

# IoT Applications for Different Phases of Covid-19: A Review

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## Abstract

The Internet of Things (IoT) has recently captured persuasive research foundation as a novel research area in an extensive range of educational and business disciplines, particularly in Medical-care. The IoT innovation is improving contemporary Medical-care services by integrating technical, commercial, and communal prospects. Medical-care systems are progressing from traditional to more custom-made medical systems, which has made examination, surgery and monitoring uncomplicated for patients. The ongoing worldwide threat of the pandemic originated by the new serious infectious lungs disease coronavirus 2 presents the extreme worldwide communal health catastrophe from the time when the pandemic influenza plague of 1918. The total cases of COVID-19 had reached more than 93 million worldwide. Subsequently the pandemic ongoing, there has been a speedy struggle in various research groups to utilize an extensive category of technologies to fight this global danger, and IoT is one of the innovators in this extent. In the situation of COVID-19, IoT supported gadgets are used to lesser the probable transmission of COVID-19 to other people by timely identification, observing victims, and performing well-defined practices once patient healing. This article reviews the functionality of IoT-based equipment used in fighting against the COVID-19 in three core phases, which comprises of early diagnosis, quarantine time, and after recovery.

## Keywords:

COVID-19; Pandemic; Internet of Things; Healthcare; Medical IoT

## 1. Introduction

An expansion in the utilization of versatile innovation and shrewd gadgets in the medical services area brings about a critical effect on the world. Possible advancement of new savvy and ground-breaking gadgets for checking of people's wellbeing, wellbeing specialists are exploiting these advances, consequently a considerable improvement in medical services in clinical settings and out of them. IoT permits incorporating actual gadgets equipped for associating with the Internet and gives constant wellbeing status of the patients to specialists. Constant illnesses, for example, diabetes, heart, circulatory strain are surprising on the planet financial and social level issues. It can likewise give a stage that permits general wellbeing offices to get to the information for checking COVID-19 pandemic. New cases in the USA are expanding quickly than in different

nations. China has controlled the Covid-19, thus the pace of expansion in new cases in China is the most minimal.

### 1.1 Overview of COVID-19

Coronavirus 2019 (COVID-19) initially perceived in 2019 December in Wuhan China is most new respiratory infection epidemic right now tormenting worldwide wellbeing. The whole world is influenced by the novel Covid (SARS-CoV-2) pandemic that was accounted for from Wuhan, China, on 31 December 2019 presently named Corona Virus Disease 2019 (COVID-19). It is the quickest spreading irresistible infection which is bringing about another danger to general wellbeing universally. It demonstrated brought about by a different Covid, extreme intense respiratory disorder Covid 2 (SARS-CoV-2) is fundamentally identified with infection which grounds SARS. Li et al. characterized an alleged COVID-19 instance as pneumonia that coordinated associated four models: (1) fever with or without a chronicled disease: (2) radiographic evidence of pneumonia: (3) typical or little white cell monitor or short lymphocyte tally: also [4] not any decrease in side effects later antimicrobial cure for 3 days [1]. As appellation recommends main source of casualty as of COVID-19 is hypoxic respiratory displeasure [2–4]. Coronavirus presented huge difficulties for clinical also nonmilitary personnel networks practically equivalent to what was knowledgeable about two going before examples of SARS-CoV infection flare-up vogueish 2002 similarly 2003, 2012 in Middle East Respiratory Syndrome (MERS) [1, 5, 6]. Meaningfully Li et al. anticipated 425 patients by avowed COVID-19 in Wuhan also assessed that vital multiplication numeral (R0) aimed at SARS-CoV-2 at that fact to be 2.2 [1]. By and large, can spread the contamination to a normal of 2.2 others. The infection will probably keep on spreading except if this number falls underneath 1.0 [5]. Also, ideal and successful regulation actions have been a foundation of dealing with COVID-19 episode also decreasing virus-related transmission.

## 1.2 Internet of Things for Healthcare

A increasing interest of figure wearable sensors has as of late arose by means of integral assets aimed at medical services applications also various devices are at present accessible economically aimed at various purposes as well as individual medical services, crusade mindfulness besides goodness. Analysts similarly have planned novel clinical usages of such improvements aimed at frameworks of distant wellbeing perceiving which incorporate functionalities for extensive haul status footage and clinical admittance to bodily data of the patient [7]. Maximum distant wellbeing checking proposed systems has engineering of a three level body sensor network level which include a wearable sensors functions as units for info obtaining for example circulatory strain heart status also internal heat level subsequent level include correspondence also organizing plus administration which collects info from sensors then sent it [8, 9]. The third level includes making as well as examining centers.

## 2. Significant Role of IoT in Covid-19

Since mid-2020, the world has been battling with the pandemic brought about by the distinctive extreme respiratory disorder Covid 2 by endeavoring to control the uncommon spread of the infection and build up an antibody [10]. As most prominent endeavors to discover a treatment or control the spread of the COVID-19 have not demonstrated sufficient outcomes up until this point, there is a great request for overall checking of patients using suggestive also asymptomatic COVID-19 disease. Figure 1 depicts the importance of IoT in Covid-19.

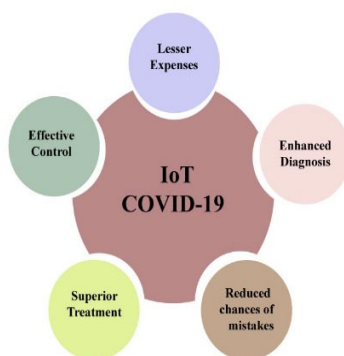


Fig. 1. Importance of IoT in Covid-19

As of late, IoT innovation has gotten significant consideration in the medical services field where it assumes a critical part in assorted phases of different

irresistible illnesses [11]. In the present pandemic, as the chance of COVID-19 is great, here is a significant requirement aimed at patients to be associated with also checked via their doctors' proactively vogueish assorted periods of COVID-19. Vogueish this examination, we inspect the IoT part innovation provide answer toward COVID-19 among three fundamental stages checking initial determination, isolate time and later recuperation. Throughout the principal period of COVID-19, which give early diagnosis [12], here is an indispensable requirement for quicker finding because of the high pace of infectiousness of COVID-19 where even an asymptomatic patient can easily spread the infection to other people. The preferably the patient is analyzed, the well the spread of the infection can be controlled then the patient can have suitable treatment. Indeed, IoT gadgets accelerate recognition cycle through catching data by patients. This can be applied by catching internal heat levels utilizing different gadgets, taking examples from suspicious cases, etc.

The subsequent stage, named quarantine time [13], is a critical time of this sickness after the patient has been determined to have COVID-19, and the individual ought to be isolated for the course of therapy. IoT gadgets in this time can screen patients remotely [14] as for their fixes and stay at home requests by the specialists. They can likewise clean districts without human collaborations. Instances of these sorts are the execution of following wearable groups, sanitizing gadgets, and so forth.

As per the Centers for Disease Control and Prevention (CDC) [15], most extreme individuals with slight manifestations can recuperate while remaining at home without getting medicines, yet there is no affirmation those individuals won't be re tainted after recuperation. Reinfection may occur with divergent indications of COVID-19 [16]. Concerning these conceivable reinfections in the after recuperation stage, the probabilities of returning manifestations and the potential infectivity can be high. To stop that event, social separating ought to be applied by sending IoT gadgets including groups, swarm checking gadgets, and so on to follow individuals to guarantee the reasonable distance is kept up. So, IoT innovation during the COVID-19 pandemic has affirmed its value in helping patients, medical care suppliers, and specialists. In this segment, we transitorily clarify the different IoT gadgets and applications tallying wearables, drones, robots, IoT catches, and cell phone applications that are generally used in the bleeding edge of battling COVID-19. The

Table I records particulars of these innovations concerning this pandemic.

## 2.1 Wearables

Wearables can be defined as gadgets shared with whatever that can be put on. The definition introduced by Juniper Research characterizes them as application empowered registering advancements that get and measure input while they are either worn or adhere to the body, for example, groups, glasses, watches, and so on [17 – 19]. These keen wearables were intended for disparate purposes in various areas, for example, medical care, wellness, way of life, etc. Despite the fact that the protection of information is as yet a significant issue for extending these gadgets, it is anticipated that medical services suppliers will burn through \$20 billion every year until 2023 on wearable IoT gadgets to screen further patients [20]. IoT wearable gadgets cover a shifted scope of various savvy wearable instruments, for example, Smart Thermometers [21, 22], Smart Helmets [23], Smart Glasses [24], IoT-Q-Band [25], Easy Band [26], and Proximity Trace [27]. Table II shows all wearable gadgets concerning their grouping with models.

## 2.2 Drones

Robots are simply airplane that are flown with no or slight human activity by far off checking. In 1849, during a battle among Italy and Austria, the principal drone, which was an inflatable furnished with bombs, was utilized [28]. The robot is otherwise called an automated airborne vehicle (UAV) that works by the guide of GPS, sensors, and correspondence administrations. IoT utilization inside robots, called as Internet of Drone Things (IoDT) styles it plausible on behalf of robots to do a range of errands, for example, looking, observing, conveying, and so forth [29]. Smart drones might be worked via a cell phone also a regulator through at least time also energy which makes them solid in various fields for example, farming, military, medical

services, and so forth Various kinds of IoT based robots, as well as Thermal Imaging Drone [30], Disinfectant Drone [31], Medical Drone [32], Surveillance Drone [33], Announcement Drone [34], and multipurpose drone [35] also are utilized vogueish the medical care area and, in explicit, in the battle against COVID-19, will be talked about in this paper. An outline of such robots, alongside their models, can be institute in Table III.

## 2.3 Robots

As per Merriam Webster word reference, a robot named "a machine that looks like a living animal in being fit for moving freely." By way of a movement throughout the arranged robots development inside cloud and Internet of Robot Things was executed where it can do a few different errands to make life simpler [36]. With respect to introduce pandemic, robots can be arranged as Autonomous robots [37], Tele robots [38], Collaborative robots [39], and Social robots [40]. Table IV covers the basic highlights of these robots with models.

## 2.4 Smartphone Applications

Cell phone applications are application programming intended to do restricted tasks inside a cell phone, for example, a cell phone. Since there are 3.5 billion dynamic cell phones in 2020, these IoT based cell phone applications could be successful in different fields, for example, medical care, retail, farming, and so on [41]. Various cell phone applications have been produced for medical services space, and few of them have been used in counter toward COVID-19, as charted in Table VI, in particular DetectaChem [42], nCapp [43], Social Monitoring [44], Stop Corona [45], Civitas [46], Selfie application [47], AarogyaSetu [48], eRouska [49], Hamagen [50], Coalition [51], BeAware Bahrain [52], TraceTogether [53], StayHomeSafe [54], and WhatsApp [55].

**Table 1:** IoT Devices during COVID-19

<i>Devices</i>	<i>Description</i>	<i>Pros</i>	<i>Cons</i>
<b>Wearable [17]</b>	An app-enabled technology for receiving and processing data that is worn on or stick to the body	<ul style="list-style-type: none"> <li>• Consistent monitoring</li> <li>• Improving the quality of patient's medicare</li> <li>• Safer and more efficient hospitals</li> <li>• Lowering hospital visit</li> </ul>	<ul style="list-style-type: none"> <li>• Security and privacy of data</li> <li>• Short battery life</li> </ul>

<b>Drones [28]</b>	An aircraft equipped with sensors and cameras, GPS and communication systems which is flown with less or no human interactions	Perform variety of tasks such as (searching, monitoring, delivering) • Reach to hard-access locations • Lower the workers' interactions such as maintaining	• Quality of Service • Low connections • Security issue (large unstructured data)
<b>Robots [36]</b>	A programmable machine which can handles complex actions like a living creature	• Lowering interactions by remote diagnosis and treatments • Maintaining such as cleaning and disinfecting	• Bias and Privacy concerns • Reduce mental health problems
<b>Smartphone Applications [41]</b>	An application software designed to do limited tasks within a mobile device	• Cost-effective • Monitoring and Tracking	• Collected data privacy and Security

### 3. First Phase: Early Diagnosis

The way toward fighting COVID-19 is toward analyze it right on time on the road to forestall dissemination the infection generally. It will generously assist medical care suppliers toward mastermind healthier therapy plans, save more lives, also lessen pollution plus diseases. The initial phase in the initial analysis of COVID-19 is understanding its manifestations. As specified by the CDC in September 2020 COVID-19 has a varied scope of manifestations counting chills or fever, tiredness, cerebral pain, hack, muscle or body hurts, windedness or unease breathing, novel loss of smell or taste, clog or goeey nose, sore throat, retching or sickness, besides loose bowels. Among them, high or fever internal heat level is perhaps the most well-known manifestations of COVID-19 when the deliberate temperature surpasses 100.4 Degrees Fahrenheit or 38 Degrees Celsius [56]. IoT gadgets can make recognition cycle quicker and further effective through catching information inside their sensors also afterward dissecting the information aimed at patients, medical care suppliers, also specialists toward control, analyze, and eventually halt this infectious sickness [57]. Diverse gadgets of IoT might be utilized toward catch a portion of previously mentioned manifestations on a beginning phase that will be talked about in following subcategories.

#### 3.1 Wearables

Using wearable devices is consider as a well-organized means in retort to necessity for initial diagnosis throughout this epidemic [58]. Mounting such devices has ensured an extraordinary effect on preliminary uncovering of ailments. For instance wearable IoT gadget may sanction either respiratory symptoms of a sufferer is common or not. By such information patient may get slightly ups and downs in his/her health condition also choose to sort a medical appointment in advance a little further signs seem [59]. COVID-19 disease may be calmer to fight via proper wearable gadgets.

##### 3.1.1 Smart Thermometers

An extensive ranging possibility of IoT intense thermometers has been formed towards collect reliable estimations of inner heat levels. Such minimal effort, exact, simple to utilize gadgets could be worn or else adhere to skin under dress [22]. They are normally vacant in various structures, for example, contact, radiometric, and fix [22]. The application of these gadgets can be amazingly useful in early recognition of doubtful cases. Likewise, since utilization of infrared thermometers aimed at catching internal heat level can spread the infection more because of the closeness of patients and medical services suppliers, utilizing keen thermometers is strongly suggested

**Table 2:** Wearable devices used in different phases of Covid-19

<i>IOT based Devices</i>	<i>Functions</i>	<i>Phase</i>	<i>Example</i>
<b>Smart Thermometer [21,22]</b>	<ul style="list-style-type: none"> <li>• Temperature monitoring</li> <li>• Increasing the diagnosis rate</li> </ul>	I	Kinsa, Tempdrop, Rans Night, iFever, iSense
<b>Smart Helmet [23]</b>	<ul style="list-style-type: none"> <li>• Temperature monitoring</li> <li>• Capturing location and face image</li> <li>• Less human interactions</li> </ul>	I	KC N901 in China

<b>Smart Glasses</b> [24]	<ul style="list-style-type: none"> <li>• Temperature monitoring and capturing</li> <li>• Less human interactions</li> </ul>	I	Rokid in China, Vuzix & Onsight
<b>IOT-Q- Band</b> [25]	<ul style="list-style-type: none"> <li>• Tracking quarantined objects</li> <li>• Cost-effective tracking</li> <li>• Destructible</li> </ul>	II	Hong Kong electronic wristband, Electronic ankle bracelet in USA
<b>EasyBand</b> [26]	<ul style="list-style-type: none"> <li>• Monitoring social distancing practice by people</li> <li>• Alert the danger of closeness by LED</li> </ul>	III	Pact wristband
<b>Proximity Trace</b> [27]	<ul style="list-style-type: none"> <li>• Monitoring workers for the social distancing practice</li> <li>• Tracing contacts of contaminated employee</li> </ul>	III	Instant Trace Hardhat TraceTag

[30]. As indicated by [60], thermometers of Kinsa have been broadly utilized in homes also the maker is presently ready toward foresee the utmost dubious territories (tainted by COVID-19) in every situation of USA dependent on chronicled fever of individuals. Supplementary savvy thermometers for example Tempdrop, iSense, Ran's Night plus iFever (appeared in Fig. 2) can account internal heat level whenever on a cell phone. Utilizing these gadgets in individuals' everyday lives may progress opportunity of spotting novel patients at initial point.



Fig. 2. Wearable Smart Thermometers [22]

### 3.1.2 Smart Helmet

In time of COVID-19 sickness by methods for savvy protective caps through a warm camera has uncovered to

### 3.1.3 Smart Glasses

New category of gadget is IoT founded savvy spectacles by way of seemed in Fig. 4. Correlation thru

be innocuous compared to an infrared thermometer weapon because of second rate human contacts [30]. In this gadget when incredible temperature is detected by warm camera on shrewd protective cap area additionally picture of the essence of individual are taken through an optical camera. At that point they shipped off dispensed cell phone by an alert as appeared in Fig. 3, with the goal that wellbeing official may separate the infected individual, and additionally specialists can continues activity [23]. Also, Google Location History might be bound together by savvy head protector to get places visited by supposed individual in the wake of uncovering [61]. Republics, for example, China, Italy, additionally UAE have applied this wearable gadget to notice masses in two meters from spectators [62]. Curiously this model has uncovered commendable results. For instance KC N901 is a shrewd cap shaped in China which has an exactness of 96 percent for high internal heat level finding [62].

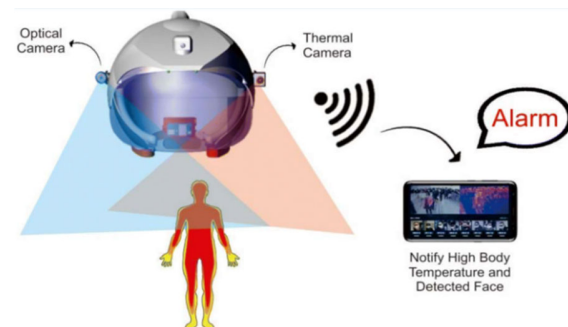


Fig. 3. Smart helmet identify temperature via thermal and optical cameras [23]

thermometer weapons keen spectacles devour slighter human influences. Optical plus warm cameras have been applied in shrewd spectacles to screen swarms [24] also fundamental face discovery innovation sorts following

strategy simpler in the wake of recognizing dubious cases. Truth be told, this permits recognizing the distinguishing proof of doubtful case (individual with great temperature). Furthermore, Google Location History might enable more activities by greater unwavering quality thru catching spots visited by dubious case [24]. Amongst various Rokid, keen glasses [63], shrewd glasses by infrared sensors, can screen equal to 200 individuals. Additional illustration of gadget is blend of Vuzix brilliant glasses by Onsight Cube deep camera (see Fig.5). These gadgets cooperate toward screen groups to identify individuals with great temperatures and give their data toward clinical specialists or focuses [64].



Fig. 4. Smart Glasses for capturing temperature [24]

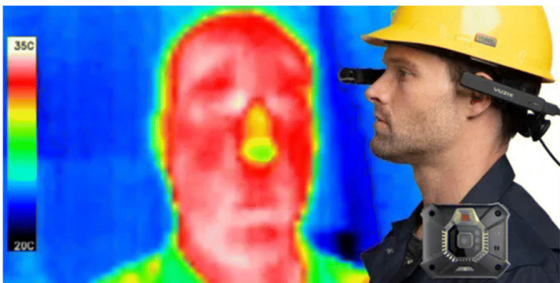


Figure 5. Vuzix Smart Glass [64]

### 3.2 Drones

As a rule, finding contaminated individuals in a group is significant in initial conclusion similarly manage of COVID-19 [65]. By means of Automated Ariel Vehicles (UAV) besides mainly IoT founded robots is one more normal method toward accelerate way toward verdict debased individuals also zones through this pandemic. Robot innovation might decrease human cooperation also can arrive at hard to get to areas [66]. Thermal Imaging Drone as appeared in Fig. 6 intended

aimed at catching temperature of individuals in groups also can be utilized in the initial determination stage. This sort of robot might be joined by Virtual Reality as a wearable gadget toward distinguish individuals with great temperatures (fevers). This gadget diminishes human communications, yet it additionally utilizes less time contrasted with thermometer weapon gadgets [30]. Single illustration of this gadget is Pandemic Drone application created through a Canadian organization [67] aimed at far off observing plus distinguishing a little instances of contamination by temperature, catching, respiratory signs, for example, pulse, and any wheezing or hacking [68].



Fig. 6. Thermal Imaging Drone [30]

### 3.3 Robots

Utilizing robots connected to IoT to help early determination is an amazing utilization of these gadgets since they can help wellbeing laborers by preparing patients' medicines and bringing down work feelings of anxiety [69]. Without connection of people, self-ruling robot can aid battle in entirely COVID-19 stages. In primary stage, it can aid cycle of finding through gathering throat gauzes tests from patients with upside of forestalling clinical team in danger (nearby contact with patients) [37]. Fig. 7 portrays how cycle functions. A design of this gadget Intelligent Care Robot has been shaped complete an association among two organizations, Meditemi [71] and Vayyar Imaging [70]. This gadget recognizes indications of COVID-19 out of 10 seconds through utilizing touchless snappy examining of an individual

Table 3: Drones during Covid-19

<i>IOT based Devices</i>	<i>Functions</i>	<i>Phase</i>	<i>Example</i>
<b>Thermal Imaging Drone [30]</b>	<ul style="list-style-type: none"> <li>• Temperature capturing in the crowd</li> <li>• Less Human Interaction</li> </ul>	I	Pandemic Drone
<b>Disinfectant Drone [31]</b>	<ul style="list-style-type: none"> <li>• Sterilizing Contaminated Areas</li> <li>• Preventing health workers from being infected</li> <li>• Less human interactions</li> </ul>	II	DJI
<b>Medical Drone [32]</b>	<ul style="list-style-type: none"> <li>• Reducing the hospital visits</li> <li>• Increasing accessibility to treatments</li> </ul>	II , III	Delivery Drone Canada
<b>Surveillance Drone [33]</b>	<ul style="list-style-type: none"> <li>• Crowd social distancing monitoring</li> </ul>	III	Micro MultiCopter Cyient
<b>Announcement Drone [34]</b>	<ul style="list-style-type: none"> <li>• Broadcasting information about COVID-19</li> </ul>	III	Broadcasting drone in Spain and Kuwait
<b>Multipurpose Drone [35]</b>	<ul style="list-style-type: none"> <li>• Temperature capturing</li> <li>• Disinfecting areas</li> <li>• Crowd monitoring</li> <li>• Broadcasting information</li> </ul>	I, II, III	Corona Combat

inside a remoteness of 1 meter toward catch respiratory symptoms also temperature [72].

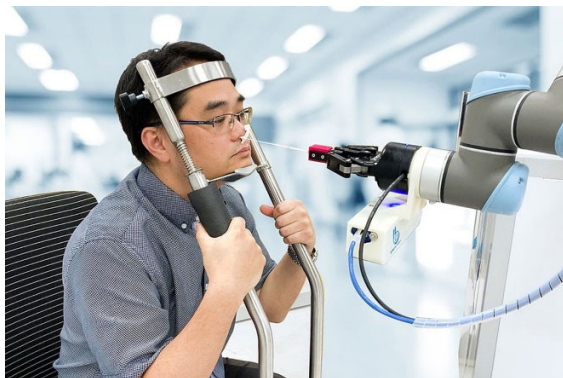


Fig. 7. Autonomous swab test robot

### 3.4 Smartphone Applications

Cell phone applications empowered with IoT utilizing data for example Global Positioning System (GPS) similarly Geographic Information System (GIS) then so forth aimed at following drives have been broadly utilized during COVID-19 pandemic toward expand opportunity of distinguishing contaminated individuals [41]. Executing cell phone applications engaging Internet of Medical Things (IoMT) going to support sufferer through giving them appropriate therapies whereas they are at home. Individuals can transfer their wellbeing data to the cloud received by IoT and get wellbeing guidance from medical clinics on the web. Utilizing this stage, patients might be reinstated at

home without growing pollution. It charges not exactly consuming an actual arrangement at clinics also permits legislatures to make a superior move to deal with the pandemic later on [73]. Since beginning of the pandemic some cell phone apps have been produced for COVID-19 conclusion also observing which will be talked about in the upcoming segments

#### 3.4.1 nCapp

Coronavirus Intelligent Analysis as well as Treatment Assistant Program (nCapp) shaped in China employing Web of Health Belongings on cloud stage. Such cell phone app is a mechanized finding framework with eight capacities that can be chosen by the client. nCapp can naturally create an analysis report dependent on mentioned information and surveys presented through patients. Conclusion is arranged keen on three cases: affirmed, dubious, or suspected. For the affirmed cases there are four conditions, counting "gentle, temperate, extreme, also basic are controlled by a doctor. Extraordinary medicines for these situations and different kinds of cases are characterized too. Other optimistic purposes of this sequence remember refreshing its own information base for request to improve its conclusion, making conference feasible for all wellbeing laborers, ensuring each patients are protected in long haul, lastly, having every one of these capacities freely accessible. When all is said in done, by utilizing nCapp the conclusion should be possible quicker and wide spread of sickness may be controlled simpler [43].

### 3.4.2 MobileDetect

Appeal intended aimed at a framework that be able to distinguish tainted individuals has prompted execution of MobileDetect application [42]. MobileDetect is viable with a varied assortment of cell phones is intended to recognize also control magnitude of COVID-19. Utilizing this app clients might undoubtedly step through exam on home using a muffled swab. Aftereffects of the test will appear on cell phone application inside 10 to 30 minutes deciding client's wellbeing circumstance with respect to COVID-19. At that point, the client can send the outcomes with any extra data expected to his/her doctor or medical care proficient for additional activity. This cell phone testing unit approved by Food also Drug Administration (FDA) under crisis entrance may be useful throughout primary period of a pandemic through bringing down spread of infection [42].

### 3.4.3 Stop Corona

Other than entirely usage aimed at initial case location, one more methodology is consuming an information base of caught every day wellbeing information. The reports incorporate communicate with others, indications, also areas. Stop Corona application [45] prescient heat maps dependent on illness spots. Such application gathers data by its clients around their day by day wellbeing status also create report and heat maps dependent on that. Created report will be available just toward wellbeing specialists. Subsequently, when a client shows another indication and declares it, incident will be show up on new report also at last specialists will have the option toward make an appropriate move and distinguish the debased territory quicker due to the reported new manifestations.

## 4. Second Phase: Quarantine Time

Subsequently cycle of recognition it is important toward disengage also afterward screening patients whether in a hospital or at home. Isolate doesn't just apply to affirm cases yet in addition can be measured for alleged patients also even various zones or city areas or states [74]. After being diagnosed of corona, the patient have to stay at home, isolate himself in as separate room away from other family members, so that the virus don't transfer to other people. The duration of isolation depend on recovery speed. This is completed to keep conceivable transmission from alleged cases or regions toward other people. Using IoT gadgets at this stage could aid moderate genuine difficulties, for example, dispersion infection thru screen patients proficiently also

control their respiratory pulse, circulatory strain, signs, etc. [75].

### 4.1 Wearables

Isolate time aimed at affirmed or alleged cases is imperative on the grounds that there is an opportunity of dispersion the infection to others by such cases.

#### 4.1.1 IoT-Q-Band

IoT wearable gatherings have set up favorable results toward shield patients from stopping disengage domains. Utilizing wearable gatherings is a functional answer focused on ensuing cases. This gadget is related with perseverance mobile phone application over Bluetooth all through disengage period and clinical administrations experts may typically screen entire cases at ordinary stretches by means of a net interface. Furthermore vulnerability a sufferer doesn't have posse on their leg or arm potentially stops separate zone, alert will be transported off guidance trained professionals and they have agree to call patient for explanation of situation. Fig. 8 displays a wearable band called IoT-Q Band work measure. Such technique has been directed in Hong Kong where an electric wristband associated by a wireless application toward follow novel makes a big appearance at the air terminals for 14 days [54], [76]. Moreover, specialists in United States have executed one more sort of this model by means of electronic lower leg arm groups (lower leg screens) to separate people who won't stay in detach [77].

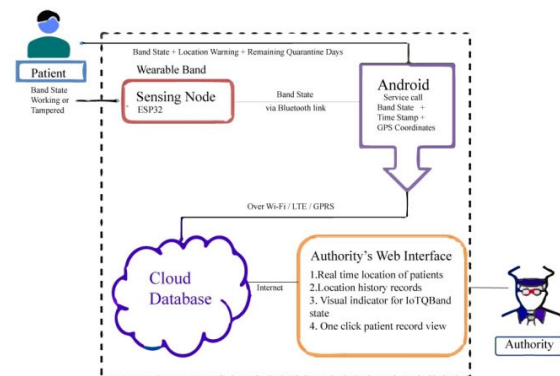


Fig. 8. IoT-Q Band workplace classification [25]

### 4.2 Drones

Using drones expects a huge occupation during seclude time to lessen the amount of COVID-19 cases by cutting down the joint effort of clinical administrations workers through patients also contaminated regions. For



instance, drones in such stage may help clinical consideration workers also

**Table 4:** Robot devices during covid-19

<i>IOT based Devices</i>	<i>Functions</i>	<i>Phase</i>	<i>Example</i>
<b>Autonomous Robots [37]</b>	<ul style="list-style-type: none"> <li>• Detecting symptoms</li> <li>• Controlling social distancing</li> <li>• Disinfecting and sterilizing contaminated areas in hospitals</li> <li>• Checking patients' respiratory signs</li> <li>• Collecting swab test</li> </ul>	I, II, III	Intelligent Care Robot Spot Robot
<b>Tele Robots [38]</b>	<ul style="list-style-type: none"> <li>• Reducing the risk of infection for medical staff</li> </ul>	II	DaVinci surgical robots
<b>Collaborative Robots [39]</b>	<ul style="list-style-type: none"> <li>• Lower healthcare workers' fatigue</li> <li>• Disinfecting hard-to-reach areas</li> </ul>	II	eXtremeDisinfection Robot Asimov Robotics
<b>Social Robots [40]</b>	<ul style="list-style-type: none"> <li>• Reducing mental strain</li> </ul>	II	Paro

patients via sterilizing zones or passing on clinical cures to patients [78].

*4.2.1 Disinfectant Drone*

Keeping zones sterilized and sanitized during the isolate period is significant and this may be accomplished through utilizing specific sort of robot named a Disinfectant Drone [82] (See Fig. 9). Such robots may lessen pollution of infection besides furthermore forestall medical services laborers from receiving tainted. Company DJI delivered such robot with capacity toward clean 100 meters in a single hour. Such sort of robot has additionally been utilized in Spain aimed at sterilizing purposes [81].



**Fig. 9.** Disinfectant Drone [66]

*4.2.2 Medical or Delivery Drone*

Clinical robots have established their capability toward starting period of COVID-19 wherever they move COVID-19 test units, tests, or else clinical provides among labs plus clinical concentrations toward get rid of human being coordinated efforts. Moreover, such a robots generally lessen crisis facility visits and addition permission to clinical thought by passing on clinical cures to patients or alternative clinical concentrate quickly. Figure 10 is depicting the medical drone. For instance, by means of clinical robots in China and Ghana has accelerated end through cutting transport period [79]. One more sort of transport drone throughout COVID-19 made through Delivery Drone Canada Inc., which can transfer COVID associated items, counting test units also swab tests. Such sort of robot may be furthermore used aimed at various initiatives, for instance, postal and staple organizations though COVID-19 attested cases are segregated in their homes during the seclude time [80].



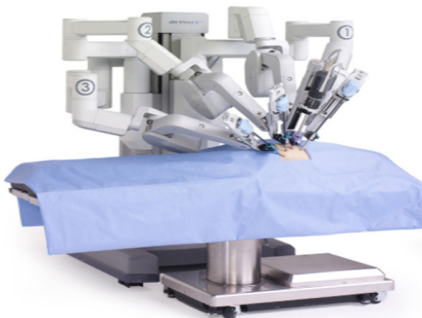
**Fig. 10.** Medical drone transferring medical related [66]

### 4.3 Robots

During the isolate time stage, robots assume a significant part in getting clinical staff far from separated patients [83]. For instance, robots can be utilized in an unexpected way, for example, catching respiratory symptoms also furnishing help toward patients by their medicines or food.

#### 4.3.1 Tele Robots

Telerobots are for the most part worked indirectly by a human and can offer different kinds of help, for instance, far away end, distant operations, and far away cures for patients while there is no human being correspondence throughout the cycle. For instance, a clinical specialist may check patients' high temperature without taking interchanges with them thru consuming these robots. Alternative model is daVinci cautious robot which is worked by a trained professional while patient is in ensured partition of plastic sheet as shown in fig. 11. This aids with preventing illnesses by acting operations distantly [84].



**Fig. 11.** DaVinci telerobot can prevent close contact between surgeon and patient during surgery [84]

#### 4.3.2 Collaborative Robots

Shared robots recognized as Cobots (Fig. 12) are proposed robots if here is a need aimed at a movement completed by individuals. They are not by way of invaluable as per telerobots for this epidemic, then instead throughout detach, this sort of robot may cut down clinical consideration workers' shortcoming similarly as way their interchanges by patients [38]. For example in India Asimov Robotics is proposed aimed at seclude time to assist patients in withdrew locales with chores, for instance, making food also giving medication then besides thwarting clinical consideration workers from being around there [39]. Alternative outline of this robot throughout this stage is eXtremeDisinfection robot

(XDBOT) that is executed through Nanyang Technological University in Singapore. Such robot may disinfectant hard toward get to regions, for instance, below a bed, also moreover may be distantly dealt with versatile stage toward avoids any nearby contact among individuals also contaminated locales [39], [85].



**Fig. 12.** Human operated collaborative robot

#### 4.3.3 Autonomous Robots

Self-administering robots have been aimed at the most part used throughout disconnect time phase. They work by less or no human being affiliations also can be used in different circumstances to disinfect spoiled districts in crisis facilities, pass on patients' prescriptions, and check their respiratory signs. These will achieve decreasing the threat of illness aimed at clinical consideration workers though patients are separated in their residences [86]. For instance disinfection robot made via Xenex [87] is prepared for cleaning besides decontaminating zones of diseases also microorganisms. Fig, 13 diagrams how Xenex robot isolates contamination by means of UV lights. Another model is UVD robots made through a Danish association are utilize for sanitizing clinical facilities with their tough UV light, which abolishes DNA of contamination [88].



**Fig. 13.** Xenex disinfectant autonomous robot [86]

**Table 5:** IoT enabled smartphone applications during covid-19

<i>Application Name</i>	<i>Function</i>	<i>Origin</i>	<i>Platform</i>	<i>Phase</i>	<i>Rating</i>	<i>Downloads</i>	<i>Review</i>
<b>nCapp [43]</b>	Keeps database updated Provide available consulting Controlling patients health in long-term	China	Cloud	I	-	-	-
<b>DetectaChem [42]</b>	Taking COVID-19 low-cost tests within a kit joined with a smartphone application	USA	Android	I	4.2	5,000+	31
<b>Stop Corona [45]</b>	Getting daily health reports including contact, symptoms and location Building a map with high risk spots	Croatia	Android, iOS	I	3.0	100,000+	3,448 total
<b>Social Monitoring [44]</b>	Track patients with the diagnose of COVID-19 Access to the user's information by government (privacy concern)	Russia	Under Development	II	-	-	-
<b>ClearSCAN app Selfie app [47]</b>	Monitoring patients by asking randomly to send selfies	Poland	Android	II	-	-	-
<b>StayHomeSafe [54]</b>	Monitoring arrivals at the airport with use of smartphone application and a wristband	Hong Kong		II	-	-	-
<b>TraceTogether [53]</b>	Notifying people who were in close contact with user if user is infected	Singapore	Android, iOS	III	3.1	1,000,000+	3,131
<b>Civitas [46]</b>	Determining perfect time for suspected cases to leave for essentials	Canada	Android	II		100	
<b>Coalition [51]</b>	Securely notifying about detected cases who users have been in contact with people	USA	Android, iOS	III	4.2	1,000+	21
<b>eRouska [49]</b>	Capturing physical contacts between user and people	Czech Republic	Android, iOS	III	3.6	1,000,000+	7,901
<b>Social Media-Whatsapp [55]</b>	Provide healthcare support without visiting hospital Available consulting with the physician	Singapore	Android, iOS, web	I, II, III	-	-	-
<b>COVID-19 Gov PK</b>	Posted about the total affected person by displaying dashboards for each province and state. Facilitate citizens for the availability of COVID19 Hospitals, ventilators, beds and testing laboratories near them.	Pakistan	Android, iOS	II, III	4.2	500,000+	6,951

#### 4.3.4 Social Robots

As demonstrated through CDC [89], separating also confining patients be able to possibly source mental prosperity issues as well. Toward thwart this social robots are planned to talk with patients throughout that time. Handiness of these robots in this epidemic is to aid reduce mental exhaustion also strain throughout detach also season of physical isolating [38]. Single outline of

such robots is Paro [40], which may aid patients throughout their control by way of a pressing factor easing device, as per showed up in Fig. 14.



**Fig. 14.** Paro social robot can prevent the effect of quarantine [38]

#### 4.4 Smartphone Applications

The most basic piece of an isolate is monitoring patients while they are disengaged. Following patients utilizing cell phones during isolate time is another generally utilized way to deal with alleviate and control the spread of this infection.

##### 4.4.1 Social Monitoring

A compulsory perception application named Social Monitoring in Russia [66] has been made through public power toward follow patients which are resolved to have COVID-19 also should be quarantined in their households. Patients are expected toward demand QR (Quick Response) code each period they need toward wander out from homebased or disengage zones [90].

##### 4.4.2 Selfie App

Such application was prepared in Poland consolidated by Geo-region also facial affirmation development toward follow patients who have been encouraged to halt at home intended for 14 days. Patients be able to excuse presenting this app yet therefore, they will develop astonishing visits as of subject matter experts. By means of application patients will be drawn nearer to direct selfies self-assertively unfailingly [47].

##### 4.4.3 Civitas

A Canadian wireless application that has been planned to cut down COVID-19's influence. With customer's distinctive verification code this app talks with experts to applicate an authority that lets customer toward take off from house [48].

##### 4.4.4 StayHomeSafe

StayHomeSafe application is measured by way of a blend of wireless applications also wearable gadgets [49]. It has been executed in Hong Kong where novel makes a big appearance at the air terminals are provided a wristband that may be coordinated by a PDA to set confine territory with potential gain of geo fencing development utilized by application.

### 5. Third Phase: After Recovery

The limitations set up reaction to the COVID-19 pandemic has devastatingly affected numerous organizations, commercial centers, and financial matters. Following quite a while of secured social orders and cruel limitations, countries are steadily and cautiously opening up once more. This is the stage that everybody needs to encounter with additional alert. Social separating and limitations on actual administrations should be executed in the manner to ensure the infection won't spread once more [91]. In such segment, we feature effort of IoT novelty in struggling COVID-19 epidemic later lockdown.

#### 5.1 Wearables

Meanwhile businesses are progressively taking employees back toward working environments, understudies are protection to schools also economy is recoiling back aimed at resuming, there ought to be approximately assurance procedures to protect everybody from this infection. Wearables are gadgets that may be used toward follow clients' nearby interactions with others also furthermore aware them if social removing isn't looked after [92].

##### 5.1.1 EasyBand

As countries bit by bit continue occupations and business focuses after lockdown Easy Band [26] is maybe best IoT contraptions toward guarantee people are performing social isolating. Such wearable contraption that is composed with Internet of Medical Things (IoMT) is recognizing also getting data as of various devices. Easy Band working inside a precise range also displays expected peril through its LED beams uncertainty individuals are uncommonly almost each other. Meant for example in case somebody wearing an Easy band gravitates toward to a different person inside 4 meters band will begin motioning to alert both also retell them to avoid each other. An equivalent model for such apparatus is Pact wristband [93] (see Fig. 15) that warns familiarity of persons by means of a vibrator and ringer.

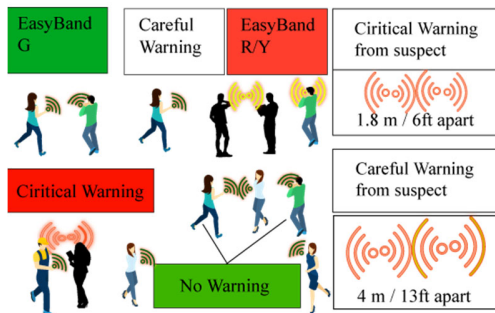


Fig. 15. Easy band process of tracking

5.1.2 Proximity Trace

This contraption helps mechanical experts with keeping up social isolating in every practical sense. Such device which may be annexed to a solid body or cap, cautions labors when they sink toward to each other by a clamorous sound. By means of this device laborers will have the alternative toward zero in on their slog devoid of obsessing around infection from disease. Fig. 16 demonstrations in what way this follow may twig to the mechanical experts' solid cap. Too, Instant Trace, showed up in Fig. 16 worn by way of an ID has very handiness which urges agents toward keep up social eliminating then follow tainted laborer's contacts [27] [92].



Fig. 16. Instant trace worn as badge [92]

5.2 Drones

As disease arrives After Rescue stage a huge number have been utilized because of the returning, which assists organizations with continuing working in a protected way. Expanding social mindfulness by observing the groups and broadcasting data is the principle reason for executing these gadgets throughout this phase.

5.2.1 Surveillance Drone

Surveillance drone was planned also created by way of a powerful method to screen jams if there should be an occurrence of individuals' inability to organize social eliminating. MicroMultiCopter [33] complete in China also Cyient [94] dual sorts of robot are from India. MicroMultiCopter drone consumes likewise been furnished using speakers toward declare significant data from specialists that will be talked about in following sort of robot inside such stage.

5.2.2 Announcement Drone

Such sort of robot is fundamentally proposed aimed at broadcasting in locales with little accessibility to Internet. For instance, specialists in Spain besides other European countries utilize such a robot to announce protest of social isolating also various standards by speakers [95]. Another country Kuwait used this robot to impart "get back" messages to persons in get-togethers [96] (see Fig.17).



Figure 17. Announcement Drone

5.2.3 Multipurpose Drone

A multipurpose robot termed Corona Battle, [35] has been done in China by blend of some excess categories of robots which may protect sum of planned targets referred to in three stages immediately. Such robot may be conceded on in any COVID-19 phases.

5.3 Robots

In period of after recuperation, everyone has to distinguish meaning of social eliminating wherever to alleviate spread of infection.

### 5.3.1 Autonomous Robots/ Spot Robot

As a result of this time of COVID-19, self-administering robots may be utilized toward power over social eliminating. For example Ad [97], a four legged robot agreed in Singapore in the direction of resemble a canine, retells people to practice social isolating straightforwardly puts. While this robot may be controlled distantly, it is moreover fit for moving data to a web interface aimed at additional noticing. [98]. Fig. 18 is Spot robot for checking demonstration of social isolating.



Fig. 18. Spot robot for social distancing

## 5.4 Smartphone Applications

Practice of IoT in medical care is currently growing also significant advantages are productive checking, cost viability, suitable therapy, less mix-ups, and outstanding findings [99]. Some cell phone applications have been grown explicitly in light of the pandemics challenges related with returning advance which will be shrouded in such portion.

### 5.4.1 Aarogya Setu

[100] is a connection subsequent app aimed at individuals toward practice on their cell phones toward expand familiarity with also battle in contradiction of this infection. Aarogya Setu is envisioned for improved correspondence among wellbeing specialist co-ops and individuals. In the application, the client will be inquired as to whether the person has any side effects of COVID-19 or has as of late voyaged universally. Dissecting the info information from the clients alongside their following data Aarogya Setu can advise the client on the off chance that the person has had contact with somebody who is now or later turns into an avowed case.

### 5.4.2 TraceTogether

An application named TraceTogether dispatched by Singapore [53] to find data by means of a mixed ID as of people who were in neighboring interaction with each other. Obtained data won't be used till a near, by communication recognizing verification is arrange. Such data consolidates term of visit also social remoteness will be taken care of for 21 days aimed at communication following causes later on.

### 5.4.3 Hamagen

This communication following app was made in Israel. Hamagen practices GPS development toward see whether the client has been hip neighboring communication with an individual who endeavored positive for COVID-19. In such app for assurance, private data won't leave the mobile phone till the customer settles on [50].

### 5.4.4 Coalition

Coalition [51] practices IoT advancement also square chain phase to provide a protected communication following system. In such application customers are allocated with sporadic IDs so that by acknowledgment of some fresh cases customers who were hip neighboring communication with individuals' cases will be educated.

### 5.4.5 BeAware Bahrain

An interaction following app completed in Bahrain such cautions individuals when they are pushing toward polluted zones by a distinguished COVID-19 incident or else uncertainty they were in neighboring connection by an inveterate incident [52].

### 5.4.6 eRouska

Such application screens also gets slightly closeness among its customers. Uncertainty one of clients' test turns positive designed aimed at COVID-19, such app will teach the more concerning the conceivable sickness so they can proceeds an action round their prosperity condition [49].

### 5.4.7 Social Media – Whatsapp

World has about 3.8 billion customers by means of online media as of April 2020. This figure of customers makes a mind blowing chance toward complete telemedicine clinical consideration maintain using on the web media applications throughout this

pandemic. Maybe utmost standard app is WhatsApp. This app offers this chance toward patients to direct distantly with their PCPs by means of virtual get-togethers that will provoke reducing clinical facility look in on by patients. By means of this methodology is appropriate toward all stages throughout COVID-19 pandemic [101].

#### 5.4.8 COVID-19 Gov PK

Posted about the total affected person by displaying dashboards for each province and state. Facilitate citizens for the availability of COVID19 Hospitals, ventilators, beds and testing laboratories near them. [102]

## 6. Discussion and Future Work

Coronavirus is considered as both a worldwide wellbeing emergency and a global monetary danger. The limitations set up reaction to the COVID-19 pandemic has devastatingly affected numerous organizations, commercial centers, financial aspects, society and our lives. The full wellbeing, social, and monetary outcomes of this pandemic and its limitations will set aside effort to be completely perceived and evaluated, be that as it may, there are loads of continuous endeavors in exploration and mechanical networks to use various innovations to recognize, treat, and follow the infection to alleviate its effects. Web of Things (IoT) innovation has indicated promising outcomes in early identification, isolate time, and after recuperation from COVID-19, in any case, as we become familiar with the infection and its conduct we ought to change and improve our methodologies in various stages. For instance, it is fascinating to incorporate Artificial Intelligence (AI) and IoT innovation to utilize AI ability to limit cooperations between medical services laborers and patients in all stages. Another model is utilizing touchless innovation with the assistance of different data sources, (for example, motion and voice) will be productively lower the spread of the sickness and end the pandemic sooner [103]. Further examination should be done on persuading affirmed instances of COVID-19 to stay in isolate to alleviate the spread of the infection. Also, how IoT gadgets can help separated patients effectively for their every day life. After lockdown, as organizations and commercial centers are opening bit by bit, how the IoT gadgets can be fused in organizations to cover both wellbeing and effectiveness. Answer to those inquiries will draw in significant consideration in both examination and mechanical teaches and open new exploration roads here.

One of the principle worries about utilizing IoT gadgets in various periods of this pandemic is security issue where patients are approached to share their data. Certainly, it is a major worries for each patient so characterizing secure channels for correspondences or using diverse encryption procedures prior to sharing private data would be a potential exploration region. Having IoT-empowered Smart urban communities can be incredibly useful in battling the current and future pandemic through cooperation between clinical focuses, urban communities, and so on [104]. Alongside previously mentioned IoT applications, Allam et al. [105] features the significance of the idea of Smart City organizations while the world is battling with the COVID-19 pandemic. Savvy City framework can assist individuals with keeping up social separating by the usage of keen transportation frameworks including swarm observing, shrewd stopping, and traffic re-directing [106]. As a piece of keen living in the Smart City, shrewd home IoT-based advances can likewise decrease the disease pace of COVID-19. For example, Smart home doorbells and security frameworks can be actualized for keeping clients from contacting surfaces so that there won't be any defilement of the infection by contacting those sorts of surfaces [107].

## 7. Conclusion

As the world reacts to the COVID-19 pandemic, many methods have been used to fight the disease. One such technology is the Internet of Things (IoT), which is widely used in healthcare. During the COVID-19 pandemic, this technology showed very interesting results in the fight against this disease. In this article, we take a look at the IoT devices recently offered to assist healthcare providers and authorities during the COVID-19 pandemic. We analyze IoT-related technologies and their application in three stages, including early diagnosis, quarantine time and subsequent recovery. At each stage, we assess the role of IoT-related technologies, including consumables, drones, robots, IoT buttons, and smartphone apps, in the fight against COVID-19. IoT technologies can be extremely effective in this pandemic, but they are also important for privacy protection. By successfully implementing IoT technology safely, more patients can be confident that IoT devices can participate in their treatment process. As a result, health officials and professionals can take more effective action in the event of a pandemic. Doing this can greatly reduce the consequences of these types of illnesses, including infection, hospitalization, and death.

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