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TraumaStation: A portable Telemedicine station

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Abstract— TraumaStation is a portable medical device which covers the mobility of the medical doctors as well as integrates the diversity of telemedicine devices. Many portable telemedicine devices has been developed the last years in order to help patients in remote areas or in emergency situationns.The medical TraumaStation is a light portable tele-medical first-aid device, which provides the physicians with an ultrasound, electrocardiogram, blood pressure, oxygen meter apparatus all in a suitcase. In addition, the portable device is equipped with all available telecommunication gateways (e.g. GSM, UMTS, ISDN, DSL, Satellite) providing a great communication convenience to the physicians utilizing XMMP instant messaging protocols and real time video conference.

***Index Terms*—Portable, DICOM, SCP-ECG, Instant messages, Telemedicine**

I. INTRODUCTION

Telemedicine is currently being used to bridge the physical distance between patients in remote areas and medical specialists around the world. Distributed client-server applications have become very popular with the explosive growth of the Internet. These distributed applications provide an inexpensive and fast way to access medical information and also provide good accessibility and availability of medical service. Telemedicine applications are client/server applications where medical and patient information is stored in a server and the information is made accessible to doctors and medical personnel at a distant site. In addition, depending on the type and the needs of the medical application different type of communication protocols and medical devices are utilized making interoperability and communication over different communication channels quite difficult [1][3][4][4].
Traumastation (Fig 1) demonstrates how several different medical devices can be integrated into one single case and support a wide variety of applications utilising thereby one single data transportation protocol.

II. TRAUMASTATION

The TraumaStation combines several medical devices:

- Echo Blaster 128 is an ultrasound scanner [5][6] The beamformer can be connected to an embedded PC via USB port. The ultrasound scanner works with 256 colours in gray scale In addition it supports full-motion and full-size real-time ultrasound imaging, up to 120 fps as well as cineloop recording/play (several thousands frames depending on computer memory size and scan mode)
- OEM 12-Kanal-ECG-Module is a miniaturized module providing 12 leads ECG. The device has an open communication protocol and can easily be integrated into patient monitoring devices. For the communication, the EKG12- UART/RS232 utilizes the standard UART port and also an RS232 port. In addition, the device can be powered via the UART port and no additional source power is needed. The power consumption is less than 140 mA and a voltage of 5V is needed. Sampling rate per channel is: 100 Hz, 500 Hz and 1000Hz. The resolution is 19bits.
- Advantage OEM BP Model 2 is a blood pressure module that uses oscillometric method of blood pressure measurement, a non-invasive method that monitors the amplitude of cuff pressure changes during cuff deflation to determine arterial blood pressure. The module is controlled via software commands issued from a host system through an asynchronous serial data port (factory configurable to Logic Level or RS-232). Serial communications baud rate is 9600, with 1 start bit, 8-bit data, no parity, and 1 stop bit. There is no hardware or software flow control. The sampling rate is 1 sample per 30 min with resolution of 24 bits.
- iPod module is a miniaturized module providing information on patient's blood oxygen level and pulses .The device is able to be connected over RS232 and external power is needed for the operation. The sampling rate is 1 Hz with a resolution of 24 bits.
- Real time video conference

In addition it can operate and exchange medical information over range of communication channels:

- Satellite(DVB-RCS)
- GRPS/UMTS
- xDSL
- POTs, ISDN
- WLAN

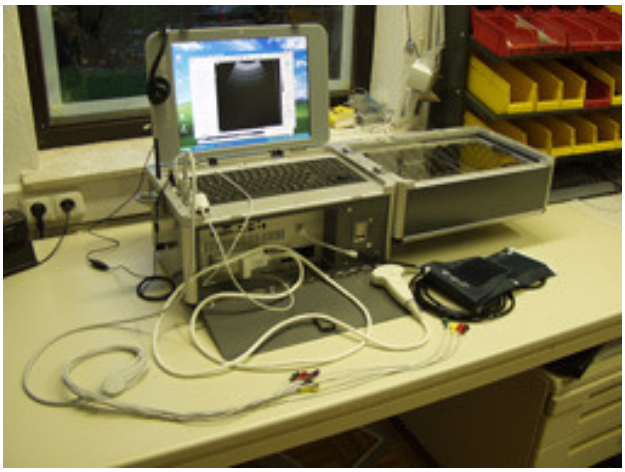

Fig.1: The TraumaStation

A. SCP-ECG protocol

Traumastation makes use of two medical standards for storing and transmitting medical information [7]:

- DICOM
- SCP-ECG

The implementation of the Standard Communication Protocol for Computer-assisted Electrocardiography based on the current version prEN 1064:2002 prepared by CEN/TC 251.

Standard Communication Protocol for Electrocardiography is supported by the European Committee for Standardization (CEN) in the field of Health Information and Communications Technology (ICT) (CEN/TC 251). The European standard EN 1064:2002 is the document that explains SCP-ECG. It was written by CEN/TC 251 WG IV under a mandate M/255 given to CEN by the European Commission and the European Free Trade Association. It is a revision of the European pre-standard ENV 1064:1993.

B. Data repository

The repository stores information that is being used in the context of the application. Due to the fact that the application uses various types of information, the repository consists of various databases, which could be combined in the same physical DB or be distributed if needed.

Specifically, information used in the application is categorized as follows:

- Medical Data Repository (MDR) which is a database, which stores all patient's vital data, as transmitted from the medical devices
- Patient Profile Database (PPD) which is the database storing all information about the registered patients
- Medical Staff Database (MSD) which is a database that holds information about doctors and paramedics.

C. Data exchange methods

TraumaStation provides two type of collaboration:

- on-line collaboration and
- off-line messaging.

The messaging is utilized with the help of jabber/XMMP protocol. The application makes use of the jabber communicator to send and receive messages to/from other users.

The on-line collaboration needs the two physicians to be on-line at the same time, whereby off-line messaging does not require that the remote communication partner is available, when the messages are sent.

Both methods have its advantages and disadvantages. On-line sessions have more options for the interaction and exchange of information. Especially within TeleConsult the principle *what you see is what I see* (WYSISIS), which means that both partners are having the same view at the images during the online-session, has great advantages .The main disadvantage is that both communication partners need to be available at the same time and an appropriate appointment for such action, needs to be booked in advance; particularly, when busy expert doctors need to be consulted.

D. Bandwidth requirements

The range and complexity of telecommunication technology vary with the specific medical application and the requirements of each medical application. Transmission of medical images would require more bandwidth. However, tele-consultations of ultrasound images require only a few megabytes of data. On the other side, transmission of biosignals might also need adequate bandwidth. The bandwidth needed for biosignals and ultrasound images is depicted in Table 1.

Signals measurements	Bandwidth
ECG 1 lead	3,6 kb/s
ECG 12 leads Pulse oxymeter (SpO2)	43,2 kb/s 72 B/s
Heart pulse	24 B/s
Blood pressure	32 B/s
Ultrasound imaging	256 Kb/s
Video conference	25 Kb/s

Table 1: Bandwith for real time communication

III. MEDICAL SOFTWARE

The medical trauma station was designed as plug and play medical solution. It can be used in emergency as well as in routine medical examinations. The software running on the medical TraumaStation is an assembly of medical software collaborating in seamless ways.

The Medical Imaging GUI is based on TeleConsult application which is a 2D and 3D DICOM viewer with feature reached medical imaging functionalities [8]. The physicians are able to manipulate the images, make notes on the images, store them into the medical database and also transmit their notes/annotation along with the medical data sets to another physician for consultation.

TeleConsult is a stand-alone application running on Windows Vista/XP. The application is able to acquire medical images from any ultrasound device through a video grabber attached to the computer. TeleConsult application is a combination of a 2D/3D DICOM viewer, an image grabbing software, medical annotation tools and a medical telecommunication tool. TeleConsult is currently used in several locations inside Europe and abroad, and provides an excellent, proven communication tool for telemedicine systems [9]. The system provides also easy localization options for Spanish and Portuguese since currently several installations are operative in Brazil and Peru.

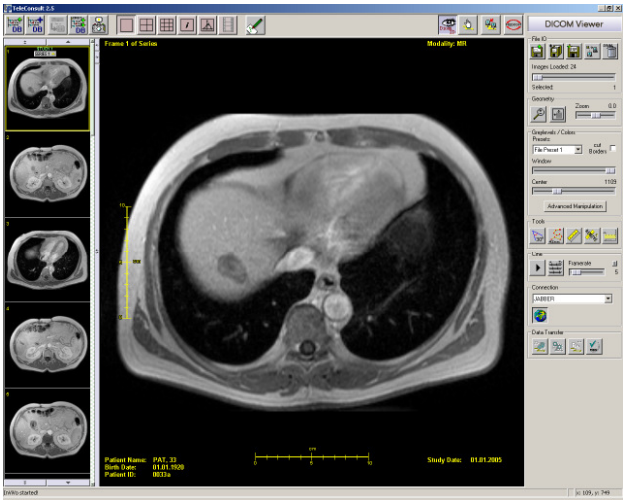

Fig. 2: Medical imaging GUI

The Fig. 2 illustrates the user interface of TeleConsult. The largest part of the user interface is used for the display of the images. On the left side of the software all images currently loaded into TeleConsult are listed. In the centre of the user interface there is place for showing the details of one or more images. All operations, a user of the software can operate can be assigned to following eight modules:

- The Database Interface menu
- The Image View menu
- The File I/O menu
- The Geometry menu
- The Greylevels/Colors menu
- The Tools menu
- The Cine menu
- The Teleconsultation menu

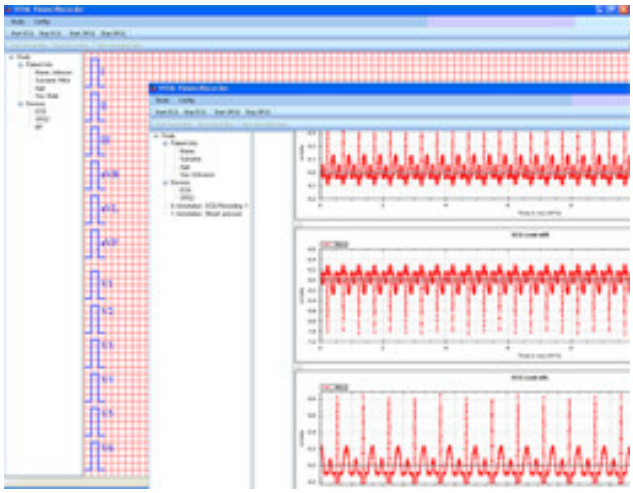

Fig.3: Vital GUI

VITAL GUI is used to acquire vital signals such as ECG, SPO2 and BP as well as to render and visualize vital medical information. ECG 12 leads traces can be recorded for a specific period and stored into the medical database. The physicians are able to go through the ECG traces by selecting an ECG lead and detect cardiac abnormalities. In addition the software gives the possibility to the physicians to measure QRS and RR time distances. Furthermore, the software is able concurrently to acquire blood pressure and blood oxygen levels helping physicians to have an accurate medical opinion of patient's health condition.

Medical communication messenger (Fig. 4) is an instant messaging module proving adequate tools for store-and-forward as well as real-time communication among physicians [10]. The communication module makes use of Jabber protocol which is open source and widely used all over the word. In this way, physicians having a unique nick-name (Jabber ID) are able to be registered on a jabber server and transmit / receive information.

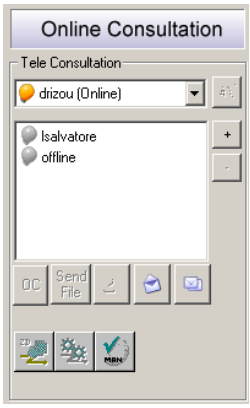

Fig. 4: Jabber Communicator

IV. MEDICAL CASES

TraumaStation (or independently the medical software in stand-alone modus) can be used for [7]:

- **Interdisciplinary communication**. In this case, doctors from various specialisations (diagnosis, surgery, radio-oncology) meet together to discuss the case regarding the patient treatment. Such a discussion takes place in a physical room with all experts collected in front of a whiteboard. Our application could offer the possibility for virtual meetings among such specialists. This enables communication between physicians with the ability for Application Sharing (in the principle what-you-see-is-what-I-see, WYSIWIS). In this way, consultations and discussions of case studies can be organised between several specialists, time- and cost-efficiently

- **Electronic Fax**. Currently, the patients' results get in the hospital are sent by courier to the referring position. This way is getting complicated to practise due to the digital form of the most data nowadays. The possibility to send data via standard fax-machine has also disadvantages. Electronic fax (e-fax) is becoming more and more popular in the telemedicine - mainly due to the fact that it is a highly efficient and cost-effective way to send patient data electronically in long distances and delivery can be guaranteed through store-and-forward mechanisms.

- **Second opinion**. In USA it is common practice for a physician facing some uncertainty about a particular case, to think about a medical professional who would offer the most beneficial consultation to determine the diagnosis. But also the patient can get an-other medical advice. S/he makes available his/her records, test results, x-rays and pathology report to a second opinion consult-ant. In this regard, generally, there are two ways of obtaining second opinion and therefore two different kinds of second expert opinion.

V. CONCLUSION

In health care domain, communications play an important role. The clinical information of the patient should flow continuously and in an integrated form among groups and institutions. Due to the limitation of resources, human and material, it is necessary to have a better utilization, on one hand lowering the costs and on other keeping or increasing the quality of the health care service provided to the citizens. Both developments and implementations of new telematics services have been increased with the technological developments in telecommunications and informatics. Telemedicine can give the necessary information regardless of the location of the patient or the health care provider, particularly in developed countries.

The presented medical imaging collaboration platform provides medical doctors with all necessary tools for communicating and exchange medical information over different communication media such internet, ADSL, and conventional phone lines. Our application provides a wide spread of possibilities to enrich a given image material with additional information and to send it as a message [11]

That can happen in off-line mode or in on-line mode. Moreover, the on-line mode gives the opportunity to communicate over long distances with a given partner in real time. In this case, both doctors observe the same image data set and through text messages and transferred mouse actions to the remote PC, they can discuss interactively over a medical case.

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