Chapter 7
Smart Wearable Devices for Remote Patient Monitoring in Healthcare 4.0

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7.1 Introduction

The Internet of Medical Things (IoMT) is a collection of health-related applications with integrated devices, in which healthcare information technology (IT) devices are linked through online computer system networks. Health products built with wi-fi permit machine-to-machine interactions, which is the idea behind the IoMT. IoMT devices connect to the cloud through services such as Amazon Web Services, Microsoft Azure Cloud, Google Cloud Computing, or customized solutions that record data for analysis and storage [1]. IoMT is known as "smart" healthcare; its structural functionality is shown in Fig. 7.1.

Applications of IoMT include the remote monitoring of individuals who have long-term problems and chronic disease. This service monitors treatment and medication adherence, as well as patients' health data through wearable devices that can transmit information to a specific caregiver. IoMT smart devices use sensors and actuators to recognize and evaluate an individual's health data, then transfer the information to the cloud, where it is both accessible to the network and secure. An intelligent system plays a significant part in offering the brain's presence and comfort to doctors and patients. It comprises a method that communicates between programs, apps, and products to allow physicians to monitor patients' vital health

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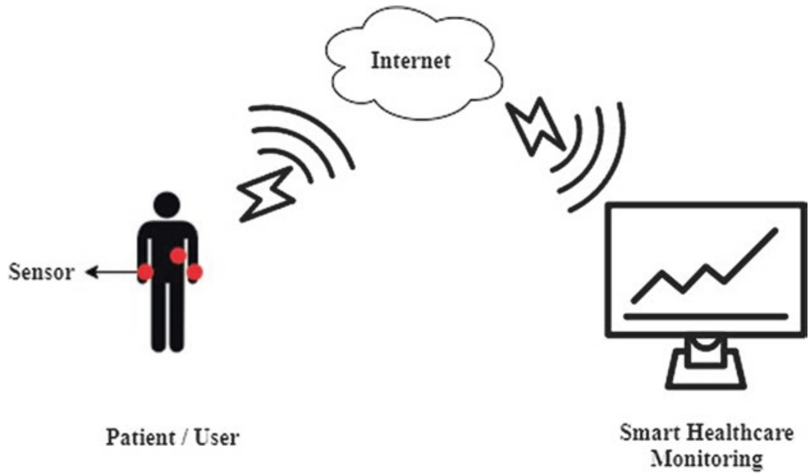

Fig. 7.1 IoMT structural functionality

information. Several products help to monitor useful metrics: wearable health and fitness rings, health and fitness shoes, radiofrequency identification (RFID) pendant watches, along with digital cameras. Additionally, smartphones can provide regular alerts and crisis expertise.

These interconnected Internet of Things (IoT) gadgets provide large amounts of data that must be handled efficiently by vendors. IoT analysis can be carried out to help process such expansive data. A piece of essential information can be made more beneficial with the ability to restore health and well-being when techniques such as data removal and data analytics are used. By 2020, more than 50–55% of techniques used to analyze raw data make better use of this particular arrival of data created by using instrumented machines and applications [2]. Thus, to address privacy concerns, the IoT depends upon several innovative developments. Real-time data from various sources need to be exceptionally easy and quick to access using IoMT. IoMT is managed by smart sensors, which effectively determine, monitor, and assess a selection of overall health signs [3], including heart rate, blood pressure, glucose level, and blood oxygen level. Smart sensors are frequently integrated into drugs and pill bottles, which can provide alerts on whether a person has taken his or her prescribed dose.

Improvements are occurring in IoT's leading solutions. The means of communication with different widgets and the display of data are alerts are changing. Wellness-related solutions are collecting, capturing, sharing, and analyzing user data efficiently in real time. Furthermore, knowledge on the systematic development and advancement of IoT could increase effectiveness. For example, different regenerative units like well-being, social occasions, monitoring the developments, prescription limits, and success are beginning to have a proper sensor held up in them, creating unrefined details, evaluating, and storing it immediately, which enable doctor's to induce appropriate action.

With the assistance of IoT, there are now ways to obtain real-time information from a variety of individuals using smart gadgets that are interconnected within society. Healthcare providers can diagnosis, provide prognosis, and make critical recommendations in a more direct way [5]. This particular evolution provides reliable and useful information, as well as time and cost savings for both patients and providers.

This chapter proposes an IoT device to track an individual's health data, including electrocardiogram (ECG), blood pressure, and heart rate. The collected data can be transferred to caretakers or healthcare providers, imparting a quick and accurate picture of a patient's health.

7.1.1 An Overview of Available IoMT Technology

IoMT devices provide real-time interventions and interconnectivity that can change the healthcare experience, affordability, delivery, and dependability. "Smart" products are connected to other devices or networks can interact with the internet [1]. According to the definition, a device with the following attributes can utilize the IoT:

- Distinctively recognizable.
- Easily discoverable.
- Able to send and receive a response from another device.
- Able to perform simple operations.

The progress in IoT devices is related to the development of sensors, which are more sensitive, easier to discover, and more affordable than in the past. The technology used for the communication of smart devices includes a mix of large wireless networks such as Bluetooth, near filed communication (NFC), wireless sensor network (WSN), low-power wide-area (LPWA), and Long Range [5]. The development of radiofrequency identification (RFID) has also helped to improve IoT applications. This engineering uses microchips for remote data and interaction and is truly a remarkable modification of standard barcodes [3], as it provides both browsing and creation capabilities [4]. Finally, cloud computing is crucial to process all of the (massive) data, which may include temperature, stress, altitude, movement, proximity, sound, or biometrics, among many others.

Wearable smart devices have the potential to greatly improve the understanding, delivery, and results of healthcare and treatment by monitoring an individual patient's health. Nevertheless, challenges exist with the use of sensors for medical trial conduct, information management, and data interpretation using wearables. Wearable devices allow for remote patient monitoring (RPM) of medical data, including heart rate and blood pressure, which can be reviewed remotely by experts and caretakers. The devices can also alert users to potential problems. For example, if an individual is experiencing breathing problems, a notification could be routed to a person monitoring the gadget, who could then appropriately respond to the issue. Furthermore, a wearable device could prevent unnecessary appointments, whereby

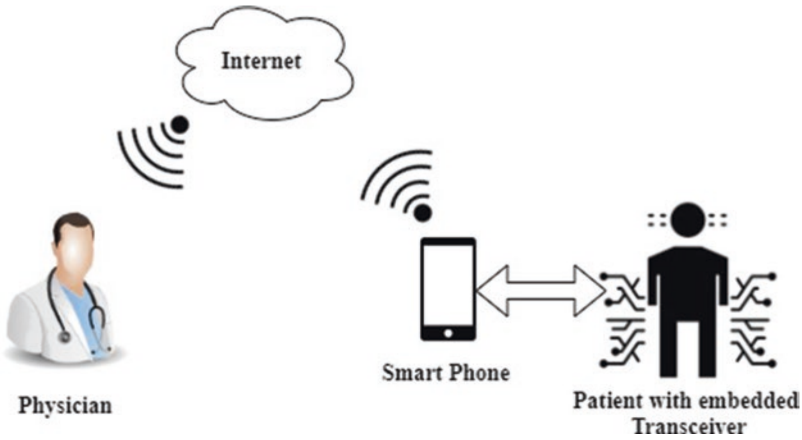

Fig. 7.2 RPM framework

individuals do not need to travel to a physician's office for routine collection of vital signs, which can now be monitored remotely. Hospital staff members can also audit data gathered by the wearable for accuracy.

Remote patient monitoring (RPM, also known as e-health) is a kind of ambulatory therapeutic assistance that allows an individual to use a portable gadget to forgo routine examinations and instead remotely transmit the relevant data to a healthcare provider as needed. RPM includes daily testing devices, such as glucose meters for individuals with and diabetes or heart monitors for aerobic exercise, which are usually routed to a physician's office through an e-health framework. Figure 7.2 shows a unique program that can be used on an individual's internet-connected computer, mobile phone, or even tablet.

7.1.2 Contribution of the Study

Wearable products can monitor a patient and capture real-time data on one's physical state and movements. Wearable sensor-based health and fitness monitors comprise distinct types of adaptable receptors that can be incorporated in textiles, garments, rings, or even placed directly on the body. The receptors can obtain physical data including electrocardiogram (ECG), electromyogram (EMG), pulse rate (PR), body temperature, electrodermal action (EDA), arterial saturation (SpO_2), blood pressure levels (BP), and respiration rate (RR) [5]. Additionally, microelectro-mechanical program (MEMS)-based monitoring receptors, such as accelerometers, gyroscopes, and magnetic area receptors, are broadly utilized. Constant monitoring of biological indicators may quickly identify certain aerobic, pulmonary, and neurological illnesses at their early onset.

The data received from the receptors inside a wireless body sensor network are transmitted to a neighboring node for processing, preferably via low-power and short-range wireless communications such as Bluetooth, ZigBee, and near field communications (NFC) [6]. The processing node may be a personal digital assistant (PDA), smartphone, computer, custom-made microcontroller, or Field Programmable Gate Array (FPGA). Noninvasive, nonintrusive receptors are essential aspects of long-term smart health monitoring. Wearable receptors are becoming much more comfortable and less obtrusive; thus, they are suitable for checking a person's health condition without disturbing their daily activities. The receptors can gauge several biological signals/parameters, movement, and activity of a person by putting them on numerous places in the body. The development contains low power, compact wearables (sensors, actuators, antennas, sensible textiles), low-cost storage, and computing products accompanied by contemporary correspondence solutions. It reduces the processing cost.

7.2 Wearable Smart Devices for Remote Healthcare Monitoring

Noninvasive, nonintrusive sensors are essential aspects of long-term health and fitness monitoring methods, as described in this section [7].

7.2.1 Body Temperature Monitoring

Body temperature is one of the most important indicators of health issues. Body temperature variations are associated with infection, many inflammatory conditions, malignancy, sleep disorders [8], and menstruation [9]. Coyne et al. [10] noted a correlation between body temperature and initial stroke severity, infarct size, and death rate in stroke patients, with infarct size increasing by 16 mm with a 1 °C increase in body temperature. Additionally, a correlation between cognitive function and body temperature was also noted in the literature [11].

Boano et al. [12] demonstrated an inconspicuous, wireless body temperature monitor that can be used by a person for an extended period of time. Two sensor devices are connected to the epidermis, which may capture and transmit information to a more powerful body-worn primary device, therefore creating a body sensor network. The primary device sends the information to the system. It communicates with healthcare services across the web. The authors attained a precision of 0.04 °C in a temperature range of 16–42 °C. Additionally, it device could obtain circadian rhythms. Afterward, the developers created a wireless monitoring method for long-distance runners, calculating the typical daytime temperature [13].

A safe, wearable temperature monitor also has been created for neonates [14]. A negative temperature coefficient (NTC) resistor is used inside a strap made from smooth bamboo fiber. The developers used a flexible and soft bronze-coated nylon strand for the transfer/transit intermediate interface within the strap rather than rigid cables. The device demonstrated a precision of 0.1 °C compared with a regular thermometer. A reliable, constant link between the sensor and fabric can be critical for this specific application.

The device may be incorporated in a smart coat or even belt, which is a non-invasive, long-term monitoring approach that is appealing for elderly individuals. Mansor et al. [15] explained the setup associated with a wireless temperature monitoring technique utilizing industrial sensors. The climate sensor, which has an incorporated ZigBee wireless node, records and sends information to a microcontroller. The microcontroller sends data to a server that is on the remote side along with a WLAN. An ethernet shield for an Arduino microcontroller was used to improve a module. Related heart rate and temperature monitoring methods have been described elsewhere [16].

Sim et al. [17] developed a method of implanting the flux probe for a dual-heat probe, with two dual-sensor thermometers interfaced in a neck pillow. Because the jugular vein passes through the neck, your head has a stable association with the core body temperature (CBT). The temperature calculated by this product is similar to that assessed by an infrared thermometer through the tympanic membrane. The developers recommended a curve-fitting technique to enhance the natural gradual effect period of a dual-heat-flux thermometer. A method also may be created for individuals to use while sleeping, inside the neckline of a shirt, or worn as a fabric strip. Kitamura et al. [18] created a heat sensor pin that gauges CBT over the epidermis. The round steel wire includes two heat flow routes for two distinct resistances; every path has a set of climate transmitters, and the receiver is attached in both ends. This method shows much effective and greater precision (96% association with a measurement calculated out of a null heat flow thermometer) as it tends to be stable or balanced heat. The required time period can undoubtedly be improved with artificial intelligence instruments rather than a copper instrument.

7.2.2 Activity Monitoring

Monitoring a person's aerobic activity and movement may be useful for rehabilitation, sports, early detection of cognitive or musculoskeletal illnesses, or sense of balance evaluation. A person's walking patterns have been associated with their health problems [19]. Any gait abnormalities may be suggestive of potential musculoskeletal or nervous system. For example, individuals in the early phase of neurodegenerative problems, such as Alzheimer and Parkinson disease, often display certain gait abnormalities [20], such as small and shuffled steps with Parkinson disease. In addition, older individuals are more susceptible to falls, which may cause accidents, hip fractures, traumatic brain injuries, and other bone fractures

[20]. Quantitative assessment and analysis can predict numerous illnesses, fall potential, and rehabilitation time after injury.

At home, camera-based methods are helpful for monitoring exercise [21]. However, the fixed location limits the detection of motion to a particular area. Other methods are more expensive and complicated. Recently, wearable movement receptors, such as magnetometers, gyroscopes, and accelerometers, have become more popular for monitoring activity in real time [22]. A sensor evaluates the body's angular and linear activity by selecting certain parameters to measure. A schematic of the activity monitoring with accelerometers and gyroscopes is provided in Fig. 7.3.

Bertolotti et al. [23] created a small, wireless wearable unit used to evaluate balance by monitoring limb motions for an extended period using a gyroscope, a magnetometer, and an accelerometer. Several models may also be attached within a body sensor network to calculate various parameters. The method was authenticated by evaluating the center-of-mass (CoM) movement calculated through a Nintendo Wii Balance Board (https://www.analog.com/en/applications/markets/healthcare-pavilion-home.html). Additionally, analysis is recommended to determine treatment options based on data measurements. Panahandeh et al. [24] recommended a gait evaluation algorithm based upon the Hidden Markov Model with measurements obtained from a tri-axial accelerometer and gyroscope. They proposed a function removal technique grounded on measuring Discrete Fourier Transform (DFT) coefficients are commencing sections of motion. Experts attained higher categorical precision depending on sport function. Because of the lack of wireless connectivity, a computer had to be used for testing or research, which affected the subject's activities. Otherwise, the evaluation was carried out with an ad-hoc schedule. The device can be upgraded by integrating wireless connectivity and including other algorithms.

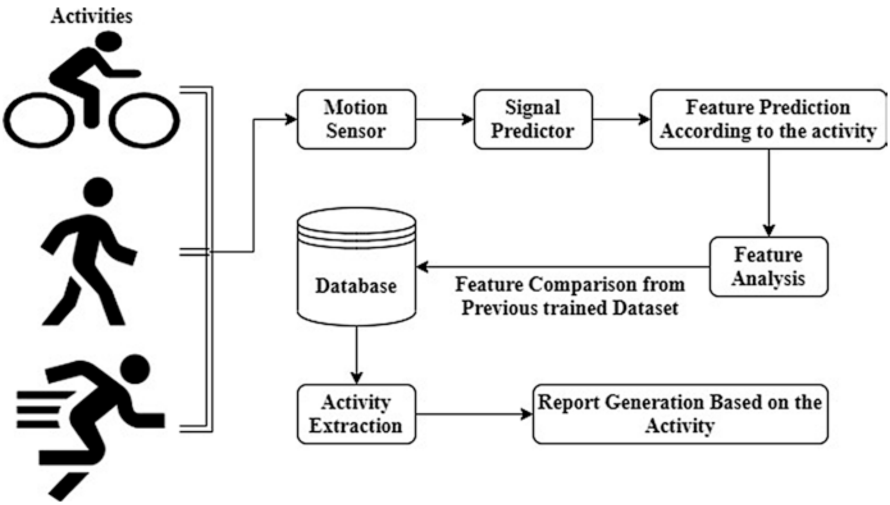

Fig. 7.3 Activity monitoring

Friedman et al. [25] created a wearable wrist and a finger joint checking technique using magnetic technologies. The device is made up of a neodymium band with data storage. The finger band has a magnetic area assessed by two tri-axis magnetometers installed in the wrist device. A radial timeframe feature estimates the characteristics of the wrist and finger bones in the dimensions. The authors found the same result for the angular distance for wrist bones.

Nevertheless, finger flexion and extension evaluation is complicated. Evaluation can be improved by ensuring the calibration is correct for each user. A method for joining perspective evaluation of pairing kinematic arm designs together with the express design algorithm continues to be accessible [26]. Inertial dimensions were taken from three sets of inertial measurement unit (IMUs) placed on the top arm, forearm, and a wrist. The expressive design integrated arbitrary drift clothes areas and zero velocity adjustments, which could reduce the sensor flow. The unit also found restrictions of joint motions with substantial reliability. The authors approximated joint movement using the unscented Kalman filter [27]; a more complex algorithm, the extended Kalman filter (EKF), can be used for devices with increased nonlinearities. It may attain a top-level evaluation and precision during various intensities of arm actions.

Validation of this particular algorithm for the primary subject matter is essential. Kalman-based solutions are computationally rigorous and require a high sampling pace for human activities. Thus, using the devices for real-time programs might be difficult.

7.2.3 Galvanic Skin Response Monitoring

Autonomic nervous system (ANS) responses can be measured with an external or internal stimulus by controlling tasks within its two subdivisions: the sympathetic and parasympathetic nervous systems [28]. The parasympathetic system conserves and restores all of the body's electricity, the sympathetic system sparks the so-called flight-or-fight response by increasing the metabolic changes to cope with an outside stimulus. The sympathetic system can increase pulse rate, blood pressure, and sweat secretion to prepare the body for activity by pumping additional blood to muscles, the lungs, and the brain.

Much is unknown about dysautonomia, postural orthostatic tachycardia syndrome (POTS), and tachycardia. Increased sweat secretion from eccrine glands loads the sweat ducts. Sweat, being a weak electrolyte, increases the skin's conduction through an enhanced discharge of secretion. Perturbation of epidermis conductance is known as EDA. Galvanic skin response (GSR) mirrors the response of the sympathetic central nervous system. It may also offer a straightforward, reliable, and sensitive approach for evaluating sympathetic responses linked to anxiety and emotion [29].

Generally, GSR is calculated from the skin's components, from the many sweat glands in the soles, fingers, or palm. Passive measurement, a DC voltage, has been used on two body electrodes. In addition, the epidermis conductance can be computed by Ohm's law. Early research in this area mostly centered on time-limited GSR measurement devices in the laboratory or healthcare facilities. The advancement of wearable technologies is providing exciting opportunities for inconspicuous, extended-use GSR [30]. Long-term GSR monitoring allows for evaluation of the sympathetic central nervous system for an extended period to possibly obtain important biological data that cannot be captured during short-term monitoring. In addition, wearable GSR allows users to monitor GSR from home to better evaluate their psychophysiological condition versus analysis occurring in hospitals or laboratories with fewer measurements [31]. A diagram of wearable GSR monitoring is provided in Fig. 7.4.

A wearable GSR sensor can carry out measurements from the entire body and transmit information via a Bluetooth device. This sensor is located on a flexible printed circuit board (PCB) that includes silicon, making continuous contact with a curved body area [32]. A conductive polymer foam was also used because the initial substance was only for the flexible electrodes. The electrodes' adaptive dynamics provide a steady and dependable skin-electrode user interface and comfort for the end user. The GSR assessed through this method had a significant association (average ~ 0.768) with the typical GSR process, although the comparison was carried out with a limited number of topics. Garbarino et al. [33] created a multi-sensor wristband (Empatica E3) that incorporated GSR, temperature, Photoplethysmogram (PPG), and a movement sensor. The information acquisition unit has a dimension of 4×4 implanted within a wristband. It can capture information from all four sensors continuously for 30+ hours. The device may also stream data in real-time using Bluetooth. A longer battery life, lower-power wireless connectivity, and ability to track multiple parameters are important characteristics for future development.

Setz et al. [34] attempted to differentiate cognitive stress and load in GSR measurements. The developers individually assessed GSR from the toes for a selection of topics during two synthetically produced mental circumstances mimicking cognitive stress and load. A wearable device calculated and transmitted the GSR signal via Bluetooth to a website. For 16 options available for GSR signal distributions, the correct GSR level was rapidly selected, offering much better outcomes for differen-

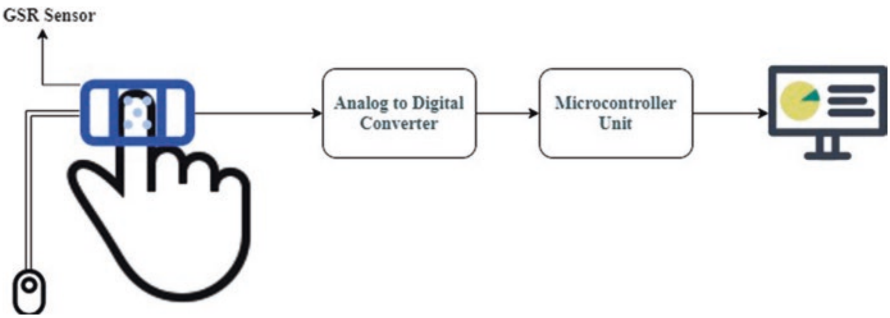

Fig. 7.4 Galvanic skin response (GSR) monitoring

tiating the cognitive load of anxiety. Akbulut et al. [35] examined the feasibility of wearable, wireless GSR and HR monitoring for evaluating the strain amount and the performance of an autonomic process in an ambulatory state.

7.2.4 Multiple Device Monitoring

Nearly all of the previously discussed track one specific biosignal or parameter, such as only heart rate and ECG [36]. However, it is often essential to track multiple physical symptoms, such as pulse or heart rate, respiratory rate, blood pressure, and body temperature. Frequently, both oxygen saturation in the bloodstream and GSR provide a much better evaluation of a person's health issues. However, using a different device for each parameter is neither pragmatic nor ergonomically possible for ambulatory monitoring. A system of several sensors lodged together inside a wearable device with transmitter and receiver components may be a practical option to keeping track of multiple parameters. For example, many researchers have used the Bramwell-Hill and Moens-Korteweg calculations to determine blood pressure from pulse transit time. Figure 7.5 presents the concept of multiple sensor monitoring.

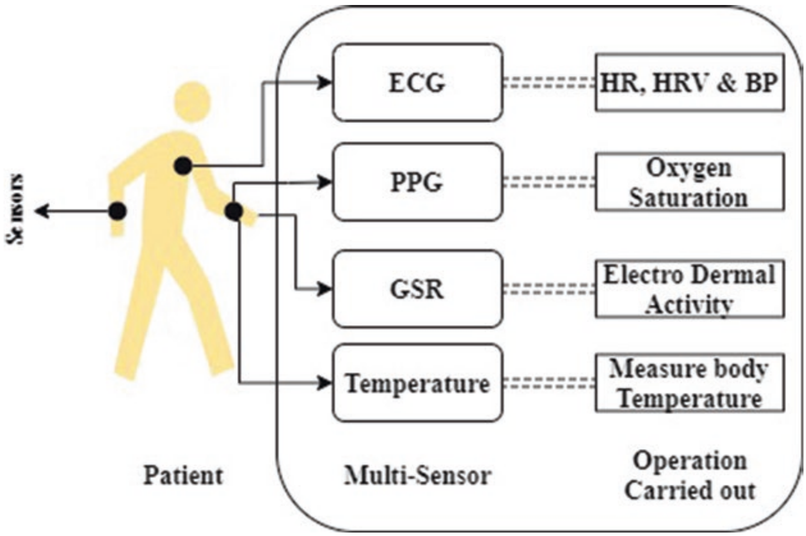

Fig. 7.5 Multiple sensor monitoring

7.3 Fabric-Based Wearables

Smart fabrics can be linked to sensors embedded within, providing a comfortable and unobtrusive way to monitor biological indicators [37]. The active realizing substance is generally constructed on a substrate and is directly connected with the body surface or remains encapsulated within the fabric [38]. Smart textiles can be used with body electrodes to measure electrophysiological indicators such as ECG, electroencephalography, GSR, and EMG. Textile-based electrodes of silver chloride have been reported to be reliable [39]. Textile electrodes can be categorized into two different types: passive and active. Passive textile electrodes determine the electrical qualities of the epidermis. They may be utilized to keep track of cardiac or muscle measurement. They also have been used in GSR measurements, with perspiration being evaluated by connecting electrodes on the skin. Conventional electrodes are affixed to the skin by conductive and adhesive gel , which may cause irritation or allergies [40]. Also, signal quality may decrease when the gel dries. Damp electrodes offer better signal quality, but they are not ideal for long-term use or wearable devices [41].

Fabric electrodes may be sewn to appropriate places on the clothing or may exclusively deposit conductive levels within the cloth. The conductive levels can be created on the clothing surface by depositing nanofibers [42] utilizing an electrodeposition procedure or using a conductive level together through assistance to display spluttering procedure by removing and evaporation [43].

7.3.1 Fabric-Based Rectal Sensor

A rectal thermometer is often the most accurate method for determining body temperature. A tympanic thermometer have measurement reliability issues [44], as do oral and axillary (armpit) temperature measurements [45]. Skin temperature varies from the core body temperature by as much as 3 °C [46]. A fabric-based temperature sensor works well for calculating body temperature inside a wearable wedge. It is composed of fiber or yarn using traditional garment production solutions, such as weaving, embroidery, knitting, and then printing. Climate receptors fabricated on flexible substrates also may be integrated into textiles. Sensitivity, linearity, accuracy, and rapid results in a range of 34–40 °C are vital characteristics of these heat sensors. The number of suitable encapsulation substances is also critical to protect it from external physical and environmental impacts.

7.3.2 Fabric-Based Activity Monitoring

Researchers have investigated MEMS-based inertial receptors, including accelerometers, magnetic field sensors, gyroscopes, and their combinations to monitor human locomotion. A very small PCB panel may be inserted into belts, flexible rings, and Velcro straps. MEMS-based movement sensors are small and inexpensive, with great detection ability, reliability, and low power requirements; thus, they are ideal for real-time and long-term monitoring. However, rigid PCB boards might not feel comfortable for some people. Rajdi et al. [47] fabricated a MEMS accelerometer on cotton fabric to compute pelvic tilt. The accelerometer used the piezoresistive characteristics of conductive Ag nanoparticles incorporated in the garments by pressing/ironing. If the tilt changes, a cantilever beam system on the accelerometer suffers from physical tension, ultimately adjusting the conductive content linearly. Researchers found an excellent correlation between distant relative opposition shifts and the stress used along with the textile-based accelerometer.

Stretchable and flexible stress sensors were also used by many researchers in textile-based monitoring. Stress sensors determine physical deformation by modifying electric qualities, including capacitance and resistance, in reaction to physical tension. The stress receptors for textile applicationssmust be extremely versatile, stretchable, and long-lasting. Furthermore, sensitivity and a quick response/recovery period are vital for real-time monitoring [48].

An optical fiber Bragg Grating (FBG)-based monitoring technique has been described elsewhere [49]. One optical FBG sensor wrapped with polymer foil was built into a flexible joint strip. The flexion motion in knees leads to stress and varies from the resonance wavelength on the FBG. Additionally, it incorporates FBG sensors within a glove and Velcro straps to enhance FBG sensors' ability to detecting finger motions recognizing finger movements and breath out. Rather than optical strength, the FBG sensor carried out measurements based on the wavelength, which was much less sensitive to outside noise and variations within the optical energy source. The system exhibited excessive awareness, measurement accuracy, and stability.

Kaysir et al. [50] created an optical fiber-based versatile pressure sensor that may be incorporated into textiles. The optical fiber was created with an adaptable copolymer that contains polyurethane and silicon. The optical fiber has an oval-shaped/egg-shaped twist down the cross-section of its outside pressure. This particular deformation increases light deflection inside the fiber, resulting in decreased severity of gentle within the result. This particular deformation increases light deflection inside the fiber, resulting in decreased severity of the outcome. The power, consequently, could be approximated as a result of gentle severeness. The sensor is versatile, allowing it to be incorporated into garments to identify, for example, limb motion and respiratory rate. The sensor used here is hypersensitive for temperature, bends, then finally strains, which causes accuracy issues.

7.4 Communication Technologies for Remote Healthcare Monitoring

The biological indicators assessed through the on-body sensors require the ability to transfer information to a remote server. For basic monitoring, a short distance is needed to transfer the calculated information to the closest gateway node, such as a PDA, custom-designed FPGA, laptop, personal computer, or smartphone. A more complex entry must be transmitted a remote server at a clinic. Thus, the information may be transferred via an online network or mobile correspondence system. At present, most cellular networks provide seamless access to the web by way of Long-Term Evolution (LTE) solutions [51]. Nevertheless, strong authentication and encryption are necessary to protect sensitive, private data during transmission.

In short-range correspondence, the sensors can communicate directly with the gateway. A wireless body area network (WBAN) may be created using sensors and topology through primary WBAN nodes. The WBAN node transmits information to the gateway, immediately executing a few processes. The on-body sensors and WBAN node may commincate in a wireless or wired manner. User mobility may be delayed with wired contacts, and also it could cause regular unsuccessful contacts. As a result, wired communication is not ideal for long-term and wearable monitoring methods.

Bluetooth is the preferred low-power radiofrequency technological innovation, as it is prevalent in products such as laptop computers, smartphones, and health and fitness trackers for small amounts of data. It uses a 2.4 GHz frequency band within the ISM stereo spectrum and sends signals to more than 78 specified route, using the frequency-hopping spread spectrum (FHSS) technique for communication. ZigBee is another wireless standard format that requires low power and inexpensive interactions inside small areas. It works on the unlicensed 2.4 GHz frequency rings of the ISM spectrum and sends information to more than 16 channels, using quadrature phase shift keying (QPSK) modulation for interaction.

Medical implant services use low-range, very-low-energy wireless technology to communicate with fixed health-related products such as cardiac pacemakers, defibrillators, and neurostimulators. It works in the frequency band of 402–405 MHz with 300-kHz stations. This particular frequency band provides great signal propagation qualities within the human body, making it ideal for implantable units. There are some different wireless solutions for short-range correspondence, such as IrDA, UWB, RFID, and NFC [6, 52]. Because of its high energy utilization and complicated configurations, wi-fi not suitable to track the patient for a long time period due to the additional power required to extend the network.

7.5 Proposed Methodology

The proposed RPM framework has the ability to filter the individual patient details through the IoT, which could assemble the data with this framework. The system could compile an individual's heart rate, ECG, body temperature, and BP, then transmit an alert to a person's caretaker with his or her existing condition and complete remedial information. The caretaker can examine the patient and provide the appropriate response according to the patient's health status without an in-person healthcare visit. The process uses body receptors that capture details from each sensor and send it to a data server, where the information may be viewed and downloaded by healthcare professionals. Sustaining a data server is crucial to ensure a history of health data is available for the individual. A general and enhanced view of previous health issues is shown in Fig. 7.6.

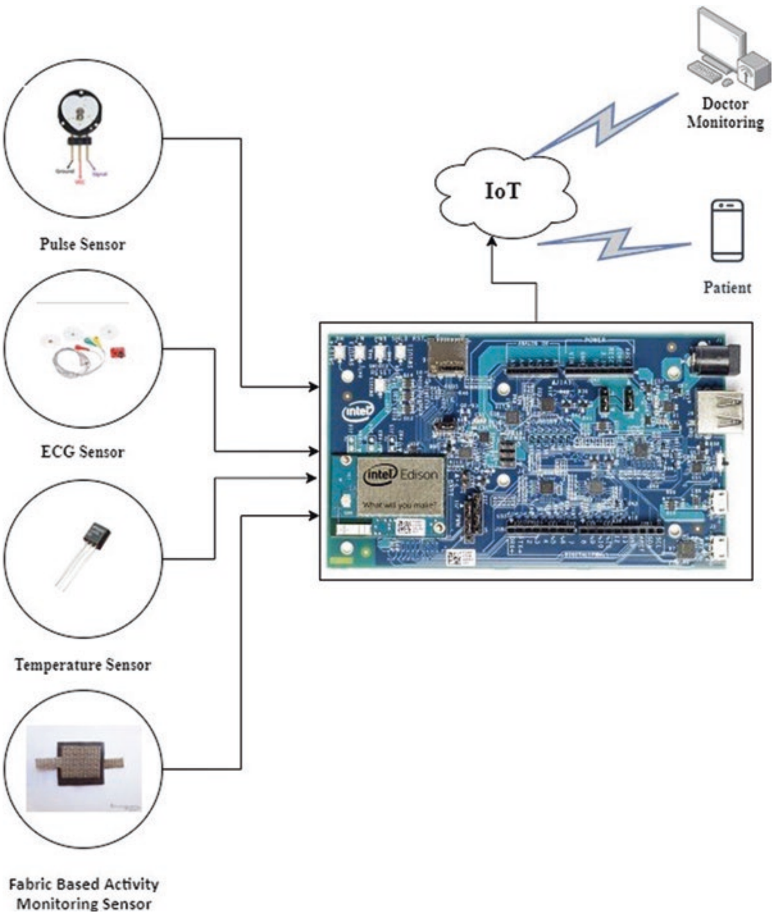

Fig. 7.6 Remote patient monitoring framework using Intel Edison

The framework consists of an Intel Edison (system on chip). This framework receives the information from all of the receptors attached to the individual and uploads this information to the internet server via an ethernet connection. The physician can monitor a patient's details by an internet-based program or mobile device. The sensors connected to inpatient include a heart monitor (SEN 11574 pulse sensor), which requires +3.3 V to +5 V at VCC and a climate sensor that provides a history of the person's general health and fitness. For overall body temperature, an LM 35 climate sensor (DHT 11) is used. If the heartbeat detector is operating, the corresponding LED flashes in unison with every heartbeat. This particular electronic data is usually connected to a microcontroller to determine the beats per minute (BPM).

The system part consolidates an Arduino IDE that is a necessary framework for our Intel Edison Board that was used-to swap the last code of ours of staying in touch with a repository. All information from the receptors is delivered to a Windows, Apache, MySQL, PHP (WAMP)-based data source server to log regular details, which should assist caregivers with determining the need for a specialist consultation and prescriptions. Additionally, these datasets stored in the database are used to plot graphs to identify every sensor's patterns. The server could move the individual's data source with unobtrusive components and patient history. The information on the server can be viewed at any time by an administrator using the internet, An administrator or mobile application can view the server's information, and the service provider can notice the present living feed of the person's healing situation. Tracking the patient's overall health report is reserved for a potential guide for professionals. It could hold and safeguard the patient's details for 24×7 hours of various people. A individual could also view his or her personal health record.

With this display, the professional or a guardian can enter the web page's login credentials, as shown in Fig. 7.7. After the qualifications are confirmed, the device shows a summary of individuals assigned to the healthcare provider. The professional chooses which individual's information to display, including temperature, heart rate, ECG, and more.

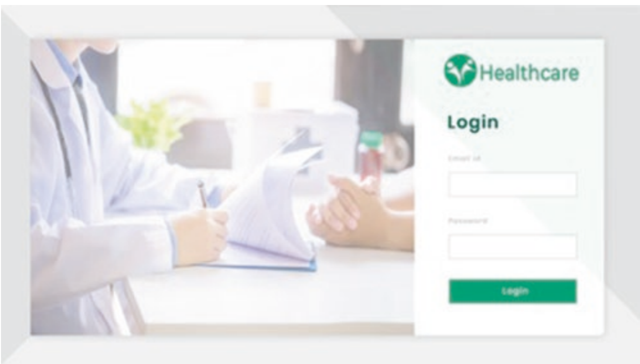

Fig. 7.7 Remote patient monitoring login page

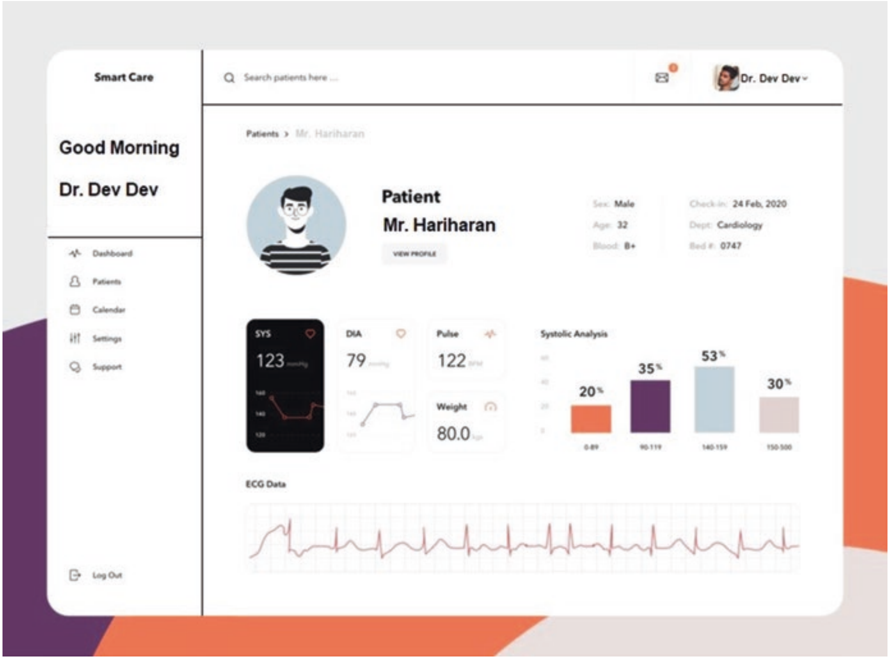

Fig. 7.8 Patient monitoring

To protect patient data, transferred information is encrypted while being delivered to the data source server, then is decoded while duplicated data is copied to the website, as shown in Fig. 7.8.

In picture subheadings, providers glean insight from the patient's current readings when communications with devices complete without error. If the gadget isn't associated or any of the sensors isn't attached to the patient. At that time, each reading should be set to zero to prevent an incorrect analysis. Because of the possibility that the gadget may turn off inadvertently, this web page displays any shut-off errors. The information coming from different receptors is now published to the data server with plot charts and evaluations.

7.6 Conclusion

Continual monitoring of a patient's overall health condition can provide instant insight into an individual's well-being. Wearable sensors and actuators, integrated with sophisticated communications and data solutions, unlock new opportunities for remote healthcare products. The methods consist of monitoring and evaluation with predictive algorithms, which can determine the prognosis of particular illnesses with greater confidence, therefore reducing unnecessary treatment and incorrect diagnoses. A device can generate an alert to notify the user or a healthcare provider of any issues. Smart fabrics, including textile-based connections for sensors, can be used with wearable devices to provide a more comfortable, less intrusive framework for overall health monitoring.

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