IoT Based Humanoid Software for Identification and Diagnosis of Covid-19 Suspects

[1] **Swapnili Karmore**, [2] **Rushikesh Bodhe**, [3] **Fadi Al-Turjman**, [4] **R Lakshmana Kumar**, [5] **Sofia Pillai**

[1] Associate Professor, [2] Student, [3] Professor, [4] Assistant Professor, [5] In-charge

[1]Department of Computer Science, S. B Jain Institute of Technology, Management and Research, Nagpur, India [2] Department of Information Technology, S. B Jain Institute of Technology, Management and Research, Nagpur, India, [3] Research Center for AI and IoT, Near East University, Nicosia, Mersin 10, Turkey, [4] Department of Computer Science, Hindusthan College of Engineering and Technology, Coimbatore, India, [5] Centre Of Excellence in AIML, Galgotias University, Greater Noida, India

***Abstract*—COVID-19 pandemic has a catastrophic consequence globally since its first case was detected in December 2019, with an aggressive spread. Currently an exponential growth is expected. If not diagnosed at the proper time, COVID-19 may lead to death of the infected individuals. Thus, continuous screening, early diagnosis and prompt actions are crucial to control the spread and reduce the mortality. In this paper we focus on developing a Medical Diagnosis Humanoid (MDH) which is a cost effective, safety critical mobile robotic system that provides a complete diagnostic test to check whether an individual is infected by Covid-19 or not. This paper highlights the development of a system based on Artificial Intelligence for Medical Science, where humanoids can navigate through desired destinations, diagnose an individual for Covid-19 through various parameters and make a survey of a locality for the same. The humanoid uses the concept of real time data sensing and processing through machine learning produced by various sensors used in the context.**

***Index Terms*—Covid-19, Internet of Things, Machine Learning, Medical Diagnosis Humanoid**

I. Introduction

THE risk of Covid-19 is massive for many, especially for the developing nations, where the majority faces poverty and depends on non-sustainable forms of energy. The World Health Organization evaluates that up-till now most of the cases of infection are confirmed and many people died mostly from the age group of above sixty years and people with pre-existing health conditions [7]. The prominent symptoms include Dyspepsia, respiratory symptoms, cough and fever. In complicated cases, the infection may lead to multi-organ failure, pneumonia, septic shock, intense respiratory syndromes, and even death. Death between the ages of 0-9 years also occurs [8]. Cases with respiratory syndromes with COVID-19 have been demonstrated to be faster compared to healthy people. Even in many developed nations like the USA, the health system collapsed due to the expanding health care units intensively [9]. The present public health system failure lies in the low sensitivity of RT-PCR which signifies that a considerable number of COVID-19 patients won't be diagnosed rapidly and may not get suitable treatment on time due to rapid outbreak and low availability of medical facilities. Moreover, due to the extremely infectious nature of the virus, it endangers a bigger part of the population. Contamination because of the

Dr. Swapnili Karmore is an Associate Professor and Dean R&D at S. B. Jain Institute of Technology, Management and Research, Nagpur, India. Rushikesh Bodhe is a student at S.B. Jain Institute of Technology, Management and Research, Nagpur, India. Fadi Al-Turjman is Full-Professor at Research Center for AI and IoT, Near East University, Nicosia, Mersin 10, Turkey. R Lakshmana Kumar is an Assistant Professor at Hindusthan College of Engineering and Technology, Coimbatore, India. Sofia Pillai is an In-charge at Centre of Excellence AIML, Galgotias University, Greater Noida, India.
(Correspondence e-mail : research.laksha@gmail.com)

This article has been accepted for publication in a future issue of this journal, but has not been fully edited. Content may change prior to final publication. Citation information: DOI 10.1109/JSEN.2020.3030905, IEEE Sensors Journal

infected case causes serious problems. Rather than getting rapidly diagnosed, patients have to wait now a days for being tested, which may further create harder times for the patient to be cured [5].

II. LITERATURE SURVEY

A. Localization and Autonomous Navigation

In some papers, the authors put forward a method of route planning and inspection of ground robots in these conditions. They use unordered point clouds, as a major contribution instead of building any unequivocal depiction surrounding them. These 3-D focuses are utilized as space tests by an Optimal-RRT planner (RRT*) to process, protect in effective ways. The path development objective function along with the natural exploratory behavior of the RRT* planner makes it suitable for the tasks [1][11]. Researchers in other papers focus on the cutting-edge MOP calculations including quick Rapid Random Tree (RRT) and those actualized in the ROS course stack. The results reveal that these algorithms have been intended for a square shape impression robot and consequently have obstructions for MOOR with a rectangular impression shape [2].

Researchers have designed a model of a localized IoT primarily based biometric face detection framework for cities that are under lockdown situation throughout COVID-19 outbreaks. To impose restrictions on public movements, the researchers have used face detection with three-layered edge computing architecture. They need to build a deep learning framework of multi-task cascading to acknowledge the face [20].

B. Identification and Diagnosis System

Researchers in some paper assesses a quick prototyping solution for data blending dependent on five health sensors and two ease universal processing parts: Arduino and Raspberry-Pi. The investigation depicts the end goal of reproducibility, planned to assess the degree to which versatile advances are equipped for incorporating wearable sensors by looking at Raspberry-Pi 3 and Personal Computer. The coordination is actualized utilizing a movement motor to transmit information from sensors to a presentation unit utilizing web administrations and a basic correspondence convention with two methods of information recovery [3]. The researcher focuses on the natural development of pneumonia and its detection using the x-ray imaging technique. The paper presents the studies undertaken on enhancing the degree of research. The consequences in the robotization of x-ray images depend on different boundaries to distinguish the infection at an early stage [8]. Researchers proposed a data-pushed dynamic clustering framework for moderating the unfavorable monetary effect of COVID-19 flare-up. Through a clever fusion of healthcare and simulated mobility data, they presented lockdown as a clustering problem and layout as a dynamic clustering set of rules for localized lockdown with the aid of using deliberating the pandemic, monetary, and mobility [18]. The researchers examined the overall performance of a custom CNN version use of cyclical stochastic gradient descent (SGD) optimizer with automated gaining knowledge of price finder and acquire accuracy of 30% in classifying wholesome and inflamed mobile pictures with an excessive diploma of precision and sensitivity [21]. The authors have discussed the Privacy-Aware Energy-Efficient Framework using the Internet of Medical Things for COVID-19 [24]. The Internet affords possibilities to behavior surveys greater correctly and successfully than conventional means. These article evaluations preceding research uses the Internet for survey research. It discusses the methodological problems and issues related to this new approach [22][23].

C. Report Generation

Another referred Paper explains the working of the ESP8266 Wi-Fi module, able to do either facilitating an application or discarding all Wi-Fi regulating capacities from the other application processor [4]. This module has the capacity which permits it to be integrated with the sensors and other application explicit gadgets through its GPIOs with a slight improvement and almost no stacking during run-time [4]. In the world of cybercrime, data security, data hacking, and tampering are some of the major issues.

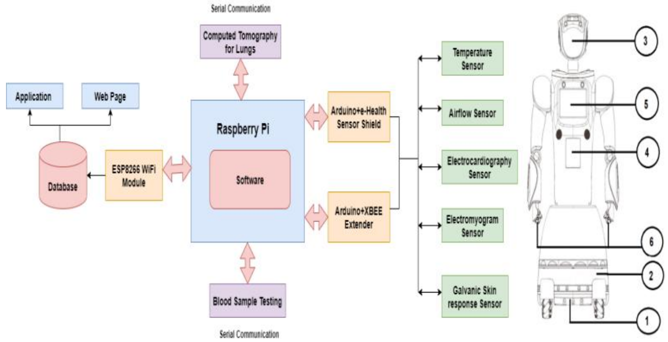
In most cases, the IoT devices are not used with security layers which make the model highly vulnerable to security issues. Hence, it is important to incorporate security layers at the development stage of the IoT model [5]. In this context, the researchers have discussed solutions to cybercrime. Device authentication, secured internet connection, secured cloud storage, regular software updates, and encrypted security layers are some of the discussed methodologies that help the data with security. Securing the cloud platforms for the exchange of data with IoT devices is essential. The researcher details the improvement of a Wi-Fi network. 5G and the way 5G cellular communication Technology can now not be described with the aid of using an unmarried commercial enterprise version or ordinary technical characteristics [17].

III. DESIGN METHODOLOGY

The whole framework is divided into three major working systems: Localization and autonomous navigation, Identification, and diagnosis system, and Report generation. The humanoid is mainly categorized into six different working modules. These are (1) IR Sensors, (2) Autonomous Navigation, (3) Camera Module, (4) E-Health Sensor Kit and other diagnostic sensors, (5) CT for Chest, and (6) Blood Sample collection. Using Autonomous navigation and path

This article has been accepted for publication in a future issue of this journal, but has not been fully edited. Content may change prior to final publication. Citation information: DOI 10.1109/JSEN.2020.3030905, IEEE Sensors Journal

planning algorithm from the first, second, and third modules, the humanoid autonomously reaches the targeted destination. Using data and video processing techniques, the IR and camera sensors help the humanoid to tackle obstacles and navigate the correct path. As soon as the humanoid reaches the destination, it moves towards the stage of sanitization, where using 90% alcoholic solution in liquid-gas form the humanoid protects and sanitizes itself.



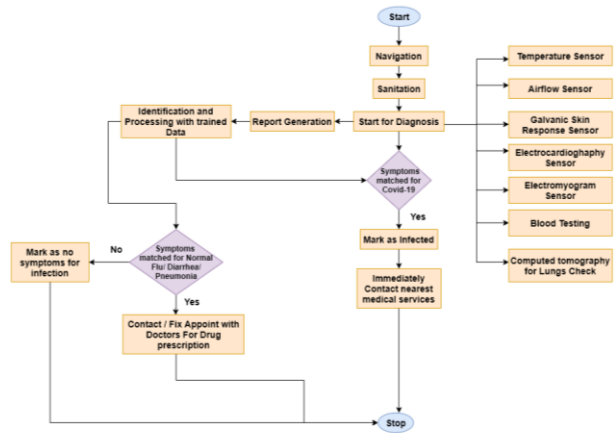
[Fig.1: Block Architecture Diagram on IoT based software for Humanoid for Identification and diagnosis of Covid-19 Suspect]

Next, in the diagnosis stage, the humanoid uses the fourth, fifth and sixth module, which carries out several diagnostic tests for COVID-19 using different methodologies where the system collects different sensory data, X-ray images, and blood samples from the patient. As soon as data collection gets completed, the system processes the data generated using machine learning algorithms where the patients are categorized into two categories as Positive class and Normal class, and a brief report is generated mentioning all the data collected from the system. If the patient is found positive, medical authorities are informed to carry out further procedures. The system also prescribes medical help if diagnosed with any other health issues like pneumonia or viral fever. Further, we have discussed detailed procedure explanations for the system working.

A. Algorithm design

The fixed path planning refers to the surroundings which consist of only fixed objects or obstacles other than a navigating humanoid. Depending upon the origin of the track various types of obstacle avoidance algorithms are used [2]. Researchers have discovered how tons of facts approximately the traits of stop-to-stop community paths can be inferred from depending completely on passive packet-degree lines of present site visitors accumulated from an unmarried faucet factor within the network [21].

Phase 1 - Expansion of the Tree: Initialize the tree by choosing the initial position of the humanoid as the root element. Pre-define the sampling length and the total number of points to be sampled. Now a random point is chosen from the configuration space and checked if the randomly sampled point coincides with any obstacles. Next, the algorithm filters the whole tree to locate the nearest neighbor to the inspected arbitrary point. If the sampled point falls within the sampling radius of the nearest neighbor, it is added into the tree. If the limitation isn't fulfilled, then a point at the separation equivalent to test length toward the new state is picked and added to the tree. Thus, results in the expansion of the tree in that direction [2].



[Fig.2: Flowchart representation for IoT based software for Humanoid for Identification and diagnosis of Covid-19 Suspect]

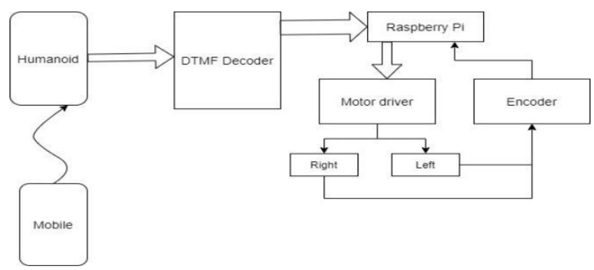
Phase 2 - Determining the Final Path: The calculation again begins from the root hub and outputs the whole tree to find the objective point. If the objective point is absent, then at that point the point nearest to the objective area is taken. When the goal point arrives at the beginning of the goal the calculation discovers the parent hub and moves to it until the root hub is reached. Along the process, all the parent nodes are stored in an array and reversed, which constitutes the route on which the humanoid must move to reach the destination. RRT Algorithm gives the final path to be taken to reach the destination by avoiding all the obstacles in the given space [1].

B. RRT * with Variants

The RRT algorithm cannot be determined. RRT alone may not be proper to tackle a way to arrange issues for a portable humanoid as it can't join extra cost data. The motion planning algorithm indicates that, under specialized conditions, the ideal way created by RRT meets most exceedingly awful qualities, as the quantities of preliminaries were raised [1][12]. To address this issue, another calculation called the Rapidly Investigating Random Graph (RRG) was created and it has been demonstrated that the expense of the best way returned by RRG joins the ideal unquestionably. Moreover, the methodology is that the tree structure is lost and supplanted with chart hypothesis. Consequently, there is a need to keep up the tree structure while protecting the asymptotic optimality of RRG. This is accomplished by RRT*, an effective steady

This article has been accepted for publication in a future issue of this journal, but has not been fully edited. Content may change prior to final publication. Citation information: DOI 10.1109/JSEN.2020.3030905, IEEE Sensors Journal

inspecting-based calculation that keeps up the tree structure but difficult to actualize alongside provable optimality properties. This refinement property is worthwhile, as most automated frameworks set more effort to execute directions than to design them [10][13].



[Fig.3: Block Architectural diagram for working of Autonomous Navigation]

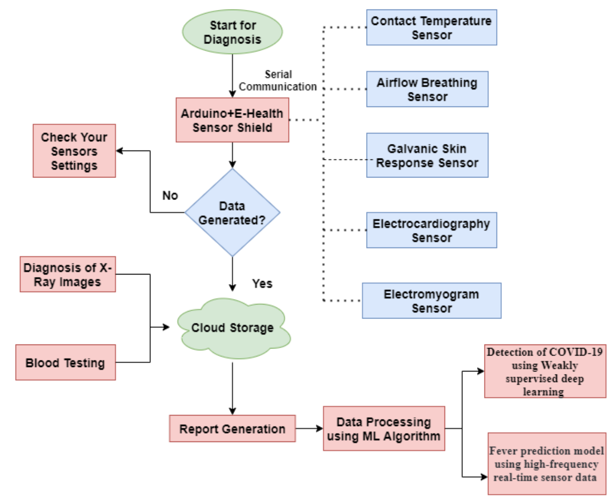
C. Outdoor Localization and Humanoid Navigation

IV. IDENTIFICATION AND DIAGNOSIS SYSTEM

The humanoid uses an odometer for navigation and to obtain its position. The optimized RRT* algorithm is used to find the path to the goal. When the complete path is acquired from the upgraded RRT* algorithm, the objective focuses in the way are resolved and the fitting wheel speeds should be given for moving the humanoid from its present area to the main transitional objective point. To facilitate the movement of the humanoid from one grid to another, the humanoid is rotated in place at every grid so that its orientation matches the requirement for traversal from the present network to the following objective point. Moving from one block to another, the Euclidean distance between the humanoid's initial position and the final position, in terms of pixels is determined [9].

A. Material Methodology:

This section details the methodologies used to diagnose the deployment circumstances for preserving the health of the board structure. Primarily, portray the gear to distinguish biometric signals by employing the e-Health Sensors pack and Arduino. Secondly, depict the blended perspective reliant on organization development. Thirdly, portray the correspondence show. Finally, depict the test course of action. These sensors produce real-time data that is collected and stored in cloud storage, later processed by the system. The database gets updated as soon as new data is generated. A report is generated from the data stored in the database and later the data undergoes machine learning and deep learning algorithms, to categorize and identify positive patients. Hence two major algorithms are used in the context for diagnosis. First is a weekly supervised deep learning method to detect COVID-19 patients in which neural networks are used to categorize the Chest X-rays into positive and normal categories. Second is fever detection using machine learning in which real-time sensor data is categorized and processed into different types of fever according to the symptoms. The system consists of 8 sections. The detail and brief working of each section are explained in the following subsections.



[Fig.4: Flowchart representation for working identification and diagnosis system.]

1. Contact Temperature Sensor (CTS):

The contact temperature sensor senses a small change in body heat or coldness of the patient producing digital output. The sensor needs to touch a body part to measure the temperature. The Internal heat level depends on the estimated body spot, time of the day, and the subject's degree of movement. Body temperature differs from various parts of the body [3].

2. Airflow Breathing Sensor (ABS):

The Airflow Breathing Sensor measures the respiratory rate of the patient producing digital output. The sensor has two flexible threads and two prongs placed at nostrils. Respiratory rate is a comprehensive indicator of significant physiological flimsiness. The sensor measures the breathing movement and nasal temperature rate from avionics routes of the nose [3].

3. Galvanic Skin Response Sensor (GSR):

The GSR sensor measures the change in sweat gland activity and change in emotional response of the patient. This is primarily used to quantify the electrical conductance between two centers of the skin, which changes with the dampness level. Skin conductance is an indicator of mental or physiological energy and emotional arousal [3].

4. Electrocardiography Sensor (ECS):

It collects the electrical signals generated by the heart of the patient, which is issued to monitor the electrical and muscular functions of the heart. ECG has gotten one of the most usually

This article has been accepted for publication in a future issue of this journal, but has not been fully edited. Content may change prior to final publication. Citation information: DOI 10.1109/JSEN.2020.3030905, IEEE Sensors Journal

used clinical tests in current drugs. A couple of ailments have no progressions on ECG waveform [3].

5. Electromyogram Sensor (EMS):

The Electromyogram sensor is used to measure the muscle response produced by nerve's stimulation of muscle. It will be used as a symptomatic instrument to diagnose and record the electrical development made by skeletal muscles by assessing their electrical activity while they are still and under pressure. EMG is used for perceiving neuromuscular afflictions, looking over low-back torment, kinesiology, and disarranges of motor control [3].

6. Diagnosis of X-ray images using Deep Learning:

This system uses Chest X-ray images of patients to detect whether a person is infected or not using machine learning based transfer learning process. The system is trained with more than 3000 chest images and tested with 1500 images extracted from kaggle.com. We used ResNet50, InceptionV3 and Inception ResNetV2 models for characterization of chest X-ray images into COVID-19 and ordinary classes. The training stage has been carried out up to 30^{th} epoch to avoid over-fitting for all pre-trained models. All testing is performed on Google Colab Linux server with Ubuntu OS. The system takes the patient's chest x-ray and processes it through the machine learning algorithm. The algorithm processes the images and detects whether the patient is tested positive or not [6].

7. Blood Testing:

This test distinguishes both early marker and late marker, IgM/IgG antibodies in human finger-prick (thin) or venous whole blood, serum, and plasma samples. It can be used for quick screening of bearers of the disease that are characteristic or asymptomatic. Late examinations suggest that an elevated level of patients show no clinical appearances of the disease, thus screening patients is basically huge. This test has an indicator with different colors changes according to the antibodies. This test is completed in at-most 2 minutes and has very accurate results [8].

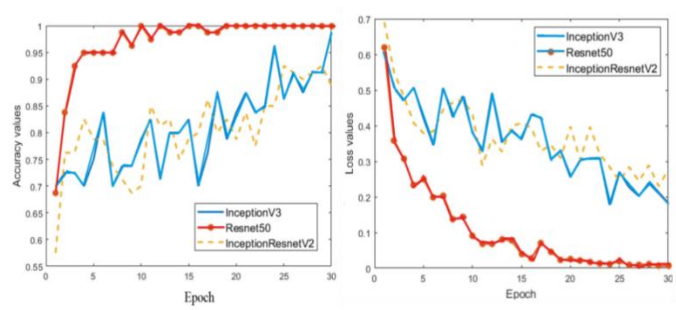
V. RESULTS AND DISCUSSION

This study aims to perform rapid testing and diagnosis of COVID-19 using medical diagnosis humanoid (MDH). This study uses chest X-ray images for the prediction of COVID-19 infection patients (COVID-19). Pre-trained models such as ResNet50, InceptionV3, and Inception ResNetV2 have been trained and tested on chest X-ray images. The training stage has been carried up to the 30th epoch to avoid over-fitting for all pre-trained models. InceptionV3 and Inception-ResNetV2 models have similar performance beneath 70% because of the low amount of data. The training loss function values for ResNet50, Inception V3, and Inception ResNetV2 are used to enhance the algorithm.

Layer (type)	Output Shape	Param #
conv2d_5 (Conv2D)	(None, 222, 222, 32)	896
conv2d_6 (Conv2D)	(None, 220, 220, 64)	18496
max_pooling2d_4	(None, 110, 110, 64)	0
dropout_5 (Dropout)	(None, 110,110,64)	0
conv2d_7 (Conv2D)	(None, 108,108,64)	36928
dropout_6 (Dropout)	(None,54,54, 64)	0
conv2d_8 (Conv2D)	(None, 52,52,128)	73856
dropout_7 (Dropout)	(None,26,26, 128)	0
flatten_2 (Flatten)	(None, 86528)	0
dense_3 (Dense)	(None, 64)	5537856
dropout_8 (Dropout)	(None, 64)	0
dense_4 (Dense)	(None, 1)	65

[Table I. Training Model Summary. Total Params: 5,668,097, Total Trainable Params: 5,668,097, Total Non-Trainable Prams: 0]

The interpretation of loss values is done based on calculated loss values from training and validation. Loss values also implement the performance of the model after iteration. When the loss figure is analyzed, it is seen that the loss values decline in three pre-trained models during the training stage.



[Fig.5: The performance of three Pre-trained models (Training accuracy and loss values for fold-3]

It tends to be the ResNet50 model; both models both decrease loss values faster and approach zero. The testing results were exact and noteworthy as the PR AUC esteem was 0.975. On the ROC curve, the algorithm got sensitivity and specificity esteems bigger than 0.9, which were both clinically implementable. However, ResNet50 shows a faster training process than other models. Metrics like score, F1 score and AUROC were calculated. We have got the best result from Temporal Convolution Networks. Other primary diagnostic factors such as body temperature, heart rate, respiratory/breathing rate, SaO_2 value, CVP value, systolic

This article has been accepted for publication in a future issue of this journal, but has not been fully edited. Content may change prior to final publication. Citation information: DOI 10.1109/JSEN.2020.3030905, IEEE Sensors Journal

value, diastolic value and mean pressure can provide valuable information using high frequency real time sensor data for diagnosis and can be used to accurately predict fever onset by applying machine learning technique on continuous physiological data generated for the system.

Folds	Performance Metrics			
	Sensitivity	Specificity	Precision	Accuracy
Fold-1	100	100	100	100
Fold-2	95.00	96.67	90.00	97.60
Fold-3	98.33	93.75	93.75	96.80
Fold-4	90.47	98.57	95.93	97.60
Fold-5	93.75	98.58	95.62	97.60
Overlapped	NIL	NIL	NIL	NIL
Positive Tested	90.65	97.57	94.17	98.05
Negative Tested	99.54	98.08	98.84	98.05
Average	95.39	97.60	95.47	97.95

[Table II. Sensitivity, Specificity, Precision, Accuracy values for no finding and COVID-19 finding classes of the proposed model]

For the feature extraction process, the system uses concepts of time windows and time before true on-set. The amount of data generated within a time period required to train a model is kept constant for 8 hours and analyzed by using machine learning algorithms for calculating precision.

Cases	AUROC#	False Positive rate	True Positive Rate	Sensitivity	Specificity
COVID-19	0.957	0.088	0.967	96.73	91.18
Pneumonia	0.863	0.071	0.555	55.57	92.75
Normal-Flu	0.815	0.069	0.573	57.37	93.83
Infectious diseases	0.817	0.157	0.727	72.76	84.24

[Table III. Area under ROC curve of Vector machine Algorithm for different un-differential fever cases]

Soon after the analysis of all the factors involved in the diagnosis such as body temperature, heart rate, pulse rate, breathing rate, blood tests, and X-ray reports, the natural language processing algorithm and weakly supervised deep learning algorithm which makes an analysis of all the factors and detects whether the patient is positive for the virus or not. The data is first divided into the train set (80%) and test set (20%) and then trained on the models mentioned above. Metrics like score, F1 score, and AUROC were calculated. We have got the best result from Temporal Convolution Networks. The capability of temporal neural networks suggests that they can make the best predictions by learning the temporal context of input sequences. As we are using the real-time sensor data, CT images of lungs and Blood samples as an input, the model needs to predict whether the patient is affected by COVID-19 or not, hence the temporal neural network is considered to be best for their finest prediction capability and results.

A. Evaluation Metrics:

We have used three evaluation metrics for calculation of performances of deep learning modules:

1. Precision

The ratio of positive reviews to the total number of reviews. It can be defined as: Precision = (TP/TP+FP)

2. *Recall*

It is the ratio of positive reviews to all the reviews in a particular class. It can be defined as: Recall = (TP/TP+FP)

3. F1-Score

It can be calculated as a harmonic mean of precision and recall. It can be defined as: F1-Score = 2* {(Precision*Recall) / (Precision + Recall)}

Where, TP is defined as True Positive, the sum of diagonal elements, and FP is defined as False Positive, Sum of each column excluding diagonal elements.

VI. Limitations and Challenges

Developing AI solutions for automated COVID-19 detection is still a challenging task. Getting the right algorithm and gathering enough real-world data to train the algorithm is challenging due to autonomous navigation in a dynamic environment. Creating precision motion control and reducing false positives for human detection is important for increasing the capabilities of end-user applications. Generally, it is difficult to use sensor data from virtual environments to reduce false positives. The data generated is so large that it is difficult to move it over the network to a central location. Connected IoT devices must work together for most IoT use cases, but this increases security issues. Sometimes the use of faulty devices may start sending false values to the system hence we used multiple diagnosis methods to confirm testing cases. The radiologists have not labeled the CT volumes of COVID-19 lesions used for training the model and only patient-level indicators are used for preparing the algorithm. Small infected regions by COVID-19 in X-ray images may get missed even by proficient radiologists; hence we tried to solve these issues by using the ResNet50 model. It applies extensive data argumentation techniques on training CT volumes to get more volumes. Having a satisfactory accuracy rate and effective implementation, still, the system has some constraints. Initially, the design of neural networks can be more improved to improve the accuracy of the system. The real-time data produced by the system is in a huge quantity that needs to be managed. The UNet model was trained using imperfect ground truth masks for lung segmentation. Accuracy improved using 3D segmented networks and using accurate ground-truth volumes analyzed by experts. Secondly, the data used in this study to train the models were from a single hospital where cross-validation was not performed. Third, since the algorithm was designed using deep learning and was still at an early stage, the algorithm worked in a black-box manner.

VII. Conclusion and Future Work

Thus, we conclude that the medical diagnosis humanoid (MTH) system is a cost-effective, safety-critical mobile robotic system that provides a complete diagnostic test to check whether an individual is infected by Covid-19 or not conducting multiple tests. Also, our model is effectively capable of carrying out a complete diagnosis and figuring out Covid-19 patients. Consequently, our algorithm can be applied in clinical application for precise and rapid COVID-19 diagnosis, which is of incredible assistance for the front-line medical staff and is essential to control this epidemic around the world. The system contains multiple diagnostic devices, which help in confirming Corona Virus cases precisely. As the system is automated there is no requirement for human interference, unless it is a case of device failure or report of a bug. In the future, the neural network can be improved by switching from the database to cloud technology which can be proven best for data handling and management issues. Much improvement can be done on security aspects by providing a 5G network which can be used for more compatibility.

VIII. Data Availability Statement

The dataset and code used in the development can be found in an online repository. Please check out the GitHub repository: https://github.com/Rushikesh042/Humanoid-software

References

[1] Pérez Higueras, Noé & Jardon Huete, Alberto & Rodriguez, Angel & Balaguer, Carlos. 3D Exploration and Navigation with Optimal-RRT Planners for Ground Robots in Indoor Incidents. Sensors. 20. 220. 10.3390/s20010220.

[2] Bazhan, Sepideh & Hosseininaveh, Ali, A Moving Obstacles Planner Algorithm for a Six-Wheeled Surveying Robot. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. XLII-4/W18. 191-195. 10.5194/isprs-archives-XLII-4-W18-191-2019.

[3] Bayo Montón, José & Martinez-Millana, Antonio & Han, Weisi & Fernandez-Llatas, Carlos & Sun, Yan & Traver, Vicente. “Wearable Sensors Integrated with Internet of Things for advancing e-Health Care”. Sensors. 18. 1851. 10.3390/s18061851.

[4] Aziz, Dlnya, “Webserver Based Smart Monitoring System Using ESP8266 Node MCU Module”. International Journal of Scientific and Engineering Research. 9. 801.

[5] Karmore, Swapnili. “Internet of Things Based Monitoring and AI Based Testing Approach for Sensor Activity Testing of Embedded Systems”. Helix 8. 3828-3832. 10.29042/2018-3828-3832.

[6] Zheng, Chuansheng & Deng, Xianbo & Fu, Qing & Zhou, Qiang & Feng, Jiapei & Ma, Hui & Liu, Wenyu & Wang, Xinggang. “Deep Learning-based Detection for COVID-19 from Chest CT using Weak Label”. 10.1101/2020.03.12.20027185.

[7] Stoecklin, S. B., Rolland, P., Silue, Y., Mailles, A., Campese, C., Simondon, “First cases of coronavirus disease 2019 (COVID-19) in France: surveillance, investigations and control measures”, January 2020. Eurosurveillance, 25(6):2000094, 2020.

[8] D. Wang, B. Hu, C. Hu, F. Zhu, X. Liu, J. Zhang, et al., “Clinical characteristics of 138 hospitalized patients with 2019 novel Corona virus Infected pneumonia in Wuhan, China”, JAMA, vol. 323, no. 11, pp. 1061, Mar. 2020.

[9] Hlaing, Ni & Naing, Ma & Naing, San, “GPS and GSM Based Vehicle Tracking System”. International Journal of Trend in Scientific Research and Development. Volume-3. 271-275. 10.31142/ijtsrd23718.

[10] Rotake, Dinesh R. and S. Karmore. “Intelligent Traffic Signal Control System Using Embedded System.” Innovative Systems Design and Engineering 3 (2012): 11-20.

[11] A Basavaraja CG, Mangala CN, “Traffic Signal Control Based on Vehicle Detection Algorithm & IOT,” International Journal of Computer Sciences and Engineering, Vol.07, Issue.15, pp.320-324, 2019.

[12] Mandhare, Pallavi & Kharat, Vilas & Patil, C.Y.,”Intelligent Road Traffic Control System for Traffic Congestion a Perspective.” International Journal of Computer Sciences and Engineering. 6. 908-915. 10.26438/ijcse/v6i7.908915

[13] M. Tang, M. Alazab and Y. Luo, “Big Data for Cybersecurity: Vulnerability Disclosure Trends and Dependencies,” in IEEE Transactions on Big Data, vol. 5, no. 3, pp. 317-329, 1 Sept. 2019, doi: 10.1109/TBDATA.2017.2723570.

[14] N. Etaher, G. R. S. Weir and M. Alazab, "From ZeuS to Zitmo: Trends in Banking Malware," 2015 IEEE Trustcom/BigDataSE/ISPA, Helsinki, 2015, pp. 1386-1391, doi: 10.1109/Trustcom.2015.535.

[15] A. Azab, M. Alazab and M. Aiash, “Machine Learning Based Botnet Identification Traffic,” 2016 IEEE Trustcom/BigDataSE/ISPA, Tianjin, 2016, pp. 1788-1794, doi: 10.1109/TrustCom.2016.0275.

[16] Azab, Ahmad & Khasawneh, Mahmoud. “MSIC: Malware Spectrogram Image Classification” IEEE Access. PP. 1-1. 10.1109/ACCESS.2020.2999320.

[17] Yin Zhang & Min Chen, “Cloud Based 5G Wireless Networks”. 10.1007/978-3-319-47343-7.

[18] M. Rahman, et. al., “Data-Driven Dynamic Clustering Framework for Mitigating the Adverse Economic Impact of Covid-19 Lockdown Practices”, Elsevier Sustainable Cities and Societies, vol. 62, pp. 102372, 2020

[19] Zhang, Yin & Duffield, Nick, “On the Constancy of Internet Path Properties” 197-211. 10.1145/505202.505228.

[20] M. Kolhar, et. al., "A Three Layered Decentralized IoT Biometric Architecture for City Lockdown during COVID-19 Outbreak", IEEE Access, vol. 8, no. 1, pp. 163608-163617, 2020.

[21] Yin Zhang, et al., “COCME: Content-Oriented Caching on the Mobile Edge for Wireless Communications”, IEEE Wireless Communications, vol. 26, no. 3, pp. 26-31, JUN 2019.

[22] Yin Zhang, et al., "Edge Intelligence in the Cognitive Internet of Things: Improving Sensitivity and Interactivity", IEEE Network, vol. 33, no. 3, pp. 58-64, 2019.

[23] Zhang, Yin, "Using the Internet for survey research: A case study." J. Am. Soc. Inf. Sci. 51 (2000): 57-68

[24] F. Al-Turjman, D. Deebak, "Privacy-Aware Energy-Efficient Framework using Internet of Medical Things for COVID-19", IEEE Internet of Things Magazine, 2020. DOI. 10.1109/IOTM.0001.2000123

Swapnili Karmore is from Nagpur, Maharashtra India. She received her Ph.D. degree in Computer Science & Technology from the Rashtrasant Tukdoji Maharaj Nagpur University From 2010 to 2015; she is Dean R&D and an Associate Professor in S.B. Jain Institute of Technology Management & Research, Nagpur. She has been an Assistant Professor with the Computer Science & Engineering Department, G.H. Raisoni College of Engineering Nagpur, from 2010 to 2017. She has published five patents and published a total seventy four papers in International and National conferences and Journals. She has organized an "International Conference on Innovation in Engineering Sciences, Management and Technology" 12 -13 December 2019. She has organized and conducted several workshops & guest lecturers for students and faculties. Her research interests include Internet of Things, Artificial Intelligence, Embedded software Testing. She got Sanman Stri Shakticha "Nari Shakti Award" by All India Sonar Federation (AISF) on 8th March 2019 for Technical education excellence & remarkable work in women empowerment. She was recipient of the Outstanding Contribution in Reviewing ELSEVIER ISTA January 2018, and "Shiksha Ratan Puraskar", Certificate of Excellence for Meritorious Service, Outstanding Performance and Remarkable Role at a seminar on Economic Growth & National Integration at New Delhi 10th June, 2013. She got UGC International Travel Grant for Paper Publication during Research work for paper publication in International Conference on Computer Science and education 2013, SriLanka, Colombo (ICCSE-2013). She has guided several projects including inter disciplinary projects of undergraduate and postgraduate students

Rushikesh Bodhe is a student of third-year Bachelor of Engineering at S. B. Jain Institute of Technology, Management, and Research, Nagpur from Information Technology branch. He is working on in Python-based technologies and an open-source contributor to Python libraries. He is associated with Google developer's club, Facebook developer's circle, Alexa developer's club,women code and as a Committee member at IEEE Nagpur subsections Student's Committee. He was awarded "Best research paper" at "ICIESMT" December 2019 and won the National level Hackathon(IEEE Kerala section).

Fadi Al-Turjman received his Ph.D. in computer science from Queen's University, Kingston, Ontario, Canada, in 2011. He is Full-Professor at Research Center for AI and IoT, Near East University, Nicosia, Mersin 10, Turkey. He is a leading authority in the areas of smart/intelligent, wireless, and mobile networks' architectures, protocols, deployments, and performance evaluation. His publication history spans over 250 publications in journals, conferences, patents, books, and book chapters, in addition to numerous keynotes and plenary talks at flagship venues. He has authored and edited more than 25 books about cognition, security, and wireless sensor networks' deployments in smart environments, published by Taylor and Francis, Elsevier, and Springer. He has received several recognitions and best papers' awards at top international conferences. He received the prestigious *Best Research Paper Award* from Elsevier Computer Communications Journal for the period 2015-2018, in addition to the *Top Researcher Award* for 2018 at Antalya Bilim University, Turkey. He has led a number of international symposia and workshops in flagship communication society conferences. Currently, he serves as an associate editor and the lead guest/associate editor for well reputed journals, including the *IEEE Communications Surveys and Tutorials* **(IF 22.9)** and the Elsevier Sustainable Cities and Society **(IF 4.7)**.

R Lakshmana Kumar is an Assistant professor and also leading the technical training team in Hindusthan College of Engineering and Technology, Coimbatore, India. He is Member in Board of Directors and also a Chief Research scientist at ASIQC in British Columbia, Canada. He is a global chapter Lead for MLCS [Machine Learning for Cyber Security. He has a passion towards development and he holds the International certification on SCJP (Sun Certificated Java Programmer). His special interest is to write special issues for publishers like Elsevier, Inderscience, Springer and IGI-global. He has around 25+ publications in international journals and conferences. He hold 4 edited book from CRC press. He holds around 17 patents. He is an Editor in chief for the book series "Advances in Quantum Computing, Artificial Intelligence, and Data Sciences for Industrial Transformation Series" and "Convergence of IoT and Blockchain through Machine Learning Approaches" in CRC Press - Taylor & Francis Group, LLC. He is acting as a vibrant reviewer for the journals like"IEEE Access (SCI indexed)", "Transactions on emerging telecommunications technologies (SCI indexed)", "International Journal of Web Services Research (IJWSR) (SCI indexed)","International journal of grid and utility computing" [Scopus], "International Journal of Computer Aided Engineering and Technology "[Scopus], "World Review of Science, Technology and Sustainable Development" [Scopus], Journal of Information Systems Education" [Scopus] and many.

Sofia K. Pillai is working as In charge of Centre of Excellence in AI ML at Galgotias University. She is recipient of Best Teacher Award from GHRCE, Nagpur. She is a recipient of Microsoft AI for Earth Grant. She has received first prize in university level innovation competition "AVISHKAR". She has delivered workshops on Alexa, Machine Learning, AI and Its applications, AWS, Google Cloud and Deep Learning for both faculty and students. She has filed one patent and received one copyright. She has published more than 15 research papers. She has set up two Centre of excellence, and also has worked to develop the curriculum for B.Tech. in AI and started first B.Tech in AI Program in private institution in India. She has guided several interdisciplinary projects based on applied AI in agriculture and biomedical. She has also organized two International AI Summits for industry collaboration. She has also given one month and six month internship to students in AIML. She has also conducted AI for Teens, special AI course for School kids and AI Train the trainers for school teachers. She has also worked as faculty advisory of IEEE Computational Intelligence Society and started first IEEE CIS chapter under Bombay Section.