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REVIEW ON APPLICATION OF LOCATION TRACKING TO MONITOR PEOPLE IN HEALTH FIELD AGAINST COVID-19

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Abstract

Location tracking stands for technologies that physically identify and electronically register and monitor the tracking of individuals or objects. This technology is widely implemented in the health field for tracking clinicians and patient locations. The history of visited location data is used for many purposes and is mainly applied to monitor and assess the patient's movement to provide helpful knowledge. This data is obtained using the Global positioning system (GPS), Bluetooth, and Radio-frequency identification (RFID) built into the device such as smartphones, smart watches, or wearable devices. In some Research, other technologies like Google Location History (GLH) provide the history of visited locations made by the Google Account. Location tracking can be an alternative and potentially help monitor and track Covid-19 infectee to prevent wider diffusion. This paper reviews location tracking applications in healthcare based on how the location data is obtained and analyzed. The application of location tracking was differentiated and reviewed based on the applied methods in acquiring knowledgeable data. Furthermore, the data analysis used to track location was also discussed to know what knowledge that obtained from the location history data. Getting the location and assessing the data for specific purposes was also highlighted.

Keywords: Location Tracking, GPS, RFID, WLAN, Bluetooth, Covid-19

1. INTRODUCTION

The technology of location tracking refers to the physical identification and electronic recording of movements for objects or people [1-3]. It can be applied to understand human mobility and how it manifests across temporal and spatial scales that are widely used across health and social applications [4]. It gets more attention from specialists to apply in various sectors like health, tourism, security, etc [5,6]. Regarding the health sector, some issues involve the analysis and location tracking of patient movement to acquire necessary data for a tracking system in a hospital known by the hospital's real-time location system (HRTLS). Thus, it is substantial to design and performs a suitable HRTLS to fulfill the requirements of healthcare centers. [1]. The HRTLS involves many significant applications such as the online location of the patient, monitoring physician workflow management during a medical emergency, increased patient/provider safety, enhancing staff usage, minimization of error in data transfer, tracking of the worthy hospital apparatuses like medical property temperature monitoring, management of bed limit, patient elopement, equipment maintenance, and other useful utilization [1].

Generally, location tracking is linked with a smartphone because it is a built-in GPS chip. The location data is acquired via numerous tracking technologies used in medical centers like WLAN, RFID, Bluetooth, and Wi-Fi [7]–[10]. These technologies are implemented in different coverage of area tracking. The accuracy and purpose of any utilized technology depend on the decided points in implementing certain devices in data collection. The obtained location in the wide coverage area, such as data of daily run route, is captured using GPS. The

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accuracy of the GPS is less than the Radio frequency-based tracking location indoors [9], but it overcomes the RFID in terms of wide coverage. In real implementations, it is used to track people's location as well as medical equipment [1], [11], [12]. The accuracy of user's location is needed in the tracking process inside the building. The indoor tracking location faces challenges in identifying details such as rooms, floors, etc [9].

The Location history has been used in a research field to assess user's habit mobility [13] to provide supportable insight for infrastructure planning, control of infectious diseases, and procedure of reaction to disastrous occasions. The researchers have applied many approaches to acquire data on real-time location history [9], [10]. The history data is sent and stored in the base station for further processing and analysis. The analyzing process aims to mine the knowledge of the data. This location-tracking technology can be a helpful alternative against Covid-19. Covid-19 is a disease caused by a new type of Coronavirus that has recently become a world concern. Figures 1 and 2 show the number of accumulated infected and deaths by COVID-19 cases worldwide between (4th of January 2020 and 5th of July 2023). It can be noticed that the total number of people that infected by COVID-19 exceeds 700 million persons. While the total number of people that dead by COVID-19 exceeds 6 million persons [14-15]. Location tracking can be a useful technology to track and monitor the hospital equipment and the infection of Covid-19 to prevent further transmission. The recent work relating to tracking the location of Covid-19 is applied to the GIS (Geographical Information system) to map the situation cases and track the coronavirus epidemic [16]. Early detection and isolation of infected can minimize the impact caused by the pandemic. Therefore, some devices with advanced technologies have been adopted to screen and evaluate the location history of Covid-19 infectees, like drones [17], smart glasses [18], and smart helmets [19]. As gaining knowledge through location history is possible and widely being investigated recently [20]–[22].

The scope of this research paper is highly aligned with medical diagnostics using signal processing techniques and theory of the technical diagnostics fields. The use of location tracking technologies in the health field was presented, especially during the covid-19 pandemic. Recently, monitoring and detection systems have become more effective and accurate for the movements of patients and medical staff. In addition to the significantly improved responsiveness to contact tracing, compliance with public health measures. Also, it was achieved a comprehensive overview of the characteristics of various strategies (GPS, Google location history, RFID, BLE Beacons, Wi-Fi, and Sensor (Doorjamb Detection)), and emphasizing their importance in medical diagnosis. Furthermore, it was shown that the technical aspects related to diagnosis by evaluating these strategies and presenting their advantages, disadvantages, and performance characteristics in disease monitoring and management. The main contribution of this work is providing valuable insights and knowledge for bridging the areas of location tracking and medical diagnosis. Finally, it was presented some comparisons between the current strategies used in healthcare technology, as well as the effectiveness of these strategies in light of public health crises such as the COVID-19 pandemic..

2. TRACKING INDOOR MOBILITY

In general, the performance of GPS in an indoor environment is poor, which enables boosting investigations to perform proficiently in indoor localization. [9]. Here are the two proposed methods that are mainly used in an indoor tracking location by the researchers:

a) **Radio Frequency based detection**.
RF signal-based location tracking depends on determining the range of the transmitted wireless signal. Such an approach necessitates the client to use a mobile device in addition to radio-frequency access points (APs) like Wi-Fi routers and/or Bluetooth beacons in the domestic regions [9], [10]. RF-based systems estimate how the signal is strong among mobile devices to all the

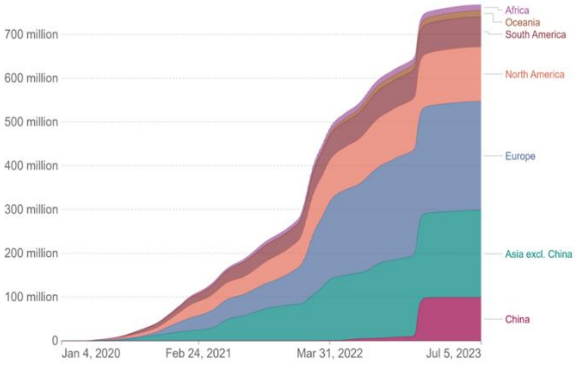

Fig. 1. The accumulated infected by COVID-19 cases around the world [14]

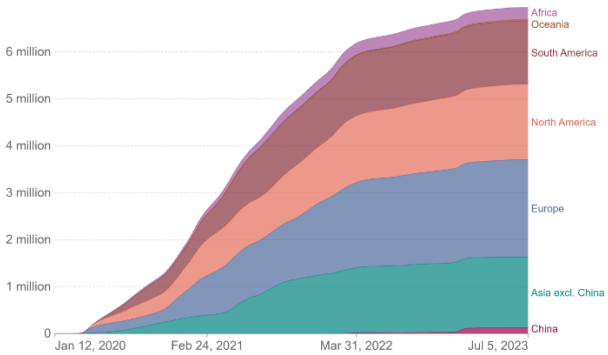

Fig. 2. The accumulated death by COVID-19 cases around the world [15]

access points (Aps) and accordingly map the device location. The user's location can be inferred from the location of the mobile device or wearable device. Bluetooth is a short-range wireless communication that permits devices such as cell phones, PC computers, and peripherals to transfer wireless data or voice across a short distance [10], [23]. Many researchers have investigated implementing Bluetooth Low Energy (BLE) Beacons to track medical staff or equipment in the hospital. Other technologies were also being used, such as Radio Frequency Identification (RFID), in which the RFID tags are utilized for saving primary information of the patient and the server addresses of the medical branches where the patient was checked.

b) **Sensor for movement detection**.
The sensor-based tracking location method is applied to detect the user's movement by a set of sensors inside the home. It can be detected people's movement through the door, for example, by detecting the doorjamb. This technique beat the related coverage issues with monitoring houses having strangely shaped rooms and huge open living areas by simplifying the doorway tracking. This data (in or out of the room) estimate the user position or rooms in the home and is sent to the base center. The published work in [9] presented an infrared transmitter to detect door movement and a wearable device to track multiple user movements. The motion of people who move to another room will be able to be detected by analyzing the door movement and accelerometer to detect movement. The accelerometer is a sensor that can detect movement by tracking acceleration per unit of time around the x, y, and z coordinates [24].

3. TRACKING INDOOR MOBILITY

In general, the performance of GPS in an indoor environment is poor, which enables boosting investigations

Tracking location is performed in the wider area, such as their activity in the city. This aims to evaluate the daily mobility of users with GPS attached to their smartphones, smartwatch, or other wearable devices. Here are the following methods used to acquire tracking location data in the outdoor environment.

a) Global Positioning System
Global Positioning System (GPS) is a reliable navigation system that depends on utilizing satellites and algorithms to synchronize positions, receivers, speed, and time data for air, sea, and land travel [7]. GPS receivers produce the amount of raw data, such as a set of coordinates for time-stamped geographic accompanied by some supplementary data involving velocity or orientation and technical factors associated with signal acquisition. GPS tracking means to inform us 'where and when'. The GPS receiver is commonly built in the smartphone, smartwatches, or other wearable devices. GPS can work with or without utilize of internet reception. The Internet can greatly improve GPS data. GPS is speedily utilized in military applications and gets several worldwide clients. New geo-locating technologies have become ubiquitous. Information supplied by GPS enables the utilizer to perform many functions, like an estimation of individual tracks that can bolster extra modern utilizations such as adaptive mobile services [25].

b) Location History Application
Location History application is an application that develops to obtain the user's position data. Although the location history application also uses GPS technology to obtain the data, it also focuses more on utilizing Google Location History (GLH) or Google Timeline. The Google Timeline is a feature that is available for Google users to evaluate their history of visits. The researchers further develop the application to obtain data for many purposes, such as assessing air pollution [26], physical activity [27], etc. GLH constantly and passively gathers the position information from a person's cell phone by utilizing technologies like GPS, Wi-Fi, and cellular locating once it's enabled [7]. Figure 3 depicts the applied mobility tracking methods for indoor and outdoor environments.

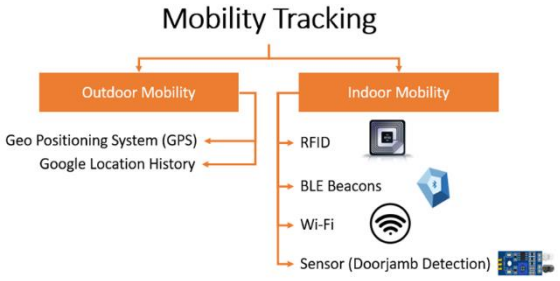

Figure 3. Method of obtaining mobility in indoor and outdoor environments

4. TRACKING INDOOR MOBILITY

This section presents the differences between applied methods in mobility tracking in indoor and outdoor conditions, the related issues for those environments, and finally, the indoor and outdoor data analysis.

a) The differences between applied methods
Location tracking has been seen to be important to be analyzed in many sectors. The gained knowledge of that data can support the decision in certain situations. Specifically, in the health sector, the location of medical equipment is tracked for security purposes, and medical staff is being tracked to know their location in the hospital so they can be notified in emergencies [1]. In the wider coverage of location tracking, GPS-based location tracking is used to monitor the daily mobility of users in evaluating the exposure estimation for retrospective

epidemiological studies [26]. This involves two environments to be monitored. Commonly in the health sector, location tracking is performed in the hospital. Some researchers also conduct studies to evaluate human mobility in wider coverage areas such as cities to evaluate their daily activity. The method of obtaining the location data is different because it deals with different types of data that want to be measured. Indoor location tracking aims to know the location of medical equipment or medical staff, which requires detailed accuracy, like which room their location is. Researchers have come up with many different approaches to tackle this challenge. The device like BLE Beacons, RFID and Infrared sensor to detect doorjamb in identifying mobility in home or hospital. Outdoor mobility is tracked using GPS that built in the smartphone, smart watch and other wearable devices. The required detail in the outdoor tracking location is only to the visited places like building, public places, park, etc. The detailed like what store inside of the building that being visited is unable to be captured since GPS has poor performance in an indoor condition. The following table presents the existed wearable device in the market based on [22].

Table 1. The tracking location devices with various technology and coverage area [22]

Coverage Area	Technology	Devices
Indoor	Beacons, Ultra-wideband	TRX Systems
	RF, Bluetooth, WLAN	Q-Track NFER RTLS
	Wi-Fi, Beacons	Accuware
	Wi-Fi, Beacons, Ultra-wideband, RFID	infsoft
Outdoor	GNSS/GPS, GPRS/GSM	Amcrest
	GPS, GLONASS	Trax
	GPS, GSM	Americaloc GL300W
	GPS, GSM	AngelSense
	GPS, GSM	GPS SmartSole
	GPS, GSM	Mindme
	GPS, GSM	Safe Link
	GPS, GSM	Spy Tec
	RF	Project Lifesaver
	Wi-Fi, GPS, GSM	MX-LOCare
Indoor/Outdoor	Bluetooth, GPS, GSM	Yepzon One
	Wi-Fi, GPS, GSM	iTraq
	Wi-Fi, GPS, GSM	PocketFinde
	Wi-Fi, LBS, GPS, GPRS/GSM	Mini A9 GPS Tracker

Issues in indoor and outdoor

a) The issue that arises in the location tracking research is different from indoor to outdoor environments. An issue that deals with indoor is mainly the accuracy that needs to be achieved; device limited battery life, room coverage, signal noise, etc. Many approaches develop ideas to identify locations using Bluetooth, RFID, or sensor. The BLE Beacons are applied to detect mobility in the hospital. The hospital has many pieces of equipment that can interfere with the signal of Bluetooth. The proposed method is to locate the user's location based on the number of signals captured by the wearable device [10]. This method is called RNSI (Received Number of Signals Indicator), while most approach uses RSSI (Received Signal Strength Indicator). Wall interference and unstructured room are challenges that tried to be solved using infrared sensors to detect movement. The movement between rooms is detected by the captured movement from the doorway and the accelerometer to identify if the tracked user is making any move [9]. In outdoor environments, GPS is commonly used to track location. In some implementations, GLH is used. GLH, once enabled, permits monitoring gadgets and storing their positions. This property might be beneficial in the future as obtainable data for proof in studies and analyses of human mobility. The reliability of the GLH data is needed to be checked to determine whether it returns to the real situation. The researcher has attempted to assess the error of the GLH Data compared to the data obtained by the GPS. The measurement of the potential significant parameters (e.g., connectivity configuration of portable gadget, movement speed, and environment) was tuned by sets of trials in which the true location of the gadget was stored with a base Global Positioning System (GPS) device with higher accuracy. According to the experiments, Google locations and corresponding accuracies must not be utilized in a determined method to locate the position of a mobile device. However, Google does not pass; the error values are still in the same order as the accuracies [7]. So, it indeed, on the off chance that the smartphone isn't within the circle that Google is produced in its Timeline, ordinarily, the error is not that high to deny that, at a minimum, it has been within the whereabouts [7].
b) Analysis data in indoor and outdoor
c) In the indoor environment, the research trend is steered toward identifying the location of medical equipment, medical staff, and patient. The issue revolves around proposing a method to identify user mobility in indoor environments to achieve better accuracy. The analysis made in most research is how the device can make a good estimation of the real location of the tracked item or user, as depicted in Table 2. The RNSI analysis is used instead of RSSI to calculate the number of received signals [10]. In another implementation, the analysis is based on the infrared signal received as an indication of movement in the doorway with the sensor from the accelerometer to indicate the movement of the user [9]. These two indicators are observed to

determine whether the user is actually moving to other rooms, so errors like the sensitivity of the infrared that identifies false movement can be avoided. The research on outdoor mobility mainly focuses on tracking the user's daily movement. The data is collected and analyzed to gain knowledge, like predicting user location. The purpose is not limited to the real-time location tracking of the user but also analysis of the predicted location of the user in the future. This is also applied to dementia patients to predict their location when they are missing. A crucial set of individuals having dementia are at risk of getting lost or wandering, so based on their mobility, machine learning is applied to make predictions [22].

Table 2. Data analysis comparison of indoor and outdoor mobility data

Indoor Tracking Location	Outdoor Tracking Location
• Tracking Medical equipment, staff and patient • Improve accuracy to track the location in level of room location • Implementation of new method to deal with the unstructured room	• Tracking location of user (patient with dementia) • Tracking visited location • Predicting future visited location

Implementation of indoor and outdoor tracking locations in healthcare have widely researched, as explained in Table 3. The indoor environment research revolves around radio frequency-based tracking using technology like RFID or BLE Beacons. Implementation of RFID has been widely implemented to track medical equipment, staff, and patients. The RFID tags are also implemented for blood injection, which reduces errors in this process [28], [29]. Blood packs were labeled, and the recording of the injection phase was later done. The medication presented to the patient can also be monitored to avoid any errors. Before the prescription, the physician sets a tag on the medicine box that enables the readers to view tag information once the drug is withdrawn from the store and update the patient's case to the server [30]. In another implementation, the system can monitor, trace, and track patients and empower taking care of their health, and thus produce effective medical services that could be given at a suitable time [31]. The application of tracking the indoor environment using an infrared sensor to track movement through the doorway is proposed [9]. In outdoor coverage of tracking, the GPS is applied to identify the location. The location is analyzed to predict the future location of the person with dementia if they are missing or to give suggestions of the usual visited place [22]. The implementation using GLH data is also proposed to gain knowledge related to Air pollution studies.

Table 4 presents the most important monitoring and detection applications in the health field according to the type of diseases, how the medical staff participates, the accuracy, the level of risk, and response time. Rapid and significant developments in the field of self-monitoring and remote monitoring of various health conditions have occurred due to the technological revolution in the last few years. Smartphone and wearable applications have the ability to track the current health of patients with diabetes and cardiovascular disorders, for example, in real-time. So the patients can be made decisions and manage their conditions effectively based on the obtained information. The importance of self-monitoring tools and applications has emerged significantly in infectious diseases such as covid-19 and tuberculosis. It is now possible to track the symptoms, determine the possible exposure percentage and facilitate the timely medical intervention process. The monitoring process is a function of the response time and accuracy, which depends mainly on the technology used and the patient's condition. Despite the current significant development in this field, there is an urgent need for more research and technological development to improve monitoring and detection applications in the health field.

Table 5 presents an overview regarding the characteristics, advantages, disadvantages, and diseases that can be diagnosed using the strategies (GPS, google location history, RFID, BLE Beacons, Wi-Fi, Sensor (Doorjamb Detection)) in the monitoring and detections applications in the health field. There is a limitation when using GPS in indoor settings, while its very effective in outdoor applications. Google Location History needs an active internet connection to obtain simultaneous

Table 3. Research of location tracking across indoor and outdoor environments

Method	Implementation	Paper
RF based tracking	• Monitoring Blood Transfusion • Monitoring Medication • Monitoring Medical Equipment and Patient	[28]–[31]
Sensor based tracking	• Monitoring Dementia Patient in Home	[9]
GPS	• Tracking location (patient with dementia) • Predicting Future Location	[2], [22], [32-34]
GLH	• Air Pollution Studies • Dietary and Physical Activity	[26], [27]

Table 4. The classifications of monitoring applications for different diseases.

no.	Type of Disease	Patients	Medical Staff Involvement	Level of Risk	Accuracy	Response Time
1	Chronic Diseases	Diabetes	Self-monitoring	Low	High	Real-time
		Cardiovascular	Self-monitoring	Moderate	High	Real-time
		Asthma	Self-monitoring	Low to Moderate	Moderate	Real-time
2	Infectious Diseases	COVID-19	Self-monitoring ;Contact tracing apps	High	Variable	Real-time
		Tuberculosis	Self-monitoring ;Healthcare worker involvement	Moderate to High	High	Within 48 hours
3	Cancer	Various types	Healthcare provider monitoring, Remote patient monitoring	High	High	Real-time
4	Respiratory Diseases	Chronic obstructive pulmonary disease (COPD)	Self-monitoring ;Healthcare provider monitoring	Moderate to High	High	Real-time
		Sleep Apnea	Self-monitoring, Healthcare provider monitoring	Moderate	High	Real-time
5	Neurological Disorders	Epilepsy	Self-monitoring ;Remote patient monitoring	Moderate	High	Real-time
		Parkinson's Disease	Self-monitoring ;Remote patient monitoring	Moderate	High	Real-time
6	Mental Health	Depression	Self-monitoring ;Mental health apps	Low to Moderate	Variable	Variable
		Anxiety	Self-monitoring, Mental health apps	Low to Moderate	Variable	Variable
7	Maternal and Child Health	Pregnancy	Remote monitoring; Telehealth consultations	Low to Moderate	High	Real-time
		Neonatal Care	Remote monitoring; Telehealth consultations	High	High	Real-time
8	Type of Disease	Patients	Medical Staff Involvement	Level of Risk	Accuracy	Response Time
9	Chronic Diseases	Diabetes	Self-monitoring	Low	High	Real-time
		Cardiovascular	Self-monitoring	Moderate	High	Real-time

Table 5. The Characteristics of the strategies used for monitoring and detection.

Strategy	Characteristics	Advantages	Disadvantages/Limitations	Diseases Diagnosed
Global Positioning System (GPS)	Satellite-based system for accurate positioning	High accuracy	Requires line of sight to satellites	Alzheimer's disease
		Global coverage	Limited accuracy in indoor environments	Autism spectrum disorder
		Real-time tracking	Power consumption in continuous tracking	Dementia
Google Location History	Utilizes smartphone location data	Continuous tracking without additional hardware	Convenient and widely accessible	Privacy concerns
		Real-time & historical location data	Accuracy affected by signal strength	Tracking patients with memory disorders
		Integration with other applications	-	Behavioral analysis for mental health
Radio Frequency Identification (RFID)	Uses radio waves for identification and tracking	Scalable and cost-effective	Limited range	Medical inventory management
		Can track multiple items simultaneously	Interference from metal and liquids	Patient tracking in hospitals
		It can be integrated with existing systems	Limited accuracy in crowded areas	Asset tracking in healthcare facilities
BLE Beacons	Bluetooth Low Energy-based tracking	Low power consumption	Limited range	Patient tracking in hospitals
		Indoor and outdoor tracking capabilities	Requires devices to be within range	Asset tracking in healthcare facilities
		Real-time proximity detection	Privacy concerns	Elderly patient monitoring
Wi-Fi-Based Tracking	Utilizes Wi-Fi signals for localization	Works indoors and outdoors	Limited accuracy in crowded areas	Asset tracking in hospitals
		Wide availability of Wi-Fi networks	Vulnerable to signal interference	Patient monitoring in hospitals
		It can be integrated with existing Wi-Fi	Privacy concerns	Equipment tracking in healthcare facilities
Sensor (Doorjamb Detection)	Uses sensors to detect entry/exit through doorjambs	Non-invasive and discreet	Limited coverage	Patient tracking in hospitals
		Real-time detection of movement	Restricted to specific entry points	Staff monitoring in healthcare facilities
		Integration with access control systems	Dependency on door infrastructure	Wandering behavior in dementia patients

data. RFID has excellent accuracy for tracking medical equipment but for a limited range. The main advantage of BLE Beacons is low power consumption, but it needs to deploy the beacons to ensure tracking accuracy. The disadvantage of Wi-Fi-Based Tracking is the limited accuracy, but on the other hand, it has a wide range of areas. It can get non-intrusive automatic tracking at points (entry/exit) using Sensor-based tracking but only for the locations with installed sensors. Accurate decisions can be made to track disease location, diagnosis, and management by health field professionals based on understanding the characteristics and considerations of the available strategy for monitoring and detection.

Figure 4 presents the ranking of Strategy Mobility Tracking (GPS, google location history, RFID, BLE Beacons, Wi-Fi, Sensor (Door jamb Detection)) for preventive measures and treatment of people infected with COVID-19. It can be seen that the most efficient strategy is BLE Beacons because it provides close-range proximity tracking. This makes contact tracing and monitoring very precise, which is crucial for COVID-19 control measures. On the other hand, the least efficient strategy is RFID because it has a limited proximity range. Also, the monitoring and contact tracing are insufficiently precise in most cases [35-42]. Figure 5 presents the common points between Covid-19 and the SARS-CoV-2 epidemic regarding Monitoring for Location Tracking for People in the Health Field. According to the Monitoring for Location Tracking, the high similarty for the measures that should be taken for both epidemics can be noticed.

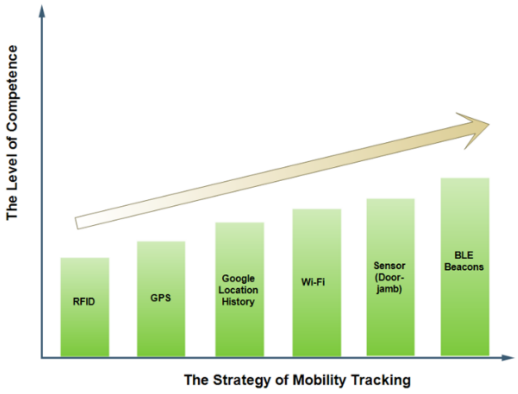

Fig. 4. The level of competence for Strategy Mobility Tracking for preventive measures and treatment of people infected with COVID-19

5. CONCLUSIONS AND REMARKS

Tracking location has been investigated by many researchers and implemented in the health sector. The methods of obtaining the location data vary across indoor and outdoor environments. The indoor environment deals with the accuracy that requires detail, like which room the item or user is needed to be captured. The indoor tracking research proposes a solution using BLE Beacons, RFID, and Infrared

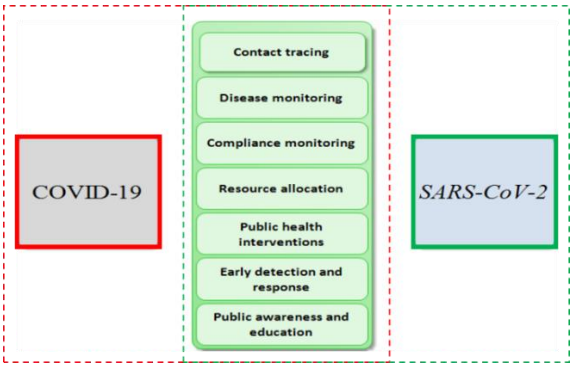

Fig. 5. The common points between Covid-19 and the SARS-CoV-2 epidemics regarding Monitoring for Location Tracking for the People in Health Field

sensor and applies analysis to estimate the movement for better accuracy. Outdoor tracking applies GPS to track the daily mobility of the user. The location data can be obtained through the GPS built-in device or Google Location History, which provides the history of visited locations once enabled. The obtained daily activity is analyzed for knowledge such as predicting future sites visited and investigating air pollution. Furthermore, location tracking can be an alternative against Covid-19 to monitor and track the infectee like it was implemented during SARS [30]. Future work is expected to improve the accuracy of multiple users that make mobility for indoor tracking. Many analyses can be made by relating the mobility data of outdoor tracking to health data, such as to evaluate older adults' physical activity.

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REFERENCES

1. Gholamhosseini L, Sadoughi F, Safaei A. Hospital real-time location system (A practical approach in healthcare): A narrative review article. Iranian Journal of Public Health 2019; 48(4): 593–602. https://doi.org/10.18502/ijph.v48i4.980.
2. Mohammed MN, Hazairin NA, Syamsudin H, Al-Zubaid S, A.K S, Mustapha S, i in. 2019 NOVEL CORONAVIRUS DISEASE (COVID-19): DETECTION AND DIAGNOSIS SYSTEM USING IOT BASED SAMART GLASSES. International Journal of Advanced Science and Technology 2020;
3. Hardy J, Veinot TC, Yan X, Berrocal VJ, Clarke P, Goodspeed R, Gomez-Lopez IN, Romero D, Vvydiswaran VGV. User acceptance of location-tracking technologies in health research: Implications for study design and data quality. Journal of

Biomedical Informatics 2018; 79: 7–19 https://doir.org/10.1016/j.jbi.2018.01.003.
4. Ruktanonchai NW, Ruktanonchai CW, Floyd JR, Tatem AJ. Using Google Location History data to quantify fine-scale human mobility. International Journal of Health Geographics 2018; 17(1): 1–13. https://doi.org/10.1186/s12942-018-0150-z.
5. Yang SY, Hsu CL. A location-based services and Google maps-based information master system for tour guiding. Computers and Electrical Engineering 2016; 54: 87–105. https://doi.org/10.1016/j.compeleceng.2015.11.020.
6. Zhang R. Applying RFID and GPS tracker for signal processing in a cargo security system. 2013 IEEE International Conference on Signal Processing, Communications and Computing ISCPCC 2013; https://doi.org/10.1109/ICSPCC.2013.6664053.
7. Macarulla Rodriguez A, Tiberius C, Bree R, Geradts Z. Google timeline accuracy assessment and error prediction. Forensic Sciences Research 2018; 3(3): 240–55. https://doi.org/10.1080/20961790.2018.1509187.
8. Yao W, Chu CH, Li Z. The use of RFID in healthcare: Benefits and barriers. Proceedings of 2010 IEEE International Conference on RFID-Technology and Applications, RFID-TA 2010 2010; (June): :128–34. https://doi.org/10.1109/RFID-TA.2010.5529874
9. Homdee N, Alam R, Wolfe S, Lach J. Mind the gaps: Edge-based monitoring for continuous room-level location tracking. Smart Health 2018; 9–10: 297–306. https://doi.org/10.1016/j.smhl.2018.07.020.
10. Surian D, Kim V, Menon R, Dunn AG, Sintchenko V, Coiera E. Tracking a moving user in indoor environments using Bluetooth low energy beacons. Journal of Biomedical Informatics 2019; 98: 103288. https://doi.org/10.1016/j.jbi.2019.103288.
11. Goodspeed R, Yan X, Hardy J, Vydiswaran VV, Berrocal VJ, Clarke P. Comparing the data quality of global positioning system devices and mobile phones for assessing relationships between place, mobility, and health: Field study. JMIR mHealth and uHealth 2018; 6(8). https://doi.org/10.2196/mhealth.9771.
12. Belciug FG, Turcu CE. Hybrid agent based algorithm for an efficient RFID-based health information system. 2017 E-Health and Bioengineering Conference, EHB 2017; 277–80. https://doi.org/10.1109/EHB.2017.7995415.
13. Sardianos C, Varlamis I, Bouras G. Extracting user habits from google maps history logs. 2018 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM); 690–697. https://doi.org/10.1109/ASONAM.2018.8508442.
14. Cumulative confirmed COVID-19 cases by world region. Available: https://ourworldindata.org/grapher/cumulative-covid-cases-region.
15. Cumulative confirmed COVID-19 deaths by world region. Available: https://ourworldindata.org/grapher/cumulative-covid-deaths-region.
16. WHO. WHO Covid-19 Weekly Operational Update 2020. Available: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/strategies-and-plans.
17. Kamel Boulos MN, Geraghty EM. Geographical tracking and mapping of coronavirus disease COVID-19/severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) epidemic and associated events around the world: How 21st century GIS technologies are supporting the global fight against outbr. International Journal of Health Geographics 2020; 19(1): 1–12. https://doi.org/10.1186/s12942-020-00202-8.
18. Mohammed MN, Hazairin NA, Al-Zubaid S, A.K S, Mustapha S, Yusuf E. Toward a novel design for coronavirus detection and diagnosis system using IOT based drone technology. International Journal of Psychosocial Rehabilitation 2020; 24(7): 2287–95. https://doi.org/10.37200/IJPR/V24I7/PR270220.
19. Mohammed MN, Hazairin NA, Syamsudin H, Al-Zubaidi S, Sairah AK, Mustapha S, Yusuf E. 2019 novel coronavirus disease (COVID-19): detection and diagnosis system using IOT based smart glasses. International Journal of Advanced Science and Technology 2020; 29(7): 954-960.
20. Mohammed MN, Syamsudin H, Al-Zubaidi S, A.K S, Ramli R, Yusuf E. Novel COVID-19 detection and diagnosis system using IOT based smart helmet. International Journal of Psychosocial Rehabilitation 2020; 24(7): 2296–303. https://doi.org/10.37200/IJPR/V24I7/PR270221.
21. Cantelmo G, Vitello P, Toader B, Antoniou, Viti F. Inferring urban mobility and habits from user location history. Transportation Research Procedia 2020; 47: 283–90. https://doi.org/10.1016/j.trpro.2020.03.100.
22. Kestens Y, Thierry B, Chaix B. Re-creating daily mobility histories for health research from raw GPS tracks: Validation of a kernel-based algorithm using real-life data. Health and Place 2016; 40: 29–33. https://doi.org/10.1016/j.healthplace.2016.04.004.
23. Wojtusiak J, Mogharab Nia R. Location prediction using GPS trackers: Can machine learning help locate the missing people with dementia? Internet of Things 2019; 100035. https://doi.org/10.1016/j.iot.2019.01.002.
24. Wu YC, Chen PF, Hu ZA, Chang CH, Lee GC, Yu WC. A mobile health monitoring system using RFID ring-type pulse sensor. 8th IEEE International Symposium on Dependable, Autonomic and Secure Computing, DASC 2009; 317–22. https://doi.org/10.1109/DASC.2009.136.
25. Razak NA, Arshad NHM, Adnan R, Misnan MF, Thamrin NM, Mahmud SF. A real-time angle deviation detection and measurement technique for straight line quadrocopter navigation using accelorometer. Proceedings - 2013 IEEE Conference on Systems, Process and Control, ICSPC 2013; 295–300. https://doi.org/10.1109/SPC.2013.6735150.
26. Bucher D, Mangili F, Cellina F, Bonesana C, Jonietz D, Raubal M. From location tracking to personalized eco-feedback: A framework for geographic information collection, processing and visualization to promote sustainable mobility behaviors. Travel Behaviour and Society 2019; 14: 43–56. https://doi.org/10.1016/j.tbs.2018.09.005.
27. Yu X, Stuart AL, Liu Y, Ivey CE, Russell AG, Kan H. On the accuracy and potential of Google Maps location history data to characterize individual mobility for air pollution health studies. Environmental Pollution 2019; 252: 924–30. https://doi.org/10.1016/j.envpol.2019.05.081.
28. Zenk SN, Schulz AJ, Matthews SA, Odoms-Young A, Wilbur JE, Wegrzyn L. Activity space environment and dietary and physical activity behaviors: A pilot

study. Health and Place 2011; 17(5): 1150–61. https://doi.org/10.1016/j.healthplace.2011.05.001.
29. Coustasse A, Cunningham B, Deslich S, Willson E, Meadows P. Benefits and barriers of implementation and utilization of radio-frequency identification (RFID) systems in transfusion medicine. Perspectives in health information management 2015; 12.
30. Dusseljee-Peute LW, Togt R, Jansen B, Jaspers MW. The value of radio frequency identification in quality management of the blood transfusion chain in an academic hospital setting. JMIR Medical Informatics 2019; 7(3). https://doi.org/10.2196/medinform.9510.
31. Martínez Pérez M, Cabrero-Canosa M, Vizoso Hermida J, Carrajo García L, Llamas Gómez D, Vázquez González G. Application of RFID technology in patient tracking and medication traceability in emergency care. Journal of Medical Systems 2012; 36(6): 3983–93. https://doi.org/10.1007/s10916-012-9871-x.
32. Madanian S. The use of e-health technology in healthcare environment: The role of RFID technology. 10th International Conference on e-Commerce in Developing Countries: With Focus on e-Tourism, ECDC 2016; 1–5. https://doi.org/10.1109/ECDC.2016.7492974.
33. Baji AM, Salini M, Sandra S, Thomas SR, Ravikumar A. Track&Go: A location prediction web application. 2017 International Conference on Networks and Advances in Computational Technologies, NetACT 2017; 52–5. https://doi.org/10.1109/NETACT.2017.8076740.
34. Alfiras M, Yassin AA, Bojiah J. Present and the Future Role of the Internet of Things in Higher Education Institutions. Journal of Positive Psychology and Wellbeing 2022; 6(1): 167-175.
35. Burdzik R. Epidemic Risk Analysis and Assessment in Transport Services: COVID-19 and Other Viruses. CRC Press 2021.
36. Budzynski M, Luczkiewicz A, Szmaglinski J. Assessing the risk in urban public transport for epidemiologic factors. Energies 2021; 14(15): 4513.
37. Alanzi T. A review of mobile applications available in the app and google play stores used during the COVID-19 outbreak. Journal of multidisciplinary healthcare 2021; 45-57.
38. Hu T, Wang S, She B, Zhang M, Huang X, Cui Y, Li Z. Human mobility data in the COVID-19 pandemic: characteristics, applications, and challenges. International Journal of Digital Earth 2021; 14(9): 1126-1147. https://doi.org/10.1080/17538947.2021.1952324.
39. Nomura S, Tanoue Y, Yoneoka D, Gilmour S, Kawashima T, Eguchi A, Miyata H. Mobility patterns in different age groups in Japan during the COVID-19 pandemic: a small area time series analysis through March 2021. Journal of Urban Health 2021; 98(5): 635-641. https://doi.org/10.1007/s11524-021-00566-7.
40. Vecino-Ortiz AI, Villanueva Congote J, Zapata Bedoya S, Cucunuba ZM. Impact of contact tracing on COVID-19 mortality: An impact evaluation using surveillance data from Colombia. PLoS One 2021; 16(3). https://doi.org/10.1371/journal.pone.0246987.
41. Felipe SGB, Parreira Batista P, da Silva CCR, de Melo RC, de Assumpção D, Perracini MR. Impact of COVID-19 pandemic on mobility of older adults: A scoping review. International journal of older people nursing 2023; 18(1). https://doi.org/10.1111/opn.12496.
42. Al-shami M, Abdulghafor R, Aborujilah A, Yagoub A, Turaev S, Ali MA. COVID-19 Tracking Applications Acceptance among General Populace: An Overview in Malaysia. Sustainability 2023; 15(5): 4060. https://doi.org/10.3390/su15054060.

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