
COMPUTER DEVICES AND INFORMATION TECHNOLOGIES FOR MEDICINE

Volodymyr Romanov, Ozar Mintser, Igor Galelyuka, Viktor Degtjaruk, Viktor Chernetsky, Illya Chaikovsky

Abstract: *Information technologies and computer devices are modern and very useful tools, which are widely and successfully applied in various areas of human activity and social life, including medicine and health care. Adoption of new information technologies and modern devices in medicine causes increasing of quality and efficiency of medical assistance and in such way lets to decrease the number of complications and unfavourable outcomes, to promote socioeconomic progress and to increase the overall quality of life. New information technologies (IT communicator, remote healthcare monitor) and computer devices (ECG device with vessels system evaluation, and digital phonendoscope) for medical application, developed in Glushkov Institute of Cybernetics in cooperation with Shupyk National Medical Academy of Postgraduate Education, are considered. Proposed devices refer to diagnostic and measuring tools. In spite of fast application of new diagnostic technologies and devices, in most cases it is very important and reasonable to have direct contact between doctor and patient or injured person. Proposed information technology, IT communicator, helps to simplify communication between doctors and patients and increase treatment efficiency beginning from the first contact. The main areas of communicator usage are family and emergency medicine, where it is necessary to support the first contact of doctors with patients (with voice limitation) and get information about patient state, for example, during the preliminary examination of patients and diagnosing. Proposed remote healthcare monitors help doctors to monitor state of their patients in remote mode and prevent possible ill health. Application of proposed computer devices and information technologies in medicine give possibility to improve the quality of life of risk group people and giving timely medical aid to health impairment patients.*

Keywords: *medical computer device, remote healthcare monitor.*

ACM Classification Keywords: *J.3 Life and Medical Sciences - Biology and Genetics*

Introduction

Information technologies and computer devices are modern and very useful tools, which are widely and successfully applied in various areas of human activity and social life, including medicine and health care. Adoption of new information technologies and modern devices in medicine causes increasing of quality and efficiency of medical assistance and in such way lets to decrease the number of complications and unfavourable outcomes, to promote socioeconomic progress and to increase the overall quality of life.

Medical computer devices and information technologies are getting wide application in the world. In the article new medical computer devices and information technologies, developed in the Glushkov Institute of Cybernetics of NAS of Ukraine with cooperation with Shupyk National Medical Academy of Postgraduate Education, are presented. The first one is medical IT communicator [Sergienko, 2013]. It is intended for supporting first contact of doctors with patients (with voice limitation), and getting information about patient state, and also for providing emergency medical aid for such patients. The second is ECG device with evaluation of vessels system. The main idea of this computer device is combining advanced software for analysis of electrocardiogram and pulse wave. The device includes updated ECG-photometric unit, advanced software for deep processing and up-to-date interpretation of ECG and pulse wave results, manuals for patients and doctors. The third computer device is used for measuring performances of cardiovascular system and is used as digital phonendoscope. The fourth one is remote healthcare monitor is based on wireless technologies and intended to remote monitoring the health state of people of risk groups, such as elderly people, chronic patients and risky job people.

Work objectives

Work objectives are analyses of possibilities of application of medical computer devices and information technologies for first aid, treatment, and providing emergency relief for risk group people.

IT communicator

Relationships and communication between doctors and patients is a very important problem in medicine. Ability of correct communication during the disease or separate stage of disease helps to diagnose, prognose a clinical behaviour, and accelerate the recovery. Communication problems between a doctor and a patient influence on correctness of the diagnoses and quality of a doctor aid, and complicate the medical treatment. Relations between doctors and patients are not limited with communication. Making a diagnosis, patient state examination, interpretation of the data received from a patient, treatment planning, and treatment evaluation are very important too. Methods of evaluation and correction of diagnosis influence on treatment planning and treatment effectiveness. It is proposed

to apply special hardware-software means, particularly IT communicators to simplify the communication of doctors with patients (particularly with voice limitation) and increase treatment efficiency beginning from the first contact.

First version of the IT communicator, presented in [Mintser, 2014], simplified the communication between doctors and patients with voice limitation and included only the general information about traumas and diseases. The last version of proposed IT communicator additionally has databases with detailed formalized information about a large number of traumas or diseases and proper methods of medical treatment or care. Such information helps both doctors and patients to act correctly during diagnosing, patient examination and medical treatment.

Developed IT communicator is a mobile tablet computer with special application-dependent software and intended for the following purposes:

1. In medicine, including emergency medical aid: for supporting first contact of doctors with patients (with voice limitation), and getting information about patient state. In this case the IT communicators help such patients to communicate with doctors. Particularly it is important for family doctors who often are the firsts to examine patients.
2. In family medicine: to support doctors, especially family doctors, during patient examination and diagnosing. In such case, if the family doctor hasn't enough experience and knowledge to diagnose in correct way, he can use digital databases with detailed formalized information about a large number of traumas or diseases and proper methods of medical treatment or care.
3. In education: during continuous professional development of doctors and pharmacist.

Special application-dependent software consists of two subsystems. The first subsystem is used for alternative communication of doctors with patient, lost temporarily or permanently possibility of speaking, during first contact or examination. The second subsystem gives detailed information about trauma or disease and proper methods of medical treatment or care to doctors or, in some cases, patients. It is needed to note, that now there are many home medical devices in the world market and the second subsystem of IT communicator consists of manuals of many of them to make easy to use the devices.

One of the aims of IT communicator is to support alternative communication with voice and motion limited patients. The idea of alternative communication is rather simple. Voice limited patient needs communication with surroundings in any way. The process of establishing relations with additional means helps patient with voice limitation to express his needs and wishes. Communicators for alternative communication are used to help voice limitation patients to understand surroundings clearly.

The IT communicator makes it possible communication between doctors and patients with move and voice limitation. Fig. 1 shows the main menu of the smart communicator and the window, where patient can locate the place of pain to help doctor. There are following Menu items: "Needs", "Requests", "Pain", "Emergency aid", and "Keyboard". By using this menu and submenus the patient with voice limitation can ask peoples around or doctor for help, service or medicaments, or explain own feelings, troubles or pain. It is possible to convert written by patient needs to voice. It is necessary to add that IT communicator stores the patient medical history.



Fig. 1. Main menu and pain location windows

The second subsystem of smart communicator is intended to support family doctors and simplify the communication between doctor and patient. To remove some problem in communication between doctor and patient it is reasonable to computerize the formalized and standard models and situations in communication, what usually lets to avoid the effect of incorrect understanding of certain "message" both data sender and data recipient.

IT communicators are reasonable to be used by family doctors to get detailed information about trauma or disease and proper methods of medical treatment or care during first examination of sick or injured person. It is very urgent, because family doctors meet a broad list of traumas or diseases immediately after their appearance. In such cases family doctors sometimes haven't enough experience and knowledge to diagnose in correct way. Information exchange between doctor and patient already includes some "distortion" of information because of incorrect or insufficient understanding of certain knowledge domain. Proposed communicator removes such problems by standardization of possible situations. For family medicine it is developed more than 500 standardized situations, which include as cases of emergency medical aid, so planned activity of medical care. The window with details of illness or injury, for example the asthma, and window with visual explanation are shown on Fig. 2. In addition, proposed communicator subsystem contains databases with reference information, what helps to avoid a lot of traumas or diseases.

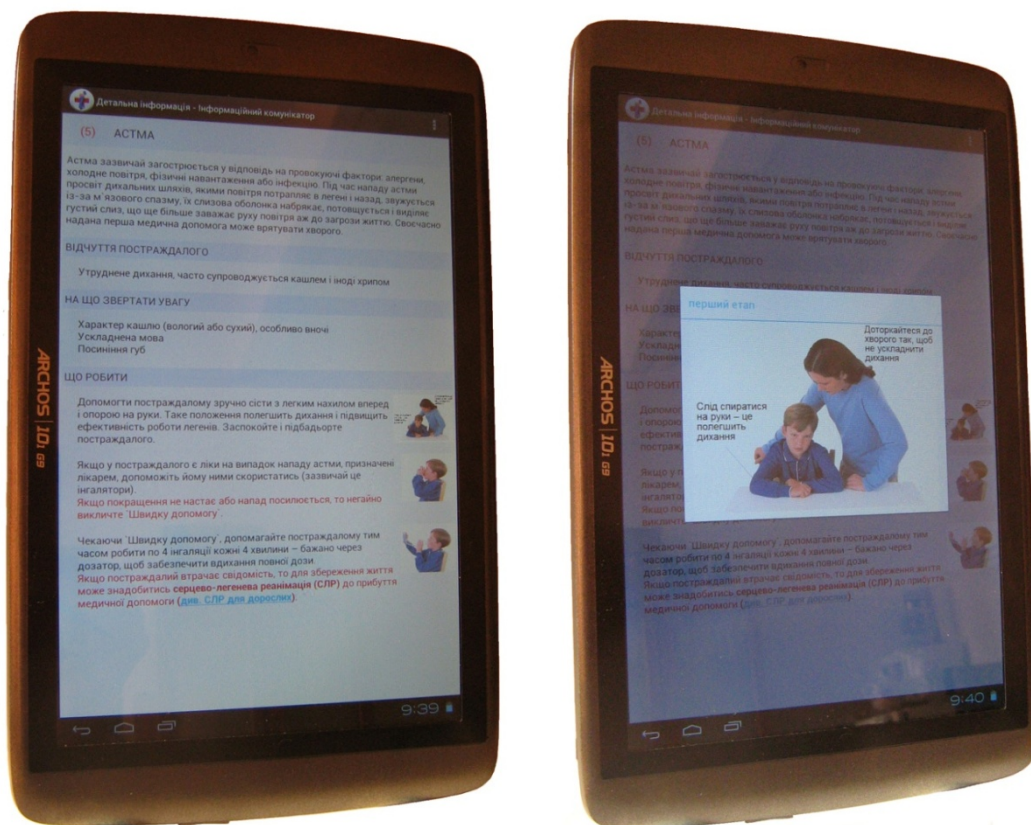


Fig. 2. Detailed information about trauma or disease (with visual explanation)

Very often in distant mode the doctor can't explain the patient how to act with some disease or trauma, because of absence visual materials or knowledge restrictions. To avoid such problems it is reasonable

to give patients access to data bases with detailed information on majority of diseases and traumas, its symptoms, diagnostic methods and first aid actions. In such case the doctor orally explain the patient the actions and direction of operations. The patient by oneself takes actions with using of detailed text explanations, high-resolution images and video materials from databases. In such cases the IT communicator is very useful tool.

It is also proposed to use smart communicators in continuous professional development of doctors and pharmacist.

ECG device with evaluation of vessels system

The main idea of this computer device is combining advanced software for analysis of electrocardiogram and pulse wave. The device includes updated ECG-photometric unit, advanced software for deep processing and up-to-date interpretation of ECG and pulse wave results, manuals for patients and doctors. This device may significantly increase the specificity and sensitivity of resting electrocardiography by using the most modern algorithms for ECG interpretation. Combination of advanced ECG with evaluation of vessels system, including its micro vessel component and endothelial dysfunction using pulse wave analysis, opens new excellent possibilities for early diagnosis of most dangerous heart diseases and for control the efficiency of treatment in clinical condition. Moreover, this devise may be used for home medicine to increase the quality of life of patients with chronic heart diseases and for healthy persons by monitoring their heart pre-conditions. During last three years the pilot series of family of the miniature devices were produced in Ukraine. The device clinical testing was done in several lead hospitals in Ukraine.

Digital phonendoscope

Digital phonendoscope is used for measuring performances of cardiovascular system. Computer device is consists of acoustic pressure sensor, data converter and microcontroller. The acoustic sensor is situated upper the vessel for cyclorama of pressure measuring. The sensor is sensitive to real time changing of pressure in vessel during the cardiac cycle. The main advantage of the device is high sensitivity due to measuring of phase shift between two sinusoidal signals (instead of voltage) caused with changing the blood pressure in vascular walls of the patient. The level of phase shift is equivalent to changing the pressure in vessel during the cardiac cycle. The different phase shifts are converted with ADC to digital codes and then digital data are displayed as time plot of changing the blood pressure in vascular walls of the patient. The device is used as digital phonendoscope.



Fig. 3. General view of portable ECG-photometric diagnostic complex

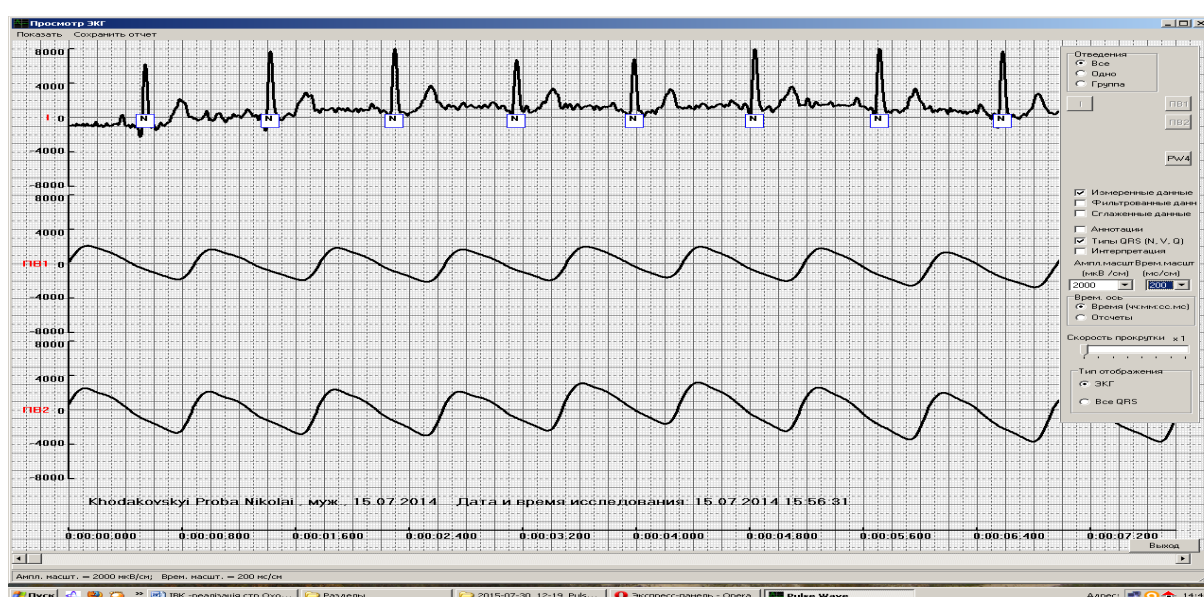


Fig. 4. Synchronized recording of cardiogram and pulse wave

Remote healthcare monitor

Remote healthcare monitor is based on two approaches. The first approach uses wireless sensor networks (WSN) to monitor the state of patients on some territory, for example, in hospital. The second one provides using of smartphones to monitor state of patients away from hospitals, for example, in their houses or on the street.

There are many advantages of WSN in different applications. It gives a lot of benefits to users in science, industry, medicine, environment protection, agriculture and so on. WSNs include from tens to hundreds of nodes equipped with micropower battery supplies. State of the art of WSN applications in medicine and healthcare is given in [Ko, 2010].

For designing pilot elements of WSN it was chosen the wireless microcontroller JN5168, manufactured by NXP Company. Microcontroller includes 32-bit processor with 1–32 MHz clock speed, 2,4 GHz IEEE802.15.4 compliant transceiver, 4-input 10-bit ADC and a comprehensive mix of analogue and digital peripherals etc. This microcontroller complies with the network nodes requirements. It supports data acquisition, data storage and data transferring via wireless channel.

The standardization and unification requirements to WSN are determined by 802.15.4 standard, which defines features of creation of networks with low data throughput. In addition ZigBee and JenNet-IP protocols determine requirements to network routing and security. We selected JenNet-IP protocol for our applied tasks. The JenNet-IP protocol combines IEEE802.15.4-based wireless network technology and the Internet Protocol (IP) to achieve integration between the two domains, supporting the wireless "Internet of Things". Due to the nodes of a wireless network are to be controlled both wirelessly and from IP-connected device, such as a smart remotely located phone.

The network node includes a set of medical sensors, placed on patient, and wireless microcontroller JN5168, which gathers data from medical sensors and transfers them to central hospital network coordinator.

On the initial development stages for proposed tasks it was proposed to use simple tree-like topology of WSN. The part of WSN topology, which was created as base fragment (cluster) of network, is shown on Fig. 5.

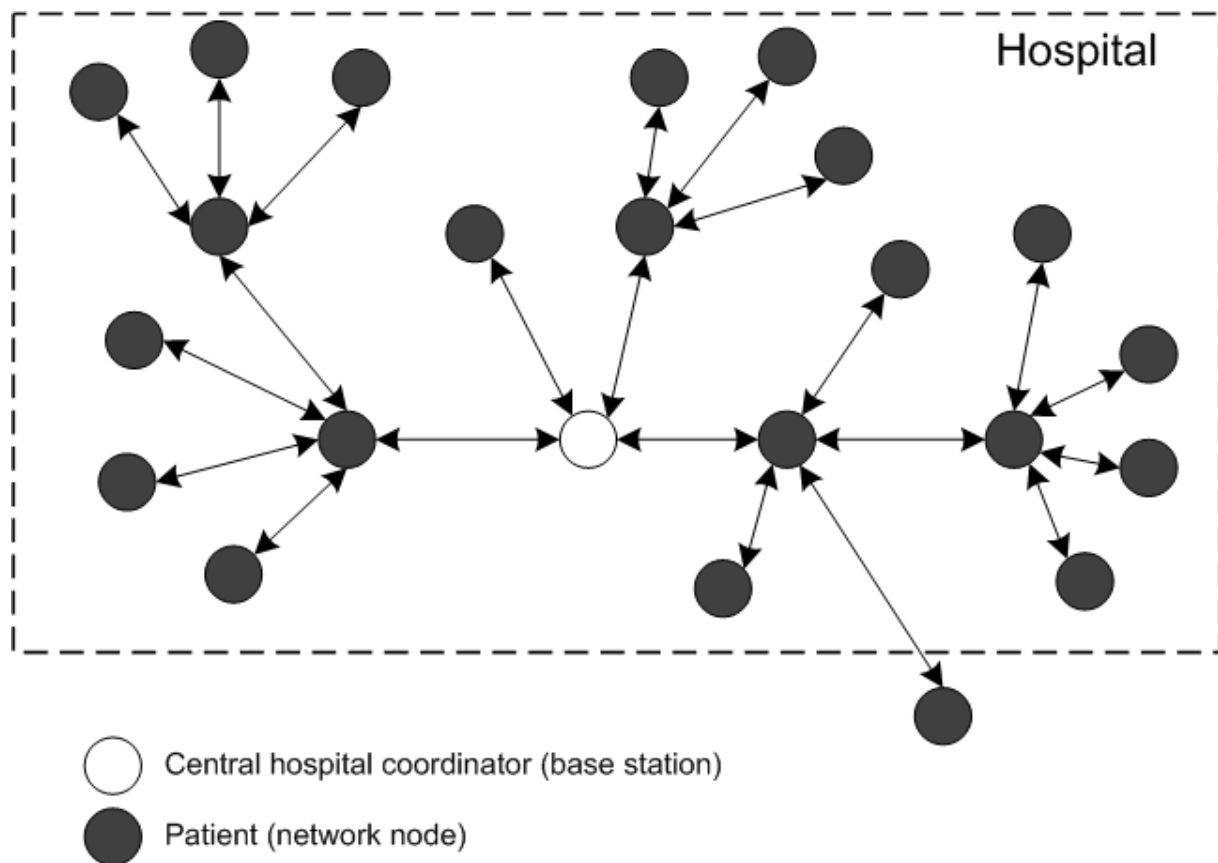


Fig. 5. Structure of remote healthcare monitor (with WSN)

The second approach provides using of smartphones to monitor state of patients away from hospitals, for example, in their houses or on the street. To implement this approach it was decided to develop concentrating unit, which acquires data from medical sensors, placed on the patient body. The set of sensors is defined by risk group, to which the patient belongs: elderly persons, people with cardiac diseases, diabetics, and etc.

For designing the concentrating unit it was used microcontroller LPC4357 with ARM Cortex-M4 (with ARM Cortex-M0 coprocessor) core. For wireless communication between concentrating unit and medical sensors it was used tiny Bluetooth units. In additional for processing data packets from medical sensors the standards of ISO/IEEE 11073 family were taken into consideration. Data packets with information about parameter of patient state are transferred from medical sensor via Bluetooth channel to concentrating unit. Concentrating unit gathers data from all medical sensors, pre-processes, archives and passes this information via smartphone and cloud environment to hospital server. If some patient parameter exceeds determined limits the alert message is formed and quickly transferred to hospital doctor. Then doctor makes a decision and, if it is necessary, calls patient and asks him to carry out some actions to prevent ill health.

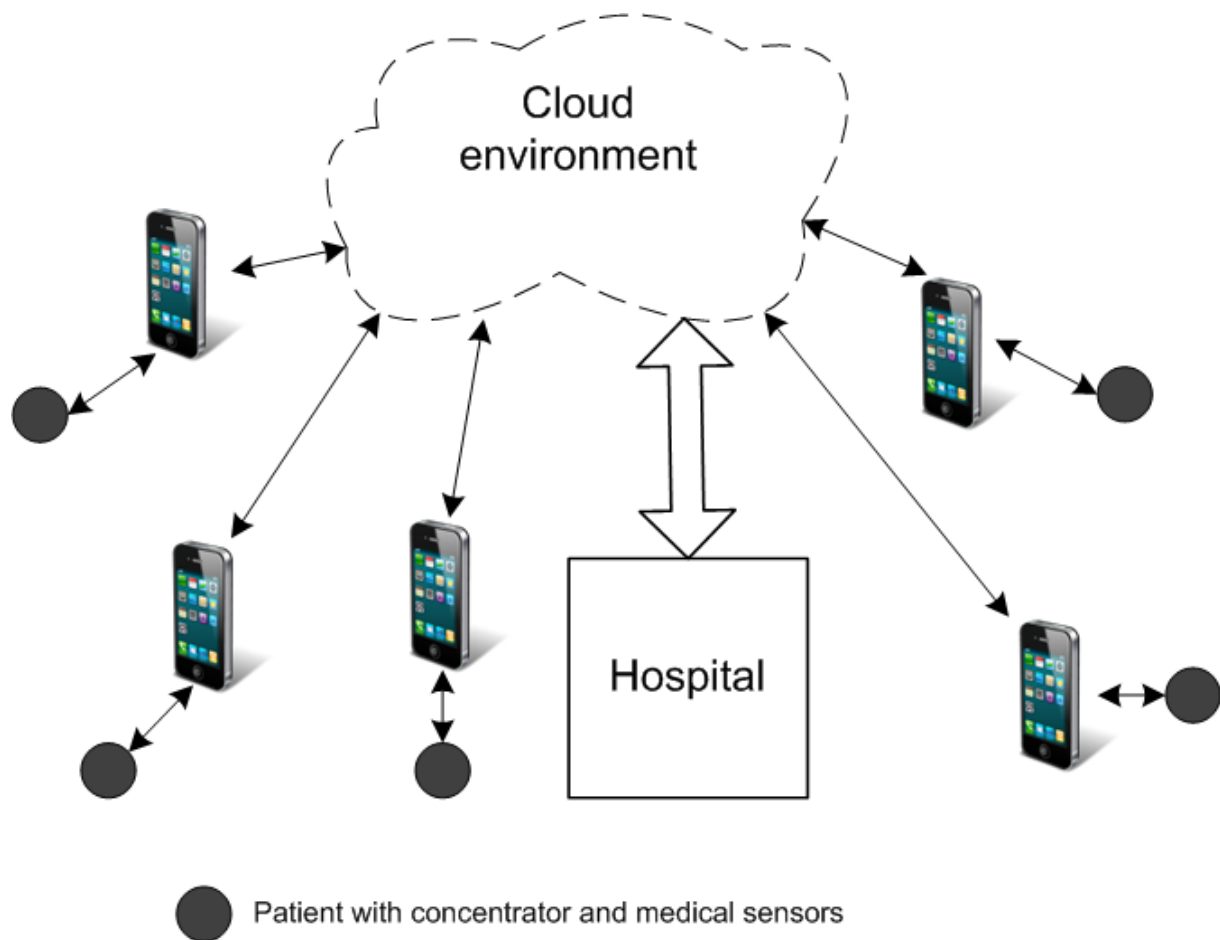


Fig. 6. Structure of remote healthcare monitor (with smartphones)

Application of individual monitoring of risky group patients, for example, elderly people state can reduce mortality, optimize using of medical service, and earlier detect physical impairment. Registration of physical impairment of such remote patients is very important information to make emergency service.

The remote healthcare monitor of any of two approaches consists of following wearable medical sensors (Fig. 7): blood pressure sensor, body temperature sensor, pulse rate sensor, oximeter, EEG and ECG sensors, accelerometer, and GPS unit.

Up to date the wireless units were developed and embedded in medical sensors. Now doctors are developing methods, which allow estimating the state of remote patients using parameters of several medical sensors.

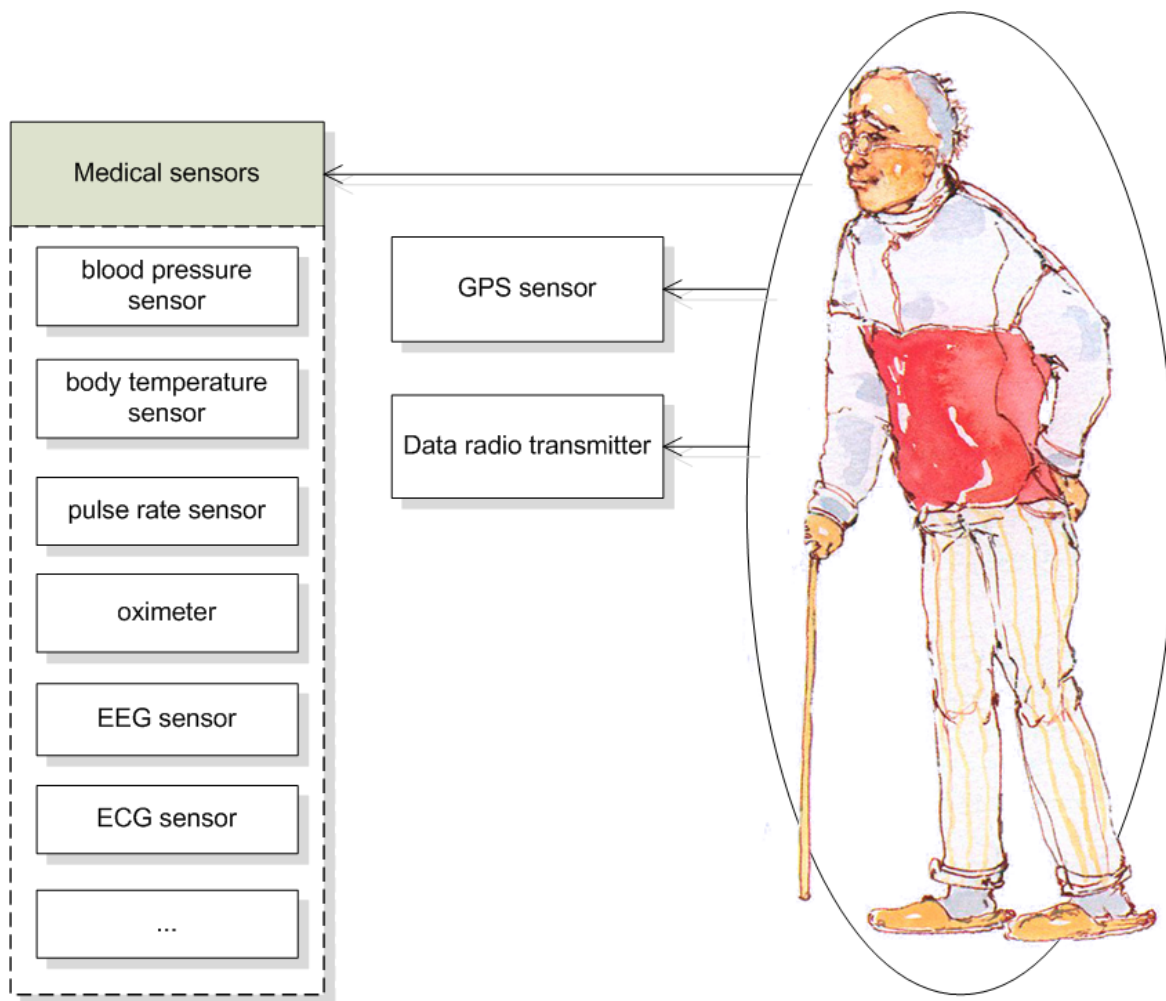


Fig. 7. Sensors of remote healthcare monitor

Conclusion

Development and creation of IT communicator, ECG device with vessels system evaluation, digital phonendoscope, and remote healthcare monitor for monitoring parameters of human state give possibility to improve the quality of life of risk group people and giving timely medical aid to health impairment patients.

Bibliography

- [Ko, 2010] Jeonggil Ko, Chenyang Lu, Mani B. Srivastava, John A. Stankovic, Andreas Terzis, Matt Welsh. "Wireless Sensor Networks for Healthcare", in Proceedings of the IEEE. Vol. 98, No. 11, November 2010, pp. 1947–1960.
- [Mintser, 2014] O. Mintser, V. Romanov, I. Galelyuka, O. Voronenko "IT-communicators for medicine", in International Journal "Information Models and Analyses", Vol. 3, Number 2, Sofia, Bulgaria, 2014, pp. 169–174.

[Sergienko, 2013] Patent of Ukraine №80490 "Method of communication with person with voice and auditory limitation" / Sergienko I.V., Voronenko O.V., Galelyuka I.B., Romanov V.O., 2013.

Acknowledgement

The paper is published with partial support by the project ITHEA XXI of the ITHEA ISS (www.ithea.org) and the ADUIS (www.aduis.com.ua).

Authors' Information



Volodymyr Romanov – Head of department of V.M.Glushkov Institute of Cybernetics of National Academy of Sciences of Ukraine, Doctor of engineering sciences, professor; Prospect Akademika Glushkova 40, Kiev–187, 03680, Ukraine; e-mail: VRomanov@i.ua; website: <http://www.dasd.com.ua>



Ozar Mintser – Head of department of P.L. Shupyk National Medical Academy of Postgraduate Education, Doctor of technical sciences, professor; Dorogozhytska str., 9, Kiev, 04112, Ukraine; e-mail: ozar7@yandex.ru



Igor Galelyuka – Senior research fellow of V.M.Glushkov Institute of Cybernetics of National Academy of Sciences of Ukraine; Candidate of engineering sciences; Prospect Akademika Glushkova 40, Kiev–187, 03680, Ukraine; e-mail: galelyuka@gmail.com; website: <http://www.dasd.com.ua>



Viktor Degtjaruk – Research fellow of V.M.Glushkov Institute of Cybernetics of National Academy of Sciences of Ukraine; Prospect Akademika Glushkova 40, Kiev–187, 03680, Ukraine



Viktor Chernetsky – Senior research fellow of V.M.Glushkov Institute of Cybernetics of National Academy of Sciences of Ukraine; Candidate of engineering sciences; Prospect Akademika Glushkova 40, Kiev–187, 03680, Ukraine

Illya Chaikovsky – Senior research fellow of V.M.Glushkov Institute of Cybernetics of National Academy of Sciences of Ukraine; Candidate of medical sciences; Prospect Akademika Glushkova 40, Kiev–187, 03680, Ukraine