

PERSONAL TELEMETRIC SYSTEM – GUARDIAN

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Abstract: This project deals with the problems of utilization of mobile equipment working in the biomedicine field, particularly telemedicine. This field is relatively new; it focuses on the observation of life functions from a distance. Practically developing system works with an ECG sensor connected to mobile equipment, such as PDA/Embedded, based on Microsoft Windows operating system. The whole system is based on the architecture of .NET Compact Framework, and other products, such as SQL Server by Microsoft too. This work also deals with the communication of mobile equipment with sensors and with the server via Bluetooth, WiFi, and GPRS/EDGE. The mobile equipment used serves primarily for measuring and processing of data from the sensors and their visualization as a graph. The data is also given to the server for further processing and the analysis of current health of the patients, due to small efficiency of the mobile equipment (Janckulík, 2007). The main task we deal with in the server part of application is receiving of the data via web services and further processing, management and analysis of this data. For the analysis of received data and further evaluation of the electrocardiogram, there is a self-organizing neural network (Vašíček, 2007).

1 MOTIVATION

Many middle-aged people like businessmen, CEOs, managers and other have very hectic lives with much stress and without good ways of living. Sometimes these people have a collapse, breakdown or heart attack and must be in hospitals or health resorts for a long time to regenerate their bodies. The time that they spend in these institutions, is nonutilisable and very long for them. Possibilities of today physics are restricted by many of prescripts so patients cannot use some of the newest techniques (like hyperbaric or arctic chambers), which make it possible to reduce the regeneration time by weeks or months. For example, these chambers are restricted to patients in the first six months after heart attack due to no information about patients' conditions during the procedure.

Here is the main area of utilization of our telemetric system. Of course the use of our system is not limited only to businessmen, but it is targeted to middle-aged people with some knowledge about new technology like mobile phones. The price of client devices of our system is not low, so we suppose people who can invest to these sorts of assistants.

The basic idea is to create a system that controls important information about the state of a wheelchair-bound person (monitoring of ECG and pulse in early phases, then other optional values like temperature or oxidation of blood ...), his situation in time and place (GPS) and an axis tilt of his body or wheelchair (2axis accelerometer).

Values are measured with the existing equipment, which communicates with the module for processing via Bluetooth wireless communication technology. Most of the data (according to heftiness) is processed directly in PDA or Embedded equipment to a form that is acceptable for simple visualization. Two variants are possible in case of embedded equipment – with visualization and without visualization (entity with/without LCD display). Data is continually sent by means of GPRS or WiFi to a server, where it is being processed and evaluated in detail. Processing and evaluating on the server consists of - receiving data, saving data to data storage, visualization in an advanced form (possibility to recur to the older graph, zoom on a histogram (graph with historical trend), copying from the graphs, printing graphs), automatic evaluation of the critical states with the help of advanced technologies (algorithms) that use

Artificial intelligence to notify the operator about the critical state and its archiving.

Application in PDA, Embedded equipment is comfortable, with minimum time - the first configuration, but also configuration after downfall of application. The level of visualization will be lower. The described system can be used with small modifications for monitoring of patients in hospitals or people working in extremely hard conditions. The biggest limitation is the availability of measuring devices in acceptable and adaptable sizes or comfortable enough to have one around.

The measuring device (ECG, plethysmograph) was tested in extreme conditions in a cryogen room in Teplice (-136°C), where the final system will be installed. Implementation of the data transmission security was not solved. The whole system is classified as „work in progress“ system and it is in a testing phase where we found mistakes and repaired them.

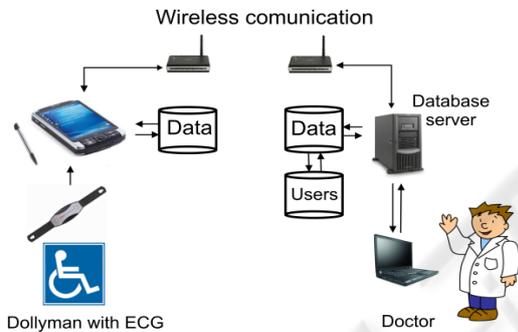


Figure 1: Measurement schema.

2 SYSTEM ARCHITECTURE

This system consists of several interconnected parts that can communicate among themselves, so they can approach their function. These parts are: measuring sensor, PDA or embedded device, and server for data processing and evaluation. Beside these, the most important parts that are worth mentioning are various kinds of accessories, such as GPRS, WiFi, GSM, Bluetooth or GPS modules. By means of them we can communicate. We mostly use the fastest technology in signal coverage.

Data acquisition and data transmission are the most important parts of this system. The Responsible for correct working are: correct sensor configuration, sensor calibration, data transfer synchronization, and mutual communication between sensors and data receiver.

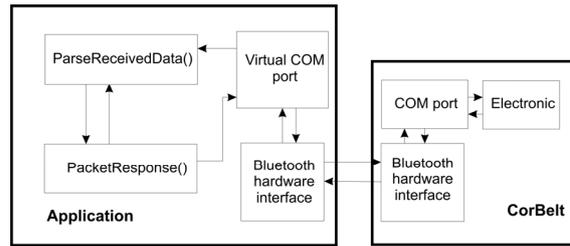


Figure 2: Bluetooth communication.

The system can display saved data from a database file. The doctor can configure or set a neurone network. A change of that is shown in the XML file enshrining, where the neurone network setting of the patient is kept.

The doctor receives information about worsening of patient’s status. In case of doctor’s reaction, he sends for an expert assistance, such as a helicopter or an ambulance. In case of false alarm, he can configure a neurone network or leave it unchanged if that was a sporadic incorrect interpretation.

The patient can browse data concerning his health status. Measured data is sent to server by WEB service.

Client’s data are not only received but also preprocessed (data checking, risk elimination etc.). Measured data is saved. And now, it is possible to analyze the data using a neurone network. If the analysis shows that the measured data from ECG is critical, a warning is sent. That notifies a doctor of incoming data.

2.1 Mobile Part

The main part of the whole system is an Embedded or PDA device. The difference in applications for measurement units is the possibility to visualize the measured data in both Real-time Graph and Historical Trend Graph, which can be omitted on an embedded device.

PDA is a much better choice for Personal Healthcare, where the patient is already healthy and needs to review his condition, or for multiple person usage. Embedded devices can be designed for one user, with the option to use an external display used for settings or with the possibility of usage in extreme conditions.

The application is communicating with an ECG Measurement Unit (Corbelt or Blue Keg) through a virtual serial port using wireless Bluetooth technology. Then, after pushing a button, all necessary parameters are set and the communication may begin. Measured data is stored on a SD

Memory Card in a database in MS SQL Server 2005 Mobile Edition.



Figure 3: PDA/MDA/SmartPhone visualization.

The performance of available devices seems insufficient for sequential access; parsing of incoming packets is heavily time-consuming. Pseudo paralleling is required. If Windows Mobile OS versions 2003 to 5.0 are used, the processing of data from a professional EKG is not realizable due to thread count limitations. A newer operating system (Windows Mobile 6) can be used to solve this.



Figure 4: PDA/MDA/SmartPhone application.

Current application is highly specialized and written to accommodate specific hardware. Usage of any other hardware is not possible. This is due to different methods of packet folding, which are unique on each device (Corbelt, BlueEKG datasheet, 2007). This is partly caused by the length of the Telemedicine branch. Operating of the device is simplified as much as possible with the least possible number of steps regarding user registration, measurement device connection and the measurement itself. The informations about user, as

ID, name, surname, address and application properties are stored in the system registry (HKEY_CURRENT_USER / Software / Guardian). Working (saving, reading, finding) with registry is easier and faster as saving this informations in file. User registry values are crypted with simple algorithm (shifting char ASCII value).

2.2 Server Part

In order to run a server, an operating system supporting IIS is needed. IIS is an Internet Information Server application allowing users to connect to the web server by the well-known HTTP protocol. The web service transfers data between the server and PDA/Embedded devices. It reads the data, sends acknowledgments, stores the data in the database and reads it from there. The service is built upon ASP.NET 2.0 technology. The SOAP protocol is used for the transport of data, which is in XML format. That is an advantage since it allows communication of multiple different technologies and platforms.

The Wireless ECG approaches a real professional ECG with data rate as high as 800 records per second (Corbelt, BlueEKG datasheet, 2007). That makes 48,000 records per minute and 2,880,000 per hour. Considering 100 patients, the value gets to 288,000,000 records per hour. Even if the server accepted only 50 records per second, the sum of records for 100 patients per hour would be 18 million. That is an extreme load for both the server and the database system; hence a better way of storing data is needed.

Methods that devices communicating with the web service can use include:

- receiving measured data.
- receiving patient data.
- deleting a patient.
- patient data sending.

To observe measured data effectively, visualization is needed. A type of graph as used in professional solutions is an ideal solution. To achieve this in a server application, a freeware Zed Graph library can be used. For data analysis, neural nets are a convenient solution. However, there are problems in the automatic detection of critical states. Every person has a specific ECG pattern. What is completely normal for one person can indicate crisis for another. The Neural net has to learn to distinguish critical states of each patient separately.

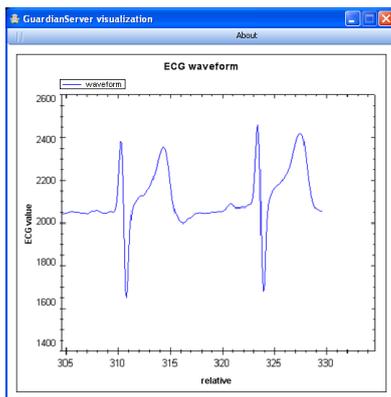


Figure 5: Server visualization.

Basic characteristics of a neuron network:

- 10 x 10 neurons.
- learning is based on 3-4 minutes of recording, which is approximately 36,000-45,000 recorded values.
- incorrect values are filtered out.
- filtering decreases the amount of values to about 10%, which is still good enough for learning.
- the learning cycle with 4,200 values takes approximately 30 seconds (CPU PIII 1.2 GHz) with C# implementation.

To make the specialist's or operator's intervention possible, the system must be provided with a user-friendly interface, possibly imitating those on medical appliances. This area is still in an early phase of development.

3 DATA ANALYSIS

Data acquired from the measuring device is incomprehensible for a man, because it is represented by a HEX format packet. The data needs to be stripped of redundant information like packet numbering and transformed to a recognizable state – a graph. This is done during the packet parsing in PDA/Embedded device, where HEX information 2 bytes in length are transformed to a binary state, where the data is carried on the first 12 bits. It is transformed to a decimal state and sent for further processing – sending the data to the server, storing it in a local database or visualizing it.

The visualization using PDA/Embedded is just a simple visualization of a curve in real-time or historical graph. In the server application, the visualization is far more complex, with the

possibility of storing the current curve as an image, printing, or zooming.

Neural net of the SOM type on the server is 10x10 in size. The initial weight of each neuron is random. The weights are assigned progressively by learning. Finally, the whole structure is ready to accept data to analyze. Each patient has his own neural net stored on a server in XML format.

4 CONCLUSIONS

The evolution of Telemedicine is unstoppable and apparent; therefore ways need to be found to improve the quality of hospital services, spa services or hazardous environment workplaces. The area of software products working in embedded devices in hazardous environments or PDAs in personal healthcare is still open and unoccupied. Personal healthcare products are freely available (<http://www.omron.com>, <http://www.weinmann.de>) and with minor hardware modifications they can be used for data acquisition using wireless Bluetooth, WiFi or ZigBee technologies. By means of data transfers, the acquired data can be gathered in database systems providing access to your personal doctor, who can be:

- alerted in case of trouble.
- send information and system message to our application.
- remotely change properties of devices (change alarm of critical limits in ECG, e.g.).

Why are there systems available to protect our property and not our health? Is it not the most valuable property of ours?

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