The Demo Prototype of Mobile Treatment Assistance System for Hypertensive Patients

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***Abstract*—Mobile treatment assistance system is a medical system implemented in the concept of mobile healthcare, which allows to take the relationship between the doctor and the patient to a new level. The patient gets easy access to medical services and the opportunity to independently health monitoring. The doctor performs less routine operations, which allows more time to be given directly to diagnosis and treatment of diseases. At the moment, the service is oriented at patients with cardiovascular diseases and arterial hypertension. The Mobile treatment assistance system consists of two parts: a mobile application for the Android and a web service.**

I. Introduction

Today, many countries around the world are strived for transition to a patient-oriented healthcare model. In a patient-oriented approach, medical services are adjusted to patient's life rhythm and render assistance in solving social problems.

Partly such transition is possible due to the development of popular today eHealth. Russia is involved into the eHealth introduction. In many cities remote recording for admission has already available, transition from paper medical records to electronic is performed, but this is only a small part of what eHealth can offer today.

One of its branches is mobile healthcare (mHealth). Mobile healthcare means using of mobile devices (smartphones, tablets and other wearable gadgets) for medical care purposes, as well as for monitoring and self-monitoring of health. The most popular example of mobile healthcare is applications for mobile devices related to control of physiological state. The usage of mobile technologies provides both improvement of medical assistance opportunities by medical organizations and abilities to control one's own health for patients. One example of applications in field of mobile healthcare is a mobile treatment assistance system service, developed at Petrozavodsk State University.

Mobile treatment assistance system is a service designed to diagnose heart diseases. Objective of the project is to simplify the interaction between doctor and patient. In small towns and villages there is a deficit of specialized doctors. It leads to queues in hospitals to doctor's examination. Mobile treatment assistance system, like mobile healthcare generally, allows to improve the relationship between the doctor and the patient, significantly simplifying the interaction on both sides. The patient is became easier to receive medical care. And the doctor performs less routine operations, which releases more time for diagnosis and treatment of diseases.

II. Classification of patient data sources

Each patient's appeal to the doctor always begins from the patient's interview. He needs to collect information about the patient and the reasons of his appeal from every possible sources, because the effectiveness of treatment largely depends on completeness of received information. The sources of patient data are great amount, and for automation the process of collecting patient data through the using of information technology, these sources need to be classified.

Two large groups of patient data sources can be distinguished: sources of objective and sources of subjective information about the patient. Objective sources provide accurate information from reliable sources. Information from subjective sources is most often obtained from the patient's words and is not always reliable.

The objective information can be considered accurate, since it can be checked. The information received from the patient does not have documentary confirmation and may be inaccurate for various reasons. For example, the patient can lie to the attending doctor, for one or the other reason, doesn't say all the truth or forget an important part of information. Despite this, subjective information should not be ignored, because it is the basic reason of the patient's appeal and helps to make a primary diagnosis.

Thus, for establishing correct diagnosis and the appointment of an effective treatment, the doctor should take into account full information obtained from all sources. Mobile treatment assistance system offers a versatile approach to collecting patient data and provides an opportunity to collect objective and subjective information about the patient.

III. Mobile treatment assistance system design

The mobile treatment assistance system consists of two parts: a mobile application for the Android and a web service. The mobile application is intended for using by the patient. All patient's data synchronised with the web service, where it becomes available to the patient's attending doctor for further study and analysis.

The Web application consists of a server and client parts. The backend of Web application is written in PHP and is based on the Yii2 framework. It is a RESTful API and provides an interface for server and client interaction.

The Web application implements a system of roles. There are three roles: the chief, the doctor and the patient. The chief has the opportunity to interact with the doctors of his organization, the doctors interact with patients.

The Web application is built on several interconnected modules:

1) Module “User” is used for registering, inviting and authorization of users.
2) Module “Organization” provides creation and management of organizations.
3) Module “Survey” is used for loading and storing of questionnaires and feedbacks.
4) Module “Doctor and Patient Interaction” which is used for managing the accounts of doctors and patients, interaction between patients and doctors (for example, setting a questionnaire for the patient), downloading the files of ECG and indicating the blood pressure of patients.

To obtaining objective information about the patient a module worked with a cardiac monitor is developed in the mobile application [1]. This module usage provides patient-friendly 24/7 monitoring of cardiac activity with a portable cardiac monitor FRUCT with subsequent transfer of results to the web server. Cardiac monitor allows to monitor the heart rate and pulse. In its turn, it can timely identify deviation from the normal state and prevent the exacerbation of the disease.

The general scheme of working with the monitor is presented at Fig. 1.

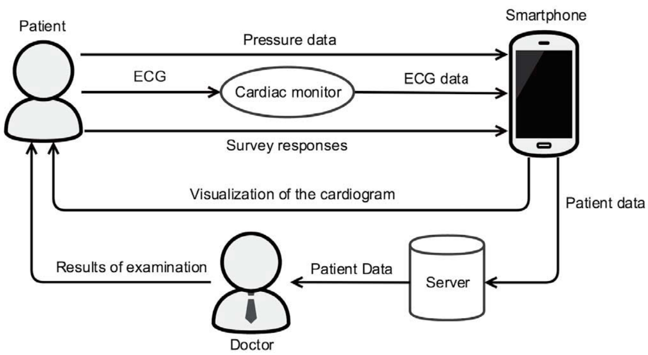

Fig. 1. General scheme of work with mobile treatment assistance system

The main scenario of working with a cardiac monitor consists of the following steps:

1) The user (the patient) puts on oneself the cardiac monitor and turns it on.
2) The user starts the mobile application and connects to the cardiac monitor via Bluetooth.
3) When the device connects to a cardiac monitor, a visualization of the cardiogram appears on the screen so that the user can regulate the position of the sensors with the cardiac monitor.
4) ECG data received from a cardiac monitor is saved to files on the user’s device.
5) After the adjusted interval (installed in the personal area of the application), the data file is sent to the server.
6) If there is no access to the Internet during ECG obtaining, ECG files will be saved on the user’s device and automatically sent to the server when connected to the Internet.
7) After sending to the server, data files are deleted from the device.
8) During ECG obtaining a widget is available in the notification area that displays the connection status to the cardiac monitor. Also the pulse, the level of the cardiac monitor’s charge and the past time of ECG obtaining are displayed on the widget.
9) Using the widget user can quickly go to the ECG obtaining screen.
10) Work with a cardiac monitor is available in the background. After connecting to a cardiac monitor, the user can hide or close the application.
11) The user completes the work with the cardiac monitor by click on the “Stop” button on the ECG obtaining screen.

The used cardiac monitor has many features. One of the features is that the FRUCT cardiac monitor is wireless. A cardiac monitor can transmit data in real time to a PC, PDA, smartphone or other device for storage and subsequent analysis. Bluetooth Low Energy 4.0 technology is used for data transfer. Battery capacity of the cardiac monitor is 300mAH, which provides continuous work for 12 hours. The dimensions and weight of the device in combination with the absence of additional wires allow to use of a cardiac monitor without inconvenience during daily activities for a long time.

When ECG data is transmitted in real time, a streaming data packages format is used. All values are multibyte, the order of the bytes is big-endian.

The structure of incoming packets is presented below:

TABLE I. PACKAGE STRUCTURE

Battery Level	Heart Rate	ECG Data	Acc Data	Check Data
1 Byte	1 Byte	10 Bytes	6 Bytes	1 Byte

For more comfortable usage service allows the device and the cardiac monitor to exchange data even with the application is turned off (in the background). To do this, the user only needs to go into the application and connect to the cardiac monitor, after that the user can close the application. Connection with the cardiac monitor is not interrupted, the data will continue to be processed and periodically sent to the server.

The service worked with a cardiac monitor is started and stopped by the user. The operating system doesn’t stop the service itself, because it is started in the foreground by the startForeground () method. Thus, the system indicates that the user is aware about the service work. Then this service can not be considered as a candidate for removal in case of a shortage of memory.

Blood pressure diary is one of the sources of subjective information in the mobile application. Using a pressure diary includes daily entering blood pressure data into the application, after that the data is sent to the web server. Blood pressure data and data from the cardiac monitor help the doctor in drawing up a complete picture of the patient's health and establishing the correct diagnosis.

Another source of subjective data about the patient is the questionnaire module. The module allows the doctor to compile patient surveys through a special web interface and assign different surveys for different patients. The doctor gets the opportunity to set the frequency of interviews, using different types of questions and other.

Scenario of working with the questionnaire module:

1) The questionnaire is downloaded from the server by click on the main application screen on the button "Pass survey".
2) The survey is presented in the form of a test consisting of a number of questions with possible answers. Sometimes there are open questions in which a response one's own or attach a file is needed.
3) Questions and answers are located on the cards [2]. Each question has its own card.
4) After passing the survey, the selected answers must be sent to the server for processing the results.
5) Answers are sent to server by click the "Send" button.
6) The answers, that were sent to the server, will be reviewed by the doctor.
7) By click the "Update" button the selected answers will be reset.
8) Automatic reset of the selected answers after sending to the server can be configured in the personal area.

The questionnaire module developed for the mobile application is universal and can be used for different types of surveys, for example, periodic and emergency surveys.

The main function of the periodic questionnaire is premature detection of deviations in the patient's health and timely necessary assistance. Using this approach, the surveying frequency for each patient is determined by the doctor. Besides, the doctor can establish different surveys for patients with different diseases.

An emergency survey is a survey conducted in a critical (emergency) situation, when the patient has an exacerbation of the disease or a deterioration in his or her health status. In perspective via mobile treatment assistance system, ambulance doctors will be able to receive the results of a patient's survey who is in an emergency situation. Thus, ambulance doctors will know in advance some of the patient's symptoms before arriving at the place of call.

After passing the survey, the user should save his answers to all questions and send them to the server. If the survey is periodic, the survey's results can be viewed by the attending doctor of the patient using a web-service. If the doctor is concerned about the results of the patient's survey, he can invite the patient to come to the admission unplanned. It allows to additionally examine him and, perhaps, to identify any exacerbations of the existing disease or to detect a new disease on the early stages.

If the survey is an emergency, the survey's results will be available to the ambulance doctors and they can get some idea of the current patient's health status. That is, they will be able to prepare all the necessary tools and medicines to help in advance, which will reduce the time of patient assistance and increase the number of calls that can responded to an ambulance.

Thus, the survey's results should be displayed both on the web-service on the personal computer of the attending doctor of the patient, and in the application on mobile devices of ambulance doctors. Therefore, it is necessary to keep the answers in a unified format. The file containing the survey is downloaded from the server in JSON format, the file containing the survey's results will also be saved in JSON format.

IV. Conclusion

Mobile health is actively developing around the world. The introduction of modern information technologies into an established healthcare system is how patients want to see the future of medicine. The mobile treatment assistance system allows to get closer to this future and make life easier for patients and doctors. Development of the service continues, and in the future it will obtain new functions, such as view of medical analysis's results, integration with EMS and many others.

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