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IoT-based centralized wireless patient tracking and surveillance system with a cutting-edge approach for advanced healthcare oversight and data-driven analysis

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Abstract. The construction of smart cities has been progressing quickly due to advancements in 5G and Internet of Things (IoT) technology. Smart transportation systems and smart medical ideas are also being explored alongside smart city initiatives. Integrating the two mentioned technologies, a smart navigational method for ambulances is being developed. When severe patients arrive via ambulance, significant time is wasted in relaying data, and the hospital needs to gain prior knowledge of the patient's condition. An efficient system called the IoT-based Wireless Patient Tracking Method (IoT-WPTM) is proposed to diagnose patients quickly by recording vital metrics such as heartbeat, temperature, and breathing rate using detectors. These variables are transmitted wirelessly to the healthcare before the ambulance is dispatched, allowing doctors to begin medical care promptly. If necessary, the patient monitors the ambulance's position to anticipate arrival and get immediate directions to the closest hospital. The user carries the gadget and is also placed in the ambulance. The gadget allows IoT devices and Android apps to enhance user interaction and streamline information delivery. IoT-WPTM can be surpassed with ease and in a more effective manner for smart medical surveillance systems.

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1 Introduction to healthcare applications

Integrating traditional urban infrastructures is essential and can be achieved via smart city concepts and Internet of Things (IoT) technologies [1]. The IoT technology employs sensors in urban areas to promote social and economic progress in creating smart cities and their services. Hence, an organized control framework requires strong collaboration among the public and commercial industries to develop smart city facilities. The Information Technology (IT) sector's engagement has significantly enhanced the effectiveness of smart cities [2]. When discussing smart city ideas, several meanings arise due to the ambiguity and need for established definitions for smart cities. Smart cities are urban areas that prioritize investment in human resources through learning, quality of life, healthcare, open governance, effective resource management, long-term viability, safety, and confidentiality for inhabitants, all facilitated by Information and Communication Technology (ICT) [3]. Smart cities have become essential, attracting interest from both businesses and academia. By examining the investing strategies of corporations such as Siemens, Intel, etc, it is evident that they are making more prudent investments for the coming years.

The process of requesting an ambulance and admitting the patient is inefficient and lacks the transmission of vital data to the hospital in advance. Inadequate access to appropriate emergency treatment determines the outcome of survival and fatality. When critically sick patients are evacuated by an ambulance, the medical facility lacks crucial patient characteristics required by the physician for first therapy until the individual's arrival [4].

The system is created to monitor individuals at various locations at home and send data wirelessly to the medical center in case of an illness. Efficient handling of medical crises requires the medical facility to promptly obtain patient data to initiate treatment upon the individual's arrival [5]. The user should get numerous essential services, especially those with severe symptoms. For instance, in elderly care facilities, it is necessary to have efficient monitoring systems in place. Individuals should be able to alert emergency contacts quickly, demand an ambulance promptly, track its arrival on time, and receive immediate navigation instructions to the closest medical center. The current method has many shortcomings, including time wasting, ineffective information transfer, absence of data transfer technology in ambulances, and needless delays. A more effective approach should be suggested to address these difficulties during an illness.

The rest of the sections are organized in the following manner: Section 2 illustrates the background and literature survey of the health monitoring model. The proposed wireless health monitoring model with IoT is discussed in section 3. Section 4 discusses the software analysis and outcomes. Section 5 concludes the research and discusses the future scope.

2 Background and literature survey

Several IoT technologies have been suggested to enhance medical facilities in recent years. The IoT facilitates remote patient surveillance by linking elderly individuals with chronic illnesses to healthcare professionals and medical services. IoT solutions have been used to assist individuals with Parkinson's and Alzheimer's disease [6]. It provides emergency preparedness services for elderly individuals living independently and requiring specialized assistance. It is used for managing gear and patients in medical facilities. IoT technology in smart healthcare settings facilitates remote diagnosis before hospital visits, leading to more effective therapy. Diabetic individuals must continually check their blood glucose levels [7]. Wearable sensors transmit blood glucose information to physicians or cell phones to track individuals' health status continuously. Castillejo et al. created an IoT e-health system using Wireless Sensor Networks (WSN) designed explicitly for firefighting [8].

Geolocating individuals provides crucial data on a possible breakout during a pandemic. There are several methods to carry out this procedure, each with advantages and disadvantages, but all provide precise estimates. A Global Positioning System (GPS) requires significant power expenditure [9]. GPS accuracy significantly decreases depending on the receiver's location and satellites, particularly while inside. Research has shown that utilizing the Received Signal Strong Indication (RSSI) to determine the user's location inside is possible [10]. The user has a mobile device linked to the Wireless Local Area Network (WLAN). The mobile device transmits a signal to many stationary access points, combined using a Center of Gravity method to determine where the consumer is. Dinh et al. discuss using beacons equipped with Bluetooth for geographical monitoring [11]. Bluetooth is widely used in many devices, such as wearables and phones. However, signal refraction is a challenge with the method, which hinders the precise determination of distance. A low-power tracking approach for IoT systems is provided [12]. The device utilizes positioning sensors and a gyroscope for geographical monitoring to minimize reliance on GPS, resulting in lower battery usage. Apple and Google previously revealed their plan to use Bluetooth technology to track iOS and Android customers. Individuals can turn it on or off; any information will only be shared with reputable medical institutions that adhere to specific privacy protocols.

Paraskevaidi et al. were among the pioneering experiments that used participants' cell phones to investigate the swift propagation of infectious illnesses [13]. Cell phones were employed to gather data about adjacent Bluetooth gadgets, GPS coordinates, and flu symptoms. The information was transmitted to a server. The suggested architecture is suitable for rural regions or poor nations, where opportunist networking and satellite connections are utilized for information transfer. New research assesses the impact of active traceability and monitoring on reducing the transmission of infectious illnesses [14]. The findings indicate that cellphone contact tracking has substantial societal and economic advantages [15].

The article introduces an architecture that includes a cost-effective and portable IoT node for monitoring body temperatures, heartbeat rate, oxygen level in the blood, and respiration trends. An app for smartphones for displaying information and analyzing risk variables. A Bluetooth 4.0 separation tracking system to notify consumers of unsafe physical proximity and a fog server for collecting information from IoT devices and utilizing a machine learning method to send relevant data to consumers.

3 Proposed IoT-based wireless patient tracking method

This research introduces a cost-effective connectivity system designed to enhance identification speed and reduce time by quickly communicating health information from the paramedic or patient to the medical evacuation center, as seen in Figure 1. IoT devices are beneficial for remotely monitoring patient variables. Patient information is sent wirelessly to the hospitals or medical centers before the paramedics are dispatched, enhancing the present technology. The patient may monitor the vehicle's position and send a Short Messaging Service (SMS) to a critical to share location data and characteristics. An immediate navigation function is available to the closest hospital or healthcare center, converting the longitude and latitude coordinates into a legible name.

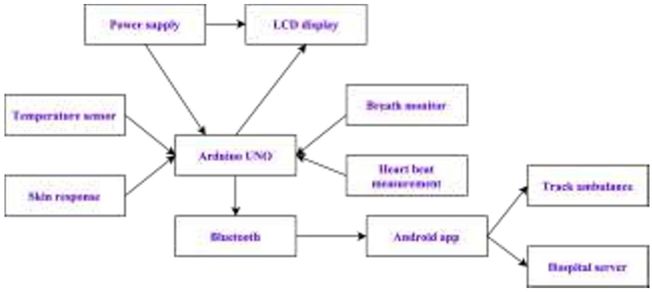

Fig. 1. Workflow of the IoT-WPTM model

The suggested structure is effective and smart, conducting a rapid thirty-second evaluation by utilizing respiration, temperatures, breathing rate, and complexion sensors to collect vital patient data doctors need to initiate therapy. This data is then transmitted to the hospital before the ambulance is dispatched. The patient can call an ambulance instantaneously by pressing a button without needing to phone the hospital. They additionally send an SMS to an emergency number with all relevant data sooner. The patient monitors the ambulance's position to anticipate its approach and get immediate guidance to the closest hospital, if necessary, as seen in Figure 2. The gadget is retained by the patient's body and placed within the vehicle. The gadget facilitates the usage of IoT devices and Android apps to enhance customer engagement and streamline information transfer.

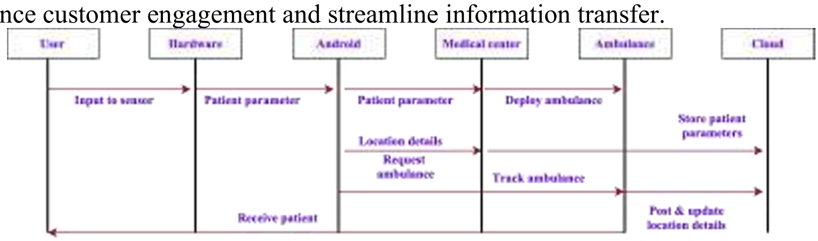

Fig. 2. Flow diagram of the proposed IoT-WPTM

3.1 Task specification

A thermistor-based circuit is employed for temperature monitoring. The skin response component assesses body resistance using two metallic sensors. A pulse oxygen measurement system serves in the pulse monitoring structure, while the respiratory monitoring device employs a turbine and magnet base component. All sensed readings are shown on the liquid crystal diode screen. A Bluetooth component connects the gadget and an Android mobile for transmitting collected metrics.

A sophisticated system has been developed for the medical center to collect essential patient data, including information on where the patient lives. This enables the hospital to keep a structured database of individuals and their information and dispatch an emergency vehicle to a particular patient’s position. A user end has been developed using Visual Studio for this platform.

A thirty-second diagnostic test was developed to design Android apps for user interfaces that are interactive and offer different services during emergencies. The patient parameters are monitored during this examination utilizing hardware-wearable devices. The requirements are transmitted to the medical center in addition to the patient’s geographical details for use with urgent services such as asking for an ambulance, notifying a crisis contact with variables and place specifics, enabling the individual to monitor the vehicle’s getting there, and providing instant navigating information to the closest medical center.

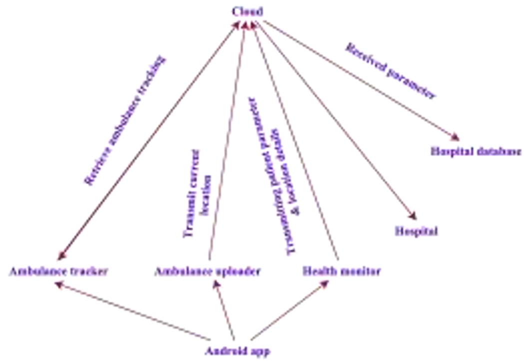

Fig. 3. The software architecture of the IoT-WPTM model

Using Bluetooth, wearable sensors assess patient variables and communicate information to an Android mobile. After receiving the information, the android transmits these variables and the individual's present location information to the medical center. The system displays patient characteristics such as heart rate, temperature, breathing measurements, and skin reaction on a screen. The suggested system is divided into three requests: health display, ambulance tracking system, and hospital uploader, to enhance information flow efficiency. The Health Monitor program sends patient metrics and location data to the medical center. The app offers features such as summoning a rescue vehicle, alerting an urgent interaction, and offering immediate directions to the closest medical center. The vehicle's uploader continuously shares its current position on the cloud, allowing the medical vehicle to provide location information. Individuals can use the vehicle tracker to monitor the arrival of the sent ambulances.

3.2 Data-driven framework

This section presents an IoT-WPTM model to extract older patients' signal characteristics and individual traits to improve compressive measurement effectiveness using fewer samples. The system consists of three units using a machine learning method: a compressive measurement sampled unit, an infrastructure, and an information recovery component. These units are implemented on mobile devices, servers, and detectors, as seen in Figure 4.

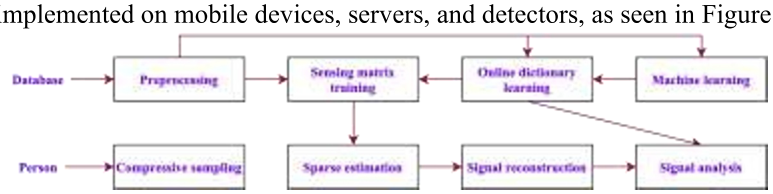

Fig. 4. Data-driven framework of the proposed IoT-WPTM model

Physiological signals might vary across individuals, making a general approach inadequate for aged people. This dictionary learning component offers a personalized foundation for specific properties essential for restoring Compressive Sensors and guarantees greater sparsity than the pre-established base.

4 Simulation analysis and outcomes

This research aims to continuously measure, show, and analyze the individual's health utilizing effectively installed devices. The research has included a feature that alerts the physician and the patient's relatives whenever vital signs exceed a specific limit. The primary objective is to create a wearable Smart Gadget that continuously checks critical signs. The research effectively used IoT technologies and internet apps such as ThinkSpeak. It created a gadget that effectively analyzes the individual's vital signs and displays them on the ThingSpeak website for the specified purpose. The findings are presented in a graphical format for interpretation. Every chart shows the real-time reading, indicating the precise time and position of the reading. The captured information is kept in an Excel file on the maker's Google Drive profile and is examined anytime.

The captured data is kept in an Excel file on the maker's Google Drive and is accessed for study at any moment. In addition to showing all the information available on the internet, it included the ability to track the vitals using a smartphone application named "ThingView Free," which can be found on the Play Store. It provides a simple method for monitoring one's health metrics. The research can determine the precise timing of each reading. An instant messaging system has been appropriately set up to notify the family and the physician when the Panic button is used.

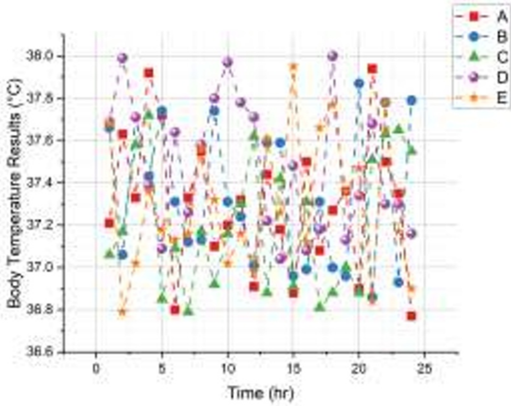

Fig. 5. Body temperature result analysis of the proposed IoT-WPTM model

Figure 5 shows the 24-hour body temperature data for participants A, B, C, D, and E. The values were calculated from variations observed throughout time. Person B's temperatures remain stable, but Person C's temperatures fluctuate. The suggested approach utilizes IoT-based Wireless Patient Tracking to provide real-time monitoring, which generates valuable data for thorough healthcare analysis and prompt medical actions in response to identified patterns.

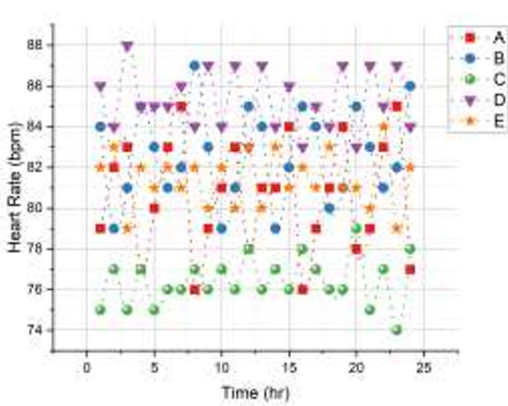

Fig. 6. Heart rate analysis of the proposed IoT-WPTM model

Figure 6 displays the 24-hour heart rate data for persons A, B, C, D, and E. The calculated data demonstrate diverse patterns, with Person C consistently expressing rates and Person D exhibiting swings. The suggested approach integrates IoT-based Wireless Patient Tracking to enable ongoing monitoring, providing significant data for thorough healthcare analysis and prompt treatments according to identified patterns.

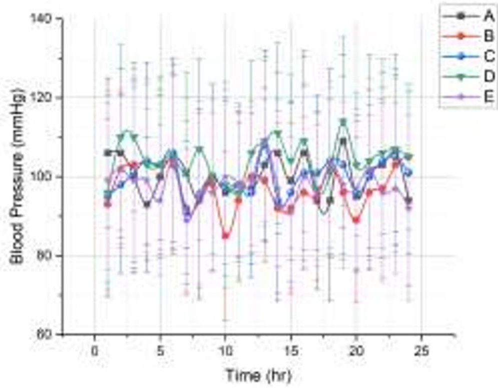

Fig. 7. Blood Pressure analysis of the proposed IoT-WPTM model

Figure 7 displays the 24-hour blood pressure data, including systolic and diastolic readings for people A, B, C, D, and E. The data analysis shows different patterns, with Person D displaying changes in both systolic and diastolic measurements. The suggested approach utilizes IoT-based Wireless Patient Tracking to provide continuous monitoring, essential data for thorough healthcare analysis, and prompt treatments guided by observed patterns.

5 Conclusion and future scope

With the rapid advancement of technology, the medical field is a prime area for using technology to enhance patient care. This study discusses and implements remote surveillance of patient medical variables utilizing Android and IoT devices. The suggested IoT-WPTM transmits crucial patient data to the medical facility before the patient arrives or dispatching a rescue vehicle. The proposed IoT-WPTM approach eliminates inefficiencies in the current system and allows continuous patient monitoring. The system software is deployed in an ambulance to promptly transfer emergency data to the medical center, enabling the patient to monitor the ambulance's location. The system concept and implementation would allow patients to send urgent messages to a designated contact with healthcare and geographic data. The IoT-WPTM offers navigation to the closest hospital with a single button press. In the future, this program may be expanded with additional security measures to protect health information.

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