International Journal of Advances in Computer Science & Its Applications– IJCSIA
Volume 5: Issue 1 [ISSN : 2250-3765]
Publication Date : 30 April, 2015

Personal Accompanying Remote-Noninvasive Medical System

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***Abstract*—At present there is a significant class of different personalized mobile systems for human health control. These personalized systems have been developed in order to run diagnostic procedures of patient's health conditions. Systems like this are passive means of measuring, control, and accumulation of medical and biological information having a limited number of active tasks. The new class of medical and biological systems is originating right now; it includes active interaction between electronic components, health aids, and human organism, wider integration of instrumental and measuring system, neural-network interaction, and human in a real-time mode. The description of one of the version under development is given below. It is a personal accompanying remote noninvasive medical system based on mobile applications.**

Keywords—**Mobile medicine, basic architecture, web-cameras, neural networks, diagnostics.**

I. Introduction

Use of computer technologies for medical purposes has led to creation of powerful diagnostic systems for long-term monitoring and recording of large amount of various biomedical signals. These diagnostic systems have been designed for stationary use and focused on long-term continuous supervision over seriously ill patients and present an opportunity for detailed analysis of recorded signals. Similar systems, but in simpler hardware-software configuration, are used for monitoring intermediate ambulatory condition of patients. The sphere of mobile devices used for sports and prevention purposes, as well as mobile phone applications, intended for solution of niche biomedical problems of individual use (fitness trackers, sport organizers, pressure meters, blood glucose meters, etc.) is developing very intensively nowadays. Mobile systems for personalized medicine should be given special consideration. Their potential has initially been oriented towards their use in aerospace medicine. Nowadays, personalized medical technologies are available for civilian use. Personal mobile medicine allows to fulfill tasks according to patients' specific needs. The system uses mobile applications, the infrastructure of cellular communication, Wi-Fi, GPS, etc.

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At the same time, personalized medicine requires high-quality diagnostics, utilization of hi-tech solutions. In order to practice it, there is no need to use costly stationary or mobile (transportable) diagnostic systems. Centralized approach to personalized medicine with creation of specialized centers and utilization of available communication networks is of vital importance here. Restriction of opportunities of the mobile personalized system does not present any problems nowadays. Development and improvement of situational (run-time) mobile diagnostics methods is an important task for improvement of personalized system mechanism: method of binding signals with time, possibility of process's optimization with the use of multi-stream architecture, individual consolidation of the system for an individual patient, depending on the clinical picture. Wide-spread implementation of personalized medicine into healthcare practice can have essential impact on diagnostics and treatment, particularly of oncological diseases.

Mobile medicine (mHealth) is not just integration of mobile technologies into medical and biological area; it is a new field of studies, new evolutional step of a civilized socium in curing diseases (Figure 1). This step immediately follows preventive and participational medicine.

Figure 1.

According to Bertran Russel, success of modern diagnostics is not in the fact that there are not healthy people today but in the fact that diagnostic algorithm does not include the mechanism of multi-threaded changes of different factors. Such changes are quite difficult to make in stationary conditions. Medical science has been developing based on principles of statics, motionlessness, isolation of a patient from the world, and creation of huge diversity of fixed medical treatment facilities (hospitals, clinics, hospices, rehabilitation centers, etc.) for too long. Human nature makes us move all the time, be involved in different external and internal

interactions; that is why treatment should meet all these requirements. It is necessary to take into consideration all destructive influences having effect on human organism in the real-time mode. In this respect mHealth is capable of contributing to the decoding process of general disease history. At this mHealth is not opposing but complementing classical medicine. Mobile medicine is not only about the preventive measures, it is mostly about early diagnostics, control of intermediate health condition and condition of particular organs. Mobile technologies allow significantly decrease the strain on medical institutions and cost of medical insurance because there will be no need in annual or quarterly (planned) preventive medical examinations or non-systematic visiting of medical institution by a patient with a wrong diagnosis.

Mobile medicine suggests that data is received in no time, for instance, while running the PCR tests in real-time mode or in a simpler version, prevention of trombophilia, spasms, heart attacks, etc. Application of mHealth presupposes the use of molecular diagnostic technologies (nano-diagnostics, micro-RNA diagnostics, molecular visualization), and also opening of metabolic engineering horizons.

II. General Idea

Mobile medicine is a technology aimed at the use of mobile communications. Creation of network infrastructure will require much support for different electronic devices: genetic microchips, nano-robots, diagnostic devices, etc. At the same time, interaction between the basic technologies called NBIC-convergence may lead to integration of human and computer (neural networks), significant increase in human brain capacities by means of biotechnologies [1]. As a global prospect, humanity is expected to integrate into planetary organism with the help of mHealth and NBIC-technologies.

With that, putting mHealth to practice is a subject of particular constructive solutions aimed at narrow group of set goals with the consideration of internetwork exchange limitations, mobility, lack of special data processing centers, data bases, etc. For instance, Scanadu project (www.scanadu.com) was not developing based on one and only diagnostic method but on data cloud that had appeared as a result of application of different sensors. It is obvious that such solutions may be effective in a particular sector of medical and biological applications (in the course of separate diagnostics) but their value will be less effective in the general system of healthcare.

Mobile medicine is one of the forms of personalized medicine. Personal medicine rests upon patient's individual features but is able to use mobile applications and mobile communications infrastructure, Wi-Fi, GPS. Personalized medicine is aimed at fulfilling the class of tasks according to genetic features of patient. Unfortunately, mHealth is not yet able to bring this class of tasks to practice.

Basic mHealth architecture is based on the developments and improvements in mobile application methods, and network technologies (Figure 2). Network exchange between the distributed systems for information accumulation, data processing center, and systems performing feedback (medicine dosage, insulin injections, electrical discharge, etc.) may appear to be the trouble spot of mHealth. Realization of these requirements, especially transferring data in multitask environment is an opportunity to optimize the process with the use of multi-threaded architecture and method of binding signal to the time. All methods for detection and correction of the mistakes apart from their exquisiteness or efficiency will be based on superabundance [2]. The necessary buffering is used for optimization of work with thread-specific data that performs cyclic processing of equipment buffer elements and thus speeds up the work with data, and frees the CPU time for other tasks. Constructive solution is to use additional channels of communication: GPRS, WiFi, organizing additional mobile access points and repeaters (portable systems, drones). The use of accompanying drones in mHealth system is acceptable and promising solution. This will not only support the patient, monitor them, organize the access point, retransmit, but will also deliver the required goods (medicines, equipment, test analyzes). The use of drones greatly expands mHealth capabilities of monitoring the patient. The system of external patient monitoring may use fixed public web-cameras.

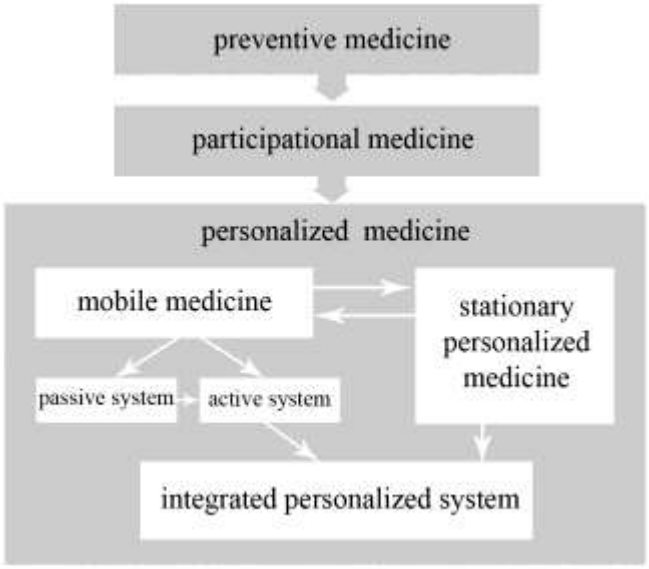

Figure 2. Basic architecture.

Development of standards for mHealth diagnostics and treatment including individual approach involves the creation of specialized computer programs with the help of doctors of different specialties. Mobile complex must be equipped individually for a particular patient depending on the pattern of the disease.

III. Practical Implementation

At present mobile medicine is presented by a huge range of developments made by different companies. All these developments are aimed at improving the quality of life, the level of medical service, individual peculiarities. Most of the

implemented projects are aimed at monitoring patients with different chronic diseases, pensioners, and physically challenged people. Along with this the implementation of mobile medicine is carried out in other areas.

Personal accompanying remote noninvasive medical system based on mobile applications (for Android Platform) was successfully approbated in IT laboratory of humanities and natural science research in Saratov State University. Basic functions of this system are preventive measures, rehabilitation medicine, diagnostics of physical parameters in real-time mode, emergency mode immediate alert, motor stimulation, and others (Figure 3). Special characteristic of the complex under development is the integrated module of external visual control of motor functions based on photogrammetric web-cameras providing high quality diagnostics of typical and atypical motor pattern [3]. We use fixed web-cameras and cameras placed on flying platforms (drones). Diagnostic system connects the objects or image fragments obtained from web-cameras to the system of coordinates by means of automatic identification of objects with the corresponding images from the database. Application of the developed system is mostly for the diagnostics of typical motor pattern, non-optimal dynamic stereotype, atypical motor pattern, and some other cases. Motor disorder measurement can be carried out anywhere (at home, in the street) directly in view of photogrammetric system. As a result the system makes up three-dimensional description of object's form and dynamics of specified format. Output data can be transmitted via the network. Also this information can be visualized as a virtual three-dimensional object with individual characteristics. The system is designed for actively moving patients (in real-time mode), and for preventive diagnostics of chances of developing the musculoskeletal system disease (the system evaluates the asymptomatic period time-line, etc.). In addition to the external accompanying module (the use of general civil access cameras, the use of flying platform) the system is also equipped with electrical stimulation, and other means of remote action.

The complete set of portable complex can be changed depending on the goals. The standard set consists of a mobile device, compact wearable waistcoat with the integrated system of sensors and active elements of impact, and power supply adapter. External support includes control center, database, support server, special software. Accompanying drone can be also used as an additional option.

Advantages: high accuracy of measurements, ease of use and a high level of automation, efficiency (diagnostics is carried out in real-time mode).

We are considering possibilities of further improvement of the approbated mHealth system, spreading of the proposed approach for solving more difficult problems.

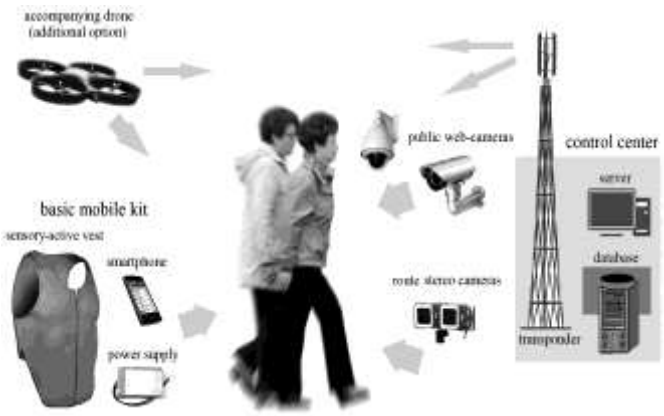

Figure 3. Personal accompanying remote-noninvasive medical system.

Summary

In 3-4 years to come we can expect appearing of advanced mobile oriented solutions in the area of medical service. Demand for thematic mHealth service will increase substantially. It will become a subject of interest for patients with chronic diseases or patients in their rehabilitation period, and also for representatives of scientific and research sector, education workers, workers of various consulting corporations, operators of complex technological industries, IT-managers, and others.

However, the modern consumer unreadiness is a serious constraining factor for mHealth market development. The core restraining factor for mHealth is unawareness of technological capabilities, issues of confidentiality and data protection, functioning security, and cost.

Creating the intermediate class of affordable mobile systems for personal interactive diagnostics, preventive measures, and rehabilitation support is currently a priority direction in the area of mHealth systems; prospects for further integration with personal biomedical information processing centers are of utmost importance. The breakthrough in such areas like genomics, proteomics, metabolomics and others (on the basis of approbated system of mobile solutions or their integration) provide opportunities for developing new databases that will take into account the characteristics of a particular person.

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