

PILOT STUDY OF TELEULTRASSOUND EXEM OVER LOW-BANDWIDTH INTERNET LINKS: FEASIBILITY OF CLINICAL APPLICATION

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Abstract - Telemedicine is a rapidly developing application of clinical medicine where medical information is transferred for the purpose of consulting, and sometimes remote medical procedures or examinations. In this paper we tested feasibility of the low-cost teleultrasound model for developmental dysplasia of the hip (DDH) exam in variety of network settings and computer configurations. Sending of data was accomplished with a software package specifically designed at Dartmouth College, Hanover, USA for teleultrasound transmission through limited Internet bandwidth. Hardware and software solution used for teleultrasound screening showed good characteristics for ultrasound image transmission in real-time. Clinical application of this model includes consultation and training at a distance while for the navigation or management of an ultrasound examination at a distance, the delay is in one of the limiting factors.

I. INTRODUCTION

Rapid growth and development of information systems and communications that fueled development of telemedicine enabled a constant increase in quality of telemedical service, primarily exemplified in improved telemedicine interfaces and increased speed of transmissions. Worldwide availability of Internet infrastructure has opened door for exchange of medical information on a global level [1] [2].

Transmission of still images and cross-sectional data has been widely used in both developed and developing world [3]. However, we focused on utilization of ultrasound and transmission of ultrasound image and video data. Reasons for this are twofold, the unique features of ultrasound and technological challenge of ultrasound data transmission.

Low-cost, availability of portable ultrasound units, safety features all enable its easy integration into both primary care and secondary care settings in developed as well as in the developing world. Two consequences, immensely important for the medical field are the

educational potential and opportunities for public service [4].

Here, we tested feasibility of the low-cost teleultrasound system for DDH exam and clinical application of this model.

II. MATERIAL AND METHODS

In the initial phase of this research, we tested software solutions and hardware configuration of the low-cost teleultrasound system for DDH exam, in four settings:

1. Local area network (LAN) with connection speed of UL/DL: 100 Mbps,
2. Metropolitan Area Network (MAN) within one internet service provider with connection speed UL/DL: 2000/2000 Kbps,
3. Wide Area Network (WAN) with connection speed UL/DL: 512/64 Kbps,
4. Wide Area Network (WAN) for trans-atlantic teleultrasound with connection speed UL/DL: 3358/863 Kbps.

A variety of computer configurations tested for transmission of ultrasound images included 2 to 3 GHz Pentium 3 and Pentium 4 processors, operative memory from 256 MB to 3GB and multiple graphics cards. All computer configurations were running on Windows XP OS.

All imaging was done with a portable ultrasound unit donated by Dartmouth-Hitchcock Medical Center (Lebanon, NH), USA and utilized in General Hospital "Djordje Joanovic", Zrenjanin, Serbia.

Ultrasound image was transmitted to the computer via a Pinnacle PCTV Analog USB TV tuner video capture card.

We tested software platform capable of transmitting real time ultrasound images as well as supporting audio

communication (Remote Ultrasound and Skype) in

This unique application was developed at Dartmouth College, Hanover, USA and enabled us to use ultrasound in the settings of limited resources [5] [6].

Figure 2 depicts software screen interface for application based on Qt programs environment and VLC multimedia libraries. Both components hold for cross-platforms and open source [7].

This software application has been tested under laboratory conditions within Department for quality and scientific-educational researches of General hospital “Djordje Joanovic” and during the DDH ultrasound examination of 20 babies that were from 2 to 7 months old, within Radiology department of General hospital “Djordje Joanovic”. During the testing in laboratory conditions there were 280 tests carried out with different codec and the values of Bandwidth and Framerate of the 100Mbps LAN. During the DDH examination of 20 babies, Remote Ultrasound software application was used for transmission of ultrasound image via low bandwidth (250kbps) public internet links without security measures between Serbia and the United States (Philadelphia, PA).

teleconference setting.

III. RESULTS

Final hardware platform used in all teleultrasound screening sessions was a notebook MSI EX610X-082EU, with AMD Athlon 64x2 TK55 chip, DDRII 3Gb, ATI HD2400, running MS Windows XP with Service pack 2.

Software application enables:

1. direct monitoring of ultrasound exam in real time via teleconferencing module that in addition to audio link transmits ultrasound video stream,
2. ability to add additional text to images,
3. recording and review of still ultrasound images, similar to functions available on ultrasound machine,
4. remote saving of ultrasound imaging - a function that saves images on local and remote computer and thus enables direct comparison of images by personnel on both locations.

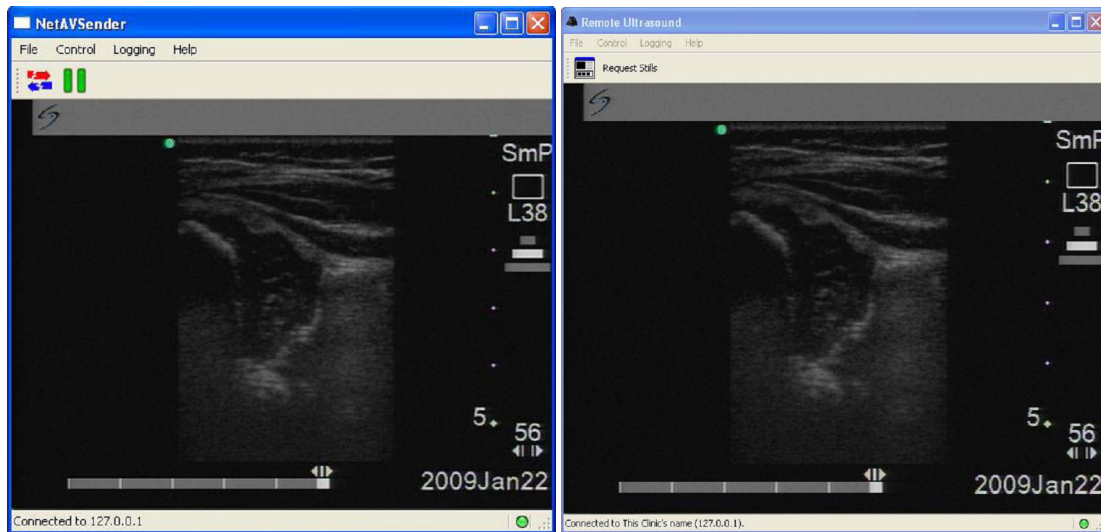


Figure 1. Software screen interface NetAVSender: the transmitting interface, Remote Ultrasound: the receiving interface.

The teleultrasound session was initiated by the sender who starts connection by adjusting the desired destination IP address.

In software solution destination IP address is registered in the Control menu options by selecting Connect and then it is possible to start the connection by pressing the button Connect to a Remote Server.

After about 2 second, the video stream appears on the receiver's computer and the exam is started.

Request Stills in application of the Remote Ultrasound interface was used to record the still images while the ultrasound probe was moved or when the images were «frozen» on the ultrasound machines. Every time Request Stills is used, it records a dataset of images on sender's and receiver's computers in date base “Still Images”.

The testing of software application in real-time, during the DDH ultrasound examination of 20 babies, on strain Remote Ultrasound was carried out by trained sonographer. On the basis of his subjective value there were no interrupted connections, or fluctuations in the quality of video.

Time delay of video image between the video sender and receiver is tested with different codecs and different values of bandwidth and framerate in the laboratory conditions for the 100Mbps LAN.

In the software application of the sender, a digital clock mechanism was set and further in real-time forwarded to the receiver. Interface of the sender and the receiver is painted so that it can record the current generated intervals. Subtracting the time recorded by the sender of recorded time, the receiver obtained the time delay video. During the test, 840 measurements was performed and it was determined that it is moving in the range of 2.046 to 2.544 seconds.

Of typically achieved over a 10/100 Mbps Ethernet network low delay is anything below about 200 milliseconds for two-way video, and about 1 second for desktop video [8]. If this fact is taken into account then it is noticeable that the results achieved are slightly above the upper limit of low delay.

During testing software application we showed that the quality of transmission image and video is successful with the proper value of the parameter framerate and bandwidth for different types of used codec (Table 1).

Table 1. Minimal values of the parameters for the transmission of ultrasound images

Codec	Bandwidth	Framerate
WMW1	>224	≥ 3
WMW2	>160	≥ 3
DivX2	>224	≥ 3
DivX3	>160	≥ 3
H263		
Theora	have not been satisfactory	
Dirac		

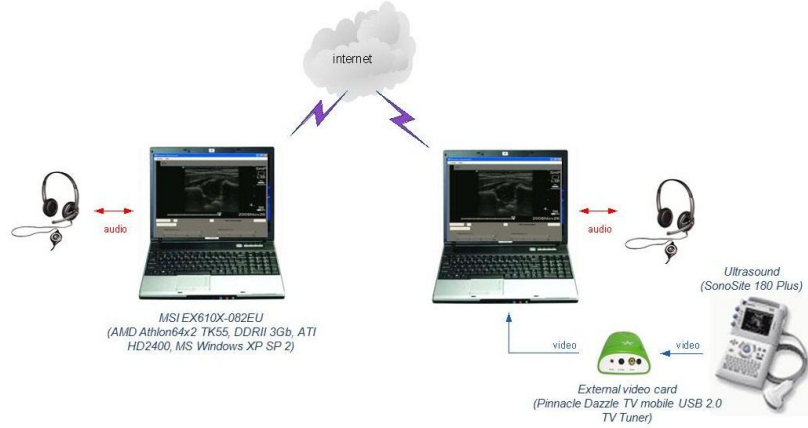


Figure 2. System Structure

IV. DISCUSSION

Nowadays, in rich and highly developed countries there is a capability of medical image transmission through highly sophisticated, specially purposed and expensive equipment, with great transmissive power of computer networks. This possibility is limited with the use of licensed and expensive software and equipment. In current situations of highly developed countries telemedicine is not practicable except in big medical centers, and beside that there is no simple and universal software for usage of telephonography. Therefore, communicational problems between developed countries are bigger, and the number of feasibility researches with low budget equipment is still unexplored.

One of the most popular standards in medicine is DICOM (Digital Imaging and Communications in Medicine). This Standard specifies the exact procedures under which the digital images are sent between devices, whether to use a network connection or a storage device. DICOM compression for still images uses JPEG format and for video uses MPEG-4 data format [9] [10]. Beside data compression, DICOM still requires a large bandwidth of computer networks.

Possibility of teleultrasound examination with limited technical resources on distance is practicable and clinically usable [5] [6].

This research created a model for low cost real-time teleultrasound exam containing commercial equipment that is far cheaper than the sophisticated equipment intended to telemedicine. Portable Sonosite 180 used in this research is standard medical equipment for clinical

practice and satisfies all current legal regulations and professional criterions.

Also, bandwidth computer network using sophisticated equipment is far greater than the bandwidth used by applying this model.

Software solution is based on open-source libraries and it showed good characteristics for ultrasound image transmission in real-time in the settings of limited resources.

Teleultrasound screening with limited resources provides access to these methods in the regions where health service is not highly developed and where there are no adequately trained medical professionals. In this way, health care practice is being improved and enables its integration into both primary care and secondary care settings.

This model can be used in clinical practice for consultation, the process of distance education and for conducting an ultrasound examination at a distance (Figure 3, Figure 4 and Figure 5). The tested model allows the application for consultation and education by video transfer in real time and deferred to the database file "Still Images". For the process of navigation, or for conducting an ultrasound examination at a distance, important reference makes a delay.

Definition of the term "real time" are different and are basically conditioned by the task with which it formed a chain of telemedicine [11] [12] [13]. Only the delay does not significantly affect the need for consultative examinations and education, while the process of navigating the delay which is slightly above the low

delay, significantly complicates the process of teleultrasonic examination on distance.

A delay in the process of navigating teleultrasound examinations could be overcome by using the navigation

module that would allow coordinating the movement of ultrasonic probe at a distance or some other method.

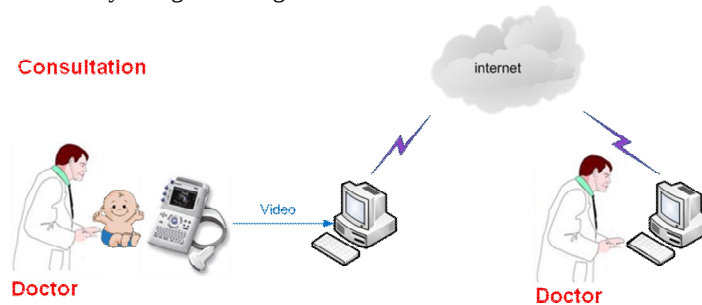


Figure 3. System structure for application in consultation

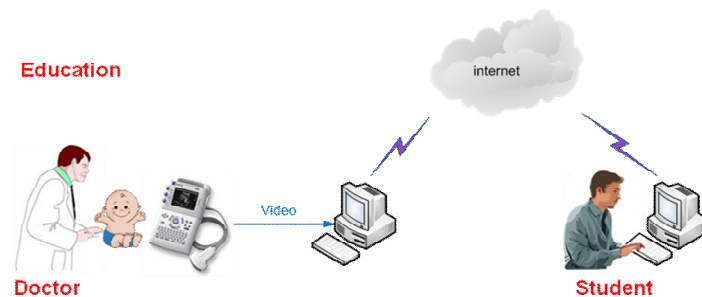


Figure 4. System structure for application in education from remote location

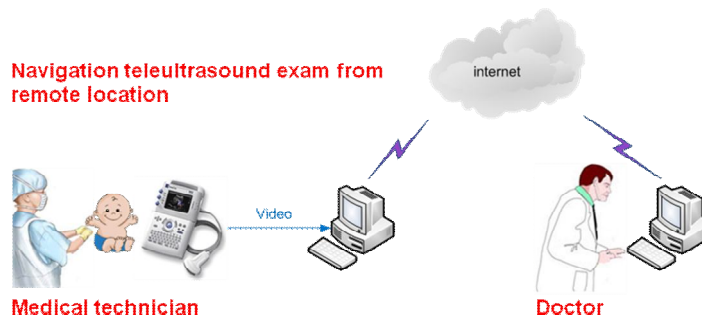


Figure 5. System structure for application in navigation teleultrasound exam from remote location

V. CONCLUSION

Transmission of ultrasound data was accomplished with software package specifically designed for teleultrasound exams through internet connections of limited resources. Using this software application, in conjunction with a hardware setup and low bandwidth internet link, we performed sonographic DDH exams in real-time. In addition, continuous monitoring of the exam via video stream, software application, offers remotely controlled recording and selection of still images on the sending and the receiving computer. Low cost model for teleultrasound examination is configured in this way.

During the testing, it was ascertained that hardware characteristics significantly affect the quality work of software application and that it is important to provide adequate speed values of processor for its successful use, the size of RAM memory and graphic card, which is

essential for sender (the computer which send ultrasound image on distance).

Model for low cost teleultrasound screening of DDH showed good characteristics for ultrasound image transmission in real-time and its potential clinical application.

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