Complex Telemonitoring of Patients and Elderly People for Telemedical and Homecare Services

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Abstract: - The paper presents a project that has as main goal researches, design and implementation of an electronic-informatics-telecom and scalable system, that allows the automatic and complex telemonitoring, everywhere and every time (at home, in hospitals, at work, of mobile subject etc, using several communication paths), in real time, of persons with chronic illnesses, of elderly people, of those having high medical risk and of those with neuro-locomotor disabilities.

Key-Words: - biomedical equipment, biomedical signal analysis, machine vision, telemedicine, fall-detection

1 Introduction

Telemedicine is part of the expanding use of communications technology in health care being used in prevention, disease management, home health care, long-term care, emergency medicine, and other applications. In Romania, the diversification of telecommunication networks and advances in communications technologies, including the Internet, has considerable potential as a medium for telemedicine applications. In this context, we propose doctors a technical solution for telemonitoring patients or elderly people.

The proposed project enables to design a secure multimedia transmission (medical telemetry, digital images, video, and text) and a secure medical records acquisition system in order to enhance the telemedical consultancy services. The main objective of this project is to enable personalized teleservices delivery and patient safety enhancement based on an earlier diagnosis with medical telemetry using and images, video, text transmissions, and also applying the suitable treatment according to the remote medical experts' recommendations [1].

Our project represents an answer to the challenges of the society and its implementation will allow persons having different (chronic) diseases and to elderly/lonely people to be monitored from medical point of view [2]. In this way the medical risks and accidents will be diminished. The final product – the TELEMON system – will act as a pilot project destined to the implementation of a public e-health service, "everywhere and every time", in real time, for people being in different hospitals, at home, at work, during the holidays, on the street etc.

2 Problem Formulation

The main objective of this project is the achievement of an integrated system, mainly composed by the following components that are near patient (Figure 1): a personal network of wireless transducers (RPT) on the ill person, a network of transducers/actuators for domotics, a data multiplexing block and a personal computer (PC). After local signal or image processing, according to the specific monitored feature, the salient data are transmitted via one of internet, GSM/GPRS or a telephonic line to the database server of the Regional Telemonitoring Centre. The personal network of transducers (RPT) includes a medical device for vital signs (ECG, heart rate, arterial pressure, oxygen saturation, body temperature), a movement sensor, eventually a respiration one, all these components having radio micro-transmitters, which allows an autonomic movement of the subject. The project will also approach the situation of the mobile subject. In this case the patient will have the personal network of transducers, the data processing will be done by a PDA (Personal Digital Assistant) having GPS localization, and data transmission will be obtained by using GSM / 3G module of the PDA. Concerning the application programs, they will act and correlate on two levels: a local data processing, near the patient, as well as another one database server. So, the general software architecture will be a client-server one, and the project will develop a so-called SOA – Service Oriented Architecture which is a standards-based approach to manage services made available by different software packages for reuse and reconfiguration. Services are written to common protocols that are interchangeable, unlike today's programmatic interfaces that are unique to each software application and typically vary by hardware platform, software language, and operating system. In healthcare the situation is the same: there are a lot of applications, running on different platforms. The SOA can be a solution not to waste all the achievements, but to use them for building a consistent process that can save time and money. [3]

The results of data processing will be in principal and if necessary different locally generated alarms, transmitted to the central server, to the family or specialist doctor, to the ambulance or to a hospital. Other results of locally or on server data processing will be different medical statistics, necessary for the evaluation of health status of the subject, for the therapeutic plan and for the healthcare entities.

The TELEMON system will include the following hardware and software components:

(A) A **local sub-system**, composed by:

1. a *personal network of wireless medical sensors* / transducers (RPT) for vital signs (ECG, heart rate, arterial pressure, oxygen saturation, body temperature), a movement transducer (accelerometer), a respiration one, all these having radio micro-transmitters [4],[5],[6] for monitoring of the glicemic level, a non-invasive glicometer will be acquired;

2. a *tri-axial accelerometer* – alerts home care personnel at a remote site that a monitored people has fallen down and monitors continuously the person's activity. It's event-oriented fall detection and classification, i.e. in case of problem, an alarm is sent to a home center.

The tri-axial accelerometer has the following features:

– alarm is generated when the device is not worn by the patient;

–there is the possibility of de-activating the system in case of false alarm or if desired;

– user's activity monitoring allows the characterization of users' mobility for diagnostic purposes;

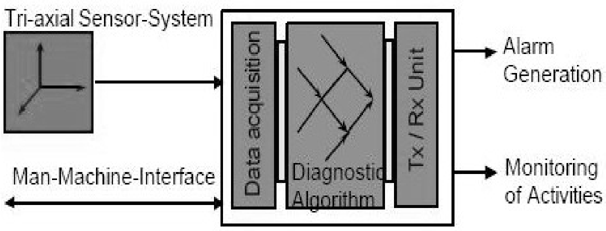

Figure 1. Functional block-scheme of the tri-axial accelerometer

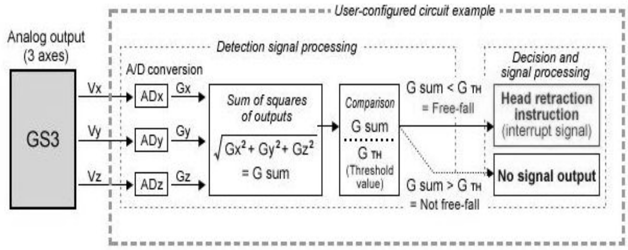

Figure 2. Sequence of free-fall detection by the three-axis accelerator sensor

3. a *network of sensors* /transducers/ actuators for domotics and *audio communication patient – caregiver* [7],[8],[9]

4. a video camera;

5. a personal computer, interfaced by radio with the above sub-systems;

6. for mobile subject the data processing will be done by a PDA interfaced with the personal network, and data transmission will be done by GSM/GPRS/UMTS and GPS modules of the PDA;

7. a local network of „ad hoc" type, composed by minicomputing units with radio transmission of data and necessary to cover a specific surface [10], [11].

(B) A **server computer** for **the main database** and other applications programs, situated at the Regional Telemonitoring Centre (CTMR).

(C) A **server computer for tele–diagnosis** (on-line consultation) and tele–consulting (off-line), where a video–conference program will be installed (also useful to organize a webinar).

(D) **Software applications** for:

1. medical data acquisition and processing, domotics signals analysis, patient images analysis [12], data transmission to central server;

2. the same functions as above, but for mobile patient;

3. interface programmes for duplex communication between local sub-system and central server;

4. specific alarms generating and their transmission to the Ambulance, family doctor, to the specialist or to a nurse; here there are necessary decision aided /expert systems based on medical specific knowledge [13],[14];

5. specific applications of e-rehabilitation and e-learning (at least 4);

6. extra data processing programmes, at the central server level (medical statistics, researches, etc.)

(E) Programmes for **data/knowledge bases** (including user-interfaces) installed on the server.

(F) A program for the **informatics management** of the system, installed on server.

The medical devices connected with the patient module are the following:

1. WristClinic™ (Figure 3) records, stocks and transmits data to the patient module through radio interfaces. Also it allows monitoring the following vital parameters:
- the cardiac rhythm
- the arterial pressure
- an ECG channel
- the oxygen saturation
- the body temperature

Figure 3. The WristClinic display

2. The Patient Display MiniClinic™ Wrist-unit (Figure 4) allows monitoring the following vital parameters:
- the cardiac rhythm
- an ECG channel
- the respiratory rhythm
- the body temperature

Figure 4 – Patient Display MiniClinic™ Wrist-unit

This records, stocks and transmits data to the medical telecenter through radio interfaces.
3. Radio interface with USB MiniGate™ output (Figure 5) allows connections with the above presented devices. Connecting this device on the USB port it activates the intern software and biomedical data can be received. It is embedded with a bidirectional radio interface and can operate on a maximum raze of 100 m.

Figure 5 – Radio interface with USB MiniGate™ output

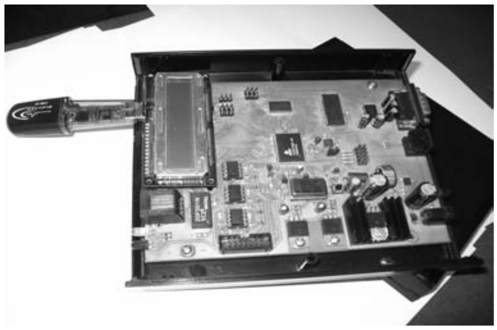

Figure 6. The module for patient's telemonitoring realized by UMF Iasi

Besides the medical and technical objectives, TELEMON project also proposes economic objectives:
- the decreasing of budgetary and personal expenses dealing with the un-justified transport of patients to the hospital;
-„zero costs" for the hospitalization in case of patients able to be treated at home.

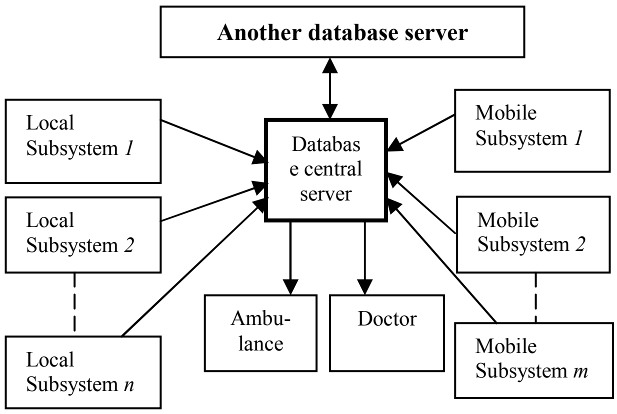

Figure 7. The basic structure of TELEMON system

3 Problem Solution

The TELEMON system (Figure 7) is built around a database server which receives data from local subsystems 1... n and also from mobile subsystems. The transferred information to database server are represented by those data above the limits and they are formed by medical recordings and also by audio/video recordings. The database server stores the recordings and it is capable to send alarms to the ambulance service and patient's doctor. Also, the database server can be connected to another database server, for example a hospital server, in order to send the patient's medical parameters and recordings. The subsystems are connected to the database server through an Internet connection (if it is available), through GSM or a telephone line (dial up). So, the database server has to be connected to the Internet and also be equipped with GSM and dial-up modems.

The Local Subsystem for the home monitoring of the patient (Figure 8) is built around a personal computer (PC) which receives data from the patient.

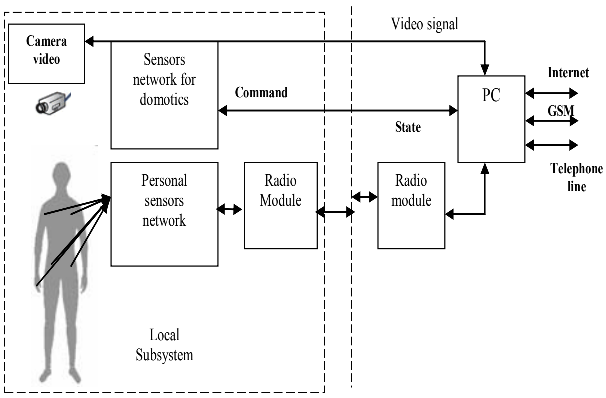

Figure 8. The local subsystem for home monitoring of the patient

The data are provided by a personal sensors/transducers network in form of medical parameters such as ECG, SpO2, blood pressure, body temperature a.s.o. [15]. The outputs of the network are connected to a radio module that sends the data to the PC. A very important feature of the network and also of the radio module is their low power consumption. Another component of a local subsystem is the sensors/actuators for domotics. The domotic sensors collect data from different points of the house sends them to the PC. The PC takes the decisions and sends commands to the actuators such as: light adjustment by controlling the windows, by controlling the patient access at doors level, by controlling the room's temperature, by controlling the audio-video receivers a.s.o. The Local Subsystem allows the video monitoring of the patient through a video camera connected to the PC. The PC records and stores images of the patient during the acquisition of the medical parameters, process these images and can send to the database server images and also processing results (e.g., alarms). The PC is equipped with a radio module that receives data from the patient's personal network, runs the monitoring algorithms, activates the alarms if the medical parameters are above the limits and sends the results to the database server. The PC is connected to the database server through an Internet, GSM or dial up connection. The same personal network is connected to a Personal Digital Assistant (PDA) through an interface module. The PDA runs the monitoring algorithms and sends the results to the database server by using the GSM connection. In the case when the patient is in a bad condition and he needs an emergency medical assistance, the PDA can send to a database server and from here to ambulance service the precise coordinates of the patient by using the internal GPS module. As to the medical wireless devices, we use some monitor units that can measure one channel ECG (Figure 9), cardiac rhythm, arterial pressure, respiratory rhythm, oxygen saturation and body temperature.

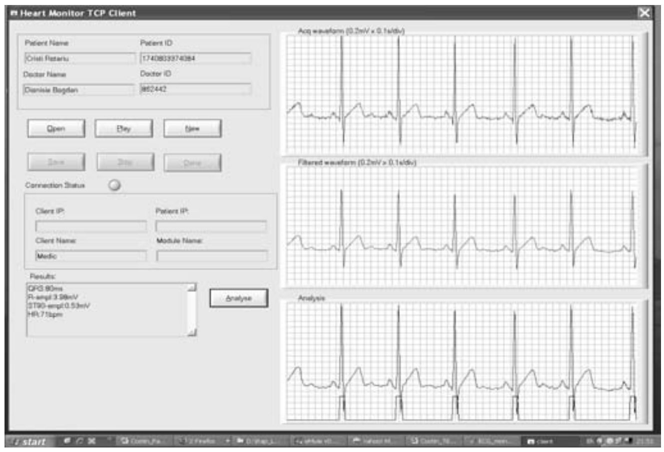

Figure 9. The ECG acquisition and analysis of a patient

Also, a 3-leads ECG amplifier was built by our team. They are connected with the telemedical centre via a radio interface having USB output and a radio interface with the fixed telephonic network [16], [17].

4 Conclusion

In this paper it is presented a project that aims to develop a secure multimedia system designed for medical consultation teleservices. The main goal is to build a complete pilot system that will connect several local telecenters into a regional telemedicine network. This network will enable the implementation of complex medical teleservices (teleconsultation, telemonitoring, homecare, urgency medicine, etc.) for a broader range of patients and medical professionals, mainly for family doctors and those people living in rural or isolated regions [18]. Thus, a multimedia, scalable network, based on modern IT&C paradigms, will result. The regional telecenter in Iasi will allow local connection of hospitals, diagnostic and treatment centers, as well as a local network of family doctors, patients, and even educational entities. As communications infrastructure, we aim to develop a combined fix-mobile-internet (broadband) links.

As a first step we implemented and tested teleconsultation and telemonitoring applications.

Such a regional telecenter will be a support for the developing of a regional medical database, that should serve for a complex range of teleservices such as teleradiology, telepathology, teleconsulting, telediagnosis, telemonitoring. It should also be a center for continuous training tasks, by tele-learning for medical personal or for informing/education of patients.

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