Chapter 4
Context Awareness for Healthcare Service Delivery with Intelligent Sensors

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4.1 Overview

Our research surveys through several application-based challenges and recent trends. It includes a complete systematical introduction of fundamental concepts of e-healthcare systems and the importance of contextual sensors with user mobility. Later, more complex and advanced topics including a case study are included to develop a research initiative required for implementing secure framework for healthcare service delivery.

4.1.1 Healthcare Service Delivery

Traditionally, providing an unwavering healthcare service for elders, loved ones, and especially the person with disabilities had become a critical issue that exacerbates the situation faced by family members. Nowadays, people usually having busy schedules do not have much time, as a result of which health issues are ignored and therefore, eventually tend to avoid consultation with doctors regularly. However, certain critical health issues, like cardiovascular and chronic diseases, cannot be ignored and hence require attention consistently.

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Rapidly, the world population is increasing day by day along with healthcare costs that are raising forcibly. On the comparison with traditional healthcare, we normally do not often lean towards digitized equipment to check our health issues regularly and timely. Therefore, efforts are being made towards ubiquitous technology in performing medical observation in a pervasive manner. This would help in transforming the healthcare system that allows continuous monitoring of inhabitants without hospitalization. The rapid development in the technology area provides us a new way of monitoring health through using mobile Internet, cloud computing technology, sensor technology, and intelligence system. Now the goal is to develop a pervasive application, or system for delivering a mobile healthcare service to customers anywhere, anytime with the help of the above technologies [1–3].

Deployment of intelligent sensors pervasively has revolutionized the delivery of sustainable healthcare services over time and space. Owing to technological advancements in electronics, sensors are embedded within the scenario we dwell in, thereby resulting in better sampling and availability of information anytime and anywhere. This next-generation infrastructure has also developed high-end mechanisms for accurate medical information mining, storage, and retrieval. This helps in building, evaluating, and presenting an improved platform for transforming the traditional healthcare systems towards innovative heights using intelligent sensor technology.

Environmental monitoring is one of the most significant and widespread applications of intelligent sensors that allows a cluster of sensing devices to monitor various environmental parameters and conditions over a stipulated period. Such healthcare services for monitoring health-related issues of patients together with significantly reducing the healthcare expenditures are incurred in present healthcare systems. These sensors can also be used to provide a more useful, collaborative, and intelligent living environment for human beings. For instance, ambient intelligence is growing in the form of a future vision of intelligent sensing and managing the delivery of medical information worldwide. This technology offers a paradigm that is capable of monitoring health status periodically as well as continuously. It can even assist in diagnosing health conditions or even can get indulged in communicating with the patient regarding lifestyle or food habits for maintaining a sound health. Ambient technology allows to remotely contact with medicinal experts for regular check-ups or in case of a medical emergency.

The pervasive availability of sensory data enhanced with context information addresses existing healthcare problems with a promising future. Context-aware services imparted by intelligent sensing electronics results in advanced healthcare delivery to patients by eradicating location, temporal, financial, and other resources limitations without compromising service coverage, timely delivery, and quality of assistance. Such advancements broadly include prevention from viral infections, regular health check-ups, healthcare maintenance with customized diets, etc. Several real-time applications extend support in making advanced healthcare services feasible. This largely involves smart homes and hospitals, advanced cloud services,

Fig. 4.1 Context-aware modeling for healthcare service delivery with intelligent sensors

mobile devices and applications, autonomous systems, etc. The intelligent healthcare system mainly includes the following significant characteristics in principal:

- Short-term healthcare monitoring
- Intelligent homing
- Long-term nursing
- Tracking health improvements
- Personalized medical supervision.
- Incidence detection
- Risk management in disasters
- Emergency medical intervention
- Transportation facilities
- Treatment updates

These features promise an effective solution with reliable access to widely distributed healthcare services, including biomedical information sharing with remote medical and surgical units with pervasive availability to attend for services or enquires.

Figure 4.1 explains the whole scenario, how mHealth services are provided by healthcare professionals at anytime and anywhere. Here, all the recorded information of patient is stored on a server that can only be retrieved by doctors and healthcare professionals for providing better treatment on time and anywhere.

4.1.2 Significance of Context Information

The word "context" refers to surrounding information for a given situation, which can be time, date, or any object of interest. It helps users to develop a consciousness of behavior with an awareness of the environment. Representation of context to communicate with the system in a more efficient manner is known as contextual

information. In other words, contextual information is any relevant information regarding the system and its users so that system can deliver personalized service as per user requirements. In the healthcare service delivery system, we need context information to deal with different users. How can be context information helps us! This question arises in our mind. In the future, the intelligent hospital will be built that would introduce new technologies, new architectures so that the implementation of the new system will be secure and reliable. The main concern is to identify, evaluate, and implement a new system or services without any hazards which provide good communication between healthcare professionals and co-operate with users, doctors, and healthcare service providers (HSPs) [4].

Dedicated Use of Context According to the researchers, we can use context in three main cases:

- To represent relevant information and service of the systems for the user
- To execute new service accurately and properly
- Tag relevant context information for lateral usage

Objects for the Representation of Context For analyzing the healthcare contexts, it is possibly necessary to explain the distinct contexts in detail. To represent the context in a synthesized way, we split the context items into three main classes: (i) environment, (ii) people, and (iii) activities.

Context-Aware Computing It refers to the building of applications that is capable of adapting certain changes in the surrounding (people, environment, activities) and responds according to the usage of the context item in that situation [5].

Context-awareness computing is still a challenging concept in healthcare services. The three major challenges are [6]:

- No recommendation regarding suggestions and usage as per functional needs in the context.
- Actual context-awareness prototypes are different from the fundamental or theoretical concept of context representation in existence. This can be performed by analyzing the real-time healthcare projects.
- It is very difficult to build an efficient computerized system for healthcare as per the customer's perspective.

These days a mobile phone has become part and parcel for several routine tasks. Everybody depends on the mobile device for everything such as shopping, paying bills, healthcare, watching movies. Mobile phones or smartphones have become one of the significant means of communication in daily lives. The International Telecommunication Union (ITU) report depicts that the population in the world who are accessing cellular networks with mobile phones/smartphones are increasing monstrously. The dependency of people on mobile phones has become even more owing to enhanced embedded wireless communication techniques (GSM, Wi-Fi, Bluetooth, and others) for more reliable communication between two parties. Also, smartphones support a variety of new applications for providing more flexible

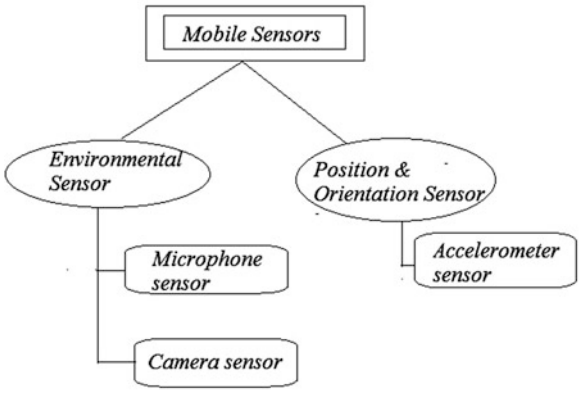

Fig. 4.2 Embedded sensors in modern mobile devices

options for users. With the help of the Internet, we can integrate healthcare services with mobile phones, to communicate healthcare centers on time. Practical medicine, online doctor consultation, and healthcare services all are supported by mobile devices, thereby providing mHealth solutions. Recently, mHealth filed is growing fast to create new applications for providing better healthcare services to all users. ThemHealth supported apps are available on webportals, such as Google Play Store. This makes its users to easily download and use the healthcare solutions efficiently on the mobile mode. Another most important factor is to determine the applicability of mobile phones in the healthcare area. In recent days, the upgraded mobile device is integrated with enhanced embedded sensing equipment, such as accelerometer, microphone for voice, and camera for imaging. These sensors intend to provide a better use of healthcare applications.

The basic applicability of a mobile sensing device is *mobility* with fewer handoffs or connection drops. Mobility is the most important factor nowadays so that users can track their health every time and anywhere. The integrated sensors in the mobile phone may be subdivided into two categories as in Fig. 4.2.

- Environment Sensors: These are used to perceive different characteristics of the mobile environment. Environment sensors include microphones, cameras, object trackers, etc.
- Position and Orientation Sensors: These sensors may include accelerometer, digital compass, gyroscope, and GPS. These electronic devices sense the location and orientation of the mobile phone with respect to time and space.

4.1.3 Applicability with Mobile Sensing Devices

Intelligent sensing devices offer dynamic extensions to static information-based healthcare systems with additional contexts. Context means instantaneous details associated with the surrounding environment, event, or entity, possessing specific

attributes. The contextual attributes are referred to those characteristics that determine the situational cases or instances of a system or organization during a time frame. Contexts can be relatively static or dynamic concerning time. A context-aware system behaves intelligently to model user requirements adaptively and more realistically. Some contextual attributes include time, date geo-location, type of connectivity, user identity (name, password, designation, etc.), type of information, level of access, propose of visit/access, etc. Sources of such contextual attributes could be drawn from manual entries (drafted from a predefined list of options), sensors hardwired in computing devices (for tracking time, date, and location-related information), external sensors embedded in the environment, system state of execution, and other context provider services. The following sections illustrate some mobile sensing devices being widely used in health-related applications [7–10].

4.1.3.1 Microphone Sensor

Microphone sensors can be used in several ways in mHealth applications, apart from its inherent usage for communication and transmission. The application of the microphone involves:

- Providing communication and training platform for healthcare workers or professionals
- Diagnosing and imparting treatment support
- Tracking of diseases

This sensor offers an efficient way to use it in mHealth application so that a proper healthcare service will be delivered to customers.

4.1.3.2 Camera Sensor

The web camera or any motion detection sensor in the mobile phone is used to get useful information about a patient in form of images and videos that data will use in those applications where remote doctor consultation is needed.

4.1.3.3 Accelerometer and Geo-Location Facilitator Sensor

The main application in healthcare services is to track a user's physical activity level regularly. This application is very important for chronic disease patients because it reduces the risk of having any critical situation.

The embedded sensors and the mobility feature make the mobile device users in the field of healthcare service delivery. Context-awareness is gaining importance owing to the increasing opportunities being provided by cloud computing for online

storage and instant availability of large-scale distributed data in homogeneous as well as in heterogeneous form.

4.1.4 Prevalent Applications

Some of the medical applications are enlisted that describes the significance of context-awareness in medical services:

4.1.4.1 Vocera

This was an initiative conducted in Birmingham, the USA by St. Vincent hospital for setting by an efficient system for communication [11]. This system is useful only for people using mobile devices. It is a wearable device for communication based on speech recognition. This system consists of an automatic calling facility, a small-size text screen that is flexible for enabling voice-call capabilities. The important features of this system are hands-free conversations and answering to perform calling, and storing voice message in case no answer to call is received. Biometric services are enabled device security with speaker identification and authentication. It transfers the relevant information to the users directly by using context-related information.

4.1.4.2 Mobile WARD

This is an innovation built by Aalborg University, Denmark, to maintain mobile electronic patient records. MobileWARD is the preliminary version of a device that is developed to sustain daily medical procedures in a hospital ward. Through this device, one can able to display the list of patients and their related information. The device can sense information and provide functionality basis on the location and time of hospital staff on duty. Patients will be chosen by a displaying list of patients or an active barcode at the hospital bed.

4.1.4.3 Other Medication Consumption Devices

Fishkin and Wang proposed a device for assisting medication facilities given at home [12]. It is a pad-like device that is specially designed for detecting:

- Lifting of a medicine bottle and putting it back
- Remaining number of pills from medicine bottles
- Postmedication suggestions
- Pills to take as per prescribed by the doctor or physician

4.1.4.4 Intelligent Hospital

Intelligent technology speeds up patient reports, diagnosis, and check-up summarization generation, by the intelligent device through context awareness [13, 14]. Some context-aware intelligent projects include:

- A hospital bed with context-awareness: With a built-in screen attached with the bed to display features as demanded by the patient (e.g., for viewing television) and also by doctors for accessing medical data of patients. The hospital bed has a sensor which could "sense" who is being allotted for the bed and what facilities are available in the nearby vicinity.
- A contextually aware container for pills intake: A self-aware container that contains pills and reports when it nears a particular patient. Moreover, containers could get labeled with the names of the patients and the respective dosage, the number of pills left, etc.
- A context-based electronic record for patients: The bed "sense" contexts, such as the patient, nurse, and the tray of medicine. It can also display other significant information as per the context, such as patient records, medicine schema.

4.1.4.5 Intelligent Wheelchair for Disabling Humans

It is an intelligent device with an accelerometer, camera, location sensors, and obstacle sensors. It allows the paralyzed person to move freely without the help of another person. It allows users to move independently. It contains an alarming system also which allows the users to call another person if they need it.

4.1.4.6 Dot Smartwatch

It is an intelligent wearable smartwatch that is easily affordable. This device helps blind people to access the messages, e-mails, tweets, books anywhere, and at any time.

4.1.4.7 MotionSavvyUNI

It is a two-way tool for communication by deaf people. It uses speech recognition technology and gesture technology for detecting the movement of hand and fingers with help of specialized camera and then it converts the signals into text in a while. In that way, it gives the meaning of sign language used by a deaf person. It has one more feature that is voice recognition. It converts speech into text for enabling both ways of communication. It further enables users to create their sign language and add custom dictionaries for custom sign language.

4.1.5 Open Challenges

Context-aware computing has some technical challenges that may occur during the implementation of healthcare service [15]:

4.1.5.1 Localization

Localization is the most important factor in mHealth solutions because it tracks the present location and provides relevant information depending upon the location of the user. For example, if the user lives in hilly areas where he takes fresh breathing air and suddenly arrives in the mainland area with too much pollution, he might not feel comfortable. mHelath solutions could prove beneficial to provide proper solutions according to his location what to do and how to survive in such an area.

4.1.5.2 Connectivity

Connectivity is the main concern also in the healthcare area. Most of the entire healthcare service is real-time so they need an Internet connection to sense the real-time data. Due to connection drop, one might fail to perceive real-time data and cannot provide proper healthcare service, promptly.

4.1.5.3 Real-Time Data

Real-time data is important through which service providers can provide accurate and proper service based on real-time conditions of users. For example, if blood pressure shoots up or steeps down from the normal level, mHealth solution should be able to react on the real-time input and respond with controlling and preventive measures. This may also involve informing family members or local emergency centers. Such attempts become infeasible in the absence of real-time data.

4.1.5.4 Environmental Issue

This issue often comes across when the device is based on the environmental condition. For instance, intelligent devices embedded in hospital beds that can sense information when some patient is assigned with all types of reports, including medicine schema, dietary chart, and so on.

4.1.5.5 Feasibility of Data

This means that the device can remark the feasibility of data. Data should be relevant and in the proper format so that doctors and service providers can provide a solution in less time. Data should not contain noise or redundancy.

4.1.5.6 Storage of Relevant Data and History

Such activity becomes very crucial in healthcare service, especially to perform a case study of patients and treat them more suitably. They can provide the exact solution or medicine after examining through the medical history of the patient and present real-time data.

4.2 Context Awareness in Healthcare

The context-aware intelligent healthcare framework provides the solution to one of the prevalent challenges confronted by traditional medical units of providing improved services to a large number of patients with constrained financial resources and manpower.

4.2.1 Smart Sensory Devices

Some of the important sensory devices used for smart healthcare delivery are enlisted as follows:

(a) Heart-Monitoring System: Smart sensors are installed unobtrusively in the patient's body for monitoring the heart. This sensor senses the heart rate, regular functioning of the heart. This system helps to prevent high death casualties due to cardiovascular disease. Based on the sensing information, the medical staff may provide treatment in advance so that the delay in treatment can be avoided if the patient is suddenly in a critical condition.
(b) Detection of Cancer: Today, cancer is one of the most critical threats to human life. The number of such patients is rising very fast every day. With a sensor capability to identify the nitric oxide that is released by the cancer cells, one can assist doctors to identify cancer cells at an early stage. These sensors are capable to distinguish the cancerous cells and based on collecting information the medical staff can detect the stage of cancer along with its possibility of treatment and cure.
(c) Hip-Guard: This system is designed for those patients who are improving from hip injuries. The embedded sensors can detect the patient's leg and position of

the hip along with the extent of rotation. Alarm signals are sent to the patients if any hip or leg position and rotation turn out to be wrong. This sensor provides real-time updates for better recovery.

(d) Asthma Sensors: Such electronic devices are used to sense agents in the environment that causes allergic reactions and report the present status constantly to the physician and patient so that necessary precautionary actions could be time taken.

(e) Mobihealth: Such an application is often deployed for continuously monitoring the patient outside the hospital environment. A sensor is used in this system to create a general platform for enabling healthcare in the domestic environment. Intelligent sensors detect the patient's conditions and assist accordingly to diagnose disease straightaway.

(f) Glucose Level Monitoring: Diabetes is a chronic disease that can lead to several chronic diseases, such as heart attack, stroke, high blood pressure, kidney disease. A diabetes sensor is capable to monitor the level of glucose and periodically send the results to a wirelessly operating digital assistant, and also provide one of the functionalities to inject insulin automatically whenever glucose threshold level is violated.

(g) E-Health Sensor Shield: In consists of different sensors, which include recording pulse, the oxygen level in the blood, breathing condition, temperature, galvanic skin response, blood pressure and electrocardiogram, and a glucometer.

(h) Encryption Algorithm Embedded Sensor: A sensor is used in this system to safeguard the confidentiality, integrity, and authentication of the collected data.

(i) 3G connectivity, Wi-Fi, and Bluetooth Sensors: These sensors allow sending the collected information at the same time. These sensors are very important for real-time data and to store it in a remote location.

(j) Environmental Monitoring Sensors: These devices are quite significant for analyzing the weather forecasting data and for quantifying the several environmental threat that can be averted before they occur. Environmental monitoring sensor collects data from a geographical region, which allows monitoring minute variations in the environmental parameters. Input from such sensors acts as crucial for suggesting mHealth solutions to patients.

4.2.2 Wireless Medical Sensors: Requirements and Challenges

The medical sensors must fulfill the following requirements, including wearability, interoperability, reliability, and security.

- Wearability: For employing inconspicuous and noninvasive monitoring of patients, the wireless medical sensors must be light in weight and small in size, so that it can easily wearable.
- Reliable Communication: Reliability of communication by medical sensors depends upon the need of sampling rates (from less than 1 to 1000 Hz). It can be

maintained by transferring the relevant information after applying data mining techniques on raw data.
- Security: It is an important requirement in medical sensors. To ensure the integral contents of patient-centric information gathered for medical examination. This further ensures the privacy of data to be maintained.
- Interoperability: The medical sensors operating wirelessly must allow users to easily construct a robust communication based on the state of health of the patients. Such information needs to be transferred reliably and rapidly to avoid the expiration of data freshness.

4.2.3 Context-Aware Sensor Data

Context-awareness describes an application that tends to make use of some context. Context-based data often helps to determine the context related to a person or object. The context-aware systems deploy mobile or wearable devices that are embedded with smart sensors particularly to monitor the current environmental situations to assist humans to maintain a suitable quality to their standard of living. The architecture of the context-aware system allows them to extract low-level context from a realistic heterogeneous physical world. Based on low-level context information acquired by sensors, high-level conceptual models are developed by the concerned authority. The following section provides a layout of key components and modeling processes in a context-aware system.

(a) Contextual Information: In the real world, sensing data and communicating mined and processed information is the key element of human interaction. The context can be defined as sensing the information and uses this information for providing better interaction between communicating parties in a real-world environment. Context-based information helps to reveal the joint-impact of all influencing contexts associated with a person or an object.

The context can be interpreted in different ways because it is completely dependent on the usage of smart sensors. The context is the assumption of a specific entity in the situation such as user profile, interaction, activity, user location. In that way, the concept of context is more powerful, more useful, more personalized, especially for mobile users.

(b) Context Representation: The context-awareness is applied to a mobile device to reduce human intervention by providing assistant services. The physical factors such as temperature, light, and location are also added in context-awareness systems, to perceive real-time contexts. The context represented in heterogeneous form or structure presents the collected information of the entity owing to situation-specific conditions of the real world. Following category of sensors are used to sample contextual data:

- Physical sensors: Sensors in this category are capable of sensing physical environment data, for instance, location detection through GPS sensors, etc.

- Virtual sensors: Such sensors obtain data that is manually fed by users about applications/services via social networking portals.
- Logical sensors: Such types of sensors buffer extra information on physical and virtual sensors which is recorded from user interaction history and records.

The context can be divided into:

- Device context: This includes Internet connectivity, cost of communication, and other resources, etc.
- User context: Such contexts include user profile, user geographic position or location, user activities in a particular situation, etc.
- Physical context: This captures temperature, noise, light intensity, traffic conditions, location, etc.
- Temporal context: Time factors such as day, week, month, and year are recorded as temporal context.

(c) Context Modeling: Context modeling aims to reduce the complexity and usability of the system/application and improve the maintainability and adaptability of the system or application for future use. This facilitates acquiring context-aware sensor data and thereby, model data according to the use.

4.2.4 Pervasive Healthcare

Pervasive healthcare systems provide telemedicine and healthcare services by caregivers and doctors. Patients can communicate with healthcare professionals at anywhere and anytime via the pervasive healthcare system. The main features of pervasive computing in the healthcare area include:

- Context-awareness
- System intelligence
- Knowledge-based discovery of database
- Privacy and security
- Mobility

Classification algorithms are used to extract the relevant data from a large data set. Such a colossal form of data undergoes through mining techniques, over which the decision-making process is executed. This further involves machine learning algorithms, real-time data collection, clustering algorithms for sensing intelligent locations, etc., for designing a better smart home healthcare system.

Pervasive computing has a mobility feature that permits users to move with their mobile devices such as Tab, Pad, cell phone, laptop and can access any service (G-mail, contacts, notifications, chat) via Internet/network at anytime and anywhere.

The objective of pervasive computing as highlighted in Fig. 4.3 helps to develop a refined and reliable service that is equipped with smart sensors embedded over

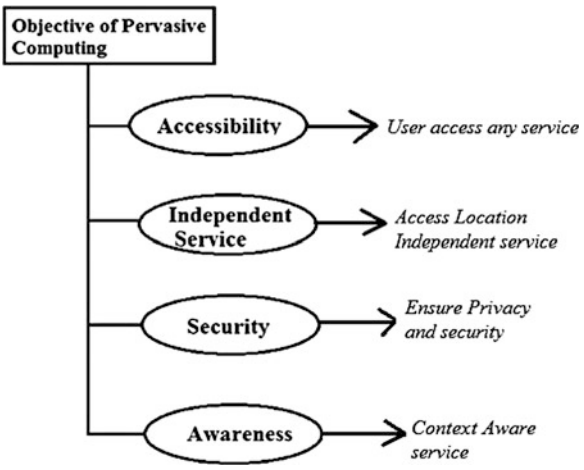

Fig. 4.3 The objective of pervasive computing

mobile devices. The pervasive healthcare systems can be classified into two main categories:

- Control and assisting for prevention systems
- Rescue in emergencies

It controls and assists the best measure for prevention. These guidelines are being provided for controlling the chronic disease and assisting with the best possible treatment for the prevention of patients from critical and adverse situations [16].

(a) Real-time Affordable Cardiovascular Emergency Detection System

This system enables handling patients suffering from chronic heart diseases. The cardiovascular emergency detection system is a wearable strap that can check the heartbeat rate timely and also draw conclusions from heart ECO. This device uses Bluetooth/Wi-Fi sensors for providing communication between healthcare providers and heart patients. This device can provide communication anywhere and at any time so that patients can be prevented from a critical situation. This system provides three types of warning messages with the help of smartphones. The system generates the following warning messages when required:

- Sending SMS alert which shows highlights the location of monitored patients
- Firing an alarm when the monitored patient's heartbeat rate exceeds the allowable optimal rate, that is, falling or rising beyond the acceptable threshold
- Sending alert messages to the emergency unit of the hospital to send an ambulance with medical facilities to rescue the monitored patient suffering in a critical state
- All such data and information are stored on the server. Data analysis application is applied to server data for decision-making purposes. This

server is directly connected to the emergency unit to promptly trigger the rescue process based on the received information.

(b) Monitoring system for diabetic's patients

The basic idea behind this system is to monitor diabetic patients. This system measures the sugar level in the blood of patients regularly. This system has mobile integration technology for sensing tasks. The patients can perform self-controlling and monitoring parameters by measuring the level of sugar in the blood using their mobile phones and in that way, they can reduce the risk of critical health conditions. This system provides many check-ups such as pulse rate, glucose level, BP, the weight of the patient and instantly provides measuring information using the smartphone. The capabilities of this system are:

- To send data report by the patient in real-time
- To transmit received data on a central server with the help of a smartphone
- To analyze stored server data by the expert team
- To make any decision (high level, very high level, diabetic or not) based on analyzed data

(c) Rescue operation in an emergency state

To achieve good health rescue systems that depend on good management of emergency services (EMS) and emergency vehicles (EMV). The management of emergency medical services follows ironic steps and takes actions to determine the priority for achieving a good precise decision. The EMV has route guidance and reception calling features. This assists the management and reduces the overall waiting time to rescue the patient, without much time elapsed.

(d) *Advanced system based on rescue operation in emergencies:* This system provides rescue operations for attending to sudden accidents. This application has four components:

- EMV: an emergency vehicle (like an ambulance)
- Traffic Management: to manage road traffic, that is, finding those areas which confront less or no traffic
- Geographic Information System: to give geographical information of accident area
- Conference Calling: to provide basic treatment in EMV through conference

This application is designed with the sole objective to reduce the EMV arrival time on accident areas, to reduce the required transfer time of patients from the accident spot to hospital, and to provide a high quality of healthcare service in EMV. This is one of the best instances of a real-time system for saving the life of people with a high success rate.

4.3 Mining Context-Based Health Aspects

Here, mining context-based health aspects means "knowledge discovery of the entire context that is related to health." Mining context-based health aspects refer to select the relevant data from the environment so that mined data will be used to determine the current health condition of users, that is, whether it is normal or critical!! For determining the health condition of the user, any application, or system needs a huge variety of data for analysis, data must contain all the aspects of health so that mining will be applied on all context data to get the relevant amount of information for generating the actual result.

4.3.1 Multiaspect Context-Based Dataset

Multiaspect context-based dataset refers to the sensing of multiple aspects of data (variety of parameters) from the current environment. Here, we define the multi-aspect of the context-based dataset by using some applications. An elaborated study is illustrated on these applications sense different parameters by context-awareness property and then maintain a context-based dataset for analysis purpose.

- To maintain blood pressure normal

  Nowadays, hypertension and stress are the most common chronic diseases all over the world. So many people are suffering from Blood pressure problems. Most of the patients use technology to monitor their BP regularly and for taking some remedies or precautions to get rid of high BP. Withings is one of the connected devices, which is easily available on the market. An app consisted device which is connected to Bluetooth for monitoring the blood pressure itself. This app measures all the relevant aspects of health which will be helpful to monitor the best result. This app measures not only blood pressure but also check the heartbeat rate and also counts the footsteps the person takes weekly. The app takes these three measurements and reports based on collecting health aspects with the medical recommendations. This app has a useful alarming feature so that patients can take his/her medicine on time and patients can set an alarm for monitoring BP. In that way, this app sensed multiaspects context data set and reports the actual result after mining.
- To keep healthy heart

  We know our heartbeats 100,000 times per day. Many gadgets are in the market to keep track of the heartbeat rate and analyze the health of the heart. In that way, users of the gadget can predict and prevent lots of heart problems such as sudden heart attacks. AliveCor Heart Monitor is an electrocardiogram with the help of a mobile phone. It is easily attached to the phone case. This device is slim and tiny in size. It records ECG, past the patient's data. It takes all aspects of health parameters to check whether the patient's heart is working normally or not! This device takes the history of the patient to report the best

result on time. This app stores all aspects of health as a context dataset. Later this dataset will be mined to get the relevant information for reporting good health.

- To measure body temperature:

  To maintain the optimal body temperature is very important. Through thermometer measuring of body temperature is very frustrating and takes long minutes of sitting. Recent innovations allow us to measure the temperature and also other parameters in less time. Viatom Checkmethe world's first medical Tricorder which diagnoses medical conditions within seconds. It is a proper medical multitool which not only measures body temperature but also records ECG, pulse rate and oxygen saturation, BP, physical activity, and sleep. This device is used to check the body temperature and all other aspects of health and provide the result whether the patient should have to visit a physician or not!! On the basis of the report, the patient can plan his day.

The above applications help us to understand how a multiaspect context-based dataset is created and how this dataset to help healthcare providers to generate the result. The huge collection of datasets may contain some noise and irrelevant data that will not be useful. For extracting the relevant and useful data from the large dataset, we apply mining techniques like clustering.

4.3.2 Collaborative Intelligent Mining

Intelligent mining or data mining refers to extracting or mining knowledge (relevant information) from a huge amount of data. It is a logical process to search for a pattern from the large dataset. The main goal of mining is to find the pattern which will be used in the future to make the right decision. In other words, intelligent mining is a knowledge discovery of data.

Intelligent mining is an iterative process. In Fig. 4.4, we define the overall procedure of collaborative intelligent mining [17, 18]. The following steps of this process highlight working in brief.

- Data wiping: It is the process to remove noise and inconsistent data from the large dataset.
- Data amalgamation: It is the process to combine multiple data sources.
- Data selection: It refers to analysis of relevant data that are retrieved from the database.
- Data alteration: Selected data are altered into other appropriate forms by applying mining rules.
- Data mining: It is a logical process to search a pattern from the large dataset.
- Pattern evaluation: It identifies the best pattern for the best prediction.
- Knowledge presentation: It represents and visualizes the knowledge or pattern for the user by applying some techniques.

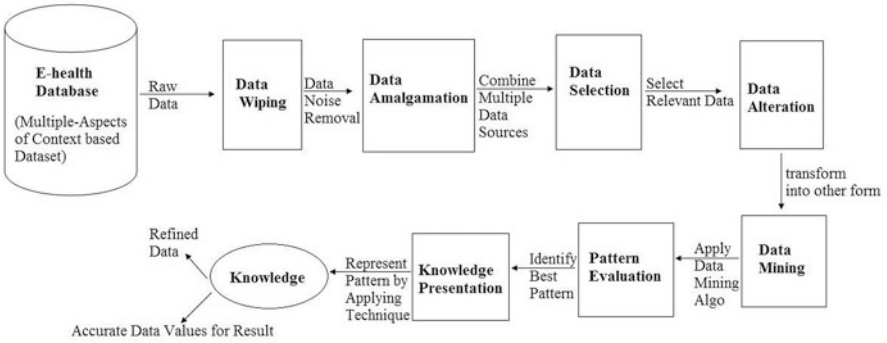

Fig. 4.4 Collaborative intelligent mining

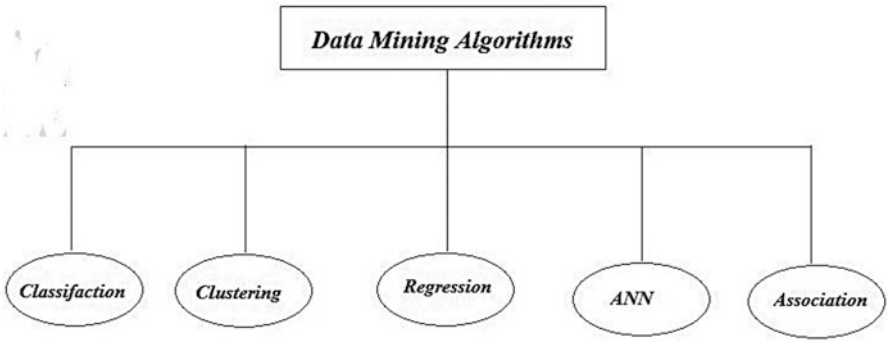

Fig. 4.5 Popular data mining algorithms for mHealth applications

Many different types of algorithms and techniques are available in intelligent mining for mining the relevant information for the user from the large dataset. Data mining algorithms and techniques are Classification, Clustering, Regression, Artificial Neural Networks (ANN), Association Rules, K-means, etc. Some Popular Data Mining Algorithms for mHealth Applications are shown in Fig. 4.5.

(a) Classification

Classification is the most commonly used intelligent data mining. Predefined examples are stored to develop a classifier that can classify the large recorded dataset. This technique can be used with neural networks and decision trees also. It is the process that involves learning by example and then classification. This technique is based on two phases:

- Learning phase: Classifier uses the training data set and then analyzed the data by classification rules.
- Classification of data: The tested data can be used to estimate the accurate classification rule for finding the best pattern or relevant data.

A classifier is just a model to perform the above two phases and provide the required and relevant pattern after applying accurate classification rules. In other words, we can say that it classifies the knowledge based on the features in the large dataset. Types of classification models:

- Decision tree classification
- Bayesian classifier
- Artificial neural intelligence
- Support vector machines
- Classification with associations rules

(b) Clustering

It is the process to identify the homogeneous classes of objects. The clustering technique helps to identify dense and spare regions of object space. It can find the distributive pattern and co-relates that pattern with the dataset. The classification works on heterogeneous data but clustering makes classes of homogeneous data. Clustering makes a class of those data objects which has similar functionality [19]. The clustered data becomes the refined knowledge discovery of large data. The different types of clustering methods include:

- Partitioning techniques
- Hierarchical clustering
- Density-based clustering methods
- Grid computing

(c) Regression

The regression technique is based on predication. This technique is used to define the relationship between the dependent and one or more independent variables. Independent variables are known attributes and they help to predict the next variables. It analyzes the relationships among the variables. It models a set of dependent data and independent data from the large dataset which is further useful for maintaining the best result. Types of regression methods are:

- Linear and logistic regression
- Multivariate linear regression
- Multivariate nonlinear regression

(d) Association rule

Association and correlation are used to find frequent item set among large data sets. This frequent item set helps to make better decisions. Association rule algorithms help to generate new rules with values less than 1. We can generate so many numbers of association rules for a given dataset with certain values. Types of association rules include multilevel, multidimensional, and quantitative.

(e) Neural networks

A neural network is a set of interconnected input and output units (called neurons). Each interconnected units has weight and activation function. Each neuron has training data to fire on particular input patterns. Neuron works on two modes: learning and training mode, using mode. In the learning phase, networks adjust the neuron weights so that the correct result can be predicted. Types of neural networks broadly involve:

- Backpropagation
- Single-layer perceptron
- Multilayer perceptron

4.4 Security in Healthcare Service Delivery Model: A Case Study

Context mainly relates to the situation concerning certain influencing factors. Contextual attributes are those characteristics or attributes that determine such situational cases of a system or organization. This section highlights a case study on context-aware security in healthcare services that aim to safeguard resources based on the present context of an entity (person, object, profile, or application) (Fig. 4.6). Context-aware security is gaining significance owing to widespread research in distributed data, cloud computing, sophisticated crime, cyber threats.

Different forms of security could be triggered for access control, authentication, authorization, encryption, etc., of records and information. Traditional security is coarse and context insensitive, and relies on consistent configuration (Fig. 4.7). Modes of context-awareness could be decided based on static or dynamic contexts. Depending upon which contextual cluster on entity belongs will decide the type or level of security is being imposed. Contextual attributes include time, date, geolocation, type of connectivity, user identity (designation, user id, password), type of information, level of access, purpose. Source of contextual attributes could be from manual entries (user comment or from a predefined list of options), sensors embedded in a computing device (for recording instantaneous information, like time, date, location), extended sensors in environment, system state, other context providing service, etc.

4.5 Recent Trends in Intelligent Healthcare Delivery

Recent trends include some intelligent healthcare services are cloud-based which stores data on the cloud and IoT in real-time. Here, we are explaining some intelligent healthcare services; these are the following [20]:

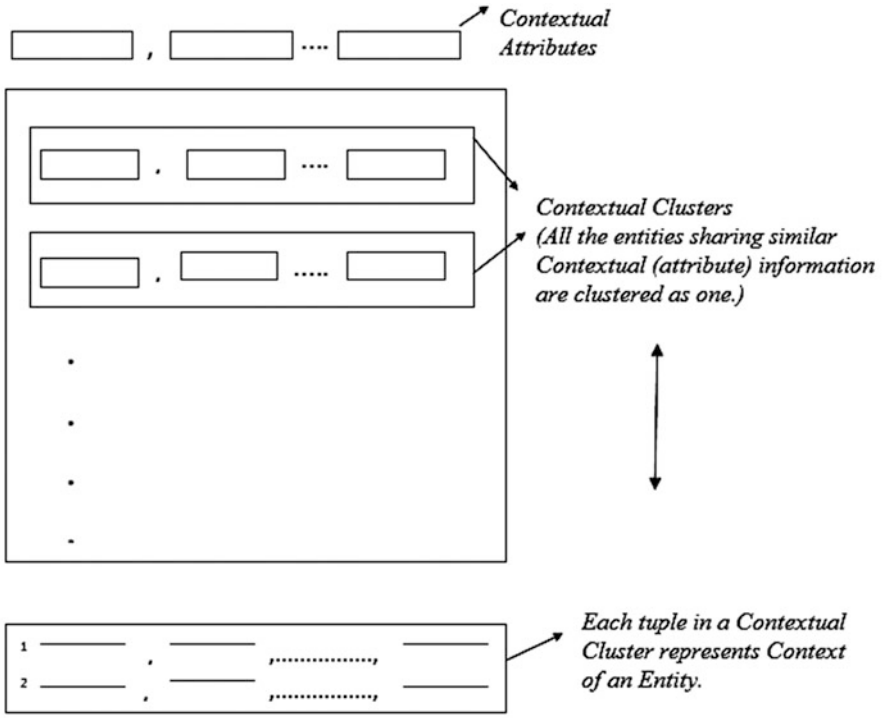

Fig. 4.6 Instances of contextual attributes and clusters for context-aware security

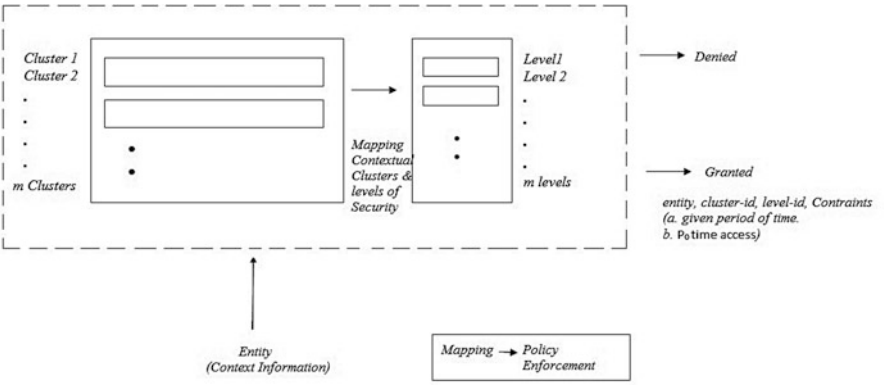

Fig. 4.7 Instances of mapping between contextual clusters and security levels

- *Intelligent wheelchair for disabling humans:* It is an intelligent device with an accelerometer, camera, location sensors, and obstacle sensors. The device allows the paralyzed person to move freely without the help of another person. It allows

users to move independently. It contains an alarming system also which allows the users to call another person if they need it.

- *Dot: It* is an intelligent wearable smartwatch that is easily affordable. This device helps blind people to access the messages, e-mails, tweets, books anywhere, and at any time.
- *UNI:* UNI is a two-way communication tool for the deaf. It uses speech technology and gesture technology for detecting the movement of hands and fingers with help of specialized camera and then it converts the signals into text in a while. In that way, it gives the meaning of sign language used by a deaf person. It has one more feature that is voice recognition. It converts speech into text for two-way communication. It also enables users to create their sign language and add custom dictionaries for custom sign language.
- *Cancer Detection:* Today's cancer is the biggest threat to human life. The number of cancer patients is rising very fast day by day. A sensor can detect the nitric oxide which is emitted by cancer cells. This sensor can be placed by doctors where they identify the cancer cells. These sensors are capable to differentiate cancerous cells between different types of cells and based on collecting information the medical staff can detect the stage of cancer at an early age.
- *Fitbit Aria:* A smart gadget to keep a track of body fat and your weight. This is a cloud-based gadget which stores measuring data on cloud server through the Wi-Fi network. It creates a separate account for the user on the cloud and maintains his/her record separately and senses the historic data also to provide the best result. With the help of this app, the user can compare their changes in weight by doing physical activity.

4.6 Conclusion

Currently, there are several prevalent healthcare applications and devices that are connected with a mobile platform to monitor human health. These are intelligent applications that work in real-time and offer dynamic extensions to the static healthcare frameworks with contextual processing of relevant medical data. Context refers to instantaneous and scenario-specific details associated with the surrounding environment or entity that enables to pour extensive insights on the cause and remedy of an ailment. Our work introduces the utility of such context-aware systems, specifically in terms of real-time adaptability.

To summarize, our research addresses the principal methods, models, current trends, and further projections of future research in intelligent healthcare. This would foster the understanding of formidable challenges confronted in developing protocols and standards. Our research would serve as a leading reference for those who seek broad knowledge with in-depth conceptualization of context-awareness in smart healthcare delivery.

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