Detection and Tracking Contagion using IoT-Edge Technologies: Confronting COVID-19 Pandemic

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***Abstract*—The ongoing pandemic of Corona-Virus (COVID-19) induced by the coming forth category of SARS-CoV-2, has terrified the worldwide human health. Primarily, COVID-19 challenges can be categorized into (a) way of epidemic prevention and blocking transmission, (b) live monitoring of infected / suspected persons (c) FDA approved vaccine. Leading to said COVID-19 (a), (b) challenges, digit technologies such Artificial Intelligence, Big data analytics and Internet of Things (IoT), can play a vital role in epidemic prevention and blocking COVID-19 transmission. In this study, we have proposed a smart edge surveillance system that is effective in remote monitoring, advance warning and detection of a person's fever, heart beat rate, cardiac conditions and some of the radiological features to detect the infected (suspicious) person using wearable smart gadgets. The proposed framework provides a continually updated map/pattern of communication chain of COVID-19 infected persons that may span around in our national community. The health and societal impact of suggested research is to help public health authorities, researchers and clinicians contain and manage this disease through smart edge surveillance systems. The proposed model will help to detect and track the contagious person. Moreover, it will also keep the patient's data record for analysis and decision making using edge computing.**

Keywords— COVID-19, IoT, Edge Computing, Cloud Computing, Ubiquitous Computing, graph transfusion, recommendations.

I. INTRODUCTION

The emergence of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2; previously provisionally named 2019 novel coronavirus or 2019-nCoV) disease (COVID-19) in China at the end of 2019 has instigated a global outbreak with major public health issues. As per data provided by the World Health Organization (WHO) on 11th February 2020 displayed more than 43000 confirmed cases acknowledged in 28 states/countries, with > 99% of cases being detected in China. On 30 January 2020, the WHO declared COVID-19 as the sixth public health emergency of international concern [1][2].

According to the World Health Organization (WHO), this epidemic disease is prevailing in the human body up-to 14 days. Furthermore, the even most challenging task, no clear coronavirus (CoVID'19) symptoms observed in its preliminary stages [2]. Therefore, in order to identify the CoVID'19 suspected person, we have to monitor his/her up to 14 days and also ensure to restrict that person in a self-isolation state during the quarantine period. The social distancing, home isolation and home quarantine could slow down the spread of the infection, interrupt transmission and reduce case numbers to low levels [4].

The terminologies like internet of things (IoT) [6][7], Edge Computing [8][9] and Artificial Intelligence (AI) [10] taking into account in order to minimize the gigantic effect of this massacre disaster. By adopting these vital concepts, we can trace, monitor and analyze the suspected human-to-human (H2H) chain. This monitoring process could be more efficient by using parallel computing technologies [29],[30] as well. Moreover, the suspected virus affected person tracking is one of the major issues in the current situation. As, this deadliest virus mostly transfer from H2H, so it is a prime concern of today's time to keep away the virus affected persons or even suspected to, with the healthy ones. It's not only the matter of one life or two, but it's also a concern of the whole universe. So, we need to tackle this issue on a priority basis.

As mentioned above, the solution to this vital issue i.e. 'H2H' tracing lies under the phenomenon of IoT and edge computing mechanism [28]. IoT is one of the most effective paradigms in the smart world. Through this concept, we can connect billions of devices with each other with the help of internet architecture under one globe [11]. Moreover, edge computing technology enhances to minimize the overall constraint device's energy utilization and back up resources. Furthermore, it uses virtual data storing model access anywhere in the world. Instead of storing the whole data on the central cloud, we can make multiple edge servers inside the cloud in order to get a quicker and robust response. Further, it also reduces the overall cloud computation through distributing the tasks among different edge, fog levels, which

978-1-7281-7116-6/20/$31.00 ©2020 IEEE

is the main beauty of this architecture [10]. The health and societal impact of our research is to help public health authorities, researchers and clinicians contain and manage this disease by developing smart edge surveillance systems.
Our intended research solution is five step tracking and monitoring surveillance system for disease suspected persons through which we analyze the person basic CoVID'19 preliminary symptoms right from the start of travel journey to reach the required destination along with highlighting each and every suspected person checkpoints during his/her voyage. The system is equipped with a wearable smart product (gadget) that is effective in remote monitoring, advance warning and detection of wearing person's fever, heart beat rate, cardiac conditions and some of the radiological features to detect the disease infected person or suspicious ones.

Research outcomes of this project will provide a continually updated map/pattern of communication chain of infected persons for COVID-19 that may span around in our national community. It would make a significant contribution in better understanding of epidemics, patterns of spread and developing diagnostics.

The rest of the paper organized as follows: Section II introduces literature study. Methodology and system components are presented in section III. Section IV presents a comprehensive future perspective plan. Lastly we conclude the study in section V.

II. RELATED WORK

CoVID-19 [12] is a global pandemic that is spreading with an exponential rate. To identify the suspected or quarantined people, some advancement has occurred with the development of data analytics [13] and machine learning. Digital healthcare systems have developed on the top of cloud computing, mobile computing artificial intelligence and the internet of things [14].

Due to the devastating spread of global pandemic COVID-19, Internet of things (IoT) enabled devices are in trend [15]. Early detection of contagious people is one of the main goals of all countries. As the CoVID-19 carrier may spread this virus with an exponential rate in population. Thus the detection of suspected people with different gadgets [16] are proposed to detect various symptoms of patients. Such as for temperature detection thermometers are used. Further for detection of respiratory systems a WHOOP's wrist worn wearable health tracking system [17] is proposed by central Queensland University Australia. They have proposed a self-identified system that will gather the patient's data, but this system is mainly dealing with an analysis of change in the respiratory system of patients. In our proposed system we are mainly dealing with more symptoms e.g. heartbeat, temperature and respiratory systems. Similar gadget is also introduced for raspberry Pi flu sense [18] that is using AI to get the number of people in a room. After that it correlates the coughing and other symptoms to detect the flu but it is lacking with other symptoms of COVID-19 e.g. respiratory system etc. In this paper the proposed system is mainly dealing with all the basic symptoms e.g. fever, respiratory system and blood pressure.

The CoVID'19 epidemic covers the whole world with its intense and drastic effect. Through its penetrating impact, the whole human tribe in the universe is going to be affected and the number still goes on day by day at an enormous rate. However, a lot of vaccine manufacturing labs work day and night in order to identify the appropriate formula for the procurement of this disaster, but it's a time taking process. In correlate to the sovereignty of this issue, we have to see options in order to control the spread of this disease.
As highlighted above, the vaccination process takes time, so we can focus on other HI-TECH IT solutions to limit the epidemic transfer rate to save human lives as much as possible. Recent events have shown us (again) how rapidly a new disease can take root and spread. Such events are accompanied by an explosion of clinical and epidemiological information and research. Given the rapid integration of artificial intelligent technologies in epidemiology and health logistics, it is needed to examine with how and what significances remote-sensing and communication technologies would be reconfigured for the practice and scope of global health [3].
Further governments of all countries are looking for the gadgets that may gather the accurate data e.g. For fever detection smart thermometers [19] are used that may gather the data sent to some server. Moreover AI enabled fever detection cameras are also used [20] but there is still a lack of devices in literature that may cover the maximum symptoms of COVID-19.

Moreover, the COVID-19 patient's data is gathered across the globe and many datasets are available [20] for the analyses. But these datasets are helpful to get some useful results after applying machine learning algorithms. For making an analysis a cloud based platform is required that can further be extended with edge computing to efficiently perform the analysis. The edge computing [21] is very effective when the proposed model has to monitor the contagious or quarantined persons at some geographically separated location. To enhance the performance, edge based analysis is performed in the proposed model to get the results efficiently.

Further communities are looking for early detection of contagious persons in the population. For this purpose many solutions have been proposed. e.g. Bluetooth based identification [22].Google and APPLE are going to launch the Bluetooth based applications [23] But these kinds of systems would be dependent on Bluetooth that may have some problems with ranges. To overcome these issues we are proposing a GPRS based detection and alerting the community for the suspected persons.

Healthcare in remote rural areas is challengeable in terms of accessibility and availability for which emerging technologies like Internet of Things (IoT)-based remote health monitoring are proving beneficial. In [5] authors present an IoT-based smart edge system to monitor health remotely. System was implemented with some wearable vital sensors to transmit data into two novel software engines named rapid active summarization for effective prognosis (RASPRO) and criticality measure index (CMI). They assessed the system with precision (0.87), recall (0.83), and F1-score (0.85).
COVID-19 is a major global health challenge. In the battle against the outbreak, Digital technologies such as 5G [24], AI and cloud computing are used .Which are effective for virus tracking, epidemic monitoring and treatments. In the

epidemic response cloud computing has become as much as necessary as electricity or water for survival. Alibaba cloud [25] has made available its AI computing power for public research universities to develop new drugs and vaccines. Hence cloud based solutions are the basic building block for epidemic tracking. For implementing this idea the proposed model is implementing a cloud based solution for pandemic monitoring and tracking. Further the cloud based solution is extended with edge computing to make the proposed model more responsive, efficient and fast.

In the literature, many QR bases applications have been proposed for detection of contagious persons. For example Travel and Health declaration system [25] , it is a Singapore application used to track the visitor through QR scan. Similarly in Wuhan QR codes were also introduced by an application to check the status of the workers [25].And that application became an integral part of the Chinese authorities to check the user's status. This application is deployed but it has also raised many privacy concerns of the users. In this paper the proposed model may keep the user's record so that with less privacy concern the data should be shared with the community.

Hence the existing models in literature are having some patient tracking and analyzing problems. That may be handled in the proposed system, as it would cover the COVID-19 person's monitoring at a broader level. In the first phase the suspected person is analyzed by the IoT enabling gadgets e.g. Wrist watch etc. After that the proposed model will keep a track of the user's history with the help of edge enabled platforms .It will also help to analyze the history of the patient with the help of a social graph. Moreover the QR enabled mobile application would help the community to get some alerts, if the suspected person is around them. Moreover, it would be very beneficial for the community to get the pre alert to be careful from the COVID -19 or quarantine patients. Hence, the proposed model may help to stop the spread of CoVID'19 pandemic in the community.

III. PROPOSED FRAMEWORK

The Proposed CoVID'19 suspected person Surveillance mechanism gets real-time values by sensors through wearable and non-wearable gadgets. It will be used to be aware of the medical health status and to track the chain of all hotspots on which the CoVID'19 suspected victim steps in. Moreover, microcontroller grabs data from sensors and transmits to the Multi-Edge layer nodes by adopting the architecture of the internet of things (IoT) where rule base analysis will perform to match between predefined conditions and current state of suspected person grabbed through sensors. After computing the data on edge and cloud layers, the appropriate action triggering module enables the notifications in the android application and to develop the track chain hierarchy on the web server. In this way, we can track the CoVID'19 suspected persons and keep safe other people from that person as much as we can. However, this section presents the block diagram and detailed layered framework of the proposed model.

The proposed system framework is accomplished in five stages. These phases will able to fulfill the ultimate objective (i.e. CoVID'19) of this work quite effectively. However, the detailed analysis of these stages shown in Fig.1 as follows.

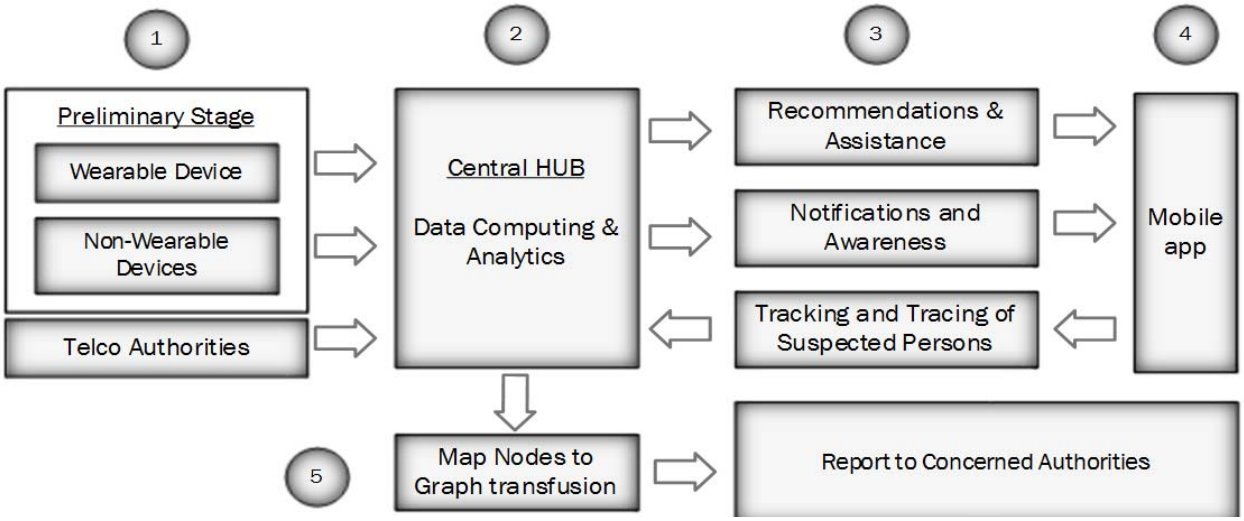

Fig. 1. Block Diagram of Proposed System framework

A. *Preliminary Stage*

In the preliminary stage, suspected CoVID'19 people's health data, transmitted to the edge and cloud layer with the help of multiple sensors embedded in wearable and non-wearable modules.

B. *Central HUB (Data Computing and Analytics)*

In this stage local and remote computations process on multiple devices. Moreover, these two computation approaches minimize the overall response time of the system which is the dire need of this scenario. Furthermore, these computed data will be further transmitted to the action triggering and graph mapping units in order to alert nearby and concerned authorities.

C. *Action Triggering*

This component is responsible for real-time action triggering such as broadcast CoVID'19 suspicious person notifications, indicators, tracking, and mapping the victim's event nodes to the graphical hierarchy. Moreover, these action responses alert and notify the nearby community and concerned authorities.

D. User Interface

This stage is responsible for providing the user end interaction which is an android application. Moreover, through this display option, CoVID'19 suspected users will assist, be aware, and recommend in case of need.

E. 3.2.5 Graphical view

In this stage, suspected user events transform into a graphical user view chain. Moreover, this graphical hierarchy will help to trace the CoVID'19 suspected root along with all their intermediate places nodes which act as hotspots to save other lives.

Further, we have described the proposed framework in order to track and detect the suspected persons who might be a victim of a current pandemic situation of CoVID'19. However, it should be accomplished in multiple layers i.e. Device layer, Edge layer 1, Edge layer 2, and Cloud Layer. Moreover, the proposed Layer wise CoVID'19 surveillance mechanism adopts a multi-stage Edge computing strategy in order to distribute the computing tasks on multiple edges and cloud-based on features selection, as shown in Fig. 2.

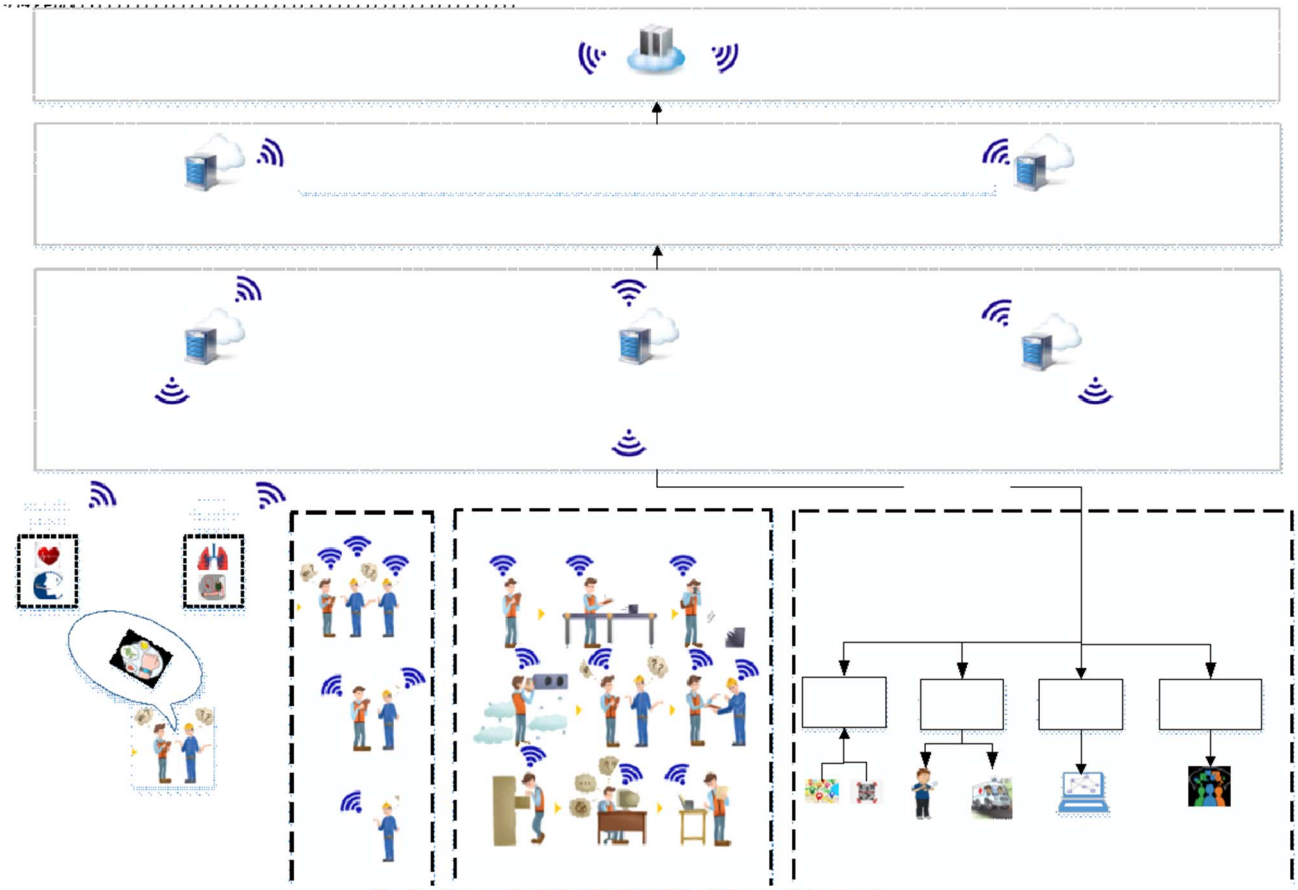

Fig. 2. Layer wise FRAME-WORK of Proposed Approach

A. Device Layer

This layer consists of two major modules (wearable and non-wearable). These two modules are able to detect the CoVID'19 suspected person with the help of multiple factors such as body temperature, Pulse rate, Respiratory rate, and Blood pressure, as suggested by the WHO precautionary symptoms details.

1) Wearable Module

This module comprises two sensors i.e. IR temperature and Pulse sensor. Moreover, it is able to calculate the human body temperature and pulse rate in real-time. According to the WHO instructions, the uneven fluctuations in the body temperature (fever) is the basic symptom of the CoVID'19 affected patients. Furthermore, we also consider the pulse rate of the user which is also one of the prominent factors to recognize the CoVID'19 suspected community. These two factors give a preliminary CoVID'19 suspected person real-time medical condition detail. However, with the help of the wearable module we cannot make sure that a particular person is affected by the CoVID'19 pandemics or not, but at least we can identify the suspected ones and take the precautionary measures. As this viral disease transfer from one human to another, so it is a dire need to detect and track the suspected person in order to secure from the healthy ones.

2) Non-Wearable Module

There is another module which will detect the human respiratory rate and blood pressure (BP) while on a journey through any transport means especially airplane and buses. Moreover, this non-wearable module will attach to the entrance of the airport's walkthrough gates, or even in the shopping malls where large human mobs are expected. Furthermore, it's also available inside the airplanes and buses in order to make sure further to the suspected CoVID'19 medical condition to take appropriate action if needed. Alongside with wearable module, the non-wearable module provides the data of respiratory and blood pressure data of a suspected victim to make sure a particular patient is either

affected to the viral disease or not, as per WHO guidelines. The design of both wearable and non-wearable modules shown in Fig. 3.

B. Edge Layer 1

In the proposed framework, we introduce a multiple-layer edge computing mechanism. In edge layer 1, we select features like body temperature and pulse rate from wearable gadgets to compute for local processing. The edge 1 device is available from where the raw data will be generated. It helps to reduce the latency factor which is the biggest issue in cloud computing. Moreover, it also helps to minimize the response of the real-time sensor triggering time. So, by computing initial features of CoVID'19 suspected person on edge layer 1, we will get a much robust response as compared to waiting for the appropriate decision from the cloud. Furthermore, robustness and effectiveness are the two major issues in this pandemic situation which will solve through this deep edge approach.

C. Edge Layer 2

After computing data from edge layer 1, we can use another edge layer to compute the remaining features i.e. non-wearable gadget outcome. This multi-edge layer strategy helps to reduce the delay factor of the system and to get a quick response in order to take in time decisions which are the prime concern of the CoVID'19 surveillance environment. Moreover, the data computing from the multi-edge layers ultimately transfers to the cloud layer in order to track the suspected person with the help of GPS and event to graph mapping terminologies.

D. Cloud Layer

This layer processes the information which will compute through a multi-edge layer approach. In this way, the cloud layer becomes less burdened in terms of response factor instead of the whole raw data computed on it. Finally, this layer provides the overall user medical status to the android application modules.

E. Application Layer

This is the front end interface of the user. Moreover, it consists of multiple modules like notification, QR scanning, and recommendation. Therefore, it is mandatory for the suspected CoVID'19 people to scan the QR code before entering any Mall or any public place. Furthermore, the QR tag contains the suspected person details and it is also being live tracked through GPS and its medical health status regarding CoVID'19 factors are analyzed on the edge and cloud Servers to take precautionary measures in real-time.

1) Notification Module

This module broadcasts the beacon message of suspected CoVID'19 victim around his nearby region through an application or even SMS too. Moreover, it also alerts the related authorities to take appropriate action in order to save others as much as we can.

2) Recommendation Module

This application also has the feature to chat with the medical experts in real-time or even get the possible precautions that you have to follow in case of preliminary CoVID'19 symptoms.

F. Events to Graph mapping

This is another unique surveillance feature in our proposed CoVID'19 system. However, the basic purpose of this system is to map the Suspected User tracking details that we get from the cloud server into graphical hierarchy notation as mentioned in [26], [27]. Moreover, with the help of this user graphical chain representation, we can track the origin or even in-between places of suspected CoVID'19 affected hotspots quite effectively.

II. FUTURE PERSPECTIVE PLAN

During such a difficult time where the entire world is busy fighting the pandemic and everything is closed due to COVID-19, we were unable to perform the experimental work for the proposed framework. However, in order to successfully accomplish this research, we will develop two sensor modules categorize as wearable and non-wearable modules to get real-time CoVID'19 suspected medical health parameters. An initial setup has been proposed and presented in Fig. 3 (a) for wearable gadget, (b) for non-wearable gadget as follows.

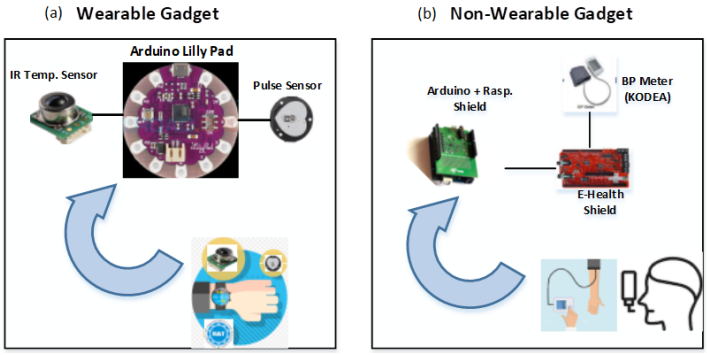

Fig. 3. Experimental Setup of wearable/non-wearable gadgets

Moreover, we will develop a communication mechanism with the edge and cloud layers as shown above in fig. 1. Furthermore, with the adoption of two viral technologies in current time i.e. IoT and Edge computing, we will develop a hybrid mechanism to detect and track the suspected CoVID'19 victims. These two hot phenomena bring overwhelming results in multiple scenarios, some of them practically hands-on like smart agriculture, fire-disaster etc. It shows the effectiveness of these approaches. However, the proposed system will bring fruitful results in order to detect and surveillance the CoVID'19 viral victims.

While the world continues to rely on classic public-health measures for tackling the COVID-19 pandemic, in 2020, there is now a wide range of digital technology that can be used to augment and enhance these public-health strategies

III. CONCLUSION

While in 2020, the world continues to rely on classic public-health measures for undertaking the COVID-19 pandemic, a variety of digital technology is available that can be utilized to enhance worldwide human health strategies. In order to overcome COVID-19 pandemic challenges through digital technologies, current study propose a novel smart edge surveillance system which is capable to (a) diagnose coronavirus infection in human body with the help of health monitoring gadget, (b) recognize the virus suspected H2H chain with the help of deep edge computing and IoT and (c)

monitor the suspected person live tracking through Application. The proposed model also provides a recommendation and alert mechanism module to secure healthy persons whenever an infected/suspected person enters in any public place. Leading to these concerns, we have presented proposed framework as well as layered architecture of the system. The health and societal impact of suggested research is to help public health authorities, researchers and clinicians contain and manage this disease through smart edge surveillance systems.

From future perspectives, we will develop two sensor modules categorized as wearable and non-wearable modules to get real-time CoVID'19 suspected medical health parameters. An initial experimental setup of these gadgets has been proposed in this research. Moreover, we will develop a communication mechanism with the edge and cloud layers. We also need to consider the adoption of two viral technologies in current time i.e. IoT and Edge computing, to develop a hybrid mechanism that will detect and track the suspected CoVID'19 victims. While working on proposed model in future, security and privacy will also be the major concerns that can be addressed by using advance techniques [31][32][33].

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