Remote Interaction in Web-Based Medical Visual Application

Ciril Bohak, Primož Lavrič, Matija Marolt
Faculty for Computer and Information Science
University of Ljubljana
Večna pot 113
1000 Ljubljana, Slovenia
ciril.bohak@fri.uni-lj.si

ABSTRACT
In this paper we present a novel integration of four remote collaboration modalities into an existing web-based medical data visualization framework: (1) visualization data sharing, (2) camera view sharing, (3) data annotation sharing and (4) chat. The integration of remote collaboration modalities was done for two reasons: for getting the second opinion on diagnosis or for getting a diagnosis from the remote medical specialist. We present an integration of these modalities and a preliminary evaluation by the medical expert. In conclusion we show that we are on the correct track of integrating collaboration modalities into the visualization framework.

Categories and Subject Descriptors
H.4 [**Information Systems Applications**]: Miscellaneous; J.3 [**Computer Applications**]: Life and Medical Sciences

General Terms
Vizualization, Collaboration

Keywords
medical visualization, remote collaboration

1. INTRODUCTION
It is generally accepted fact, that collaboration yields better results in most of the fields. It is even more so for the case of medical diagnosis, where doctors are commonly looking for the second opinions of colleagues with more experiences or with different view on the problem. Since doctors with same expertise are often not in the same institution or even country the collaboration between them can be slow or requires lots of resources.

Medical collaboration applications have already been presented in different forms. Such cloud based solution is presented in [3] where authors claim, that such solution might reduce the storage costs of increasing volume of radiological data being produced on daily basis. While radiologists still need to transfer the data back to their devices for their examination it is the first step towards remote collaboration.

Early examples of remote collaboration in reviewing of ultrasound images using low-cost voice and video connections is presented in [1].

A collaboration system with broad specter of features is presented in [4]. The telemedicine system integrated many features of collaboration such as cooperative diagnostics and remote analysis of digital medical imaging data, audio-visual discussions as well as remote computing support for data analysis.

Where there are no radiologists available, hospitals can make use of remote diagnostic services. In such service the companies offer to make diagnosis based on radiological data at distance. In such case the hospital staff still has to send the data to the company which then makes a diagnostic process offline. Such example is a Canadian company Realtime Medical, which assures privacy, data security and fast processing of requests via their PACS/RIS-neutral workflow management platform DiaShare[1].

Another example of remote collaboration allows radiology specialists to guide and direct the technicians at the distance. Such system iMedHD2[2] was presented by Remote Medical Technologies and consists of two parts: (1) a wearable telemedicine device, a hands-free secure live HD streaming device, and (2) Tele-Ultrasound system, which provides multi-participant real-time sharing of images, annotations, snapshots and moreover, secure connection. The users can join the sessions in the web browser.

An image based viewer for tablets was presented by Khandheria [5]. Primarily the image viewer is intended for face-to-face consultation with colleagues, but offers a remote access to radiological images as well. The application integrates web-based PACS viewer and real-time audio/video teleconferencing with remote users.

Researchers have also investigated what is the acceptance of the Web-based distribution of radiology services. Such study for regional and remote centres of Western Australia is presented in [8].

This paper addresses different communication modalities for remote collaboration. In the next section we present the Med3D framework – a web-based framework for viewing me-

[1] `http://www.realtimemedical.com/`
[2] `http://www2.rmtcentral.com/tag/real-time-radiology/`

dical volumetric data. In section 3 we present the integration of novel remote collaboration modalities in the Med3D framework. Section 4 presents a preliminary evaluation of integrated collaboration modalities, followed by discussion in section 5. In last section we present conclusions and possible future work.

2. THE MED3D FRAMEWORK

A web-based visualisation framework Med3D [6], an adaptation of Java based visualization framework NeckVeins [2], was developed with purpose of platform independent tool for visualization of medical volumetric data. The framework is developed using WebGL 2.0 library for exploiting the hardware accelerated graphics rendering in the browsers. While currently the framework allows indirect visualization of volumetric data through the use of Marching Cube algorithm [7] for transformation to polygonal mesh model of the data, it is designed for integration of direct volumetric rendering algorithms such as ray casting as well.

Med3D also allows users to annotate the data they are viewing with 3D position based annotations and save the annotations for later review. We have also implemented a support for remote collaboration enabling specialists, mostly radiologists, getting second opinions form colleagues over the Internet or getting diagnosis from remote specialists at all. The data can be viewed locally by individual user it can be uploaded and shared with designated users of the framework, or it can be directly shared with an individual or group of users. The framework user interface is displayed in Fig. 1.

Figure 1: ***The Med3D framework with loaded 3D model of medical data. Figure also shows annotations pinned to the exact locations on the model.***

3. INTEGRATION OF REMOTE COLLABORATION

The main contribution of this paper is integration of remote collaboration in the web-based visualization tool Med3D. The remote collaboration includes four different modalities: (1) sharing visualization data, (2) sharing camera view, (3) sharing annotations and (4) integrated chat between connected users.

3.1 Visualization data sharing

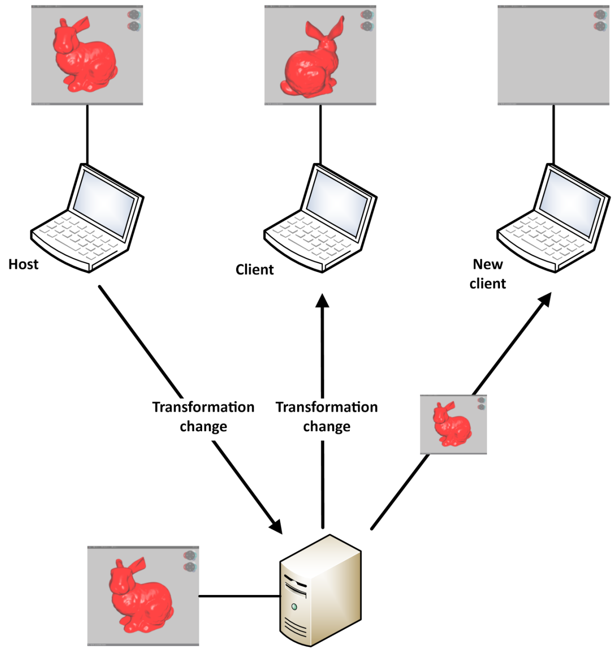

Figure 2: ***The communication schema during remote collaboration. In top left is the session host, who shares the scene with other users of Med3D application. The host in the schema has already synchronised the scene with the server (bottom right) and sends the updates of the shared scene, that is then sent to all the subscribers and updates the local copy of scene as well. In the top middle is the guest (subscriber) to she session, which has already transferred the scene from the server and is receiving updates from the host. Top right is the new client who transfers the most recent version of the scene from the server.***

The sharing of visualization data between users over network is not a novel idea. However, to the best of our knowledge, we do not know the implementation of the idea in such form. The data between users in Med3D can be shared in two ways. First option allows users to upload their data and make it available to other users of the framework. This is a common implementation done in multiple web-based collaborative applications. In this way the data is stored on the server and shared with selected users. The second approach, also implemented in our framework allows users to share data from current session. A user can share their session and define data sharing. Other users can connect to shared session and obtain the shared data in same form as original users has them. Such scheme is presented in Fig. 2.

3.2 Camera view sharing

While data sharing is quite common in many applications it is not very common to have an ability of sharing your view of the data as well. There are some examples of such collaborations in form of collaborative document editing (e.g. Google Drive). There are also applications that allow users to share their computer screen or single application window. But this still differs from our aim, where we wanted to enable user to have her own view on the data, but also have an option of seeing a view of a remote user.

We implemented this by sharing user's camera transformations with other users. Each user has an option to share her view and other users can attach to their shared view, thus sharing their viewing experience in real time, while still being able to switch back to their own view at any point in time. In our case this gives the users option to better explain their decisions and also to show which portion of the data they are currently studying.

Due to small amount of data being distributed between users there is no major latency between screen view synchronisation. The synchronisation speed is dependant on the latency of network itself between users and Med3D server. The distribution of camera transformations between users is also shown in Fig. 2.

3.3 Annotation sharing

Previously presented 3D position dependant annotations can also be shared with other users. Here we only share the content of the annotations and their anchoring position on 3D model, but not the position of actual annotation window in user interface. Each shared annotation is displayed in the middle of the screen upon its first display, but saves its position for individual user afterwards. This is done due to different sizes and aspect rations of individual screens (we do not want to put annotations outside the visible area for users with smaller screens).

Each user can decide whether she wants to share her annotations or not. In the future we will also implement the option of sharing individual annotation. List of local and shared annotations is displayed in left side of the Med3D user interface in Fig. 1.

3.4 Chat

Fourth collaboration modality is group chat integrated into Med3D framework. Such collaboration is not new but gives participating users option of communication. We implemented interactive chat because of low bandwidth consumption. The chat in framework is available to all the the participants in same session. An example of chat is displayed in Fig. 3 We are also planning on integrating voice and video conference support in later versions which were originally omitted due to their high bandwidth consumption.

4. EVALUATION

We have done preliminary evaluation with a medical expert who uses radiological data on everyday basis for diagnosis and preparations for medical procedures. The medical expert tried out the Med3D application and implemented workflow. He also tried out the presented remote collaboration features and pointed out that the implementation of collaboration is done well, but could use further improvements. First he missed integrated voice and video chat, the feature that is already planned for future implementation, and second, he missed an option of adding hand drawn annotations on desired view. This option allows doctors to better plan the procedure with visual annotations. We have added the proposed collaboration modalities to our list of future improvements.

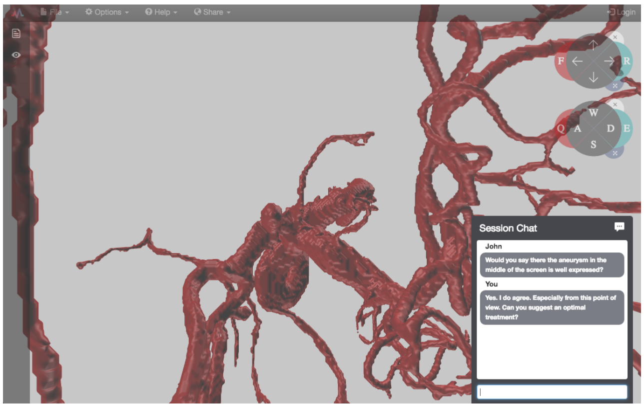

Figure 3: ***Integrated chat service for real-time discussions on displayed data.***

During the interview with a medical expert we got a good insight into desired workflow and features that allow doctors to improve their current work. The medical expert responded very positive to our implementation of remote camera synchronisation which enables collaborators in-depth study of the data from same point of view.

The medical expert has also pointed out that Med3D with well annotated data collection could also be used for educational purposes with support for students from experts with use of integrated remote collaboration modalities.

5. DISCUSSION

With integration of remote collaboration into medical visualization framework has proved as good idea according to the results of previous studies as well as from a positive feedback we got from the medical expert. We decided to integrate the remote collaboration option in an early stage of development of Med3D framework, which gives us the possibility of blending remote collaboration features with the single user workflow, making the features easier to learn and to use.

Our decisions were confirmed and supported with a preliminary evaluation interview with medical expert who gave us positive feedback with pointers on what and how to improve in the future. Medical expert also pointed out that the data visualization itself is very important and should be done well.

6. CONCLUSIONS AND FUTURE WORK

In this paper we have presented an integration of remote collaboration modalities into an existing web-based 3D visualization framework Med3D. We have presented each individual collaboration modality, presented results of a preliminary user evaluation and highlighted the pros and cons of presented collaboration modalities. The future work includes extension and specialization of each individual collaboration modalities, such as per user and per group permissions of collaboration options. We are also planning on introducing additional collaboration options in form of voice and video group calls between the users of the framework.

7. ACKNOWLEDGES

We would like to thank medical expert for great feedback on implemented features and guidelines for future improvements of the framework.

8. REFERENCES

[1] D. V. Beard, B. M. Hemniger, B. Keefe, C. Mittelstaedt, E. D. Pisano, and J. K. Lee. Real-Time Radiologist Review of Remote Ultrasound Using Low-Cost Video and Voice. *Investigative Radiology*, 28(8), August 1993.

[2] C. Bohak, S. Žagar, A. Sodja, P. Škrlj, U. Mitrović, F. Pernuš, and M. Marolt. Neck veins: an interactive 3D visualization of head veins. In *Proceedings of the 4th International Conference World Usability Day Slovenia 2013, 25 Nov, Ljubljana, Slovenia, E. Stojmenova (Ed.)*, pages 64–66, 2013.

[3] C. Bolan. Cloud pacs and mobile apps reinvent radiology workflow. *Applied Radiology*, 42(6):24–29, 2013.

[4] H. Handels, C. Busch, J. Encarnação, C. Hahn, V. Kühn, J. Miehe, S. Pöppl, E. Rinast, C. Roßmanith, F. Seibert, and A. Will. Kamedin: a telemedicine system for computer supported cooperative work and remote image analysis in radiology. *Computer Methods and Programs in Biomedicine*, 52(3):175 – 183, 1997.

[5] P. Khandheria. Integrating Tablet-Based Videoconferencing with an Image Viewer and a Shared PACS Session to Provide a Platform for Remote Consultation for Radiology Studies. In *Society for Imaging Informatics in Medicine*, Long Beach, CA, 2014.

[6] P. Lavrič, C. Bohak, and M. Marolt. Web based visualisation framework with remote collaboration support. In *Proceedings of 25th International Electrotechnical and Computer Science Conference ERK 2016*, to appear in september 2016.

[7] W. E. Lorensen and H. E. Cline. Marching cubes: A high resolution 3D surface construction algorithm. *Proceedings of the 14th annual conference on Computer graphics and interactive techniques - SIGGRAPH '87*, 21(4):163–169, 1987.

[8] P. Tually, C. Stavrianou, and J. Walker. User acceptance of the web-based distribution of radiology services in regional and remote centres of western australia. *Journal of Telemedicine and Telecare*, 11(2):93–95, December 2005.