TeleUS: Design and Implementation of Telesonography

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ABSTRACT

This paper deals with telesonography. Telesonography is real-time video collaboration for remote ultrasound examinations. We present here a generalized design of an interactive videoconferencing system that supports the various fields of ultrasound expertise. The work here focuses on integrating such a system in the demanding environment of ultrasound examinations.

Our design includes a logical model, open architecture, and appropriate user interface. This design was implemented in the TeleUS prototype, tested in a series of simulations and experiments, and proved adequate.

Keywords

Teleradiology, ultrasound, videoconferencing, design

INTRODUCTION

Teleradiology belongs to the field of telemedicine. Real-time ultrasound transmission systems are called telesonography systems [2,3]. The importance of teleradiology lies in the improvement of the medical service and in the availability of quality medicine. The ability to receive remote experts' opinion provides an opportunity for faster and improved medical services.

Telesonography can use Video Conferencing (VC) tools and applications. VC enables the users to take advantage of a variety of multimedia tools: audio, video, whiteboard, chat, etc. Moreover, VC can support group work.

The contribution of this poster is in the generalized design of an interactive system for telesonography that supports the HCI needs of ultrasound personnel and the patients requiring their care.

Telesonography

One of the more important areas of teleradiology is telesonography [3]. The frequent use of ultrasound for obstetric medicine and the growing experience in using ultrasound technology for a variety of other examinations turned ultrasound into a very important diagnostic tool [1]. This created the need for expertise collaboration beyond location confines. Thus, the high motivation to implement telesonography. However, telesonography is a very demanding field because it requires a high data transfer rate for direct involvement of experts in real-time.

Moreover, ultrasound is used in various fields of expertise: radiology, obstetrics and gynecology, and cardiology. The characterization of the examination changes from field to field, as are the requirements from the telesonography system. In any case, in all examinations, an additional expert opinion is often sought after.

Previous work in this area [1] has defined 3 levels of telesonography:

1) **Store and forward** systems are asynchronous.
2) **Interactive video** systems are synchronous. They transmit live ultrasound video and enable real-time collaboration between the participants.
3) **Remote controlled** systems with robotics are synchronous. They include live video and devices for remote expert control over the ultrasound hardware.

The work in [2] defined an initial model for telesonography. It is based mainly on **Store and forward** and on a one-way ultrasound video transmission. The work here addresses the first two levels: **Store and forward**, and **Interactive video**. Our design is generalized because it caters to the different fields of ultrasound expertise, because it covers the different stages of an ultrasound examination, and since it is technology independent.

DESIGN

Since a model that defines the process and modes of telesonography has not been fully presented yet, we developed a logical model for telesonography [4]. This model characterizes the various requirements to be supported in a telesonography system, and defines the different work modes and the needed connections.

The three main participants in an ultrasound examination are the patient, sonographer (operator) and physician (expert). In order to succeed with telesonography, one has to take into consideration many factors: human, environmental, technical, and economical [2, 4, 5].

Connections

When working remotely, several connections exist among the participants. The model defines five connections:

1) **Voice connection** – audio for talking and hearing.

2) **Visual connection** – video for viewing all or certain participants.

3) **Ultrasound connection** – for real-rime ultrasound video transmission.

4) **Information connection** – for transferring data among the participants.

5) **Coordination connection** – for signaling and synchronization of the involved computers.

Work Modes

For telesonography, several work modes should be supported using the above connections. The model relates to them in stages, as follows:

1) **Local work –** the first stage, in which the operator does the ultrasound examination stand-alone.

2) **Remote work –** interactive work of the operator with the expert. This remote work has a few sub-modes:

   One. **Remote background work –** the operator and the expert are communicating, but the patient's file is transferred in the background. This mode is divided into two sub-modes:

   A. **Transparent transfer** – when the file is transferred without interaction between the participants, or even in batch.

   B. **Interactive transfer –** when the participants talk and interact while the file is transferred.

   Two. **Remote scaled work** – the expert views the operator's display in lower quality, while full quality information is transferred as in remote background work.

   Three. **Remote full work –** the expert views the operator's display in quality close to the original, thus enabling a direct diagnosis.

3) **Group work –** a group of distant experts is in a "conference talk" consultation. This work mode can use all the above remote work sub-modes.

The model also defines the process workflow and the conditions for passing from mode to mode.

IMPLEMENTATION

To support the logical model, an open multi-layered architecture has been defined [4]. The architecture defines a communication infrastructure at the bottom layer, above it is a hardware layer, above it a tools layer, and the upper layer is the user interface layer.

To approve the adequateness of the design, a prototype was developed [4]. The prototype was called TeleUS for double meaning: it supports Tele-UltraSound and because it sounds "Telecommunicate us". The computerized environment for the prototype consisted of a desktop PC/Windows, Microsoft Visual C++ and freeware NetMeeting SDK for VC.

The prototype was designed for internal ultrasound. It includes support for **local work** and **remote work** of both **background** and **scaled**, and employs a variety of multimedia tools such as whiteboard and chat.

TeleUS was divided into two programs: Operator (TeleUS-Operator) and Expert (TeleUS-Expert). The two programs are designed to work together from the different locations. The physician may be acting both roles: as an operator asking for a second opinion from an expert, and as an expert diagnosing from afar. Hence, the two interfaces were designed with the same "look and feel" and support common features.

Since the operator is busy handling the ultrasound device, operating also the PC at the same time is very difficult. Consequently, hardware devices and cordless equipment should be used. Unlike the operator, the expert's hands are free. Thus, the interface designed gives the expert full control over all the system. For example, moving and sizing windows, changing video resolution, capturing images and video, etc.

The simulations tested the TeleUS prototype in a variety of communication environments. We also conducted a series of experiments using TeleUS at the Tel-Hashomer hospital, during which the staff involved expressed their opinions by filling in questionnaires [4]. The feedback received, revealed that the staff is enthusiastic about telesonography. They found the TeleUS prototype friendly and efficient, having useful options, and even extremely appealing when running on a high bandwidth infrastructure.

In summary, our generalized design for interactive telesonography proved itself as adequate for the demanding environment of ultrasound examinations.

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