fetal monitoring,
home monitoring,
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TELEMEDICINE FRAMEWORK FOR FOLLOW-UP HIGH RISK PERGNANCY

The system was designed for medical investigation beyond hospital unit. It can be applied in all places which are within the range of mobile phone network area. It shows the signal acquired from the cardiotocograph on the patient device screen and send all received data to the Clinical Surveillance Center (CSC). The data in CSC are analysed and presented on the medical doctor PC display. This system give possibility of permanent woman monitoring without hospitalisation. If medical doctor notes something suspicious, he can remotely take decision about medical intervention. Presented system of data acquisition and teletransmission fulfils the last standards of medicine, which expect more quickly exploration, better patient comfort and make communication with a medical doctor much easier.

1. INTRODUCTION

In a modern healthcare service, where the health authorities optimise the resources most effectively, it is in many cases an option to monitor as many patients as possible at their home [2]. The purpose of the study was to develop the telemedicine system for remote surveillance of pregnant women enabling fetal monitoring at home. Telemedicine implies telecommunication technology, information technology and biomedical engineering, and it is showing its value in a rapid increasing number of clinical situations [1,3]. Fetal monitoring is aimed at early detection of the risk for fetus health and life. It is based mainly on evaluation of fetal heart activity which is accomplished by analysis of cardiotographic signals recorded by fetal monitor. The medical care at home is especially suitable for patient with low mobility i.e. in high risk pregnancy women. Telemedicine system assures permanent medical care which is remotely carried out by the central monitoring station located in the clinical centre.

Mobile patient's monitor can be applied in all places which are within the range of mobile phone network area, even in mountains and in places without good road communications system. This approach guarantees better patients comfort by decreasing the number of visits in hospital,

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which sometimes should be everyday ones. The distance can be long, the same expensive and stressful for pregnant women. Simultaneous monitoring pregnant women in their homes can significantly reduce costs of perinatal medical care. Advantage of the telemedicine system is the ability to perform monitoring in any time and any place and to give psychical comfort to the patients.

2. METHODS

The system was designed to acquire the biophysical data from patients and transmit them to the Clinical Surveillance Center (CSC). The system contains fetal monitor, personal digital assistant (PDA) with possibility to use general packet radio transmission service (GPRS) [2], and PC server connected to the Internet network, placed in a clinical center (Fig. 1).

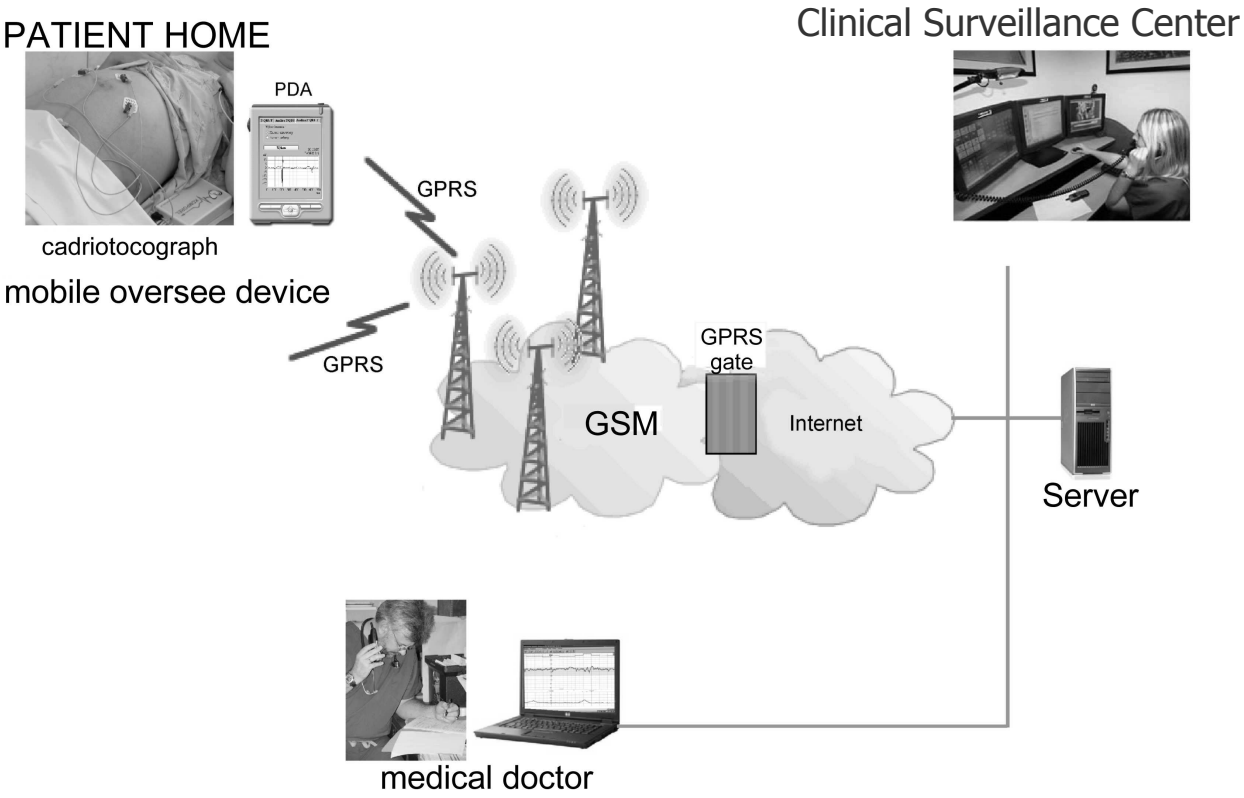

Fig. 1 General scheme of the proposed fetal surveillance

At patients home, the PDA device with appropriate application acquires cardiotocographic signals provided by fetal monitor, analyses and presents them on-line. The PDA device storages the incoming data and sends them to the PC server in clinical centre. Data are formatted in a packets, which are sent at 2-4 s intervals to the server. Every packet has a structure, which ensures a correct arrange of received data in the server disc space and correctly interpretation of biological signals. At the CSC side, the system consist of the server with a constant Internet network connection. It

receives and arranges data. It also makes ascription of current investigation for patient records in the hospital base. This option allows to view all of examinations of current woman from the beginning of the pregnancy. All of this information can be available in real-time by the medical doctor, who takes care of pregnant woman. If he notes something suspicious, he can take decision about hospitalisation [3].

The necessary applications was developed in LabView software (National Instruments), which is virtual instruments language. LabView is the software language whose advantage is a quick and intuitive creating the software code. It provides also fundamental procedures for RS and USB control, and GPRS communication. The embedded libraries provide many procedures for acquisition, analysis and visualization of signals. The main field of the use LabView has been an industrial application, but it is widely used in medicine also.

The system contains PDA device cooperated with fetal monitor and PC computer runs as a monitoring station in clinical centre. PDA device is equipped with GSM module which includes sim-card from one of the cell phone operators which assures regular access to the global network. Data are sending to the server using the packet data transmission (GPRS). The PC computer with Internet access works as a server, which in the Clinical Surveillance Center received data from PDA. It can manage the data sent from several PDAs at the same time. It enables to monitor a few patients in one moment. The large part in this project play the capacity and reliability of GSM connection.

3. PRELIMINARY TESTS

In this project the most important is the selection of parameters of acquisition and teletransmission. This required checking all parameters offer by the device and GSM provider, and adjust them to the requirements of pregnant women real-time monitoring.

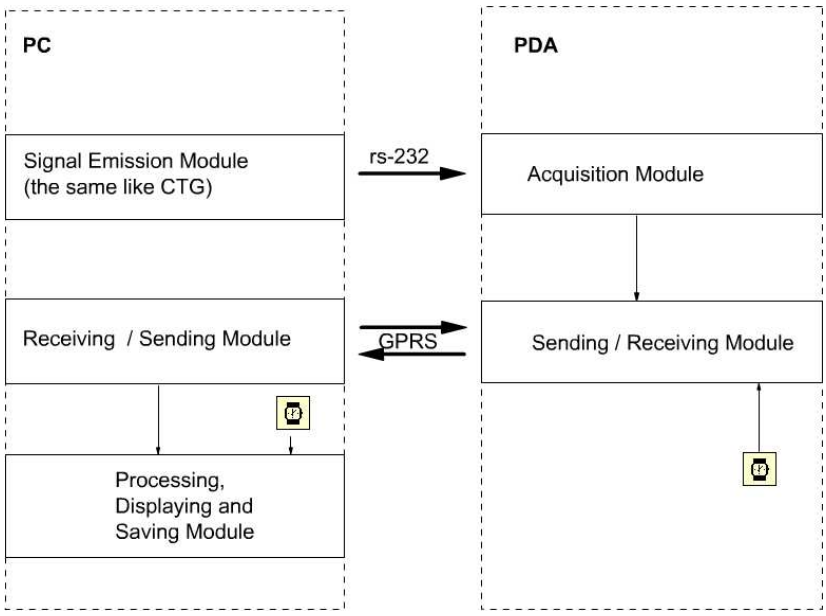

Fig. 2 The structure of software designed for testing set (PC and PDA devices)

The testing set (Fig. 2) was used to check the transmission timing parameters. Signal Emission Module played the role of a virtual fetal monitor, which sent the data packets every second. The number of bytes in the packet was changed from 10 to 8 000.

One of the test problem was to check the time between sending and receiving the data on the following data flow path: fetal monitor - RS232 connection - PDA device – internet connection with GPRS technology - PC. The data packet from virtual signal monitor was extended with the time stamp of when it was sent. After passing through the data flow path, this time information is compared with a current time in the PC. The precise time computation was ensured by the fact that the same PC worked as a virtual fetal monitor and as Receiving Module. The time difference between present time and time stamp in data packet gives the information about the time of data flow. Data packet which contain 10-100 bytes can flow this way in about 2-3 s. In following test the data received from RS-232 socket are put in to the array in the PDA device, and from this are sent to the PC with the use GPRS technology. The data packet being sent to PC are extended with the headline the information about time between current and last sending packet.

The Fig. 3 shows the time between current and following data packets. The time intervals are measured separately: between neighbouring occurrences of packet receive in PC (plus signs) and between neighbouring occurrences of packed send from PDA (dots). The graph shows also amount of bytes in every data packet (line). Number of bytes in every consecutive data packet was increased by 10 bytes. From the fetal monitor 40 bytes are sent every second with 1200 baud rate. Acquisition and transmission speed of such amount of data are possible and could be accomplished with high reliability. To pass the path: Fetal monitor - PDA - PC the approximation time of 2 s is needed. This allows sending even four traces from Fetal monitor in each data packet. Thus, this gives a possibility to continuously check of data flow to the server, and to react for possibly delay and disturbance of data teletransmission. This delay and disturbance can be result of limited capacity of GPRS transmission. The transmission of collected data will be accelerate as soon as disturbance stops. The 10-second data buffer placed in PC is enough to ensure the reliable work of the system (during testing maximum delay of 5 s was stated). The developed system fulfils the requirements of data acquisition and teletransmission speed. It also assures stable work.

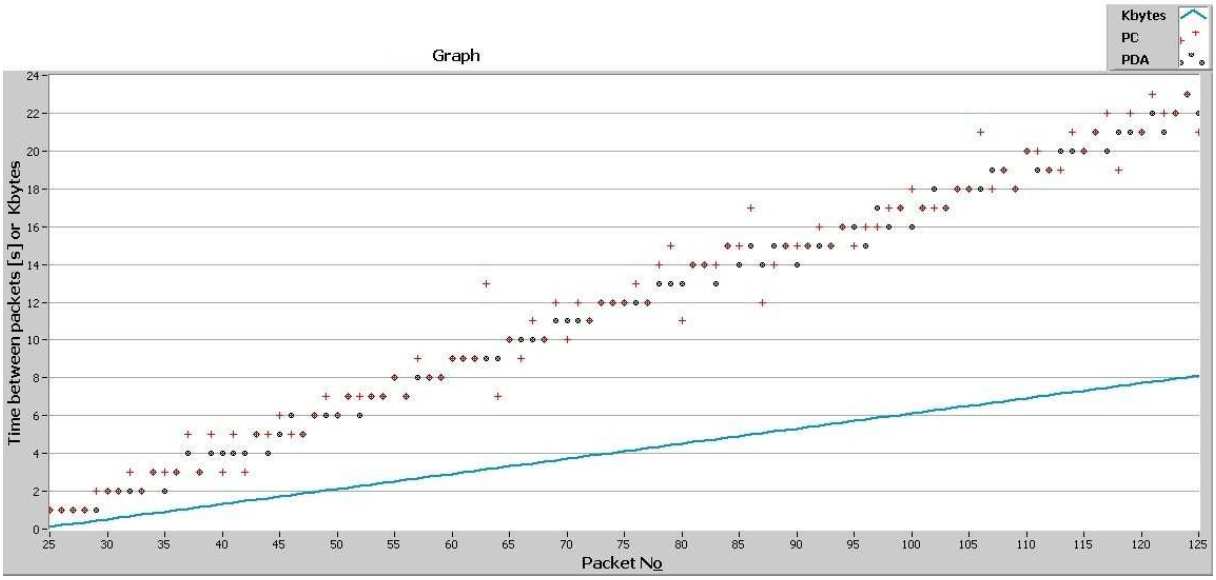

Fig. 3 The timing parameters of transmission procedure
as a function of the number of bytes in consecutive data packets.

4. CONCLUSION

Presented system of data acquisition and teletransmission fulfils the last standards of medicine, which expect more quickly exploration, better patient comfort and make communication with a medical doctor much easier. Cost reduction of hospitalisation and observation is the next advantage of this project.

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