An AR-solution for training and consulting during microscopic surgery

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Purpose

In microscopic surgery, teaching is a crucial and demanding task. With state-of-the-art optical microscopes, either the left or the right eye's view of the surgeon is captured and presented to the trainee, resident or any other co-observer. Today's more advanced optical microscopes also offer the possibility to capture the view of both eye's with the option to present the images in 3D on stereoscopic displays using polarizing glasses. With the latest generation of fully native digital microscopes, the image is captured by very sensitive, high-resolution video sensors and displayed in 3D in digital binoculars and/or on attached 2D/3D displays [1].
The challenging part in medical education is the moment when trainees perform their first surgery on their own. A close interaction between trainee and trainer is fundamental for both, the learning effect and the patient outcome.
During surgery even experienced surgeons face problems in instructing and consulting trainees or other surgeons, as today's interaction is limited to three possibilities: First, the expert may give verbal instructions, or secondly, can gesture on a remote monitor, with the disadvantage of distracting the trainee's view from the microscope's binocular to a display somewhere in the OR. This results in the trainee losing focus of the actual case and temporarily dropping the hand–eye coordination. Finally, the expert can wash-in and actively take over the microscope and indicate with a sterile instrument directly in the situs, while the trainee is following on the remote display [2].
To overcome these workflow interruptions during surgical training or even for consultancy, we developed an augmented-reality tool for a digital microscope. This enables the consultant/trainer to telestrate in real-time. Telestrations/annotations become directly visible in the surgeon's binocular, right in front of the trainee's eyes.

Methods

Integration of the augmented-reality-tool was done in a fully digital microscope (ARRISCOPE, ARRI Medical GmbH, Munich, Germany). This microscope captures the magnified image with a high performance CMOS sensor with a resolution of 3392x2200 pixels (px) and a framerate of 60 fps. The captured image is then processed by the integrated computer, divided into the images for the left and right eye and displayed on digital OLED binoculars, each with a resolution of 1920x1080 px and other attached 2D/3D displays.
As input device for the telestrator, the touch-screen user-interface (UI) of the microscope with a resolution of 1920x1080 px is used. After starting the telestration application, the image as displayed in the left binocular is presented on the touch UI. Any input positions on the UI are captured and the respective touch position for displaying in the right binocular calculated by applying a linear transformation based on the fixed, known disparity.

In the image processing chain, the respective input on the touch display is then overlayed in real-time to the live image in both binoculars as illustrated in Fig. 1 for one binocular. To indicate that the mode for assistance is activated, a small surrounding border is added.

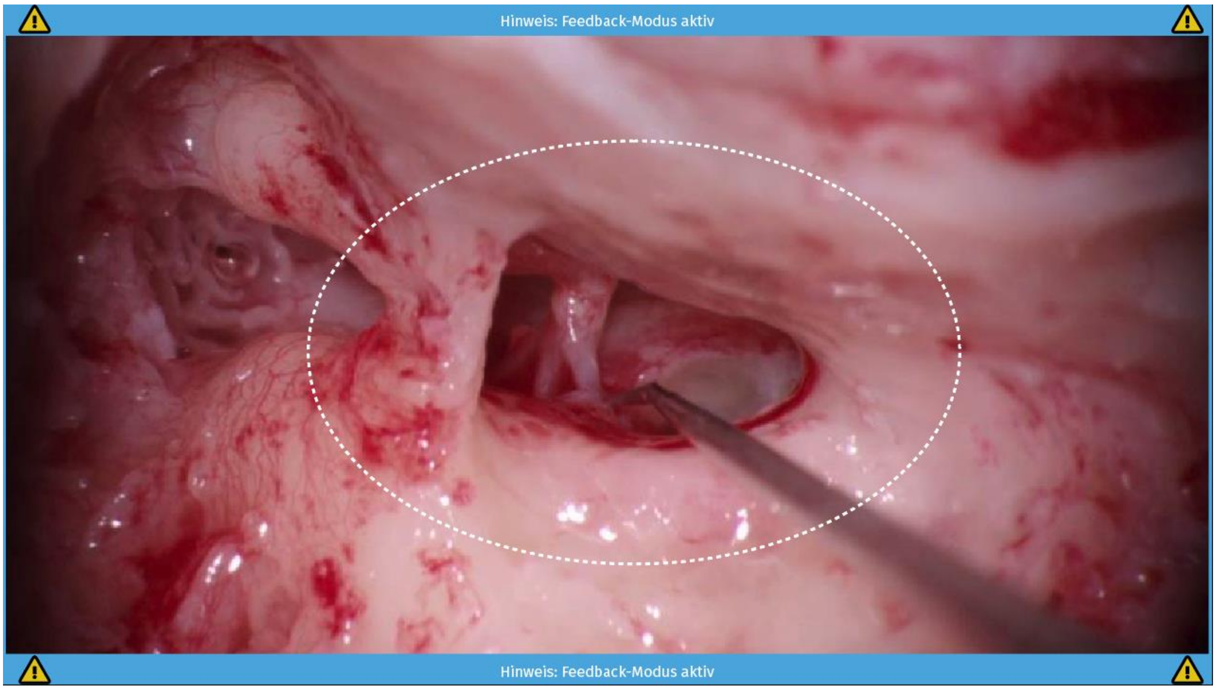

Fig. 1 View of the augmented image of the left binocular with indication in the blue frame that telestration mode is active

As requested by surgeons, different display methods were developed. In the user interface on the touch display (Fig. 2), either an arrow can be chosen, but also the possibility to draw lines or circles for marking resection margins or tissue structures are given. In order to avoid misinterpretations, any annotation will be immediately removed when the microscope is moved.

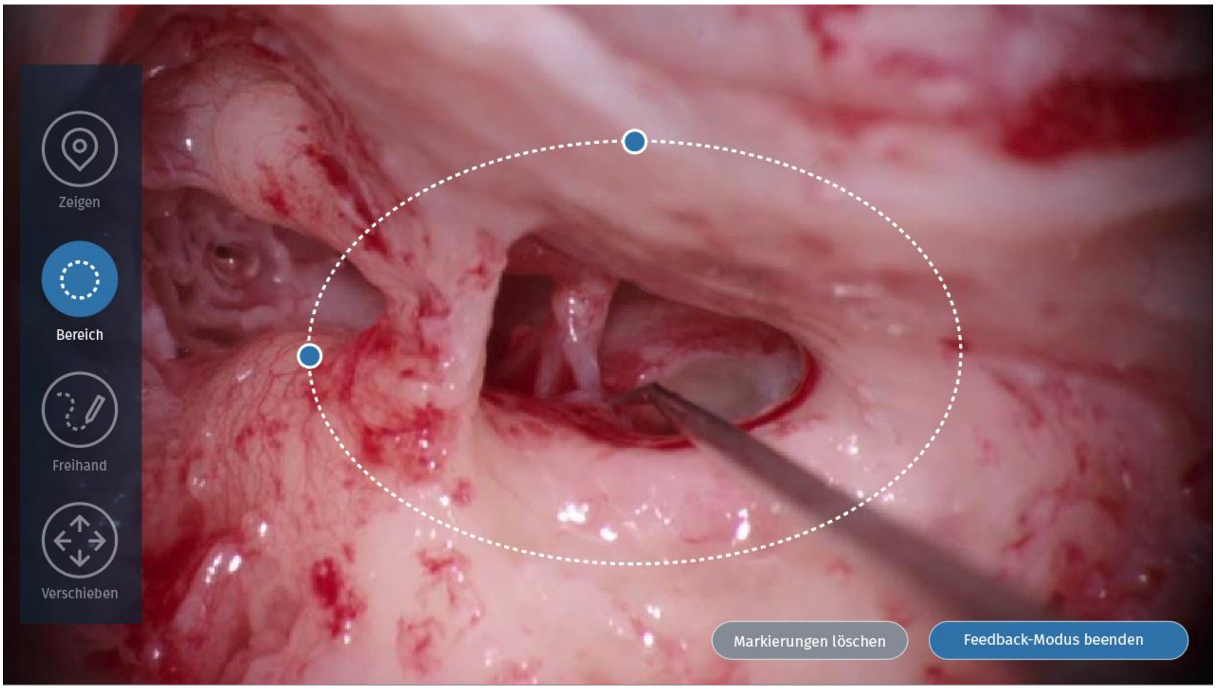

Fig. 2 Display on the touch UI with control panel for the telestration mode on the left side

To validate the tool, a principal in vitro study with participants of different training levels based on recorded video material and on artificial temporal bones was conducted.

Results

The evaluation has shown that augmentation of the live image can be done without any visual observable additional latency. Because of the known fixed disparity, augmentation is possible in a comfortable depths'' visualization. Nevertheless, the augmentation is currently not related to the image content, resulting in an augmentation remaining at the same position, even if the image content is changing due to heartbeat or respiratory movements.
The arrowhead in combination with verbal explanation is the tool mostly used for telestration, particularly due to the possibility to move this dynamically on the display. The study participants reported that our tool significantly improves the training effect, since distractions of the workflow are avoided. Trainers reported a better interaction and reduced misunderstandings while educating.

Conclusion

It is shown, that telestration is an effective method to improve communication and training between trainee and trainer during microscopic surgery. It is expected, that this tool will also have an impact on patients' safety, as surgeons remain focused on the procedure without being distracted by workflow interruptions. Furthermore, the hurdle to call a consultant will be reduced, since the cumbersome and time-consuming washing-in procedure will be avoided.

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