

# SURVEYING SOCIAL DISTANCING MONITORING WITH WEARABLE AND IOT SENSORS: TECHNIQUES AND TRENDS

## Abstract

The global COVID-19 pandemic has resulted in a significant number of individuals becoming infected with the coronavirus, with the total number of cases continuing to rise. The transmission of the virus occurs through direct, indirect, or intimate contact with persons who are infected. This study survey presents a novel smart social distance system that enables individuals to effectively uphold appropriate social distances from others in various settings, including both indoor and outdoor environments. By doing so, this system effectively mitigates the risk of COVID-19 exposure and curtails its transmission at both local and national levels.

It is challenging to ascertain the behaviours of individuals infected with COVID-19, including predicting symptoms, identifying cases, and monitoring isolated individuals. The use of the Internet of Things (IoT) platform is suggested as an effective means to accomplish this objective, owing to its well-established sensing capabilities and seamless connectivity. The integration of Internet of Things (IoT) technology is being employed in several domains such as healthcare, residences, and cities to establish a more efficient and sophisticated community. The present study aimed to collect data on the potential integration of the Internet of Things (IoT) inside an epidemic prevention and control framework.

**Keywords:** Social Distance; COVID-19; Pandemic; Iternet Of Things; Healthcare;

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## I. INTRODUCTION

The one-of-a-kind COVID-19 virus was unearthed for the first time at the beginning of December 2019 in Wuhan, China. After only a few short months, it has infected millions of people all over the world. The severe acute respiratory syndrome virus, often known as SARS, is a serious disease that is transmitted through the respiratory system. It often disseminates through the air as a consequence of infected individuals (people and animals) coming into touch with healthy individuals [1]. The virus is transmitted from person to person by the droplets produced by an infected cough or sneeze, which have a range of up to 2 metres (about 6 feet). The World Health Organisation (WHO) officially recognised it as a pandemic in March of 2020 [2]. Up to this point, the potentially fatal virus has infected around 8 million individuals all across the world. In order to tackle this fatal sickness, medical experts, scientists, and researchers have been toiling away around the clock to discover a vaccine and a therapy [3].

The global community is looking into alternative approaches and processes in the hopes of reducing the spread of the virus. Management of social distance has been regarded as one of the most effective approaches for controlling the global spread of this illness under the current circumstances. It is important to keep enough distance between people in crowded areas while at the same time minimising the amount of physical touch that occurs between them [4]. By lowering the amount of close physical contact that individuals have with one another, we can reduce the likelihood of viral transmission and flatten the curve of reported cases. Controlling one's exposure to COVID-19 in social settings is absolutely necessary for those who are at a greater risk of developing serious sickness from the virus [5].

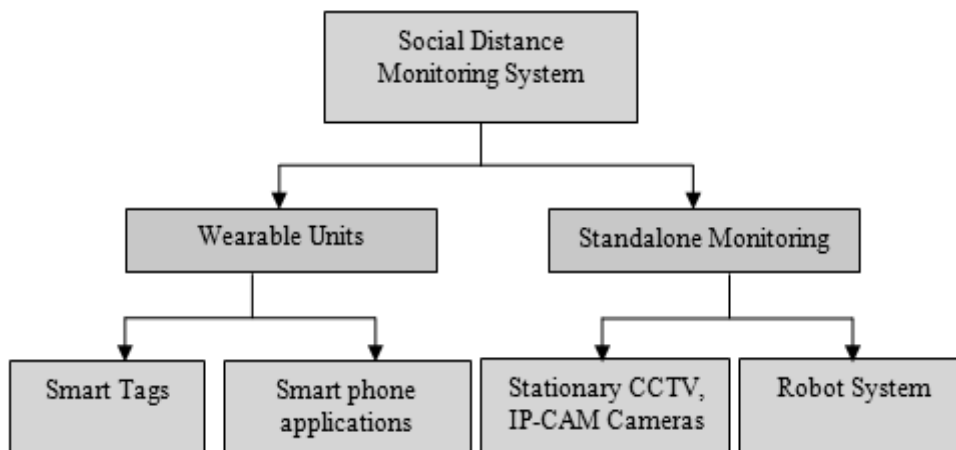
During the recent terrible event involving COVID-19, the Internet of Things (IoT) has been utilised in a wide number of healthcare applications, where it has shown to be quite helpful. In general, Internet of Things (IoT) networks are constructed from a wide array of low-cost, low-power, and compact devices that may be attached to anybody or incorporated into any item [6]. People who are more likely to become severely ill as a result of COVID-19 should maintain a safe distance from others. Maintaining a safe distance of at least one metre between oneself and other individuals in both indoor and outdoor settings is important for preventing the transmission of the virus. Because people might spread the virus even before they are aware that they are sick, intimate contact with other people, whether they are outdoors or indoors, is discouraged because of this condition [7].

Recently, it has come to light that maintaining social distance can be an effective method for reducing the transmission of COVID-19. Researchers and engineers have been motivated to develop technical solutions to counteract the spread of the COVID-19 virus [8] as a direct result of the social gap that exists between individuals. Recently, a number of mobile applications and Internet of Things devices have been created in an effort to stop the spread of the COVID-19 virus. The present epidemic of COVID-19 has forced significant adjustments on various parts of society, and it has illustrated the influence that illnesses like respiratory infections may have in a world that is more interconnected. Travel restrictions [8], isolation and quarantine, and the closing of common places [8] are only some of the unprecedented containment and mitigation strategies that have been enacted in an effort to prevent the spread of the COVID-19 virus.

The remaining aspects of the survey may be broken down as follows: In Section 2, we have compiled a survey of the research literature that has been published over the past several years in the field of social distance monitoring. We have also included efforts that are linked to this field, with an emphasis on image classification approaches. In Section 3, we explain what kinds of sensors and technologies are necessary for observing and controlling the social distance between people. The present research on social monitoring systems is the emphasis of Section 4, while the conclusions drawn from this study as well as its potential applications in the future are discussed in Section 5.

## II. LITERATURE SURVEY

Extensive research and development efforts are currently underway to devise and implement various digital solutions aimed at mitigating the transmission of Covid-19. This section examines the existing methods employed for monitoring and issuing warnings on social distancing. There are currently two types of technologies available for maintaining social distance: wearable social distance systems and independent social monitoring systems, as seen in Figure 1.



**Figure 1:** The Possibility of Monitoring the Social Distance

The extant literature explores the practice of affixing a tag onto an individual (referred to as the user) with the aim of quantifying the spatial separation between said user and the persons in their near vicinity. Conversely, the latter approach relies on image processing techniques and employs either stationary or mobile equipment to observe and measure the distances maintained between individuals within a certain geographic area [9]. To commence, the evaluation of wearable-based systems is conducted through the use of two distinct methodologies: smart tags encompassing technologies such as RFID, GPS, or Bluetooth, and smart phone applications available on either the IOS or Android platforms. In order to do distance measurements and issue warning alerts when a user approaches a crowded location, it is imperative that these techniques are linked to the respective user [10].

In their study, Cunha et al. [11] designed a compact and affordable wearable electronic device capable of estimating the proximity distance between users. This estimation is achieved by analysing the Received Signal Strength (RSS) of Wi-Fi signals emitted by

other wearable devices of the same type. The device is programmed to issue a notification when the calculated distance between users falls below a predetermined threshold value. Bian et al. [12] devised a proximity sensing system that utilises wearable technology and magnetic fields to monitor and measure social distances among individuals. The researchers constructed a compact node capable of detecting individuals at a range of 1.5 to 2.0 metres. These nodes underwent testing both in a controlled laboratory setting and in a real-world environment within a sizable retail space. As shown in Figure 2, the gadget under consideration has a detection range above 2 metres and possesses sufficient durability to withstand routine usage scenarios [13].



**Figure 2:** Sample Images of Social Distance Monitoring Position

In order to mitigate the spread of COVID-19 infections, Kobayashi et al. developed a social distancing monitoring system specifically tailored for students inside the confines of a university campus [14]. The proposed method for granting campus access involves the implementation of ESP32-based microcontroller nodes that are dispersed throughout the student population. Neelavathy et al. (year) introduced a mobile application-based monitoring system called smart social distance (SSD), which utilises mobile Bluetooth and a mobile camera to forecast the social distances between individuals [15]. The SSD programme consists of two primary components in order to predict social distancing. The proposed methodology has two main components. Firstly, deep learning techniques are employed to accurately detect pedestrians inside video frames. Subsequently, image processing methods are utilised to calculate the spatial separation between the identified pedestrians. The implemented software application is capable of estimating the signal strength received and then calculating the distance utilising Bluetooth Low Energy (BLE) technology [16]. Jahmunah has created an Internet of Things (IoT)-based social distance monitoring system, which includes a mobile phone application and a wearable gadget [17]. The mobile application consists of a compilation of contact tracking applications that are capable of collecting and analysing data. Lubis introduced a proximity-based COVID-19 contact tracing system utilising Bluetooth Low Energy (BLE) technology [18]. This system aims to monitor and control the spread of COVID-19 within the immediate neighbourhood. The gadget is

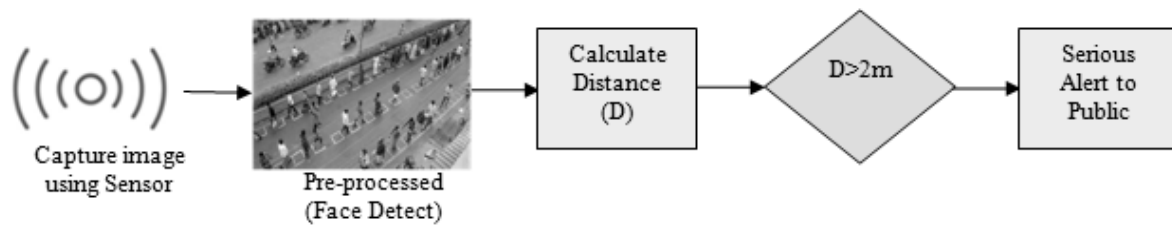
engineered to monitor the proximity of individuals and subsequently synchronise this data with their cellphones.

In contrast, several localization and tracking systems utilising wireless sensor networks have been created [19]. These systems have the capability to estimate the distance between individuals in interior environments, therefore providing notifications to users in densely populated areas. The use of the Received Signal Strength Indicator (RSSI) characteristic enables the estimation of the spatial separation between sensor nodes, hence facilitating the identification of regions with high population density. In the context of analysing social distances between individuals, there has been a consideration of utilising standalone social monitoring systems [20]. These systems rely on stationary or mobile devices that are strategically placed throughout the research area. The assessment of social distances is achieved by analysing images that are collected by either fixed or mobile digital cameras [21]. Examples of such technologies include digital cameras and robot systems. Ahmed et al. (2018) proposed a deep learning framework for the purpose of monitoring social distancing. This framework utilises the YOLOv3 object detection model to identify individuals in video sequences and then estimate the distance between individuals in open-space environments. In a scholarly work, Al-Khazraji [22] introduced a novel smart monitoring system designed to assess individuals' physical distances and offer tailored feedback accordingly. The technology under consideration quantifies the population within a certain geographical area and computes the distances between individuals. Subsequently, the system proceeds to emit cautionary messages to those who fail to adhere to the prescribed social distancing measures.

As previously said, some researchers have conducted studies with the aim of developing an improved and efficient social distance monitoring system. However, there has been a lack of focus on the development of a social monitoring system specifically based on Internet of Things (IoT) sensors [23]. In addition, it is worth noting that there is currently a lack of identified practical solutions for assessing social distance in real-world settings. This article primarily centres on the utilisation of IoT sensor and wearable sensors to establish a practical model for monitoring social distancing in real-world scenarios. The objective is to shorten the process of social distance monitoring, hence offering assistance in addressing the gravity of the current problem.

### **III. IOT AND WEARABLE BASED SOCIAL DISTANCE MONITORING SYSTEMS**

Wireless technologies such as Wi-Fi, cellular networks, Bluetooth, Ultrawideband (UWB), Global Navigation Satellite Systems (GNSS), Zigbee, and Radio Frequency Identification (RFID) can be employed to facilitate the implementation of social distancing measures. In this section, we will provide an overview of the fundamental principles behind these technologies. Subsequently, we will explore their potential in facilitating the implementation of social distancing measures by means of permitting, promoting, and enforcing such practises [24]. Subsequently, we proceed to examine the potential applications, advantages, limitations, and viability of the technologies. Figure 3 illustrates the operational process of a social monitoring system that utilises IoT sensors.



**Figure 3:** Workflow of Social Monitoring System Using IOT Sensor

### 1. Radio Frequency Identification (RFID)

Radio Frequency Identification (RFID) technology plays a crucial role in facilitating real-time tracking and localization of objects. An RFID localization system has three primary constituents, namely RFID readers, RFID tags, and a data processing system. RFID tags are commonly classified into two distinct kinds, namely active tags and passive tags [25]. Passive RFID tags derive their power from the electromagnetic field generated by the RFID reader, obviating the need for any external power source. In contrast, an active RFID tag is equipped with an independent power source, often a battery, which enables it to emit continuous signals autonomously. Active RFID tags are commonly employed in the majority of localization systems. Consequently, RFID technology might be seen as a potential instrument for facilitating social distancing measures. One potential use of RFID technology is the utilisation of new localization technologies based on RFID, which enables the tracking and identification of people inside interior environments. In order to achieve this objective, every user is provided with an RFID tag, which is located on either their staff identification or member cards [26]. The user's position may be ascertained by the RFID reader through analysis of the backscattered signals emitted by the RFID tag. In the event of an excessive concentration of individuals inside a certain location, the system has the capability to promptly notify the relevant authorities. Subsequently, these authorities may implement appropriate actions, such as compelling individuals to vacate the premises in order to facilitate the practise of social distancing [27].

In a similar vein, Radio Frequency Identification (RFID) technology is employed for the purpose of monitoring social distancing measures in public spaces such as supermarkets or buildings [28]. A Radio Frequency Identification (RFID) reader is proposed to be deployed at the primary entrance of a designated area, wherein individuals will be issued RFID badges, which may consist of either active or passive tags. When the RFID reader emits radio frequency signals, the tags belonging to the users have the capability to either actively broadcast their identification or passively transmit their identification. The RFID reader has the capability to receive the user's identification (ID) and increase the value of the counter when the user reaches the specified place. Consequently, the RFID reader has the capability to approximate the quantity of individuals in attendance. In the event of an excessive number of individuals, the system possesses the capability to notify the local management, who may then implement a measure wherein individuals are required to form a queue prior to entry, so facilitating the practise of social distancing [29]. This methodology can be implemented in retail establishments or corporate environments where individuals often possess membership or staff identification cards equipped with radio-frequency identification (RFID) tags.

## **2. Bluetooth Technology**

Bluetooth technology has emerged as a viable solution for promoting social distance in many settings, encompassing both indoor and outdoor environments. This can be attributed to the growing prevalence of gadgets equipped with Bluetooth capabilities. Bluetooth is a wireless communication technology that functions within the frequency range of 2.4 to 2.485 GHz. It is mostly employed for facilitating short-range wireless transmissions. Bluetooth Low Energy (BLE) was recently introduced as an enhanced iteration of traditional Bluetooth, aiming to minimise device power usage and enhance communication efficiency [30]. Considering the aforementioned points, it can be said that BLE localization technology possesses some benefits in comparison to Wi-Fi localization. To begin with, it is worth noting that Bluetooth Low Energy (BLE) signals possess a greater sample rate, ranging from 0.25 Hz to 2 Hz, in comparison to Wi-Fi signals. Furthermore, Bluetooth Low Energy (BLE) technology has a lower power consumption compared to Wi-Fi technology, making it highly suitable for extensive integration into various mobile devices [31].

## **3. Global Navigation Satellite Systems (Gnss)**

The Global Navigation Satellite System (GNSS) is widely employed for locating in contemporary outdoor settings. Global Navigation Satellite System (GNSS) satellites are in a state of perpetual orbit around the Earth, ensuring a continuous transmission of navigation messages [32]. When a receiver receives navigation messages from satellites, it utilises the sent time information included within the messages to calculate the spatial separation between its own location and the respective satellites. In order to determine the precise geographical coordinates of a user's present position, it is necessary to obtain navigation signals from a minimum of three distinct satellites. In practical use, it is often required to receive signals from a minimum of four individual satellites in order to accurately determine a user's location. Certain Global Navigation Satellite Systems (GNSS) presently exhibit a level of accuracy that is below 1 metre. Consequently, Global Navigation Satellite Systems (GNSS) have considerable potential in facilitating the implementation of social distancing measures [33].

Global Navigation Satellite System (GNSS) technology possesses notable advantages in monitoring individuals to ensure adherence to social distancing measures, mostly due to its exceptional capabilities in accurately determining the precise location of individuals, particularly in outdoor environments. Currently, the majority of smartphones are equipped with GPS sensors that enable the tracking of mobile users' locations as required. Individuals who are suspected of being exposed to contamination, such as those who have just returned from an area with a high prevalence of infection, will be required to engage in a period of self-isolation in the case of a widespread outbreak, such as the COVID-19 pandemic. Consequently, governmental entities have the ability to request that these persons utilise GPS-based tracking devices in order to guarantee compliance with quarantine measures by restricting their movement outside of their residences.

## **IV. CURRENT RESEARCH IN SOCIAL DISTANCE MONITORING**

The use of Internet of Things (IoT), big data, and artificial intelligence (AI), in conjunction with the innovative application of healthcare IoT in smart cities across China, Europe, and the United States, has played a significant role in combating the COVID-19 pandemic. The advent of technology has facilitated the ability to engage in continuous monitoring and make speedy decisions. The fundamental elements of urban intelligence necessary in the context of a pandemic. Likewise, there exists a heightened dedication towards the advancement of many state-of-the-art technologies aimed at mitigating the diverse challenges linked to the global viral outbreak. In our presentation, we discussed the evolution of several healthcare Internet of Things (IoT) technologies in response to the COVID-19 pandemic, as documented in reference [34].

### **1. Cloud Assist IOT**

Advancements in wireless and digital technologies have facilitated the provision of computer system resources, including databases, networking, servers, and intelligence, over the internet [29]. Cloud computing facilitates faster and more adaptable allocation of resources, along with cost-efficient and effective administration of infrastructure. During the COVID-19 pandemic, a significant number of persons experienced a state of isolation from their regular routines. However, they were able to sustain their digital activities through the use of various applications such as Zoom video, Google Meet, Google Cloud, Slack, Amazon Web Services, Netflix, and Microsoft Azure. Likewise, the use of healthcare-specific applications such as Salesforce Care solution enabled healthcare personnel to effectively handle a substantial influx of inquiries stemming from the COVID-19 pandemic [35].

Cloud services have provided support to resource-constrained H-IoT devices in several domains, such as restricted electrical supply and processing capabilities. The advent of cloud computing technology has facilitated the relocation of energy-intensive and resource-intensive occupations. The primary function of sensor nodes is to collect COVID-19 data and transmit it to the cloud by the conclusion of each day [36]. Consequently, the predominant energy consumption of these devices occurs during the periods of antenna transmission and reception. When coupled with suitable energy-conserving algorithms, this can contribute to the prolonged lifespan of Internet of Things (IoT) devices.

### **2. AI based H-IOT**

An evaluation of the threat of infection and a screening of inhabitants are both possible utilising AI. Moreover, AI may be used to train computers to detect, explain, and forecast patterns using models based on huge data, leading to practical insight. Artificial intelligence apps have been used, for instance, to monitor citizens' movements out of impacted areas and report their movements to authorities. Having this information is crucial for preventing the transmission of the virus and predicting when an epidemic will occur. Similarly, there is a great deal of incorrect material about the virus circulating on social media, so AI-based systems may be taught to weed it out. In addition, AI can help speed up the process of developing new medicines and vaccines through clinical trials. In addition, AI



has been utilised to develop robots that can both clean and sanitise the environment and do online medical exams/AI aided diagnosis on locals.

To ensure people in China abided by the country's strict quarantine regulations, CCTV cameras equipped with facial recognition software were installed in the entrances of each building's apartments. Also, in order to find people infected with COVID-19, AI was employed to conduct decentralised testing in different Chinese towns. For even more public COVID-19 detection, businesses like Megvil Technology Limited, Baidu, and Sense Time have created AI-assisted contactless body temperature screening equipment. Screening about 15 people per second from a distance of 3 metres is possible, for example, with AI-assisted systems using contactless remote temperature screening. The construction of anti-COVID-19 measures has been facilitated by AI systems in general. It has also supplied reprieve for overworked health-care systems [37].

### **3. AI based H-IOT**

Drones have the potential to be utilised for the purpose of monitoring and tracing the COVID-19 pandemic, encompassing the tracking of individuals who have had contact with people afflicted by the virus. Drones may be effectively employed in the enforcement and monitoring of individuals who violate quarantine protocols, as well as in the verification of compliance with face mask usage. Drones were utilised in several regions, including Hubei, Europe, and the United States, with the aim of ensuring compliance among inhabitants with regard to lock-down measures and social distancing protocols. Instructions and warnings were issued to those who were not adhering to emergency measures or wearing face masks through the use of drones equipped with cameras. Drones can also be employed for the purpose of monitoring patients within their residences or regions with a high prevalence of illness from a remote location. Drones have been utilised in several applications, such as the transportation of critical medical supplies to healthcare professionals and the collection and delivery of samples for testing purposes at neighbouring institutions.

## **V. CONCLUSIONS**

The use of social distancing measures has been widely acknowledged as a crucial strategy to mitigate the spread of hazardous illnesses such as COVID-19. This article provides a comprehensive analysis of the ways in which technology may effectively support, promote, and enforce the practise of social distance. Initially, we provided a comprehensive introduction to the concept of social distance, elucidating its significance in the ongoing COVID-19 pandemic, and subsequently showed many pragmatic scenarios whereby technology might be employed to facilitate social distancing. Next, we engaged in a comprehensive discussion about a diverse range of wireless technologies that possess the potential to promote and enable the implementation of a social distance monitoring system. An overview of each technology was provided, followed by an examination of their current state-of-the-art. Furthermore, an exploration was conducted to ascertain their potential applications in different social distance scenarios. Additionally, this analysis identified unresolved challenges in the implementation of social distancing measures and proposed potential solutions.

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