COVID-19 Disease Diagnosis using Smart Deep Learning Techniques

M.Kavitha[1], T. Jayasankar[2], P.Maheswara Venkatesh[3], G.Mani[3], C.Bharatiraja[4*], and Bhekisipho Twala[5]

[1] *Department of Electronics and Communication Engineering, K.Ramakrishnan College of Technology, Tiruchirappalli, Tamilnadu, India.*
[2] *Department of Electronics and Communication Engineering, University College of Engineering, BIT Campus, Anna University, Tiruchirappalli, Tamilnadu, India.*
[3] *Department of Computer Science Engineering, University College of Engineering, Arani, Tamilnadu, India.*
[4] *Department of Electrical and Electronics Engineering, SRM Institute of Science and Technology, SRM Nagar, Kattankulathur, 603203, Kanchipuram, Chennai, TN, India.*
[5] *Faculty of Engineering the Built Environment, Durban University of Technology (DUT), South Africa.*
[*] *Corresponding author. E-mail: bharatiraja@gmail.com*

Received: June 21, 2020; Accepted: Nov. 16, 2020

Corona virus is a big family of virus which cans origin disease from communal cold to additional severe disease such as MERS-CoV and SARS-CoV. A coronavirus is a new straining that has not been earlier recognized in humans. Recently, COVID-19 pandemic infection is spreading from human to human rapidly all over the world. Initially it was identified in China, December 2019. The main objective of this investigation is to identify and diagnosis the corona virus family rapidly. The RestNet-100 Convolutional Neural Network (RCNN) deep learning technique along with Logistic Regression (LR) classifier is used to identify the corona virus pandemic rapidly. The Artificial Intelligence (AI) application against COVID-19 are medical imaging, cough samples, molecular scale from protein to drug development, Lung delination etc.

Keywords: COVID-19, Artificial Intelligence, LR, Deep Learning, Diagnosis, Image acquisition.

http://dx.doi.org/10.6180/jase.202106_24(3).0001

1. Introduction

A corona virus was recognized in 2012 as the origin of lung infection in persons. The novel corona virus is not same as Severe Acute Respiratory Syndrome (SARS)in 2003. However, similar the SARS virus, the novel coronavirus is most related to those originate in bats. The novel corona virus spread is happened for two clustered region in 2012. The first cluster disease spread in a hospital near Amman, Jordan, in April 2012. A second group disease spread happened in October 2012, in Saudi Arabia. In April 2012, they found 68 confirmed cases and 38 are died out of 68 in 8 different countries for Middle East Respiratory Syndrome Corona Virus (MERS-CoV).

The virus spread is originated in bats which are identified in September 2012. The spreading of MERS-CoV is shown in Fig. 1. The virus is spreading from bats to camel and then its spreading to humans. Another way, the virus is spreading from person to person directly. As on 4th may 2014, 480 persons are infected with MERS-CoV and 133 persons are died with a mortality rate of 28 %.

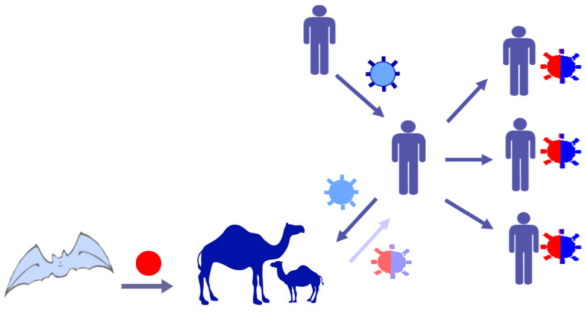

Fig. 1. Spread of MERS-CoV.

Now the family of MERS-CoV and SARS-CoV-2 virus is

called as Corona Virus Disease-19 (COVID-19). COVID-19 is the name of this new disease announced on 11 February 2020, following guidelines previously developed with World Organization for Animal Health (WOAH) and Food and Agriculture Organization (FAO). The major symptoms for Corona virus are Fever, Dry cough, Breathing difficulty, headache and body pain, runny nose, nasal blocking, throat pain [1]. The corona virus can transferred through droplets with different particle size. Respiratory droplet particle sizes are $>5-10\mu m$ and droplet nuclei particle size is $<5\mu m$. The respiratory droplets are spreading easily through direct contact compare to droplet nuclei. The droplet transmission occurs within 1m direct contact with COVID-19 infected people [2]. Up to May 22, 2020, 4,995,996 Confirmed cases of corona virus in over 216 countries and territories and 3,27,821 Confirmed deaths [3]. The shape of COVID-19 virus is shown in Fig. 2.

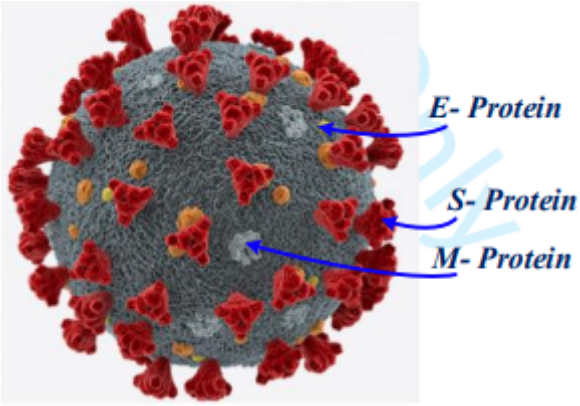

Fig. 2. The shape of COVID-19 virus.

2. Literature review

The multi-objective differential evaluation convolution neural network utilizes CT scan images to categorize the COVID-19 diseased patient as positive or negative [4]. The AI algorithms to incorporate with CT scan images using clinical symptoms, past experience with laboratory testing to diagnose COVID-19 result rapidly [5]. The prevention control, diagnosis and treatment for COVID-19 virus a rapid advice guidelines are followed. They are guideline methodology, virus screening and population avoidance, epidemiological characteristics, diagnose, medicine and control, and virus treatment of the 2019-nCoV [6]. The deep convolutional neural network is used to classify the medical image and diagnosis the disease as pneumonia or COVID19. The linear support vector machine, VGG16 and InceptionV3 for convolutional neural networks models are used to experiment the results [7]. Supervised machine learning algorithm such as SVM, Naive Bayes algorithm and Random forest algorithm are mostly utilized to predict the disease easily. Among 17 studies the random forest are applied to provide highest accuracy with 53 % in 9 of them. Among these three SVM is the topmost classification for disease prediction [8]. To protect healthcare workers direct contact from COVID-19 patients automatic investigative systems based on AI and machine learning devices are developed to detect the corona virus accurately and rapidly [9].

Artificial Intelligence with radiological imaging was help to identify the corona virus accurately. The corona virus finding using chest X-Ray images to detect the virus automatically. The projected model provides the result of binary classification and multi-class classification. The final result shows that binary class produces 98.085 accuracy level and 87.02 % for multi class cases [10]. Radiological imaging preferred chest X-Ray imageries to diagnose corona virus. AI based SqueezeNet with Bayesian optimization to diagnosis the corona virus rapidly and accurately [11]. The COVID-19 results are validated with the help of MLDSP using decision tree approach for correlation coefficient analysis. The COVID-19 viruses are classified as Sarbecovirus, within Betacoronavirus. The result shows that 100 % classification accuracy over 5000 virus-related genomes within a few records [12].

FIGO and associated companions gave material to healthcare experts to monitor corona virus infection during pregnancy [13]. The statistical and ML tools are useful for feature extractions from CT images in combination with composite hybrid feature extraction are applied to diagnose the COVID-19 virus rapidly [14]. To identify the misdiagnosis disease of corona virus and assess the routine of chest CT images in identification and supervision [15]. The combination of CT image, genome sequence was primarily used to monitor and recognize SARS-CoV-2 [16]. DeTraC DCNN is utilized to classify the corona virus chest X-Ray images accurately. The 95.12 % accuracy is achieved using DeTraC in the finding of corona virus X-Ray images [17]. To develop deep learning model to extract CT image features to provide clinical diagnosis using pathogenic test thus save the time for virus resistor [18]. The AI4COVID19 app is used to record cough voice sample for 2 seconds. The challenging issue is to identify COVID-19 cough voice sample with Non Covid-19 cough voice samples. Finally the voice samples are matched with corona virus patients and Non COVID-19 patients the result shows provides 90 % accuracy [19].

The deep learning techniques are utilized to monitor distinguishes between corona virus pneumonia using Com-

puted Tomography (CT) images [20]. COVID-19, pneumonia, and X-ray image data classes are applied to fuzzy coloring technique for preprocessing step. The preprocessing datasets are trained with DL models such as MobileNetV2, SqueezeNet. Finally the support vector machine is used to classify and extract the data feature result of COVID-19 virus detection up to 99.27 % accurately [21]. To distinguish between corona virus and Non corona virus group the 10 convolution neural network techniques are utilized. Among all these networks ResNet-101 and Xception both was achieved better performance with an AUC of 0.994. But the radiologist performance is moderate with an Area Under the Curve (AUC) of 0.873 [22]. Agent centered classic to assess the corona virus spread risk from human to human. The agents make decision based upon programming rule which reduce the spread threats of corona virus within the services [23]. The person health records are assessed by health protection algorithm which reduces encryption time by 0.364 seconds and decryption time by 0.188 seconds [24].

3. Methodology

The following diagnosis methods are generally utilized for COVID-19. They are CBC, Chest X-Ray, Polymerase Chain Reaction (PCR), Chest CT Scan, IgM/IgG combo test. The chest X-Ray models are cheaper and easier with 60 % sensitivity. The PCR model result produces 30 %-70 % sensitivity. Chest CT scan have low specificity and 95 % sensitivity. Among these CT scan result produces better performance for COVID-19 diagnosis. The COVID-19 symptoms can be classified into three categories. They are mild case, severe case and critical case. The following Table 1 shows corona virus compared to other common circumstances.

Based upon the above conditions the COVID-19 virus diagnose rapidly with the help of deep learning convolutional model with logistic regression classifier. The block diagram for corona virus diagnosis model is shown in Fig. 3. The CT scan image input is given to Restnet101 deep convolutional neural network model. Then the result is passed to logistic regression classifier. The logistic regression classifier classifies the result as COVID-19, Normal and Pneumonia.

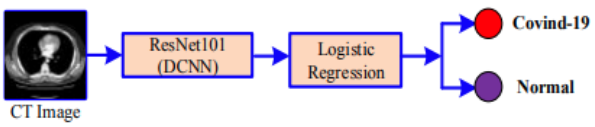

Fig. 3. Block diagram of COVID-19 Diagnosis Model.

Algorithm for ResNet101 (DCNN)

1. Initialize the attention weights fill it with 1
2. Construct 101-layer ResNets by using more 3-layer blocks
3. Modify the forward function in 2D convolution module
4. Stop the process

Algorithm for Logistic Regression Classifier

1. Preprocess the ResNet101 input data
2. Fitting Logistic Regression to the Training set
3. Predicting the test result
4. Test accuracy of the result
5. Visualizing the test set result as normal or COVID-19.

The CT images of person with corona virus, Non corona virus and Pneumonia are collected as input for COVID-19 diagnosis flow diagram as shown in Fig. 4 and CoVID-19 diagnosis process is shown in Fig. 5. The input image is cropped and resize into 60 x 60 pixels for further process. The RestNet-101 has 101 layers deep with 33 residual blocks. Initially its start with two convolutional layers followed by depth wise separate convolutional layer, four convolutional layer and fully connected layer. Here every layer output is given to input of another layer. The result of RestNet-101 is applied to logistic regression classifier. The logistic regression classifier was classifies the result as normal, pneumonia and COVID-19 accurately.

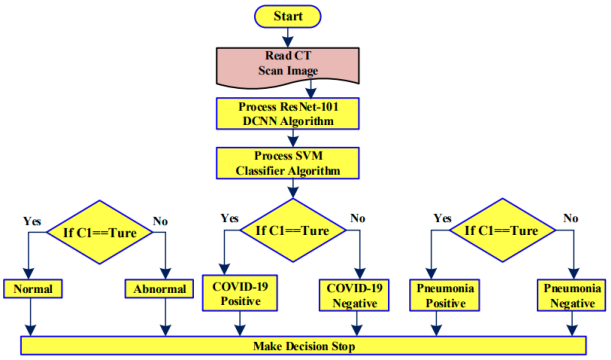

Fig. 4. COVID-19 Diagnosis Process Flow Diagram.

The design of logistic regression method classification process is shown in Fig. 6. In the diagram red circle indicates COVID-19 positive classes; green circle indicates COVID-19 negative class. The logistic regression straight

Table 1. Corona virus compared to other common circumstances.

S.No	Symptom	COVID-19	Communal Cold	Flu	Allergies
1	**Fever**	Communal	Rare	Communal	Occasionally
2	**Dry Cough**	Communal	Mild	Communal	Occasionally
3	**Shortness of Breath**	Communal	No	No	Communal
4	**Headaches**	Occasionally	Rare	Communal	Occasionally
5	**Heaches and Pains**	Occasionally	Communal	Communal	No
6	**Sore Throat**	Occasionally	Communal	Communal	No
7	**Fatigue**	Occasionally	Occasionally	Communal	Occasionally
8	**Diarrhea**	Rare	No	Sometimes	No
9	**Runny Nose**	Rare	Communal	Sometimes	Communal
10	**Sneezing**	No	Communal	No	Communal

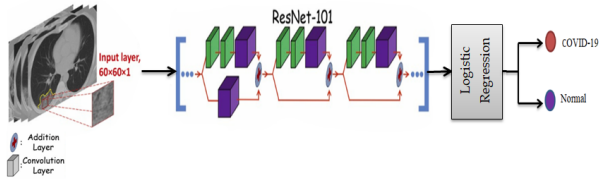

Fig. 5. ResNet-101 Deep Convolutional Neural Network with SVM classifier.

line equation can be written as $y = b_0 + b_{1\times1} + b_{2\times2} + \cdots + b_{n\times n}$. In logistic regression y can be between 0 and 1 so for this lets divides the above equation by (1-y), y/(1-y); 0 for y=0 and infinity for y=1. But we need range between -[infinity] to +[infinity], then take logarithm of the equation it will become: $\log[y/1-y] = b_0 + b_{1\times1} + b_{2\times2} + \cdots + b_{n\times n}$.

3.1. Dataset

Here 101 CT images are acquired from 85 COVID-19 and 90 CT images are acquired from 85 pneumonia confirmed patients, and 1354 CT images are diagnosed as Non-COVID-19 from 1094 patients. Further, the COVID-19 and pneumonia datasets are available in the Github repository [25]. The screening performance is evaluated by the sensitivity, specificity and accuracy. The accuracy was used to measure the COVID-19 positive and negative results. The sensitivity and specificity was used to measure proportion of correctly identified positive and negative results.

The following formula's which is used to measure the accuracy, sensitivity and specificity [26–28].

$$\text{Accuracy} = \frac{\text{True Positive}(TP) + \text{True Negative}(TN)}{\text{Total number of tested images}} \tag{1}$$

Where, true positive and true negative is the numbers were

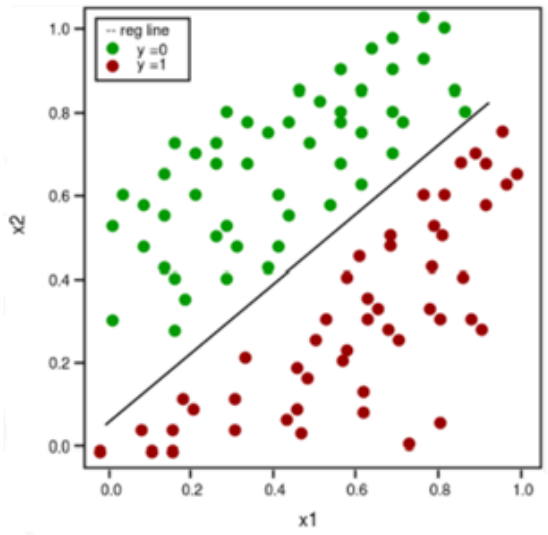

Fig. 6. LR binary classification process [21].

truly identified Corona virus and Non-Corona virus patients.

$$\text{Sensitivity} = \frac{TP}{TP + \text{False Negative}(FN)} \tag{2}$$

Where, FN is a false negative classification which incorrectly classified as Non-COVID 19 for CT-Scan.

$$\text{Specificity} = \frac{TN}{TN + \text{False Positive}(FP)} \tag{3}$$

Where, FP is a false positive classification which misclassified as COVID 19 for CT-Scan.

3.2. Results and Discussion

The COVID-19 result is diagnosed from threshold value 0 to 1. The value 0 indicates normal and 1 indicates COVID-19

Table 2. Corona virus compared to other common circumstances.

Threshold	True Positive (COVID-19)	False Positive (Non COVID-19)	True Negative (COVID-19)	False Negative (Non COVID-19)	Total number of Tested images	Sensitivity %	Specificity %	Accuracy %
0.5	86	25	1392	42	1545	67.18	98.23	95.66
0.6	88	22	1400	35		75.15	98.45	96.31
0.7	90	17	1413	25		78.26	98.81	97.28
0.8	92	13	1422	18		83.63	99.09	97.99
0.9	96	10	1424	15		86.48	99.30	98.38
1	99	5	1433	8		92.52	99.44	99.15

or Pneumonia. The RestNet-101 DCNN with LR classifier result is shown in Table 2 and corresponding graph is shown in Fig. 7.

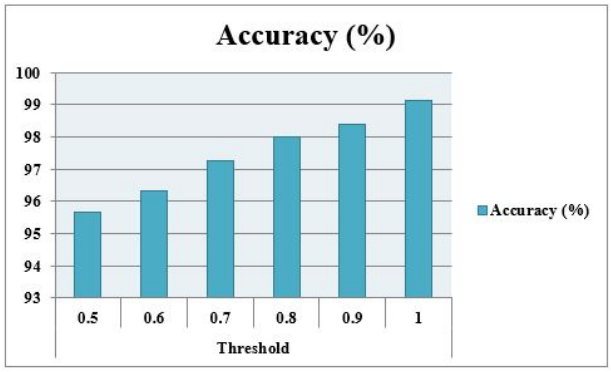

Fig. 7. CT- Scan image COVID-19 detection accuracy (%) with respect to threshold.

4. Conclusion

The RestNet-100 deep convolutional neural network along with LR classifier classifies the result classes as COVID-19, and normal. In the laboratory rapid COVID-19 tests are prepared with DCNN using LR classifier. It produces 99.15 % accuracy with COVID-19 positive patient. The COVID-19 virus diagnosis with the threshold value 0 or 1. The value 1 indicates the person is affected with corona virus or pneumonia and the result zero indicates the person not affected with corona virus. The threshold value is utilized for CT images classification to identify the patient condition from initial stage to severe stage. Threshold value 0.5 initial stage of the patient and 1 indicates severe condition of the patient. The proposed methods were utilized for some weighting parameters to reduce both false positive and false negative image classification results for diagnosis COVID-19 rapidly and accurately.

References

[1] Cheryl A. Glass, Jill C. Cash, and Jenny Mullen. Coronavirus Disease (COVID-19). In *Family Practice Guidelines*. 2020.

[2] World Health Organization (WHO). Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations. *Geneva: World Health Organization;*, Available, 2020.

[3] Cheryl A. Glass, Jill C. Cash, and Jenny Mullen. Coronavirus Disease (COVID-19). In *Family Practice Guidelines*. 2020.

[4] Dilbag Singh, Vijay Kumar, Vaishali, and Manjit Kaur. Classification of COVID-19 patients from chest CT images using multi-objective differential evolution–based convolutional neural networks. *European Journal of Clinical Microbiology and Infectious Diseases*, 39(7):1379–1389, 2020.

[5] X Mei, HC Lee, K Diao, M Huang, B Lin, C Liu, Z Xie Nature Medicine, and Undefined 2020. Artificial intelligence–enabled rapid diagnosis of patients with COVID-19. *Nature Medicine*, 2020.

[6] Ying Hui Jin, Lin Cai, Zhen Shun Cheng, Hong Cheng, Tong Deng, Yi Pin Fan, Cheng Fang, Di Huang, Lu Qi Huang, Qiao Huang, Yong Han, Bo Hu, Fen Hu, Bing Hui Li, Yi Rong Li, Ke Liang, Li Kai Lin, Li Sha Luo, Jing Ma, Lin Lu Ma, Zhi Yong Peng, Yun Bao Pan, Zhen Yu Pan, Xue Qun Ren, Hui Min Sun, Ying Wang, Yun Yun Wang, Hong Weng, Chao Jie Wei, Dong Fang Wu, Jian Xia, Yong Xiong, Hai Bo Xu, Xiao Mei Yao, Yu Feng Yuan, Tai Sheng Ye, Xiao Chun Zhang, Ying Wen Zhang, Yin Gao Zhang, Hua Min Zhang, Yan Zhao, Ming Juan Zhao, Hao Zi, Xian Tao Zeng, Yong Yan Wang, and Xing Huan Wang. A rapid advice guideline for the diagnosis and treatment of 2019 novel coronavirus (2019-nCoV) infected pneumo-

nia (standard version), feb 2020.

[7] Samir S. Yadav and Shivajirao M. Jadhav. Deep convolutional neural network based medical image classification for disease diagnosis. *Journal of Big Data*, 6(1), dec 2019.

[8] Shahadat Uddin, Arif Khan, Md Ekramul Hossain, and Mohammad Ali Moni. Comparing different supervised machine learning algorithms for disease prediction. *BMC Medical Informatics and Decision Making*, 19(1), dec 2019.

[9] Ahmad Alimadadi, Sachin Aryal, Ishan Manandhar, Patricia B. Munroe, Bina Joe, and Xi Cheng. Artificial intelligence and machine learning to fight covid-19, apr 2020.

[10] Tulin Ozturk, Muhammed Talo, Eylul Azra Yildirim, Ulas Baran Baloglu, Ozal Yildirim, and U. Rajendra Acharya. Automated detection of COVID-19 cases using deep neural networks with X-ray images. *Computers in Biology and Medicine*, 121, 2020.

[11] F Ucar, D Korkmaz Medical Hypotheses, and Undefined 2020. COVIDiagnosis-Net: Deep Bayes-SqueezeNet based Diagnostic of the Coronavirus Disease 2019 (COVID-19) from X-Ray Images. *Medical Hypotheses*, 2020.

[12] Gurjit S. Randhawa, Maximillian P.M. Soltysiak, Hadi El Roz, Camila P.E. de Souza, Kathleen A. Hill, and Lila Kari. Machine learning using intrinsic genomic signatures for rapid classification of novel pathogens: COVID-19 case study. *PLoS ONE*, 15(4), apr 2020.

[13] Liona C. Poon, Huixia Yang, Anil Kapur, Nir Melamed, Blami Dao, Hema Divakar, H. David McIntyre, Anne B. Kihara, Diogo Ayres-de Campos, Enrico M. Ferrazzi, Gian Carlo Di Renzo, and Moshe Hod. Global interim guidance on coronavirus disease 2019 (COVID-19) during pregnancy and puerperium from FIGO and allied partners: Information for healthcare professionals. *International Journal of Gynecology and Obstetrics*, 149(3):273–286, jun 2020.

[14] Ahmed Abdullah Farid, Gamal Ibrahim Selim, and Hatem Awad A. Khater. A Novel Approach of CT Images Feature Analysis and Prediction to Screen for Corona Virus Disease (COVID-19). *International Journal of Scientific & Engineering Research*, 11(03):1141–1149, 2020.

[15] Yan Li and Liming Xia. Coronavirus disease 2019 (COVID-19): Role of chest CT in diagnosis and management. *American Journal of Roentgenology*, 214(6):1280–1286, jun 2020.

[16] Buddhisha Udugama, Pranav Kadhiresan, Hannah N. Kozlowski, Ayden Malekjahani, Matthew Osborne, Vanessa Y.C. Li, Hongmin Chen, Samira Mubareka, Jonathan B. Gubbay, and Warren C.W. Chan. Diagnosing COVID-19: The Disease and Tools for Detection, apr 2020.

[17] Asmaa Abbas, Mohammed M. Abdelsamea, and Mohamed Medhat Gaber. Classification of COVID-19 in chest X-ray images using DeTraC deep convolutional neural network. *Applied Intelligence*, 2020.

[18] Shuai Wang, Bo Kang, Jinlu Ma, Xianjun Zeng, Mingming Xiao, Jia Guo, Mengjiao Cai, Jingyi Yang, Yaodong Li, Xiangfei Meng, and Bo Xu. A deep learning algorithm using CT images to screen for Corona Virus Disease (COVID-19), 2020.

[19] Ali Imran, Iryna Posokhova, Haneya N. Qureshi, Usama Masood, Muhammad Sajid Riaz, Kamran Ali, Charles N. John, MD Iftikhar Hussain, and Muhammad Nabeel. AI4COVID-19: AI enabled preliminary diagnosis for COVID-19 from cough samples via an app. *Informatics in Medicine Unlocked*, 20, jan 2020.

[20] Xiaowei Xu, Xiangao Jiang, Chunlian Ma, Peng Du, Xukun Li, Shuangzhi Lv, Liang Yu, Yanfei Chen, Junwei Su, Guanjing Lang, Yongtao Li, Hong Zhao, Kaijin Xu, Lingxiang Ruan, and Wei Wu. Deep learning system to screen coronavirus disease 2019 pneumonia, 2020.

[21] Mesut Toğaçar, Burhan Ergen, and Zafer Cömert. COVID-19 detection using deep learning models to exploit Social Mimic Optimization and structured chest X-ray images using fuzzy color and stacking approaches. *Computers in Biology and Medicine*, 121, 2020.

[22] Ali Abbasian Ardakani, Alireza Rajabzadeh Kanafi, U. Rajendra Acharya, Nazanin Khadem, and Afshin Mohammadi. Application of deep learning technique to manage COVID-19 in routine clinical practice using CT images: Results of 10 convolutional neural networks. *Computers in Biology and Medicine*, 121, 2020.

[23] Erik Cuevas. An agent-based model to evaluate the COVID-19 transmission risks in facilities. *Computers in Biology and Medicine*, 121, 2020.

[24] Azath Mubarakali, M. Ashwin, Dinesh Mavaluru, and A. Dinesh Kumar. Design an attribute based health record protection algorithm for healthcare services in cloud environment. *Multimedia Tools and Applications*, 79(5-6):3943–3956, feb 2020.

[25] Joseph Paul Cohen, Paul Morrison, Lan Dao, Karsten Roth, Tim Q Duong, and Marzyeh Ghassemi. COVID-19 Image Data Collection: Prospective predictions are the future, jun 2020.

[26] Halgurd S Maghdid, Aras T Asaad, Kayhan Zrar Ghafoor, Ali Safaa Sadiq, and Muhammad Khurram Khan. Diagnosing COVID-19 Pneumonia from X-Ray

and CT Images using Deep Learning and Transfer Learning Algorithms, 2020.

[27] Srinath Balasubramanian, Bharatiraja Chokkalingam, Ramesh Krishnamoorthy, and Yusuff Adedayo. Power optimization through FuzzyMinProduct algorithm for voltage assignment in SOC design. *Journal of Applied Science and Engineering*, 23(4):655–659, 2020.

[28] M S Kamalesh, Bharatiraja Chokkalingam, Jeevanantham Arumugam, Sengottaiyan Gomathy, Shanmugavadivel Subramani, and Mansoor Ahmad Shah. An Intelligent Real Time Pothole Detection and Warning System for Automobile Applications Based on IoT Technology. *Journal of Applied Science and Engineering*, 24(1):77–81, 2021.