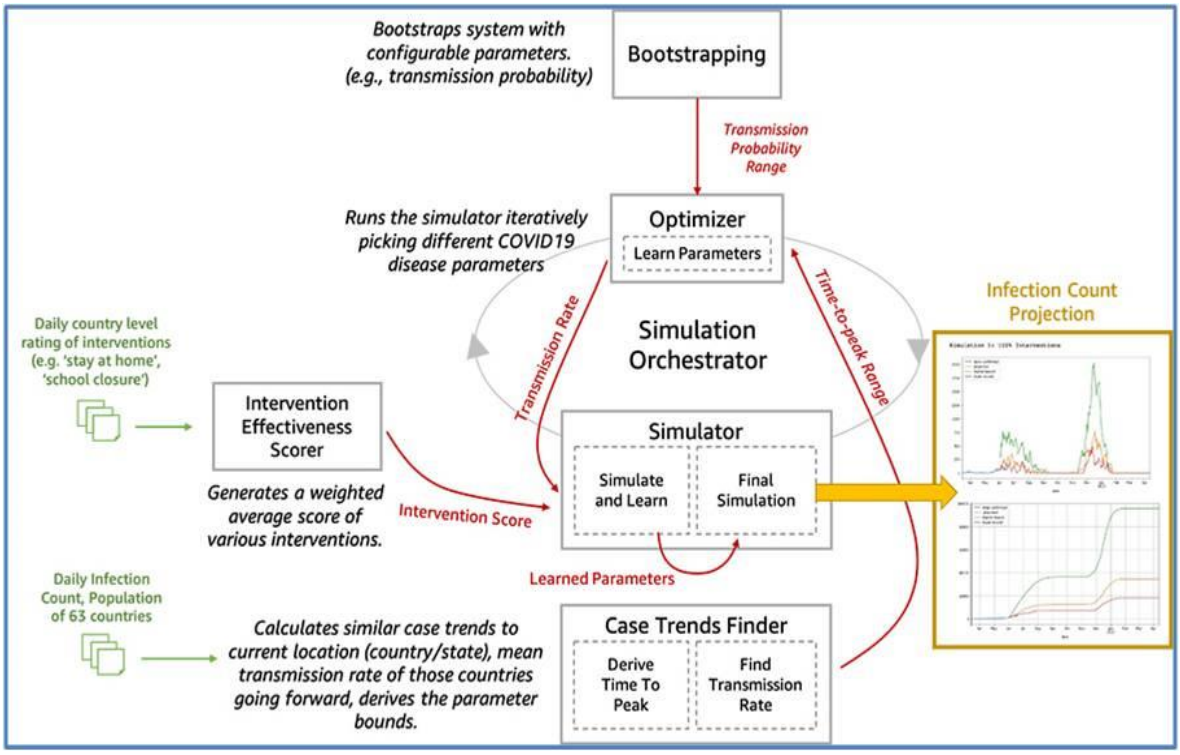

Figure 5 Simulation and Modeling based on AI/ML: Toolkit for Predicting COVID-19 Spread | AWS Machine Learning Blog (amazon.com)

4. Medical Image Processing in diagnosis of COVID-19 using AI and ML

AI based models can be effectively used for quicker and exact diagnosis of COVID-19 cases thereby curbing the spread of the disease and saving thousands of innocents' lives. AI based diagnostic kits are rapider and less expensive compared to regular tests. Doctors are now using AI and ML augmented X-rays and CT scans, fastening their time of diagnosis. COVID-Net is a most relevant example of an artificial intelligence application which has been launched for analyzing COVID-19 symptoms in Chest X-rays utilizing different lung conditions of COVID-19 patients [15]. Figure 6 shows the COVID-Net architecture; tailored for COVID-19 case detection from CXR images. Wang et al. [16] have developed an AI program by using a deep learning method to analyze features of CT images. They achieved 89.5% accuracy by using modified inception migration neural network by employing a retrospective, multicohort, diagnostic method. They have shown that their CNN model can effectively be used for screening of COVID-19 and other pandemics. Xu et al. [17] have used a deep learning technology to design a classification framework that can distinguish COVID-19 and Influenza-A viral pneumonia. They have used ResNet for the extraction of feature from CT scans. The overall accuracy rate achieved by them is 86.7% and so they are considered to be most relevant complementary methods.

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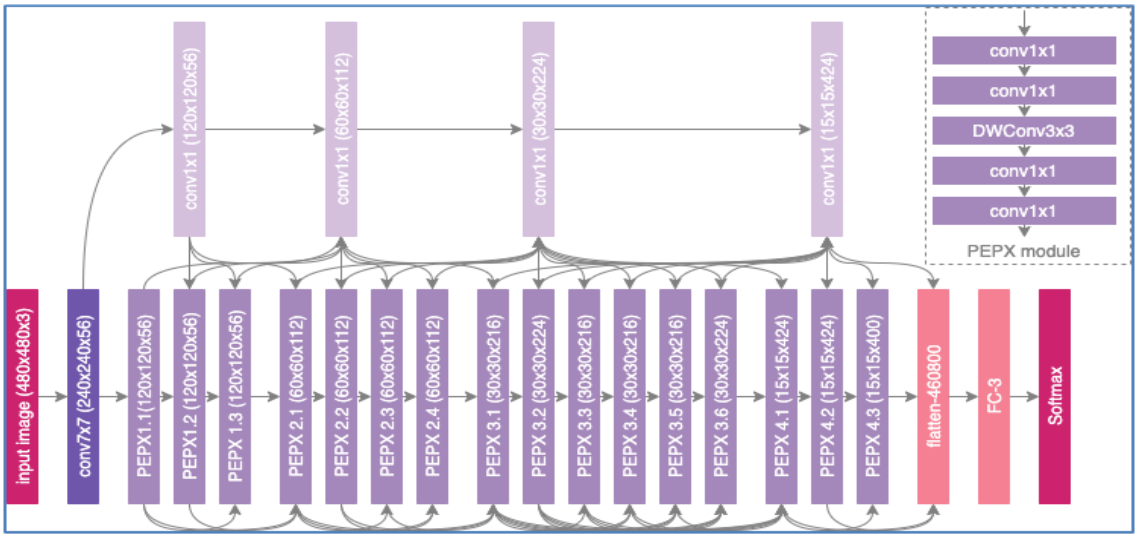

Figure 2 COVID-Net Architecture

Wang et al. [18] have used artificial intelligence based on a new modified algorithm to extract radiological features from CT images of COVID-19 positive patients. They performed transfer learning using GoogleNet Inception specifically its v3 CNN model. The network had already been trained over more than one million colour images from ImageNet. They have divided the whole neural network into two parts; the first part uses a pre-trained inception network that converts image data into one-dimensional feature vectors, and the second part uses a network for prediction of classification. They have achieved exactness of near about 89.5% with a exactness of 0.88 and sensitivity of 0.87. Using external testing dataset and other real dataset; a total exctness of 79.3% with a specificity of 0.83 and sensitivity of 0.67 achieved . This demonstrates that artificial intelligence can be used for timely and accurate COVID-19 diagnosis.

5. Proposed Model

Apostolopoulos et al. [19] have used transfer learning method based on Convolutional Neural Network architectures (CNN) to detect COVID-19. The experiment utilizes a dataset consisting of 1427 X-Ray images out of which 224 images are COVID-19 positive cases, 700 images are common pneumonia positive cases and 504 images are of normal cases. The dataset of X-Ray Image has been collected from Cohen and GitHub, the image dataset has been collected from Radiological Society of North America (RSNA), Radiopaedia, and Italian Society of Medical and Interventional Radiology (SIRM). They have reported an overall accuracy of 97.82% in the detection of COVID-19 cases by using the transfer learning methodology.

Huang et al. [20] have used automated deep learning (DL) method to detect COVID-19 by using serial CT scans to qualitatively evaluate lung burden changes in COVID-19 patients. The dataset comprises of various CT scans of COVID-19 patients who had undergone CT scans between January 1 and February3, 2020. The patients have been divided into mild, moderate, severe and critical types, according to their diagnostic findings. Afterwards they have used commercial deep learning software for

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automatic quantification of whole lung and five lobes based on opacification percentages of lung CT scans. Results prove that quantification of lung opacification in COVID-19 patients measured using their lung CT scans varies among groups; thus, helping in initial assessment and follow-up of COVID-19 pulmonary findings.

Narin et al. [21] have used five pre-trained Convolutional Neural Network (CNN) based models namely ResNet50, ResNet101, etc. for the detection of COVID-19 patients using their chest X-Ray scans. Three different binary classifications have been used along with four classes by using fivefold cross validation. Results show that ResNet50 model outperformed other models with an average accuracy rate of 98.43% if all the three datasets are considered. These findings are believed to help radiologists in early detection of COVID-19 patients. A number of other research has been done in many fields not limited to medical image processing but extended to networking, wireless networks , work done in [23], [24], [25] & [26] are suitable example of AI, ML in other field too.

Saha et al. [22] have proposed EMCNet an automatic and robust detection scheme to detect and identify COVID-19 patients by analyzing their chest X-Ray scans. They have developed a Convolutional Neural Network (CNN) to extract features from X-Ray images of COVID-19 positive cases.

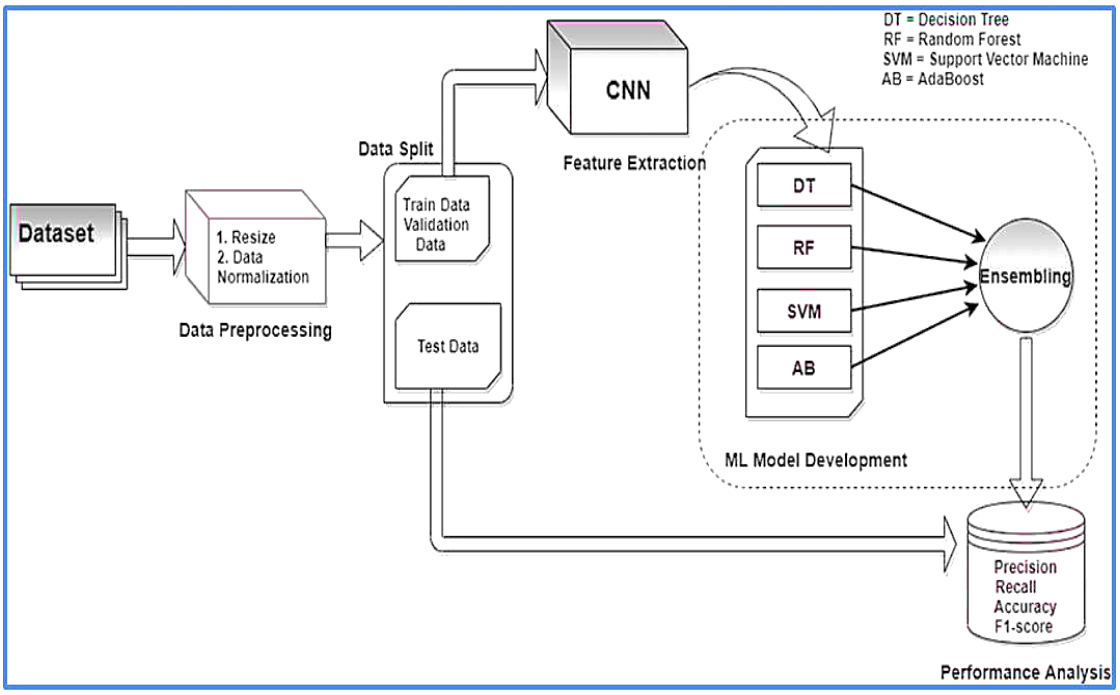

Figure 7 Architecture of EMCNet

They have collected a total of 4600 images from multiple resources such as Github, TCIA, SIRM database, radiopaedia.org, and Mendeley etc. Data normalization is performed to prevent overfitting to expedite generalization.

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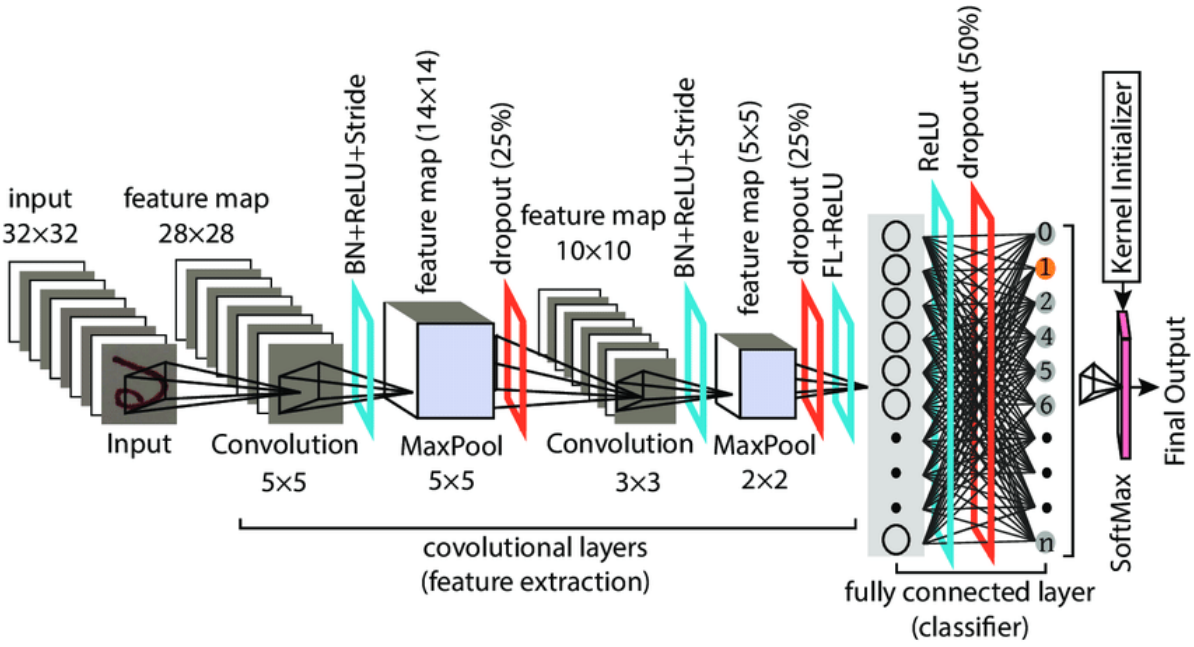

Figure 8 CNN Explaine*6*.

The datasets have been partitioned into testing datasets also to train & validate. The proposed CNN model is trained on training and validation sets. CNN model is used to extract features from the available datasets, afterwards the feature set is passed to machine learning (ML) classifiers (random forest, support vector machine, decision tree, and AdaBoost) to train them and finally the models have been combined to develop an ensemble of classifiers. Figure 9 shows the training process of ML classifiers. The result shows that EMCNet performed better compared to other deep learning-based systems with 98.91% accuracy, 100% precision, 97.82% recall and 98.89% F1-score.

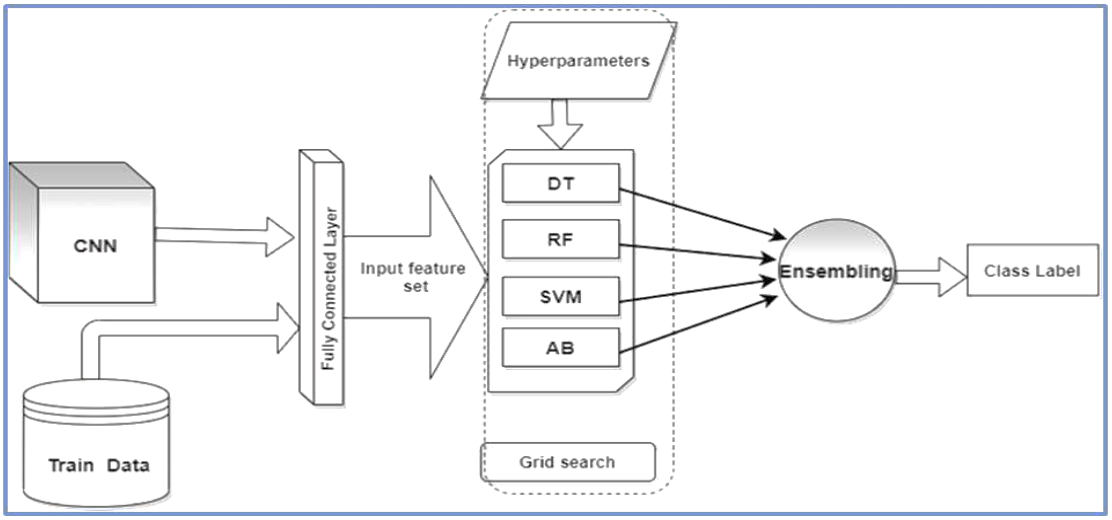

Figure 8 Training process of ML classifiers and ensemble of classifiers.

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6. Conclusion

Artificial intelligence has been considered as one of the effective techniques to tackle COVID-19 pandemic. AI is being employed to achieve effective solutions for COVID-19 pandemic that includes outbreak prediction, tracking COVID-19 spread, diagnosis, vaccine and drug discovery etc. The effective use of AI for COVID-19 medical image processing requires time and effort as well as cooperation of Government, industries and academia. We believe and hope that AI and Machine Learning will be a great help to control the spread of COVID-19.

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