Chapter 1

Book Chapter

Enabling Technologies of IoT on Health Care

Allwin Ebinesar Jacob Samuel Sehar [*1], Ramya D L [†2], Shobha G [‡3], and Kavya M V [§4]

[1]Department of Biotechnology,Acharya Institute of Technology
[2]Department of Biotechnology, Sapthagiri college of Engineering
[3]Department of Applied sciences and Technologies, K S Institute of Technology
[4]Department of Biotechnology, Sapthagiri college of Engineering

Abstract

Human beings are highly stressed because of their profession, life style, food habits and environmental conditions. Due to these issues humans are facing chronic health issues like kidney, liver, pancreas failure, cardiovascular disease, changes in blood pressure and diabetes etc. The physical approaches are mainly used to monitor pressure, flow rate, temperature and organ imaging, while the chemical approach analyse the levels of different chemical analytes namely glucose, creatinine level, bilirubin, urea, WBC, RBC and Haemoglobin content etc., Both approaches are followed to determine the quality of human health through laboratories. In recent times, Internet of Things (IoT) is very helpful to monitor the human health, collection of data about the patient, storage, retrieval and usage of data. Internet of Medical Things (IoMT) is a novel emerging technology in the field of healthcare with a lot of scope for précised treatment.

Keywords: Human health. IoMT. Analytical Methods. Wearable Sensor System.

*Email: allwin2979@acharya.ac.in Corresponding Author
†Email: ramyadl@sapthagiri.edu.in
‡Email: shobhag@ksit.edu.in
§Email: kavyamv@sapthagiri.edu.in

1 Introduction

Internet of things, a domain which connects person from any place, with any preferable time, any kind of service and through any kind of network. It's a single high-level technology that makes more impact on business and health care improvements, uniting the internet system and nifty artifacts with huge benefits. For various applications such as smart city development, waste management, health, trade controls, emergency equipment and traffic mobbing, the IoT offers suitable solutions and comprehensive knowledge (Islam et al., 2015). The IoT domain helps to plan better appointment timings, best service in patient care, continuous monitoring of patients with reduced costs by healthcare organization, improve access to chronic illnesses, initial stage diagnosis and real-time monitoring by wireless technology. In the future, IoT thoughts will be handled by digitalized marketing and prescription of medicinal goods using devices like (web, phone, smartphone, etc.) to generate proper medications, reduce clinical evaluations for the treatment of patients.

The key benefits of Pharma IoT treatments are accessing the stable life of patients affected by multiple sclerosis and Parkinson's disease (van Uem et al., 2016). Nowadays several prototype instruments and apps are used to track health conditions.For example, the Myo motion simulator is used to track the recovery of orthopedic patients by monitoring the angle of movement and determining the necessary exercise duration after a fracture. The Zio Patch, approved by the FDA in the USA, measures heart rate and electrocardiograms (ECG) data (Tung et al., 2015). Glaxo introduced bioelectrical drugs that function through micro-stimulation of nerves. Additionally, robotic surgery developed by Johnson & Johnson (J&J) involved collaborations with Google, and the company also partnered with Philips to create wearable devices such as blood pressure (BP) sensors. Novartis developed wearable devices to monitor sugar levels, which were linked with Google's technology (Famm et al., 2013). The IoT technology applied for various wearable IoT sensors and devices that will be categorized mainly as wearables, robotics, environmental sensors, biometric sensors, wearable cameras, smartphones and microphones. The specific requirements for software and hardware equipment quality for biomedical wearables depends mainly on the distinction between medical and non-medical wearables. The major factors considered in the development of these wearables include the features of the output signal, human factors, cost-effectiveness, and suitability for environmental conditions (Y. & S., 2017). This book chapter discusses the enabling technologies for IoT, the various types of sensors used in IoT, and explores a range of IoT applications in healthcare.

Editors: Shilpa Sivashankar, S. Pandikumar, Pallavi M O
DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

2 Enabling technologies for IoT

The IoT has the ability to organize sensor network, universal network, machine to machine network by using technology such as identifying, omnipresent figuring, wireless sensing, and cloud computing (Pretz, 2013). This system functions facilitated by IoT architecture system which helps integrate the physical and virtual world. The factors considered in the designing of IoT system have the ability to extend the system, increase the capability, and exchange the information among heterogeneous devices and their business models.

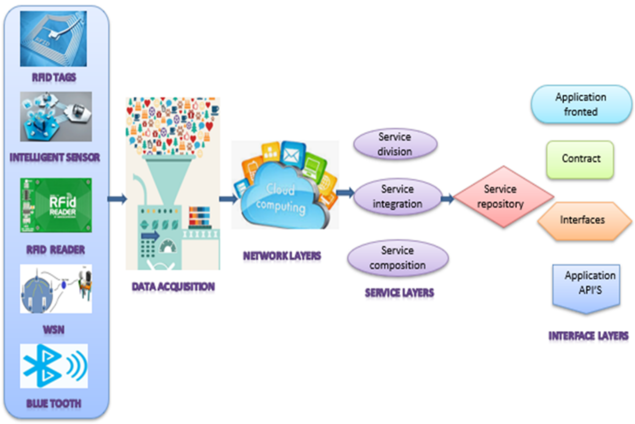

Figure 1. Schematic representation of Service oriented architecture IoT

The Service-oriented architecture (SOA) comprised with four different stages such as sensing layers, network layers, service layers, and interface layers and interconnected with different functionalities. Figure 1 depicts that, Sensing layers: it serves as a layer that reads hardware object conditions and receives protocols to transfer the data, Network layers: helps in supporting the integration of various networks namely wireless network and mobile networks, Service layers: achieves the functions of generating and handling the services by the sources and users' application, Interface layers: interacts the services for the service layer . The e-health care system had three layers (i) Top layers: Cloud service interfaces, middle layer: moving messages from web interfaces to health-care networks, bottom layers: health-care facilities. Kart et al.'s (2007)claimed that the clinical module and pharmacy module system supports the health care system and this system provides the interface between users and patients, doctors, nurses and pharmacists. In addition, the e-health care system can be accessed through computers, personal digital assistant and smart cell phones .

Editors: Shilpa Sivashankar, S. Pandikumar, Pallavi M O
DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

2.1 Clinical segment

The clinical module linked to two edges of web servers for patient tracking systems utilizing medical staff sensors, as illustrated in figure 2. The edge of the web server is specifically designed to users for accessing health care services using the web browser. Additionally, the webservice integrate the sensors and humans to connect e-health care systems and finally the web server and web service are used to access the data. In addition, the clinical module takes care to track the doctor's continuous activity and helps preserve knowledge about the patient's physician appointment, and the clinical module also links the physician's preferred pharmacy internationally via the web service offered (Kart et al., 2007) .

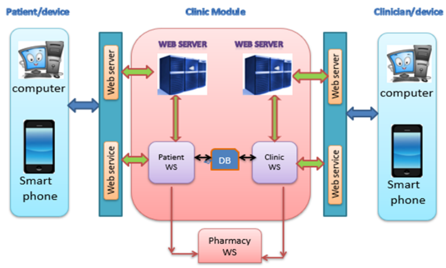

Figure 2. Block diagram of clinical module

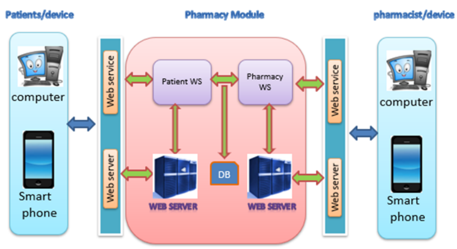

Figure 3. Schematic representation of pharma module

2.2 Pharma module

In this module the web server connects the patients with the e-health care system to the pharmacy via browser. It provides services between pharmacists, patients, and tracking tools and this module also keeps patient, pharmacist, and patient reference records of

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

prescriptions. This module also directly communicates with the pharmacy and provides advice on the provision of new medicines for patients, as represented in Figure 3.

3 Sensor devices used in IoT networks to monitor the healthcare

The sensors created continuously, called wearables for health care system to monitor patient safety. Such sensors are equipped with data communication and allow to communicate with the environment, and to read the data, sensors can be mounted within or outside the human body (Somayya Madakam, R, & Siddharth, 2015). Such sensors sense the vital parameters in the human body like BP, Temperature, oxygen concentration and heart rate level etc., under the directions given by universal health system using IoT (shown in Figure 4) (Mukkamala & al., 2017). The sensors are comprised with four part such as (i) Bioreceptor, (ii) Transducer (iii) Signal processor, (iv) Output/communication system.

Figure 4. Schematic representation of connecting the sensors with various network sources

The bioreceptor acts in the biosensor as an of recognition element, they are immunological compounds, biomacromolecules. The observed bio-signal is converted by the transducer into an electrical signal. Additionally, the electrical signal noise is minimized by the amplifier or filter. The strength of the signal requires to be improved and transmit the data for storage and analysis purposes. After that, the observed data transfer through IoT domain with the help of numerous radiocommunication protocols like Wi-Fi, ZigBee, Bluetooth, and so forth. In this context, we have a discussion about few types of biosensors, its functions and transfer of data by the IoT systems.

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

3.1 Body temperature sensor

Temperature, a significant physical parameter that specifies a patient's health status. In most health problems, temperature changes are early indicators for most illnesses (Z. Wang, Yang, & Dong, 2017). The mercury glass thermometer was used for this purpose in early days, and its fundamental concept lies in thermal expansion. But the resistance developed by glass approximately makes fluctuation in the measurement of temperature. The body temperature measured by wearables and non-invasive with the help of thermistor and optical-based sensors, and the data will be communicated in the IoT domain via Bluetooth wireless technology, in order to overcome this issue in the health care system (Chen et al., 2011). The thermistor sensors can be developed by using both metal as well as semiconductor. In case of metallic thermistor, the resistance is directly proportional to the resistance called as Positive temperature coefficient thermistor and in the other case, the temperature is inversely proportional to the resistance which is called as negative temperature co-efficient thermistor (Aleksandrowicz & Leonhardt, 2007). For the continuous monitoring of temperature, sensors are developed with integrated circuits (ICs) LM35 which can be directly placed on the skin surface.

3.2 Blood pressure sensor

When the Blood flow in the artery is normal It is said to be normal blood pressure in a human body. The variations in BP is a sign of several reasons, such as stress, organ failure, heart disease, etc., the blood pressure was measured using a sphygmomanometer based on the pressure changes observed in the systolic and diastolic pressure (Beevers, Lip, & O'Brien, 2001). But this method is not an appropriate process for the unceasing monitoring of blood pressure in the universe. A researcher ,describe that, pulse transit time (PTT) or pulse wave transit time (PWTT) are two feasible process to measure the time delay between proximate and distal arterial wave forms in two arterial sites. The observed value of BP in mmHg is inversely proportional to the pulse transit time (Jeong, Yu, & Kim, 2005). The pressure measurement has been connected to the health care system through IoT domain by using smart hub, such as a smartphone by Wi-Fi, Bluetooth, ZigBee Signal. There has been discussion about an Oscillometer device which measures the arterial blood pressure inevitably. In this process, the systolic pressure is measured by using a cuff to deliver an external pressure in the artery.Additionally, they designed the device to record the heart rate and calculated the blood pressure levels from the heart beat by using Arduino Uno (ATmega328) as Central processing unit. Figure 5 shows the schematic representation of heart rate measuring device, Oscillometer and figure 6 is Block diagram of the CCECG system.

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

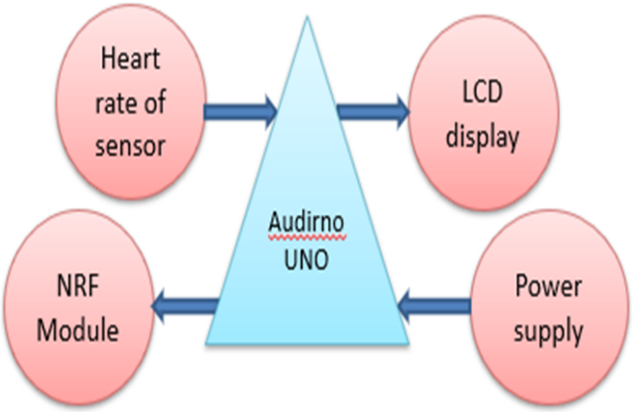

Figure 5. Heart rate measuring device

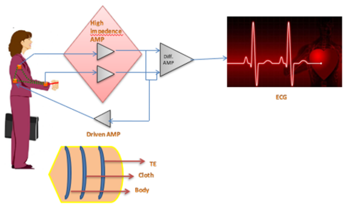

Figure 6. Block diagram of the CCECG system

3.3 Electrocardiography sensor

Electrocardiography is one of the methods to elucidate the function of a patient's cardiovascular system by analysing heart muscle electrical activity with respect to depolarization of the applied potential, and finally the heat activity described on the graph board (Chamadiya et al., 2011). In conventional methods, the endocardiography analysed from different nodes of various parts of limbs by using 12 to 15 silver- silver chloride electrodes, the signals were received from the body towards the electrodes by using a gel electrolyte. But the sensitivity can be impaired by many factors such as long-term use, irritation caused by allergies when it comes to contact with electrodes and gel, electrode oxidation contributes to degradation of signal strength and it is very difficult to track the patient continuously (Pramanik et al., 2019). Patients can track the role of the heart in the health-

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

care cycle via the IoT domain via ECG signals continuously via Capacitively Conductive Touch (CC-ECG) contact with patient body (Nemati, Deen, & Mondal, 2012). This sensor measures electric potential of heart, and the conductivity is quantified on the surface of the epidermis via the tissue of the body. During the process, the human body will be considered as conducting plate and an electrical insulation is kept separately to form a capacitor. The clothes, dry air and other materials are used as a di-electrical material. (Chamadiya et al., 2010).

3.4 Acceleration sensor

Accelerometers, wearable or human body-firm devices track person's physical activity (Yang & Hsu, 2010). It measures the rate of a moving object's velocity change (acceleration) with respect to axis orientation. The acceleration is directly proportional to frequency amplitude and external driving force. In addition to that, accelerometers are used to detect relative positioning of body and fell down situations. Generally, the accelerometers are initial sensors, magnetometer, and gyroscope to enumerate the body movements by 90oF sensors and the comments are sent by the microcontrollers. The accelerometer fabricated with circuit, Bluetooth element, and with one battery with a dimension of 60 mm × 35 mm × 20 mm. This sensor can be used in three different ways (i) the result obtained only collected from connecting the device only with PC (ii) data will be collected for long-term monitoring (iii) the most important component is the body network which was created by grouping body with multiple units and collected through a gateway unit (local memory or wireless) (Mukhopadhyay, 2015).

3.5 Pulse oximeter

Pulse oximeter, is an instrument used to monitor blood oxygen levels. If the concentration of oxygen is less it may contribute to heart and brain strain. The amount of haemoglobin contained in human blood is determined by blood saturated oxygen (SaO2) levels in the arterial blood. The saturated oxygen (SaO2) measured by using pulse oximeter and represented by (SpO2). In this device, the SaO2 concentration will be measured on the basic principle of difference of absorption in red and near infra-red light in oxygenated haemoglobin(O2Hb) and deoxygenated haemoglobin (HHb). During the analysis, the oxygenated haemoglobin absorbs higher wavelength infrared light (940 nm) and lower wavelength of red light and in case of HHb, it absorbs red light (660 nm) more and absorbs less amount of IR light. Finally, the difference in the absorption was evaluated by pulse oximeter. To determine the absorption effect, both the red light and IR light will be absorbed through the finger and then detected by a photodiode. Based on the absorption of light, the obtained values are related to the concertation of oxygenated

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

haemoglobin (O2Hb) . In the pervasive environment, the collected data from the signals is forwarded to the health care system through wireless (WLAN) and smartphone etc., diagram (Chamadiya et al., 2011).

4 Applications of IoT

4.1 Ingestible Sensors and Cameras

Ingestible sensors, a non-invasive system used to view the gut environment directly, are safely passed through the gastrointestinal tract. The gut is facilitated with mucous membrane which leads to rapid chemical transfer and exchange. A lot of chemicals like electrolytes, metabolites, enzymes and even bacteria, chemicals by consumers generate a significant health impact in the intestines. This sensor has been designed based on certain special features, such as quick response, reliability, increased sensitivity, selectivity and lower power work . The ingestible sensor capsules through images, ionic strength, pressure, temperature data, gives evidence about health conditions of the gut and also measure the chemical constituents within the gut. The gut composed of many organs including the stomach, oesophagus, small intestines, large intestine and oral cavity.

4.1.1 Importance of ingestible sensors in guts

As we discussed in the context, the gut consists of various parts and several biological and chemical products could infect these organs. We address the sensing role of ingestible sensors in each organ in this subject. In oral cavity: the ingestible sensor is used for examining ulcer issues, cold sores, lacerations and inflammations (Hooper, Littman, & Macpherson, 2012). In addition to that, mouth point consists DNA samples and it can be extracted from saliva to analyse the efficiency of metabolism of the body. Electrolyte imbalance, hormone disorders, cancer, infectious conditions and allergies can be analysed from the saliva in the common clinical targets. But it is very difficult to use the saliva for analysis due to the presence of less concentration of biomarker. In oesophagus: In the region of the oesophagus wall, inflammation and lacerations are primarily accessed by means of image capsules, optical coherence tomography and endoscopy device. In addition to that, the disorders will be diagnosed by the mucosa of the oesophagus for finding eosinophilic esophagitis. In Stomach: the sensors are used to monitor the parameter such as pH, metabolite concentrations, electrolyte concentrations and enzymes concentration. Moreover, the gastric juice has to maintain its equilibrium condition properly. Furthermore, the ulcers in stomach and other disorder can be found by quality of mucosa and also the sensors are used to see the presence of microbial species such as Helicobacter pylori which causes ulcers, In the small intestines: the sensors are mainly used to identify excess growth of bacteria, different types of irritable bowel syndrome, low absorption of

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

sugars, different cancer stages and also the imbalance of electrolytes, gases, metabolites can assess the function of each individual segments of the small bowels (Hooper, Littman, & Macpherson, 2012).

4.1.2 Ingestible Sensors and Their Applications in IoT

The ingestible endoscopy sensor or wireless capsule made with image sensor, optics for illumination, modules for processing, and batteries. This has a pill-shaped structure consisting of data memorizer, machine workstation and tools for image processing as shown in Figure 7. Some of the major advantages involved in capsule sensor or ingestible sensor is less power consumption, maximum image clarity, lack of localization and active regulation of locomotion. The IoT environment is widening and enhancing capsule sensor functionality to a better level. The additional feature of integrating IoT domain in this process is clearly elucidated in the Figure 7 (Alam et al., 2019)

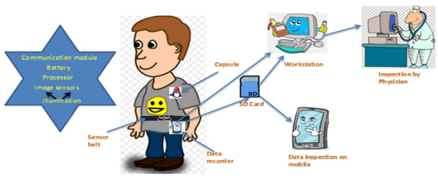

Figure 7. A typical block diagram of a wireless capsule endoscopy

4.2 Movement Detection using IoT

Detection of human activity, this process has a wide variety of uses in sports and recreational biomedicine. There's a lot of semiconductor-based motion tracking product on the market lately. In 1996, the uniaxial accelerator sensors were introduced by Veltink and boom in motion tracking operation. Throughout the medical area, this method assists extensively in several clinical trials tested using accelerometer by orientation estimation. An individual accelerometer cannot be used for any purpose, thus improving the accelerometer's efficiency by incorporating gyroscopes for performing the bio-mechanical evaluations and gait analysis. In 2002, initial research was carried out with the combination of accelerometers and gyroscopes to create 2D sagittal plane tracker.

During clinical analysis, the angles of tilting between the direction of gravity and the axes of the sensor are measured by accelerometers sensitive to gait motion and gravity. A new version motion sensor was developed in 2006 by incorporating the accelerometer, gy-

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

roscope, and magnetometer as well as the data accurately collected via 9DoF. This sensor can be used three different ways (i) the result obtained only collected from connecting the device with PC (ii) data will be collected for long-term monitoring (iii) the most important component is the body network which was created by grouping body with multiple units and collected through a gateway unit (local memory or wireless). The commercially available user devices are Motion Node Bus, Opal, MTW development kit, Memsense W2, STT-IBS, Colibri wireless, I2M Motion SXT, Shimmer3 and Physilog (Geoff Appelboom, 2014).

Dyskinesias (voluntary movement abnormality or impairment) may also be measured using accelerometer. Accelerometers with the ability to play a major role in guide choice and time required for DBS care. The diagnosis should be supported by evaluating initial response to dopamine, subsequent motor changes, and dyskinesias (Tripoliti et al., 2013). The motion sensors are developed major for various clinical applications such as Gait Posture, fall risk, timed up and go, Gait and Tremor freezing, dyskinesia induced with levodopa. Lin et al.'s (2016) spoke about the wearable posture tracking instruments. ST Microelectronics developed five different microelectromechanical system (MEMS) accelerometers by the Taiwan textile research institute. They developed three axis accelerometers configured with a sensing range of ±2 g, resolution of digital data around 12 bits, sampling rate is around 100Hz and the sensitivity of accelerometer is around 1 mg (1 mg = 2−10 g = 1/1024 g) g- acceleration due to gravity.

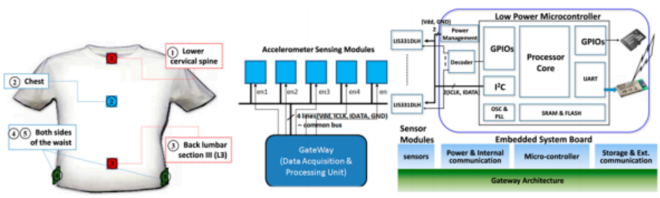

Figure 8. Design of instrumented vest for monitoring the posture

These five accelerometers are placed it in five different locations (i) lower cervical spine (ii) chest middle (iii) back lumbar section (iv) & (v) right and left sides of the waist. The sensitivity of the sensor increased by fixing the sensor at the lower border of the vest. The sensors are placed at several positions on the vest used to collect multiple signals. The positions such as, standing, sitting, leaning lying forward when walking detect by connecting the sensors on the chest as shown in Figure 8. The multichannel accelerometer-motion sensing system is located at the core of the vest. Unlike the systems proposed in most previous studies, which use either a single accelerometer or multiple accelerometers

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

with separate microcontrollers, the current study proposes a system that is capable of controlling multiple accelerometers by using a single control board, a capability that can maintain relatively low levels of cost and power consumption. The microcontroller not only acquires data from multiple sensors but also performs data processing, information transformation, and event detection operations in the algorithm and efficiently converts raw data from the three-axis accelerometers to tilting angles (Lin et al., 2016).

4.3 Real-Time Health Monitoring System Applications

4.3.1 Cardiac tracking Using Smartphone and Wearable Sensors

Integrating wireless mobile communications sensors made healthcare resources move from simpler clinic-centered to patient-centered, and named "Telemedicine" (P. Wang et al., 2005). Rapid healthcare developments services and cheap wireless connectivity has become extremely relevant in tackling fewer medical services. Smartphone apps such as Global positioning system powered facilities that offer old age patients for their independent survival of vulnerable. An alternative to built-in mobile sensors are wearable sensors used to track, store and transmit medical data over distance to healthcare providers(see figure 9). Cardio related chronic diseases can be analysed by wearable sensors instantaneously (Meystre, 2005). Wearable sensors were used to produce diagnostic information from patients and transmitted wirelessly to a smartphone thro ugh Bluetooth low-energy technology. In addition, the information collected on the device is transferred via Wi-Fi/3 G to a web interface. Some heart parameters aid early detection of diseases such as arrhythmia, hypotension, hypertension, upper- and lower-threshold systemic worrying. The developed device has two interfaces, one for patients and one for the doctor. The listening port passes this information to a web server that processes the data to display doctor interface reports (Kakria, Tripathi, & Kitipawang, 2015). Foe getting a better understanding of function of wearable biosensors, Android mobile and cloud portal for monitoring cardiac tracking, see table 1

The machine architect is tripartite Comprising (1) an interface for patients, i.e., wearable biosensors, (2) Android mobile, i.e., a tablet/Smartphone, and (3) An online site (Kakria, Tripathi, & Kitipawang, 2015).

4.3.2 Smart Wearable Device for Asthma Patients

The amount of temperature, humidity and emissions, which provides the patient insight on how long the patient will live in the environment. This is a cloud-based network in which the physicians and nurses can maintain the patient's health status. In emergency condition, the doctors and caretaker shall be notified immediately (Mohanapriya & Vadivel, 2013).

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

Figure 9. Device architecture for patient remote management program

Table 1. Function of wearable biosensors, Android mobile and cloud portal for monitoring cardiac tracking.

Patient's Interface	Android Smartphone	Cloud portal
Layer transmits real time data wirelessly through low energy Bluetooth from wearable devices worn by the Patient to second level of the network	Used to gather the data of patients from wearable sensors. Web portal including GPRS, 3G or the other Wi-Fi networks, GPS android app helps to find out who the individuals are being observed.	Is a network that acquires data from numerous patients wearing wearable sensors and displays it on the web interface, also known as doctor app, along with location and authentication personal information.

4.3.3 Dust sensor

The dust from the air causes acute respiratory issues in patients with asthma. This tool offers an honest indicator of the air quality at Associate in Nursing, by calculating the concentration of dust. The volume of material within the air is determined in a given amount by counting the Low Pulse Occupancy Period. Period at LPO is proportional to concentration at PM. It is a small module with sensors (Mohanraj & Sakthisudhan, 2019).

4.3.4 Humidity and temperature sensor

reduced temperature or elevated humidity directly impacts the wheezing patient. The Humidity and Temperature sensors are used to detect the ambient conditions changes.

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

4.3.5 Barometer sensor

Live air pressure is used to monitor the weather forecast short-term adjustments. Conjointly varies with elevation as a result of ambient pressure. Therefore, the regional conditions analyzed change.

4.3.6 Controller unit

The controller unit is the system's main hardware through which all the sensor units are connected directly and allows cloud access. For each sensor the threshold values are set individually by evaluating the patient's physical parameters. When patient senses any abnormalities, the doctors and patients are immediately informed. The program will continue to operate on an advanced cell phone, and can access information using cloud storage remotely. The flexible application can immediately notify the patient of their well-being status and ecological hazards or potentially send a warning message by facilitating the patient area and addressing the system based on the application justification rules to some predefined numbers.

4.4 Personal Activity Trackers

The use of fitness-tracking devices in particular recently explored and tracking one's daily activity has become normal (Lowe & ÓLaighin, 2014). Incentivising patients to track their behaviours may provide the regular routine Reminder and inspiration are needed to really make the exercise plan a success. There are activity trackers with alarm like the one in figure 10. Majmudar, Colucci, and Landman's (2015) depicted the devices has closed loop feedback systems among the options, behaviour and overall wellbeing of a patient . The new type of wearable devices usually stated as fitness activity trackers. These apps help its users to track information about their physical activity automatically, moving in vertical distance and heart rate to sleep cycles. As an electronic system a personal fitness tracker does have following features:

- Is intended for wearing on the body;
- Use, altimeters, accelerometers and other sensors to monitor movement and/or biometric data of the wearer; and
- Fitness trackers range from wristbands to pendants of all shapes and sizes and from wrist watches to small clips attached to the user's foot (Hoy, 2016).

Example for the individual most famous Tracker activity(see figure 11):

Editors: Shilpa Sivashankar, S. Pandikumar, Pallavi M O
DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

Figure 10. Activity tracker with a vibrating alarm

- Apple Watch Series 5: Tracks calming habits such as diabetes, making healthy food choices or reducing stress, heart rate (ECG on your wrist), menstrual cycle, noise level taps that affect your hearing and exercise monitoring such as running, yoga and swimming.
- FitBit: Various trackers available with a variety of features including monitoring workouts, Purepluse heart rate monitoring and sleep tracking.
- Garmin Vivo: Various trackers with activity monitoring, running sciences, cycling sciences, golf sciences, fitness sciences, swimming sciences and wearable sciences.
- Samsung galaxy fit fitness tracker: Records daily steps, burned calories, water / caffeine consumption. Watchdogs sleep patterns, and send real-time warnings if a high or low heart rate are detected.

4.5 Connected inhaler delivery system

Having and tracking drug use, bringing appropriate lifestyle changes and recalling and recording of symptoms, patients have major demands and obligations for treating their illness (Gallacher et al., 2013) (see figure 12)

Inhalation treatment is currently the better option for lung disorders such as cystic fibrosis, asthma, and chronic pulmonary obstructive disease (COPD) (Labiris & Dolovich, 2003). One such example is discussed here: Propeller Health is the premier digital res-

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

Figure 11. Personal activity trackers watch android IOS

piratory medicine health solution. A combination of sensors for inhaler devices, mobile applications, analytics, and regular feedback includes passive tracking of inhaler medication. It reminds to each patient with recommended dosing instructions to keep them on track.

Inhaler must be designed to monitor the exact combination of drug and system accurately and consistently, to fit different use patterns, and to function with negligible effect on the everyday lives of people with chronic respiratory disease. An inhaler holds large quantities of drug in a compact and ultra-portable form and provides precise amounts for every single use. Propeller's inhaler sensors offer auditory and visual reminders when connected to daily anti-inflammatory drug that alarm the patient for next dose timings. These kinds of notifications join other electronic alerts, such as text messages and emails, to actually inspire more frequent and suitable use through time of anti-inflammatory drugs.

4.6 Monitoring and Management System for Healthcare

Ability to manage the inventory rates is essential for the operation and supervision of the assets of the hospital. The hospital operators have to periodically monitor the patients flow to make resource capability decisions. In-patient treatment is one of the key endeavours for hospital resource demand (Broyles, Cochran, & Montgomery, 2010). Forecast plays an

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

Figure 12. MDI (metered dose inhalers) Sensor propeller and user app

important role in the management of medical inventories. The problem faced by many hospital managements is the lack of visibility and incorporation of data already available (Parker & DeLay, 2008).

4.7 Tools for forecasting wealth management

The forecasts of wealth organisation extrapolate the predictive parameters such as trend cycle, seasonal fluctuations and abnormality by present time-series method. The linguistic variables and membership function the fuzzification processer transforms smooth inputs into fuzzy sets. Fuzzy rules have been used to evaluate the relation between a fuzzy system's inputs and outputs. The rules are described in terms of IF-THEN laws, and specified on the basis of expertise or experimental results. Based on the fuzzy rules the inference engine performs inferences to produce fuzzy output data. The defuzzification processer then transforms the fuzzy outputs to non-fuzzy or clear outputs (Mohd Adnan et al., 2015).

4.8 Healthcare Asset Management System (IoT-HAMS)

The management system of healthcare assets combines with IoT technologies, e.g. Radio frequency identification and wireless sensor network, which also monitors various health-related properties, including blood bags, infusion pumps and medical waste, and also to control the conditions of those assets. Several other forms of asset management as well benefit, such as preventive maintenance, assessment of shelf-life and identification

Editors: Shilpa Sivashankar, S. Pandikumar, Pallavi M O
DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

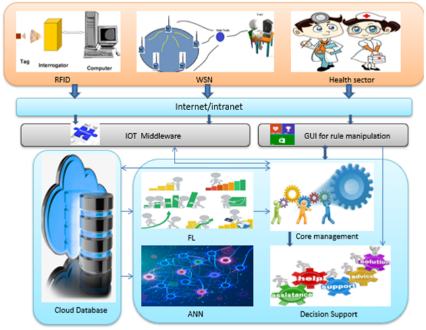

Figure 13. IoT-HAMS system Architecture

of products with high potential for deterioration (Lee, Na, & Kit, 2015). For asset demand forecasting, the data obtained from RFID and WSN devices may be returned to the internal ANN module and FL module. Each asset should have an RFID tag, used as its identifier, from the perspective of device implementation, Enough WSN base stations should be given to cover the building.The meta-data (e.g. access time, location and conditions) of the resource is automatically collected by IoT middleware., The IoT devices link and send raw data to the middleware and the middleware then transfers the data to the back-end system after pre-processing of the data (e.g. aggregation, filtering and normalization). Apart from the data collected by the IoT tools, the practitioners themselves, such as physicians, nurses and organization managers, are another source of knowledge (Lee, Na, & Kit, 2015).

4.9 Electronic Health Records

EHRs collect patient health records related to medications, diagnoses, hospital admissions, operations, imaging, laboratory tests, and pathology data(see figure 14. EHR architecture, a centralized EHR database, is established in one entity (i.e. a hospital) and gathers data from all hospital-operated healthcare such as the laboratory system, radiology information system and others. A centralized EHR database is built from several national / regional databases of EHRs within a universal EHR architecture. The electronic health record (EHR) of a patient can be viewed as a repository of information regarding his or EHR health status in a computer-readable form. The health-care system generates various types of patient-linked data by integrating medication, laboratory, imaging and narrative data at it is shown in the diagram. The data are collected according to the standards of RxNorm111 for prescription data, For laboratory information's: Logical Observation

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

Identifiers Names and Codes (LOINC), and Imaging: DICOM for imaging files. According to the standards of international classification of disease 9, (ICD-9) or ICD-10 prescribed codes for Clinical narratives.

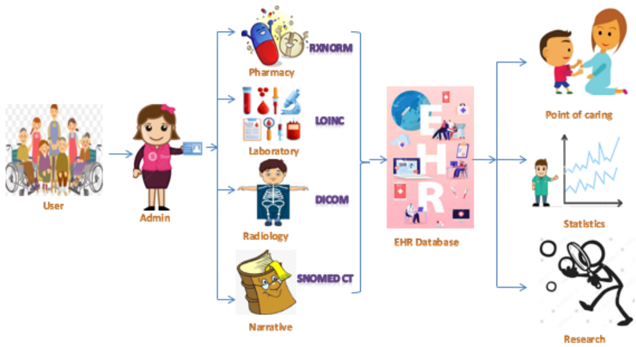

Figure 14. Electronic health record content

Additionally, the Integrated auto-coding systems also used for free text to clinical terms. Patient data are stored in a database and can be viewed in formats matching the needs and authorities of specific user groups (P.B., L.J., & S., 2012). IoMT relevance non-invasive blood glucose measurement system developed on optical detection and optimized regression model showed better results. Blood glucose level can be measured by two methods namely Invasive and Non- invasive. In invasive method blood glucose level is measured by glucometer and by using strips. In non-invasive method by the usage of sensors in target area. To provide information on diet and exercise for diabetic patients IoT is used as platform which works on the basis of calculation of glucose level in sugar using kit. The measured glucose level is sent to the server containing on diet and exercise for specific glucose levels. The server replies to the patient and doctor through SMS and email regarding diet and exercise (Geetha & Anitha, 2018).

4.10 Virtual Home System

Smart homes(see figure 15) are the collection of physiological sensors and actuators that are linked through a wireless network (Majumder et al., 2017). The main aim is to have an intelligent environment where the program operates, track and assess the health conditions to provide timely e-health programs.

The major gears are processing, sensing and communication system. Most of the current omnipresent fitness systems have the potential to converse with disabled and elderly

Editors: Shilpa Sivashankar, S. Pandikumar, Pallavi M O
DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

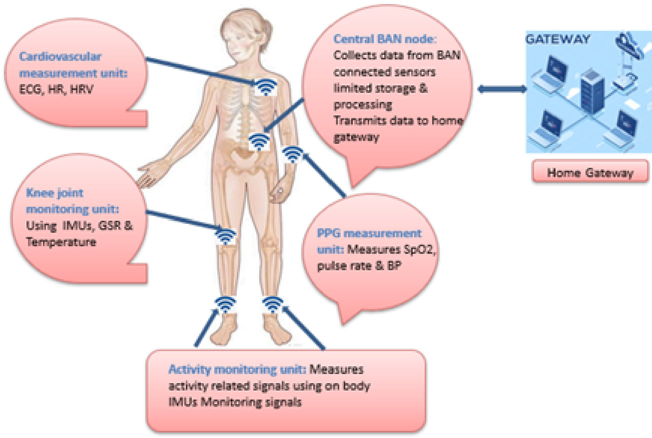

Figure 15. A four-layered smart home architecture

people using different types of sensors (Kamilaris & Pitsillides, 2016). Smart home incorporated with assisted living technologies and e-health potentially play a key role in revolutionizing the elderly health care sector. Sensors and actuators of smart home are linked through a Personal Area Network (PAN). Wearable physiological monitors such as electrocardiogram (ECG), electroencephalogram (EMG), body temperature, and saturation of oxygen (SpO2) sensors can be linked to a Wireless Body Area Network (WBAN) or Body Sensor Network (BSN) for automatic, continuous and real-time physiological signal measurement. The central computing system functions as the main gateway that transfers calculated data over the internet or a cellular network to healthcare personnel / service providers. Individuals may live in their familiar home environment and enjoy their usual life with friends and family while tracking and evaluating their wellbeing from a remote facility based on the physiological data gathered by various on-body sensors. Andreas Pitsillideset al.,2017 introduced a mobile e-health framework, called DITIS, which supports networked home healthcare collaboration. The healthcare team includes oncologists working in the oncology department, treating physicians who are usually located in the neighbourhood, home care nurses who frequently visit the patient at home, and a variety of other specialists called in as demand occurs, usually physiotherapists, counsellors, and social workers.

The Unified Modelling Language (UML) was used to define tasks, evaluate and formalize collaborative scenario among members of the virtual healthcare team. The collaborative framework program is designed using empirical tests.

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

Common scenarios include:

- Recommendation for home treatment of a new patient, referring him/ her to other specialists, and home-care visit.
- Home-care virtual team formation / introduction of members
- Homecare facility involving coordination with the treating physician such as: medication adjustment, blood testing, and chemotherapy.
- Continuity of ambulatory care, continuity of treatment for hospital admitted patients, and continuity of care for on-call staff members.
- Modelling process for new patient referral is illustrated by creating and management of virtual team.
- A virtual team offers committed, customized and private support to patients living at home in a need-based and timely basis, under the supervision of the care provider, thus reducing the risk of patient movement. This results in quality treatment being given, and a decrease in the number of visits to health providers or clinics which are away from the home of patient.

5 Personal Emergency Response System

Users would benefit from unremitting net access, statistical information generation and the creation of a large amount of data at any time and everywhere, in real time. The sensors are attached to various body parts to collect diverse medical data, such as blood glucose level, BP (for elderly individuals), body temperature, heart rate, sweating, and other medical measurements while performing various activities. The coordinator collects the data from various sensors that are connected to the body and aggregated into one unit, see figure 16.This real-time data enables continuous monitoring, early detection of abnormalities, and timely interventions, improving patient outcomes and personalized care. The collected data can be transmitted to healthcare providers or cloud systems for further analysis and decision-making.

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

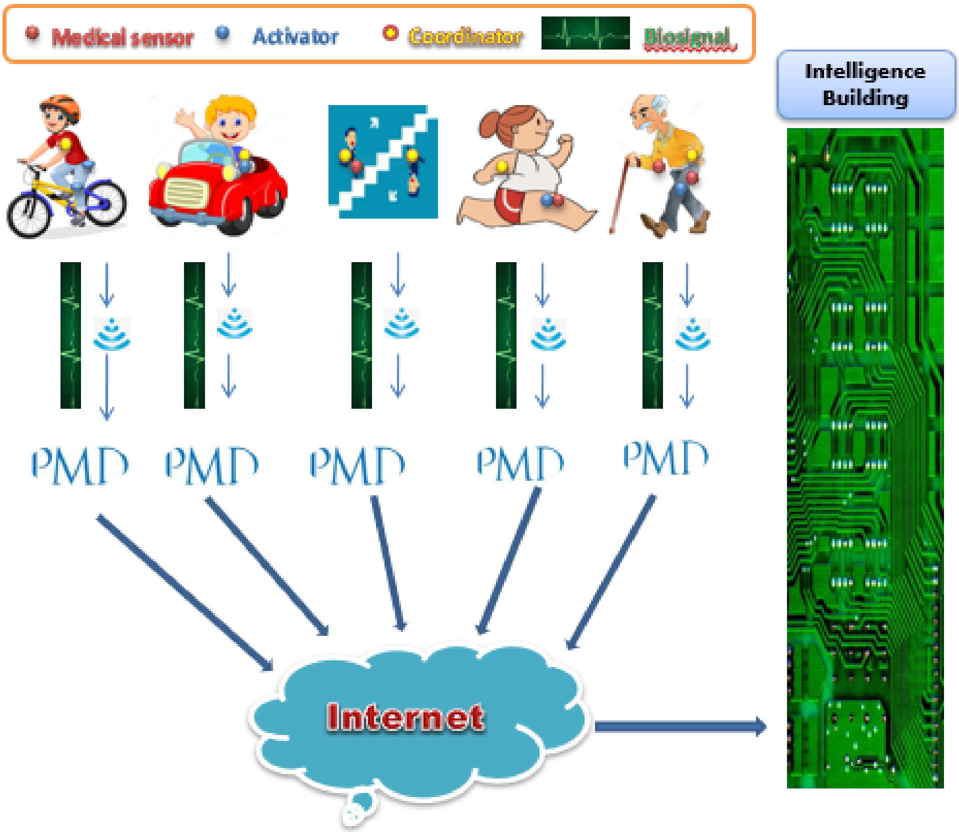

Figure 16. Arrangement set-up for personal emergency response System

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

6 Conclusion

The IoT technology applied for various wearable IoT sensors and devices that will be categorized mainly as wearables, robotics, environmental sensors, biometric sensors, wearable cameras, smartphones and microphones. The specific requirements for software and hardware equipment quality for biomedical wearables depends mainly on the distinction between medical and non-medical wearables. In this review paper, we discussed about the enabling technologies for IoT, clinical and pharma modules, sensor devices used in monitoring health care and applications of IOT including real time health monitoring and personal emergency responses.

References

Alam, M. W., Sohag, M. H. A., Khan, A. H., Sultana, T., & Wahid, K. A. (2019). IoT-Based intelligent capsule endoscopy system: A technical review. Intelligent Data Analysis for Biomedical Applications: Challenges and Solutions, 1–20. https://doi.org/10.1016/B978-0-12-815553-0.00001-X

Aleksandrowicz, A., & Leonhardt, S. (2007). Wireless and Non-contact ECG Measurement System – the “Aachen SmartChair”. Acta Polytechnica, 47(4-5). https://doi.org/10.14311/974

Beevers, G., Lip, G. Y., & O’Brien, E. (2001). ABC of hypertension: The pathophysiology of hypertension. British Medical Journal, 322(7291), 912–916.

Broyles, J. R., Cochran, J. K., & Montgomery, D. C. (2010). A statistical Markov chain approximation of transient hospital inpatient inventory. European Journal of Operational Research, 207(3), 1645–1657. https://doi.org/10.1016/j.ejor.2010.06.021

Chamadiya, B., Wagner, M., Wondrak, W., & Hofmann, U. G. (2010). Active passenger safety by Intelligent textile. 7Th International Conference on Wearable Micro and Nano Technologies for Personalized Health.

Chamadiya, B., Mankodiya, K., Wagner, M., Nasreddine, R. B., & Hofmann, U. G. (2011). Non-contact, non-obtrusive electrocardiography in clinical environements. 2011 5th International Conference on Pervasive Computing Technologies for Healthcare and Workshops, PervasiveHealth 2011, 101–106. https://doi.org/10.4108/icst.pervasivehealth.2011.246051

Chen, W., Dols, S., Oetomo, S. B., & Feijs, L. (2011). Monitoring body temperature of newborn infants at neonatal intensive care units using wearable sensors. Proceedings of the 5th International ICST Conference on Body Area Networks, BodyNets 2010, 188–194. https://doi.org/10.1145/2221924.2221960

Editors: Shilpa Sivashankar, S. Pandikumar, Pallavi M O
DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

Famm, K., Litt, B., Tracey, K. J., Boyden, E. S., & Slaoui, M. (2013). Drug discovery: A jump-start for electroceuticals. Nature, 496(7444), 159–161. https://doi.org/10.1038/496159a

Gallacher, K., Morrison, D., Jani, B., Macdonald, S., May, C. R., Montori, V. M., Erwin, P. J., Batty, G. D., Eton, D. T., Langhorne, P., & Mair, F. S. (2013). Uncovering Treatment Burden as a Key Concept for Stroke Care: A Systematic Review of Qualitative Research. PLoS Medicine, 10(6). https://doi.org/10.1371/journal.pmed.1001473

Geetha, R., & Anitha, R. (2018). IoT enabled Life Style Assistance and Glucose Monitoring System for Diabetic Patients. www.tagajournal.com

Geoff Appelboom, B. T. B. (2014). Motion Sensors to Assess and Monitor Medical and Surgical Management of Parkinson's Disease. International Journal of Physical Medicine Rehabilitation, 02(05). https://doi.org/10.4172/2329-9096.1000221

Hooper, L. V., Littman, D. R., & Macpherson, A. J. (2012). Interactions between the microbiota and the immune system. Science, 336(6086), 1268–1273. https://doi.org/10.1126/science.1223490

Hoy, M. B. (2016). Personal Activity Trackers and the Quantified Self. Medical Reference Services Quarterly, 35(1), 94–100. https://doi.org/10.1080/02763869.2016.1117300

Islam, S. M., Kwak, D., Kabir, M. H., Hossain, M., & Kwak, K. S. (2015). The internet of things for health care: A comprehensive survey. IEEE Access, 3, 678–708. https://doi.org/10.1109/ACCESS.2015.2437951

Jeong, G., Yu, K., & Kim, N. (2005). Continuous Blood Pressure Monitoring using Pulse Wave Transit Time. Measurement, 2–5. http://2005.iccas.org/submission/paper/upload/ICCAS2005_jgy.pdf

Kakria, P., Tripathi, N. K., & Kitipawang, P. (2015). A real-time health monitoring system for remote cardiac patients using smartphone and wearable sensors. International Journal of Telemedicine and Applications, 2015. https://doi.org/10.1155/2015/373474

Kamilaris, A., & Pitsillides, A. (2016). Mobile Phone Computing and the Internet of Things: A Survey. IEEE Internet of Things Journal, 3(6), 885–898. https://doi.org/10.1109/JIOT.2016.2600569

Kart, F., Miao, G., Moser, L. E., & Melliar-Smith, P. M. (2007). A distributed e-healthcare system based on the service oriented architecture. Proceedings - 2007 IEEE International Conference on Services Computing, SCC 2007, 652–659. https://doi.org/10.1109/SCC.2007.2

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

Labiris, N. R., & Dolovich, M. B. (2003). Pulmonary drug delivery. Part I: physiological factors affecting therapeutic effectiveness of aerosolized medications. British journal of clinical pharmacology, 56(6), 588–599.

Lee, C. K. M., Na, C. M., & Kit, N. C. (2015). IoT-based asset management system for healthcare-related industries. International Journal of Engineering Business Management, 7. https://doi.org/10.5772/61821

Lin, W. Y., Chou, W. C., Tsai, T. H., Lin, C. C., & Lee, M. Y. (2016). Development of a wearable instrumented vest for posture monitoring and system usability verification based on the technology acceptance model. Sensors (Switzerland), 16(12). https://doi.org/10.3390/s16122172

Lowe, S. A., & ÓLaighin, G. (2014). Monitoring human health behaviour in one's living environment: A technological review. Medical Engineering and Physics, 36(2), 147–168. https://doi.org/10.1016/j.medengphy.2013.11.010

Majmudar, M. D., Colucci, L. A., & Landman, A. B. (2015). The quantified patient of the future: Opportunities and challenges. Healthcare, 3(3), 153–156. https://doi.org/10.1016/j.hjdsi.2015.02.001

Majumder, S., Aghayi, E., Noferesti, M., Memarzadeh-Tehran, H., Mondal, T., Pang, Z., & Deen, M. J. (2017). Smart homes for elderly healthcare—Recent advances and research challenges. Sensors (Switzerland), 17(11). https://doi.org/10.3390/s17112496

Meystre, S. (2005). The current state of telemonitoring: A comment on the literature. Telemedicine and e-Health, 11(1), 63–69. https://doi.org/10.1089/tmj.2005.11.63

Mohanapriya, S., & Vadivel, M. (2013). Automatic retrival of MRI brain image using multiqueries system. 2013 International Conference on Information Communication and Embedded Systems, ICICES 2013, 1099–1103. https://doi.org/10.1109/ICICES.2013.6508214

Mohanraj, S., & Sakthisudhan, K. (2019). An internet of things based smart wearable system for asthma patients. International Journal of Recent Technology and Engineering, 7(6), 604–607.

Mohd Adnan, M. R., Sarkheyli, A., Mohd Zain, A., & Haron, H. (2015). Fuzzy logic for modeling machining process: a review. Artificial Intelligence Review, 43(3), 345–379. https://doi.org/10.1007/s10462-012-9381-8

Mukhopadhyay, S. C. (2015). Wearable sensors for human activity monitoring: A review. IEEE Sensors Journal, 15(3), 1321–1330. https://doi.org/10.1109/JSEN.2014.2370945

Mukkamala, R., & al., E. (2017). Towards Ubiquitous Blood Pressure Monitoring via Pulse Transit Time: Theory and Practice Ramakrishna. IEEE Trans Biomed Eng., 62(8), 1–10.

Editors: Shilpa Sivashankar, S. Pandikumar, Pallavi M O
DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

Nemati, E., Deen, M. J., & Mondal, T. (2012). A wireless wearable ECG sensor for long-term applications. IEEE Communications Magazine, 50(1), 36–43. https://doi.org/10.1109/MCOM.2012.6122530

Parker, J., & DeLay, D. (2008). The future of the healthcare supply chain. Healthcare financial management : journal of the Healthcare Financial Management Association, 62(4), 66–69.

P.B., J., L.J., J., & S., B. (2012). Mining electronic health records: Towards better research applications and clinical care. Nature Reviews Genetics, 13(6), 395–405. http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L51997008%5Cnhttp://dx.doi.org/10.1038/nrg3208%5Cnhttp://sfx.library.uu.nl/utrecht?sid=EMBASE&issn=14710056&id=doi:10.1038%2Fnrg3208&atitle=Mining+electronic+health+records%3A+Towards+bett

Pramanik, P. K. D., Upadhyaya, B. K., Pal, S., & Pal, T. (2019). Internet of things, smart sensors, and pervasive systems: Enabling connected and pervasive healthcare. Healthcare Data Analytics and Management, 1–58. https://doi.org/10.1016/B978-0-12-815368-0.00001-4

Pretz, K. (2013). The next evolution of the internet. IEEE Magazine The institute, 50(5), 1–20. http://theinstitute.ieee.org/technology-focus/%20technology-topic/the-next-evolution-of-the-internet

Somayya Madakam, R, R., & Siddharth, T. (2015). Internet of Things (IoT): A Literature Review. Journal of Computer and Communications, 03, 164–173. https://doi.org/10.4236/jcc.2015.35021

Tripoliti, E. E., Tzallas, A. T., Tsipouras, M. G., Rigas, G., Bougia, P., Leontiou, M., Konitsiotis, S., Chondrogiorgi, M., Tsouli, S., & Fotiadis, D. I. (2013). Automatic detection of freezing of gait events in patients with Parkinson's disease. Computer Methods and Programs in Biomedicine, 110(1), 12–26. https://doi.org/10.1016/j.cmpb.2012.10.016

Tung, C. E., Su, D., Turakhia, M. P., & Lansberg, M. G. (2015). Diagnostic yield of extended cardiac patch monitoring in patients with stroke or TIA. Frontiers in Neurology, 6(JAN). https://doi.org/10.3389/fneur.2014.00266

van Uem, J. M., Maier, K. S., Hucker, S., Scheck, O., Hobert, M. A., Santos, A. T., Fagerbakke, Ø., Larsen, F., Ferreira, J. J., & Maetzler, W. (2016). Twelve-week sensor assessment in Parkinson's disease: Impact on quality of life. Movement Disorders, 31(9), 1337–1338. https://doi.org/10.1002/mds.26676

Wang, P., Wang, J. G., Shi, X. B., & He, W. (2005). The research of telemedicine system based on embedded computer. Annual International Conference of the IEEE Engineering in Medicine and Biology - Proceedings, 7 VOLS, 114–117. https://doi.org/10.1109/iembs.2005.1616355

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1

Wang, Z., Yang, Z., & Dong, T. (2017). A review of wearable technologies for elderly care that can accurately track indoor position, recognize physical activities and monitor vital signs in real time. Sensors (Switzerland), 17(2). https://doi.org/10.3390/s17020341

Y., A., & S., K. (2017). Biosignal monitoring using wearables: Observations and opportunities. Biomedical Signal Processing and Control, 38, 22–33. http://www.embase.com/search/results?subaction=viewrecord&from=export&id=L616162512%0Ahttp://dx.doi.org/10.1016/j.bspc.2017.03.011

Yang, C. C., & Hsu, Y. L. (2010). A review of accelerometry-based wearable motion detectors for physical activity monitoring. Sensors, 10(8), 7772–7788. https://doi.org/10.3390/s100807772

DOI:10.48001/978-81-966500-0-1-1 | ISBN: 978-81-966500-0-1 |