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An internet of things assisted drone based approach to reduce rapid spread of COVID-19

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A B S T R A C T

With the quick spread of pandemic disease, many individuals have lost their lives across different parts of the world. So, the need for a novel approach or model to overcome the problem becomes a necessity. In this paper, a mechanism is proposed called DBCMS (Drone Based Covid-19 Medical Service) for the safety of medical employees who are prone to Covid-19 infection. The proposed mechanism can effectively improve the treatment process of Covid-19 patients. Drones are nowadays commonly used in the field of medical emergency situations. The proposed model in this paper uses drone service to reduce the risk of infection to the doctors or other medical staff, thereby preventing the disease spread. This paper further assumes that the primary step is to isolate people at their home instead of admitting them to the hospitals, also called a situation of lockdown or curfew. Thus, in this way, the spread can be significantly reduced across the globe if DBCMS approach is implemented at cluster level.

1. Introduction

As of November 2019, when the very first case of Covid-19 was detected, none of the researchers found effective way to prevent the spread of disease [10]. It affected almost every part of the world. India tried to control the situation by applying a lockdown entirely; still new cases continuously grew every day. It is further observed that doctors and other medical staff are always at the highest risk of Covid-19 infection as the disease can be transmitted from an infected person to non-infected very quickly [11–14]. Thus, this research paper proposes an efficient dual method that helps to mitigate the virus spread [1–9]. Till date many websites officially claimed that the medical staffs who were engaged in treating the Covid-19 patients were under highest risk. Thus, [15,16] showed the same data as of 22nd April 2020 as shown in Fig. 1. The figure clearly indicates that the 156 number of nurses, 96 doctors and 145 medical workers along with 4 technicians and 11 other staff were tested positive for covid-19.

As a result, the safety of medical professionals become utmost crucial as the numbers of medical professional are limited in number in every part of the world [17–19]. Therefore, in this paper, a two-way solution is proposed through which the risk of Covid-19 spread is likely to be reduced all over the world.

2. Problem formulation

The primary issue with Covid-19 is its rapid spread. The disease has been categorized under four stages in every nation [20–23]. The first stage is called an imported stage in which all the positive cases for Covid-19 posses some travel history of going to covid affected country.

The second stage is known as the Local Transmission stage in which the person having travel history comes in contact with other people and transfers the infection to them. The third stage is known as Community transmission phase. Here, in this stage, the source of transmission is not at all detected. In this case, the patients have no travel history and do not even have any contact with the Covid-19 patient. The last stage is the epidemic stage. In this stage, the disease has no clear end, and there is no option, but to wait for its end. There are certain areas where this proposed approach can work effectively. Using this proposed solution, stage 1 to 2 and 2 to 3 can be controlled if proper measures and actions are taken before a stage 3 arrives. The quick spread occurs through the medical professionals because of the following reasons:

1. Receptionists in the hospital who comes in contact with the corona infected patient spreads the disease to the other workers or patients in the hospital, thereby pushing the disease to the next stage.

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2. **Nurses who are responsible for delivering the medicines or other health-care essentials to the patients, touches the things or instruments placed within the premises of the hospital.**

3. **Doctors who are responsible for checking the patient are at the highest risk of getting infected, thereby transferring the infection to other patients or medical staff. Thus, it becomes precarious to treat Covid-19 patients until or unless the proper medication is formulated.**

Therefore, owing to these reasons or issues, stage advancement becomes rapid in countries. This research paper proposes two-step architecture to overcome the above mentioned problems for disease spread across nations. Next section gives DBCMS architecture followed by call tracing mechanism using Global Positioning System (GPS).

3. **Architecture for DBCMS**

The proposed architecture is a three-layer approach in which the first layer operates on the working of collecting samples as shown in Fig. 2, while the second layer works for critically ill patients who need consultation of the senior doctors or emergency admission in hospitals. Last but not least, the third layer is responsible for giving warnings to the higher authority to take other vital step to mitigate the problem of Covid-19 as the country has entered into stage-3. However, in the first step of layer-I, curfew or isolation for the people across the country is mandatory. Also, the given proposal is a city-based proposal, where an administrator has been assigned the responsibility for managing all the activities in Layer-I. The expert in Layer-I has to be professional drone expert. Further, the clustering mechanism is used to divide the area of different cities. The toll-free number is provided to the people and call would be diverted to the concerned city hospital if the distance falls within the range of its cluster. Every city hospital will have its cluster range (in Kilometers), and the same will be decided by the higher authorities.

Next is the Layer-II in which the patient gives a call to the Doctor who feels sick even after taking the prescribed medication. The contact number of Doctor would be mentioned on the medicine cover sent through the drone (in Layer I). The explanation of the proposed work can be seen in Fig. 3.
3.1. Clustering mechanism

Clustering cities is the categorization of cities partitioning the area into cluster zones so that the data in each subset can be vividly distinguished.

K-Means is one such method that falls in the type of partition clustering. Measurement of distance actually determines how to divide the elements in clustered zone and this is calculated on the basis of distance. The K-means algorithm clusters ‘m’ objects on the basis of attributes into ‘K’ partitions and here $K < m$. Further, it presumes that the object attributes form a vector space. K-means for clustering ‘M’ data points into ‘K’ disjoint subsets $Z_n$.

$$J = \sum_{j=1}^{K} \sum_{m \in Z_j} |x_m - u_j|^2$$  \hspace{1cm} (1)

Where $x_m$ is a vector representing the $m^{th}$ data point and $\mu_j$ is the geometric centroid of the data points in $Z_n$.

Below Fig. 5 represents the clustering process of the cities:

4. Working of DBCMS

The working of the proposed Drone Based Covid-19 Medical Service (DBCMS) architecture is categorized into 3 layers, each of which is explained in detail as follows:

4.1. Layer-I (Blood sample collection)

In this layer, the patient calls the reception area of the hospital, where the patient first of all tells his or her symptoms to the receptionist as shown in Fig. 2. The receptionist then matches the symptoms of the patient with the symptoms of Covid-19 disease, which may include any two or more of the following (As per World Health Organization website):

- Fever,
- Dry Cough
- Tiredness
- Shortness of breath
- Aches
- Runny nose and

**Diarrhoea**

Meanwhile, the data of that particular patient which includes GPS location gets automatically tracked via GPS tracker and is stored in the database of the hospital. Fig. 6 shows the way of getting the GPS location of a patient who is ill. When patient calls the receptionist, the receptionist asks the patient to forward his or her current location on
a dedicated whatsapp number. The patient shares the information with the receptionist. The receptionist stores the details of the patient in a database with a unique ID (Phone Number) to identify the patient for any future reference.

The receptionist adds additional information to the database that includes a unique ID (Phone Number), full name of patient, primary and secondary contact details, along with age, sex and if the symptoms appear to match with the Covid-19. The same is then forwarded to the concerned available Doctor immediately either personally or through other electronic media. The Doctor verifies the symptoms and further asks the Nurse to be ready the Blood Sample Collection Kit (Covid-19 IgM/IgG Rapid Test Kit) in case the verification is successful, otherwise prescribes the medicine as per the symptoms by a call. The Nurse inturn handovers the packed blood sample kit along with GPS information and contact number to the drone expert. The drone expert sets the One Time Password (OTP) and fits the blood sample kit in the box installed on the drone and sets an OTP for Lock/Unlock purpose. The expert also sends the same OTP via message to the patient on his contact number for unlocking the kit placed in a box. When the kit successfully delivers to the destination, the patient who receives the OTP unlocks the box and gives his blood sample through Covid-19 IgM/IgG Rapid Test Kit and again lock with the same OTP code. The drone is then directed towards the Laboratory (LAB) in the same hospital. The setting of the LAB’s location is pre-fixed by the expert in the drone. Pathologist in the LAB evaluates the report and sends the report to the concerned Doctor. In case, the outcome of the report is positive, the Doctor hands over the prescribed medicine to the Nurse. The Nurse collects the medicines from the medical store and handovers the same to the drone expert. The drone expert again sets up the GPS location along with the OTP on the drone. The OTP is sent to the patient on his mobile number. The drone then flies to the respective location and patient unlocks the medicine kit by the received OTP. However, if the patient gets recovered, then no further action is needed, but if the patient still feels sick, then the emergency call made by the patient gets diverted to the concerned Doctor. The toll free number for emergency call is provided on the prescribed medicine kit received by the patient.

4.2. Layer-II (Critically unwell patients)

The working of Layer-II begins after an emergency call is made by the patient. The Doctor arranges an ambulance for the patient for home pickup; meanwhile, also calls the senior Doctor to give an alert about the upcoming Corona positive patient. The senior Doctor sets up his position in the isolation ward where the patient is to be brought by an ambulance. Doctor then treats the patient by putting him or her on the ventilator. If the ventilator treatment is successful and the person recovers, the patient is sent back to his home. Otherwise, the treatment will continue. However, if the treatment fails and the patient dies, the body will be sent to the graveyard directly.

4.3. Layer-III (Uncontrolled emergency warning)

The third layer is the warning layer in which if the number of patients exceeds the threshold value, the city emergency will be declared by the Doctor, and the same will be intimated to the higher authority for further necessary steps. However, if proper protocol is followed as per the layer-I and layer-II, this situation will not occur. As per the proposed solution, the threshold value mentioned above will be decided by the respective administrator of the city hospital as per the number of beds and ventilators available in the hospital.

Conclusion

This paper proposed an efficient dual step method that helps to eradicate the problem of widespread disease (Covid-19). Doctors and medical staff are most prone to the infection and if their safety is not considered to be important, then it may lead to spread of infection to other patients who suffer from other medical problems and are admitted to the hospital or visits hospital for regular checkups. Further a DBCMS method can work effectively if implemented city wise (clustered manner) in the different states. In this way, the spread of disease can be controlled effectively across different nations across the world.

Declaration of Competing Interest

“Mohit Angurala, Manju Bala, Sukhivinder Singh Bamber, Prabhdeep Singh, and Rajbir Kaur” declare that there is no conflict of interest regarding the publication of this paper.

Future Work

The work presented here still suffers from some issues which must be further improved. Self battery depletion problem of Drones could be a problem, and therefore, novel techniques for recharging them should be implemented to overcome this problem.

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