**A Portable 3D Ultrasound Telemedicine System**

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**ABSTRACT**

**Introduction:** Fast and reliable detection of non-penetrating injuries, such as internal bleeding and/or rupture-organs, in far-forward operations is a critical issue for saving lives and choosing the appropriate Med-Evac method. However, diagnosis of non-penetrating injuries typically requires the availability of adequate equipment (U/S or CT scanner) and quite advanced medical diagnostic capabilities by its operator, both of them typically not readily available in far-forward operations.

To address these limitations we have completed the development of a portable ultrasound system that can provide 2D and 3D imaging. Consultations for the interpretation of ultrasound images can be performed either locally (if trained personnel available) or remotely. Remote consultations can be performed by using a built-in telemmedicine capability to send ultrasound images to consultation centers for expert interpretations.

**Methods:** Our ultrasound telemedicine system is a compact, portable device developed by MedCom GmbH in cooperation with DRDC Toronto. The system incorporates free-hand 2D and 3D ultrasound, video conference interface and different communication gateways (satellite, GRPS, UMTS, DSL, analog or ISDN telephone, WLAN etc.). It is a plug-and-play medical solution designed for far-forward combat casualty care operations. It is also applicable for civilian emergency situations, such as aboard ships and in isolated communities and devastated areas with austere medical support. Our system enables online/offline diagnostic assessments of the acquired and transmitted 2D/3D medical images. The software provides a wide selection of possibilities for inputting added information to a given image and sending it as a message. The station can be operated in two different modes:

1. **On-line mode** is used to transfer and discuss the case in interactive manner by means of two connected workstations, which display the remote actions (like mouse movements) in real-time. It supports video conferencing, on-line annotations, TelePointing for emphasizing certain details in a graphical image window and TeleChat for text-based discussions.

2. **Off-line mode** can be used to collect data, ask a question, and send the data. For example, data can be sent overnight to a remote consultant centre, which can respond either on-line or by an off-line reply.

The key characteristics of the system include its robustness; portability; versatility of supported communication channels; ease of use; and intuitive operations in austere environment.

**Results and Conclusion:** The complete ultrasound telemedicine system has been developed and received Health Canada medical device approval. A complete demonstration of the system will be presented at the Symposium.
1.0 INTRODUCTION

What is telemedicine? Telemedicine is the use of electronic information and communication technologies to provide and support health care when distance separates the participants. It is a system that connects primary care physicians, providers, specialists and patients. Telemedicine is not a new concept. It has existed for a number of years in the form of the telephone and fax machines. In recent years, with the improvements made in access, technology, and communications systems, telemedicine has expanded and, in a time of limited resources, has become a feasible alternative for smaller and rural medical facilities to provide routine and specialized services. Particularly in rural areas, it offers the potential of both improved access to care and improved quality of care [2].

In this context and focusing on far-forward casualty care operations where fast and reliable detection of non-penetrating injuries is crucial for saving lives, we developed the TraumaStation II, a medical imaging system, that provides a wide spread of possibilities: It is able to acquire 2D/3D ultrasound images directly from an ultrasound device, to enrich acquired image material with additional information/annotations and to transfer it as a message to distant expert doctors connected to the medical network over Internet, phone line, satellite (DVB-RCS) or any other existing telecommunication channel [4]. This method helps in choosing the appropriate Med-Evac method for combat casualties. The system is also applicable for civilian emergency situations, such as aboard ships and in isolated communities and devastated areas with austere medical support. Our system enables online/offline diagnostic assessments of the acquired and transmitted 2D/3D medical images.

The medical imaging application TeleConsult (running also on TraumaStation II device) provides several functions for the setup for the operation of a health telematics network. TeleConsult enables the use of other imaging modalities (such as X-Ray, MRI, CT images) and thus making it suitable for a broad range of telemedical uses including direct network access to a local HIS/RIS/PACS.

2.0 TRAUMASTATION

The TraumaStation II (Figure 1) is a compact battery operated medical device developed by MedCom GmbH in cooperation with DRDC Toronto. It is the research outcome of numerous IST and ICT telemedicine projects (TeleInViVo, @HOME, T@LEMED, TENPET, T@HIS). The TraumaStation II combines free-hand 2D and 3D ultrasound, video conference interface and different communication gateways: Satellite (DVB-RCS), GRPS/UMTS, xDSL/POTS, ISDN and WLAN [1]. It is designed as plug and play medical solution. It can be used in emergency as well as in routine medical examinations.

Figure 1: The TraumaStation II
2.1 Hardware Overview

The following figure provides an overview of the different hardware components of the whole TraumaStation II setup. In general the system consists of three different components (Figure 2):

- TraumaStation II
  - Teleconsult software and database application
  - DriveBay 3D tracking System
  - LogicScan 128 Ultrasound device
  - Internet connection
- TeleConsult Server
  - eJabberd XMPP server software
  - Offline message service
- Tele-Consultation Center
  - TeleConsult software with database application
  - Internet connection

The TraumaStation II device and the Tele-Consultation Center are connected through the TeleConsult server machine via a secured internet connection (e.g. over satellite). All communication (offline message, chat, online consultation, etc.) between the two stations goes over this server.

2.2 Software Overview

The following figure provides an overview on the structure and the software modules of the TraumaStation II system (Figure 3):
The system consists of two software applications:

- **TeleConsult**
  - Ultrasound acquisition module (capturing images from the ultrasound device)
  - 3D tracking module (tracking the position and orientation of the ultrasound probe during acquisition)
  - Rendering and visualization module (generating 3D volumes from the ultrasound images; measurements; annotations, segmentation; etc.)
  - Communicator module (offline and online consultation)

- **Database application**
  - Stores the captured ultrasound images and volumes

### 2.3 Data Exchange Methods

The TeleConsult application extends with its innovative program functionality the display of two dimensional ultrasound images, thus facilitating interpretation of diagnostic records. TeleConsult allows also a three dimensional presentation of acquired two dimensional ultrasound images and a measurement of length and volume as well as a removal of volume areas in the three dimensional display of the object.

TeleConsult enables online/offline diagnostic assessments of the acquired and transmitted 2D/3D medical images. The software provides a wide selection of possibilities for inputting added information to a given image and sending it as a message. The station can be operated in two different modes:

**Offline Consultation**: In this mode the software might be used to collect data, form a question and send the data for example over night to a remote consultant center which can respond either online or by an offline reply.

**Online Consultation**: The Online Consultation mode is used to transfer and discuss the case in an interactive manner by means of two connected workstations, which display the remote actions (like mouse movements) in real-time. This mode is especially useful together with the offline mode in order to discuss previously sent data. This mode is supported by a TelePointing option for emphasizing certain details in a graphical image window and TeleChat for text-based discussions.
TeleConsult uses the internal as the communication channel. It provides TripleDES encryption to ensure the protection of the transferred imaging and patient data.

### 3.0 COMMUNICATION PROTOCOL

The data transfer is based on an integrated instant messaging system taking advantage of the XMPP protocol [3].

The XMPP protocol is different from other instant messaging systems since it is based on XML. A XMPP instant messaging system consists of a hub server and many remote nodes, which are able to be connected to the server (Figure 4). The hub is responsible for keeping track of user’s presence status and to forward the messages to the right user.

![Figure 4: XMPP Network](image)

The XMPP protocol can be easily encapsulated into http protocol and be forwarded through firewalls. A very common problem among medical applications is how two different remote applications could exchange information when they are located behind firewalls, which permit only outgoing traffic. We tackled this problem by placing a server somewhere in the Internet, which accepts incoming connections, as shown in Figure 4.

Additionally, XMPP supports data transmission over HTTPS and SOCKS5 proxies. Furthermore, for users working in very restricted environments, with very tight firewall rules, XMPP offers a polling connection method over secure http protocol (https).

Comparing the XMPP instant messaging system to a VPN based system we have to denote that XMPP is more flexible when only http and https protocol are available. At the same time XMPP is as secure as VPN since an SSL layer in conjunction with the http protocol is used.

Additionally, using the XMPP protocol the medical application doesn’t need to keep track of the users’ presence. The XMPP server is responsible for this function. The application at any time is aware of the presence status of the register users. In this way, we support the mobility of the doctors. They are completely free to work at any available terminal or even when they are moving around.
4.0 INNOVATION

• A portable, light and battery operated medical device, combining 2D and 3D ultrasound imaging
• 3D representation of the datasets.
• Real-time medical data acquisition. Connectivity with other medical devices.
• Advanced communication gateway based on the XMPP protocol. We customized the communication protocol to support effective binary data exchange. In addition, making use of the centralized communication scheme, we eliminated the need for network configuration. Now, physician can exchange information any time and from any place, by simply connecting to the medical server.
• Seamless operation over any communication network. Our transport and data gateway makes use of TCP/IP and is able to operate without any network configuration over telephone lines, ISDN, ADSL, Ethernet, GSM/UMTS/GRPS and satellite networks.
• Support of video conferencing.
• Adequate functionality for medical imaging presentation, handling and annotation. Moreover, the physicians, with the help of the fusion module, are able to combine various imaging modalities such PET and MRI or CT.

5.0 CONCLUSION

We have completed the development of a portable ultrasound system that provides 2D and 3D ultrasound imaging. The system has received Health Canada medical device approval. Its key characteristics include its robustness; portability; versatility of supported communication channels; ease of use; and intuitive operations in austere environment.

The system provides all necessary tools for real-time communicating and exchange of medical information, thus supporting the detection of non-penetrating injuries and the choice of an appropriate Med-Evac method in far-forward operations.

REFERENCES


