

Design and Implementation of an User Centric M-Healthcare System for Patients

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Keywords

Remote health monitoring,
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Sensor

Abstract: Wireless sensor networks (WSNs) and mobile devices have the ability of managing the health monitoring systems for medical care needing people. They provide mountable sensors and wireless sensors to ensure easy health monitoring. In the paper, a remote patient monitoring system is proposed as an android application together with wireless sensors for the patients. Our system has an easy to use structure. The data is collected by touching the finger of the patient. The gained data is sent to the patient's smartphone that has an android operating system. Then the data is transmitted to the hospital database and the patient's doctor via patient's medical record. Eventually, the system provides an easy medical data collecting and storing environment for medical people and patients.

Hastalar için Kullanıcı Odaklı Mobil-Sağlık Hizmeti Tasarımı ve Uygulaması

Anahtar Kelimeler

Uzaktan izleme sistemi,
Kablosuz sensor ağlar,
Sensör

Özet: Kablosuz sensor ağlar ve mobil cihazlar, monte edilebilir sensorler ve kablosuz sensorler ile tıbbi bakım gerektiren insanlar için olan sağlık izleme sistemlerini yönetebilme ve kolay sağlık izlemeyi sağlama özelliklerine sahiptirler. Çalışmada, bir uzaktan hasta izleme sistemi, hastalar için kablosuz sensörler ile birlikte android uygulaması olarak sunuldu. Sistemimiz, kolay uygulanabilir bir yapıdadır, veriler hastanın parmağına dokunarak elde edilmektedir. Toplanan veriler, hastanın, Android işletim sistemi olan akıllı telefonuna gönderilmektedir. Sonrasında, veriler, hastane veritabanına ve hastanın hastane kaydı üzerinden hastanın doktoruna iletilmektedir. Sonuç olarak, sistem, tıp insanları ve hastalar için kolay tıbbi veri toplama ve depolama ortamı sağlamaktadır.

1. Introduction

Wireless sensor network (WSN) is a convenient technology, it can be utilized in many areas: military, environment, agriculture, livestock farming and remote health monitoring. Especially, remote health monitoring is one of the most considerable application of WSNs. Because, the considered application has less power consuming and compact structure. Also, it provides real time data by cooperating with the wireless networks. The system may be used both in hospitals and patients' houses by mounting small, light, mountable wireless sensors on the patients to collect the data about the patients. Thus, the health situation of the patient may easily be monitored by doctors and caregivers [1].

Medical care systems have been mostly based on traditional methods and devices for many years but the number of old people in world population has been increasing faster than before. This means that,

the number of medical care needing people increases too. In addition to this, the cost of medical care increases. Thus, the need for new methods are emerged instead of traditional health care and medical methods. The technological improvements lead to novel technology based methods together with devices. Old and traditional methods own wired structure based health care with stable devices and appliances. Today, this method is very tiring, useless and expensive. Because, these old fashioned medical care systems take too much time of patients and causes labor losses. Thus, wireless sensor network based methods are proposed. With the help of these methods, to provide early detection of diseases and long-term observations of patients can be provided easily and cheaply [2-6].

Patient health monitoring system is an android project which is intended to be used for following the patient if there is a medical complication occurred after the treatment or surgery and also for controlling

the treatment period. In health sector, monitoring a patient is a crucial topic. Also, some patients may need permanent monitoring and controlling: cardiopath and diabetics. Thus, the patients have to visit the hospitals. Today, there are many low cost devices that can be used in houses for blood tests but it is a complicated process, to interpret the state of the patient according to the values gained from these devices. For this reason, the patients have to go to the hospitals for every disorder. In our project, the sensors that utilize from bluetooth technology will be used for sensing. Then the collected data will be transmitted to the smartphones and then to a database where the information of the patients are collected.

The main aim of our patient health monitoring system is detecting the patients' vital function values at definite time periods. The project is designed for the patients who need monitoring after the treatment in the hospital. The detected data about the patients are transmitted to the patient's doctor over wireless communication technology as regularly, thus the doctor will gain all of the needed informations about the patients and monitor them during the 24 hours a day. Furthermore, the collected vital function values will be compared with the threshold values determined by the patient's doctor and if a higher or lower value is caught then both of the patient and the doctor will be informed with a warning message. The paper is organised as follows. In section 2, the general structure of healthcare and healthcare applications are presented. Proposed method is given in section 3. In section 4, implementations and results are proposed. In the last section, the paper is concluded.

2. Related Work

There are many healthcare applications. These applications are developed for different platforms: gps, mobile platforms, etc.

In Acibadem mobile, the patients' and their relatives' requests about having private nursery and treatment assistance personel are evaluated by supervisor nurses and home health doctors. According to these evaluations, the service process is started by assigning a nurse. The nurses serve to the patients during 12 or 24 hours a day with monitoring and providing treatment. The collected data about the patients are sent to central data system and stored. During the provided medical service, the patients are visited by home health doctor and home health supervisors to determine and consider the needs and contentments of both the patients and nurses. In the system, the patient applications and appointments are transmitted to the health teams over the network system. Thus, when the teams arrive to the patient, they have all the informations and treatment plan about the patient. When the service is provided to the patient, the informations are entered to the system.

The services, staff, vehicles and devices are followed over the system. To provide security for patients, the system use barcod at the blood sample taking for blood tests. The system owns mobile EKG devices, vehicle navigation systems and mobile x ray machine [7].

Avea mobile doctor and chronical patient servise was presented for the patients who had cardiology, diabetes, hypertension, arrhythmia and many more chronical diseases. Besides, the people who needed medical care, monitoring and control in their home after being discharged from hospital were served during seven days and 24 hours a day. The main aim of the system was providing suitable and essential medical treatment and maintenance with mobile monitoring as being faster in service. Without leaving the patients from their own living areas, providing their controls with mobility, thus they did not make changes in their daily routines. The patients followed their own states as personal. By following the state of a patient as remotely, the appeal rates to the hospitals were expected to be decreased, thus medical staff and resources would be used more efficiently. With decreasing requests of medical care needing patients, the medical centers would provide better medical care for other patients and the staff would serve to emergency patients. The costs of medical treatment, medical center management and medical center staff would decrease in medical centers. In addition to this, patient and patients' relatives blood tests, travel and accommodation costs would decrease together with time losses. With the remote blood tests, time loss and labor loss would be prevented at medical centers. In the project, a gateway received and collected four patients' data which arrive from different medical devices. Then, it transmitted the data to a mobile health device by bluetooth. Next, the data was sent to the servers at the medical center by GSM. The location data was sent with e-mail and sms by GPS and cell locator. If GSM was out of use, then with the offline record speciality, uninterruptible patient monitoring was provided [8].

Wireless smart gluco monitoring is produced by iHealthLabs. It works wirelessly with smartphones and tablets over Bluetooth. The device works with android devices. It records all of the glucose readings of the patient, also follows the expiration date of test strips. It is used to monitor and manage the glucose readings. Also, it can be utilized to record time of meals and medications taking hours while you have been fasting or taking insulin dosages. Besides, the history of patient data is kept and patient may share his/her data with his/her doctor or caregiver [9].

An overview of smart health monitoring systems were given together with considering the system design and modeling in [10]. Clinical acceptability and efficiency were examined in the system to develop actual health monitoring systems. More than

fifty monitoring systems were examined. Progressions in the system design level were considered and actual problems were discussed. An embedded system was proposed in [11] for monitoring the patient's position and health condition by utilizing a wireless sensor network of Xbee radios. The data from the heart beat sensor was sent by active RFID cards that were also used for tracking the position of the patients. In [12] technology-driven approaches were given to provide in-home cognitive assessment based on sensor data utilizing measures of daily function. For assisted living issues, stroke detection and alarm generation is studied in [13] to provide timely delivery of medical assistance. Gathered data from sensors in the home environment was analysed in [14] by proposing many methods for model building. A remote health care system is created in [15] by wireless sensor network system and radio frequency identification technologies with minimizing the hardware cost and improving the system security.

Different from many presented healthcare applications, we propose a user friendly and cheap application. Our main aim is to present an easy to use application because the application will be used by mostly old people over their smartphones. Most of the applications consider collecting data of patients' (calories burned, blood pressure, blood sugar results, and sleep efficiency) but we also consider hospital history of a patient with providing interaction between patient and her doctor. In our project, patient's doctor can reach all of the patient's history, thus he will always decide, follow and change the collected data comparison ranges. And according to these ranges, the patient will be easily monitored without visiting her doctor. So, providing a connection between the doctor and her patient is a positive speciality in our project. Also, when a critical range is detected, providing a warning alarm is an additional advantage over other healthcare applications. We can say that, our work is composed of many parts; collecting data with sensors, processing data according to the doctor's comments, storing data and utilizing data.

3. Proposed Method

Users will utilize our project over their smart phones. They can use the application, add, edit and delete their profiles. Sensors will collect the patient data and transmit it to the smart phone by bluetooth. Patient data will be stored in a database and the connection of the application with the database will be provided by web services.

In our paper, we used OEM SPO2 Pulse Meter bluetooth sensor to measure the blood pressure with % SpO₂ rates and heart pulses of the patients. It is an easy to use device with its compact dimensions and high security features. It is suitable for adults, children and patients. It owns bluetooth transmission

and it can be used on computers and android devices together with its data storage feature. The system architecture is proposed in figure 1. Eclipse and Android Studio is used to produce the application. MySQL WorkBench is used as a database modelling tool.

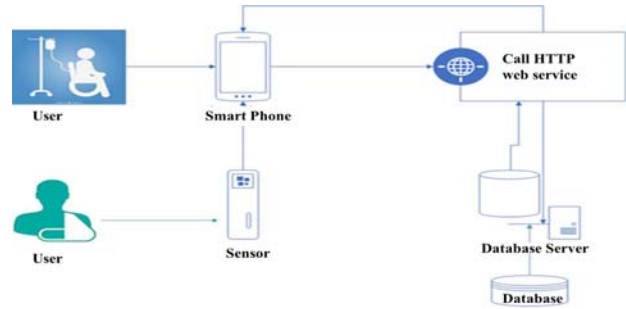


Figure 1. Health monitoring system architecture

In the system, the communication between sensors are provided by bluetooth technology. The gained information that is composed of physical symptoms and vital functions of the patients will be transmitted by android operating system having smartphones over wireless network technology to the considered database. The users may utilize the proposed system together with their own page on their own smartphones.

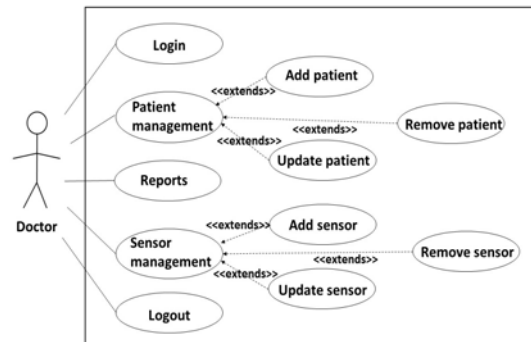


Figure 2. Health monitoring system use-case diagram

The doctor considers patient management, reports and sensor management basically as presented in figure 2. In the database design, the patient part includes personal informations of the patients and his/her doctor with doctorID. The patient detail part includes the patient's disease informations. The doctor part includes personal informations of the doctors. In the sensor part, the general informations of sensors are kept. Here, the doctors determine definite minimum and maximum values to compare with the measured values according to the disease, age, gender and many more vital factors. When a patient measures and collects her values then these values are examined if they are between the determined minimum and maximum values. And we will monitor the patients according to these values with the system. When the patient's values are out of these ranges, then the system will understand that the patient is in a critical and crucial position, thus it will produce a warning situation in the mobile device.

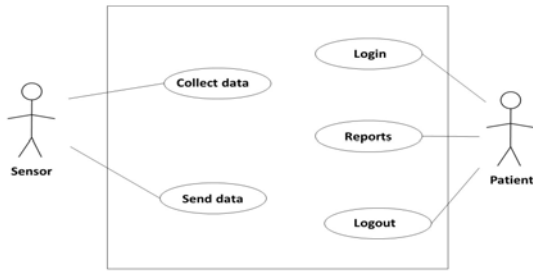


Figure 3. Sensor and patient use-case diagram

In sensor data part, the collected data from patients' sensors are kept and reports are formed with the data in sensor data part as illustrated in figure 3. Alert part includes the daily determined measurement times of the patient by their doctors. When the measurement time arrives, there will be a warning alarm in the mobile device to remind the patient his/her measurement time. With the users part, the login of the doctors and patients will be provided and controlled if they have an entrance authority. And according to the user type, they will be directed to the doctor page or patient page.



Figure 4. OEM SPO2 pulse meter [16]

Easy to use and compact sized pulse meter provides reliability for patients as presented in figure 4. The communication is provided with RS232:4800/115200 Baut Rate. Pulse rate unit is BPM. The measurement range for pulse rate is 25~250 BPM. The accuracy for pulse rate is ±1% (25-250 BPM) [16].

4. Results

The presented system will be used by the smartphones over the system's interfaces by both of the patients and doctors. The first interface of the system is the *Login* page as presented in figure 5. Also, class diagram of login page is given in figure 6 [17]. Initially, the patients and doctors should register at the system with their personal data. Next, with the *Login* page, the doctors and the patients may easily login the system. With the system, the patients enter the system with their e-mail and the doctors enter the system with their personal record numbers.

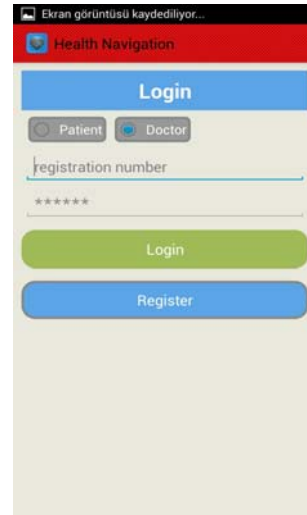


Figure 5. Login page

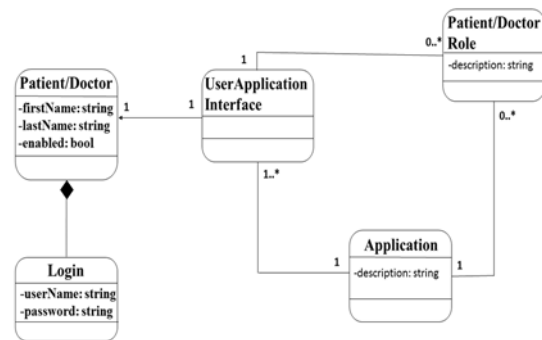


Figure 6. Login page class diagram

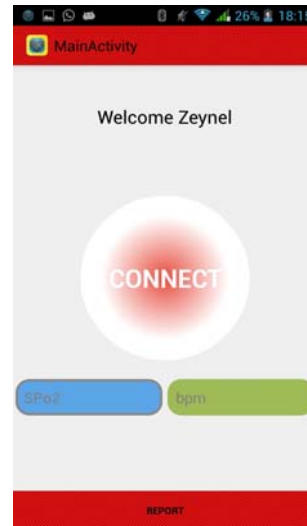


Figure 7. Patient page

At the patient page, two measurement choices are presented for patients as illustrated in figure 7. By choosing Spo2, the patients may measure their oxygen rate in their blood. With bpm, they may measure their heart beat rates. With these buttons, they may also get reports about their pre measurement values. To gain these values, after the login state, the blood values are read with sensors and recorded at the database.

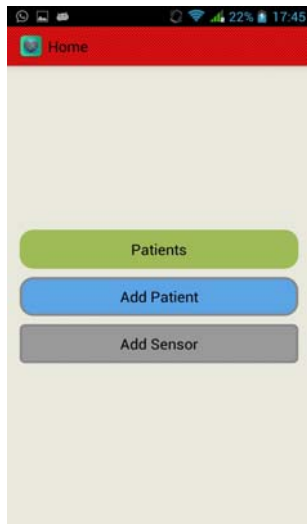


Figure 8. Doctor's page

After the login page, at the doctor's page, the doctor may list his/her patients. Also, the doctor may add a new patient or a new sensor. After listing the patients, the doctor may reach detailed informations of his/her patients, examine the patients' reports and update his/her patients' data as in Figure 8.

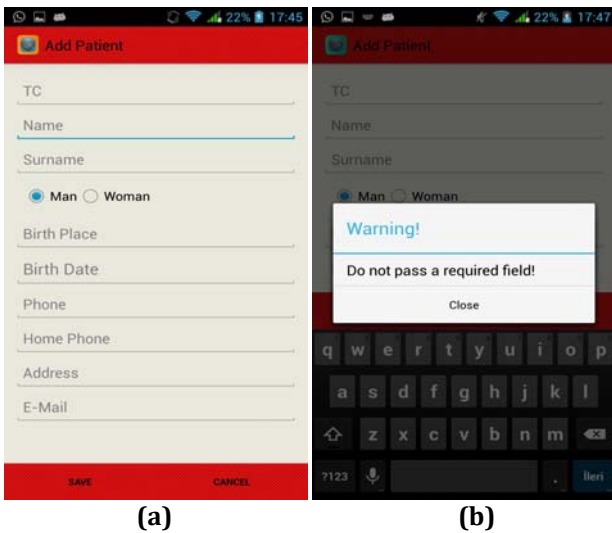


Figure 9 (a) and 9(b) Patient adding pages

With the Add patient page, the data of the patients who will use the system are added and the data of the sensor that belongs to the patient is added. And also the patient's sensor is determined as presented in Figure 9(a) and 9(b).

The patient data is edited over the edit page as given in figure 10.

A doctor's all of the patients may be listed over the listing page for the doctor after login procedure as proposed in figure 11. When the doctor wants to edit a patient's data, the doctor reaches the patient's data over this list. The doctor is directed to a detailed patient data including page and the doctor may edit the patient's data. Also, the sequence diagram of patient editing is given in Figure 12.



Figure 10. Edit patient page



Figure 11. Patient list page

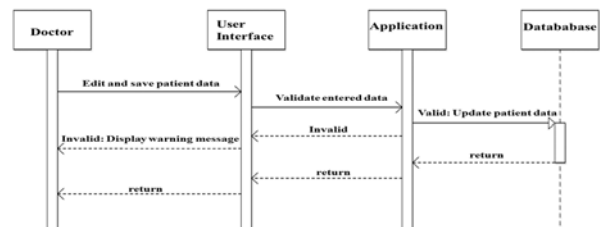


Figure 12. Sequence diagram of edit patient page

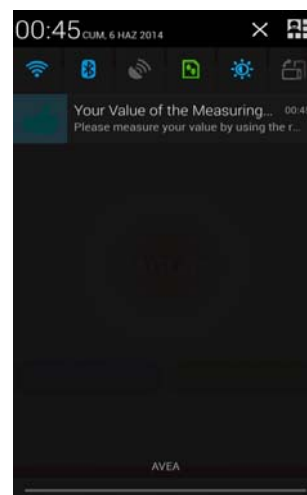


Figure 13. Alarm determination page

The doctors may define definite times for patients to measure their values. At the defined moments, the system warns and reminds the patients with alarms to use the sensor and send his/her values to the system as illustrated in figure 13. The doctor may define at most three different time periods for patients as alarm moments in a day.

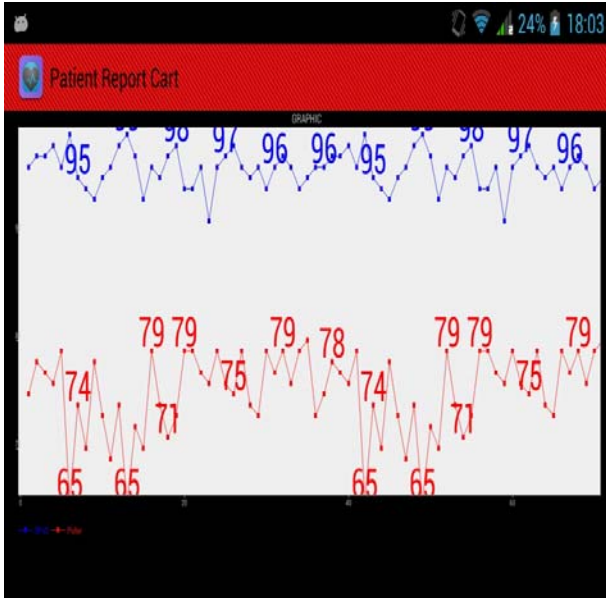


Figure 14. Report page

The oxygen rates and heart beat rates of patients that are collected by sensors can be illustrated as graphically at patient reports as given in figure 14. With these detailed and easy to understand reports the patients may follow their own states easily.

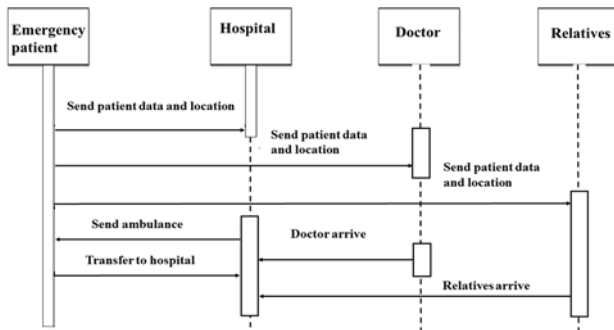


Figure 15. Sequence diagram of an emergency situation

In an emergency situation of a patient, the application sends a message to the hospital, patient’s doctor and patient’s relatives to inform them about the situation of the patient. Thus, the patient is transferred to the hospital in a shorter period of time.

5. Discussion and Conclusion

We proposed a novel remote health monitoring system deliberated for old and disabled patients together with patients having chronic diseases. The user friendly system can be used everywhere that you can use smartphones. The system is composed of a body sensor structure with a smartphone platform

for sensing and processing data with ensuring the mobility of patients. The abilities of the system are presented with the given interfaces. The sensing, collecting data, processing data, data storing, reporting and informing considered people for emergency situations are the main abilities of the system. By means of these abilities, the system provides a convenient environment for old and disabled people.

The work includes main design and implementations for permanent monitoring needed patients. The main aim of the system is warning patients with messages for informing them to sense their values with the help of the sensors, thus the patient’s health values will be stored in the database. So, the patient will be controlled at every moment of the day easily without going to hospitals. The permanent monitoring needing patients’ monitoring process will be provided by mobile devices, thus the life quality of the patients will be improved and also the work load of the hospitals will be decreased. Also, with the low cost and easy to use system, the time losses of the considered people while visiting the hospitals will be decreased.

Acknowledgment

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