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From *Déjà vu* to *Déjà vécu*: Reliving Surgery in Post-Operative Debriefing

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ABSTRACT

Learning and continuous improvement of skills, both surgical and non surgical are goals surgeons pursue all along their training and career. Postoperative debriefing is a key tool to improve performance continuously in one's career. This retrospective analysis of surgical procedures is usually performed through rewatching action through video, which provides surgeons with only an outside view of their actions, and display information such as patient physiological data in ways different than when perceived during live action. We argue that VR (Virtual Reality) through HMDs (Head Mounted Displays) can mitigate and even overcome these limitations through providing an immersive experience that enables surgeons not only to re-watch action (*déjà vu*), but to re-live action (*déjà vécu*). Moreover, it can bring new opportunities, such as adopting another person's perspective to better understand their points of view.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality;

1 INTRODUCTION

Becoming a surgeon involves mastering a diverse set of skills. The curricula includes both technical skills, such as identifying anatomies, targeting, exposing and performing resection; as well as non technical skills such as developing situational awareness, making decisions, communicating and leading a team. These skills do not only need to be learned during initial training but they also need to be updated throughout professional practice. One way to do this, is to take part in a retrospective analysis technique called *post-operative debriefing*. The use of surgical video recording as a basis for debriefing is widespread and has shown its effectiveness in terms of learning and improving the surgical skills acquisitions [5, 10]. It can be combined with the recording of intraoperative medical data in systems as black boxes [9, 24]. The perpetual quest to improve practices leads us to question of whether video is an optimal tool for postoperative debriefing.

We posit that video falls short when it comes to reliving experiences from your own inside perspective, and when processing the ever more numerous and complex data that can be recorded during surgery. It is therefore relevant to turn to new technologies in order to find a more suitable medium for debriefing. We believe that VR (Virtual Reality), especially through HMDs (Head Mounted Displays), can overcome the limitations of video for surgical debriefing, due to their immersive nature. This technology provides first person views, situated as when the action took place, and thus has the potential to provide an opportunity to relive events in realistic ways. To our knowledge, no research has explored its potential in the field of postoperative debriefing.

2 POSTOPERATIVE DEBRIEFING

Debriefing is the act of analysing an event or a situation retrospectively, which has been shown to improve learning and other outcomes in a variety of fields, including military, education, and healthcare [1, 6]. In the medical field, and more specifically in surgery, postoperative debriefing can take many forms. It can take place on site directly after surgery (hot debriefing) or at a later time (cold debriefing) [24], and the focus can vary widely, including on the learner's knowledge, the course of the operation, the learner's surgical strengths, difficulties, and areas for improvement. It can also take place between expert surgeons and concern rare surgical operations, those that have been particularly problematic or marked by a negative event.

Postoperative debriefing is considered a tool that improves both technical and nontechnical skills such as communication, teamwork and situational awareness [24]. It is thus considered necessary, educational and easily available by resident surgeons [7]. As part of a larger strategy of Comprehensive Surgical Coaching (CSC), and in combination with other strategies including performance analysis, feedback, and behavior modeling, it has been shown to improve surgical training and skill acquisition compared to conventional training [4]. Nevertheless, postoperative debriefing may be limited by fear of judgment, lack of time or lack of appropriate technology [24].

2.1 Video Debriefing

The use of video review is a commonly-used tool for debriefing, it lets learners watch themselves from the outside, and enables the team to share the same mental model about the situation. It enables the observation and evaluation of verbal and non-verbal language. Video was initially used as a tool for self-confrontation, as learners evaluated themselves through reflection by watching the video alone. However, previous work has identified that one of the main challenges is to balance individual learning experiences with expert knowledge, if we want to rethink teaching towards better learning [15]. Indeed, previous work has shown that when linked with expert feedback, using video for debriefing is more effective than when performed simply as a self-assessment, in which case it is more effective than other forms of traditional feedback (without video), as a literature review shows [11].

Specifically in surgery, research showed that using video is a key ally in improving classic postoperative debriefing. In 2013, Farquharson [5] showed in a randomised controlled trial, that combining video review with verbal feedback leads to an improvement in surgical skills acquisition when compared to verbal feedback alone, and authors suggests its integration into surgical learning programs. What is more, the use of video debriefing can reduce adverse events from technical errors in laparoscopic surgery, as it has been shown for anastomoses [10].

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2.2 Supplementing Videos with Medical Data

Other types of data can be recorded in parallel to video, as surgical procedures are high-risk situations and their retrospective analysis can take into account, in addition to the surgical act itself, social aspects including the dynamics of the operating theatre team, its coordination, and the communication among its members. Modelled on the aviation industry, operating room black box models have been developed. In 2005, Guerlain [9] created a recording and analysis system called RATE (Remote Analysis of Team Environment) enabling the recording of audiovisual data (4 videos feeds and 8 audio feeds distributed in the operating room that can be individually analysed), the scoring, the notation and the analysis of surgical team's performance. In a study of 35 laparoscopic abdominal cases, Van Dalen and colleagues [24] used a Black Box to record the patient's audiovisual feeds and anesthesia patient-monitoring device. These data were automatically analysed by artificial intelligence which outputs a "blackbox" performance report including the creation of video segments. The authors propose the Amsterdam Black Box Debrief Model, comprising six steps: Introduction, experience, observation, analyse, application and summary; to help debrief this type of information. As more and more information is recorded for debriefing, we question whether video is an adequate media to support surgical debriefing.

2.3 Are Current Technologies Sufficient for Debriefing?

We put into question whether using video to visualize the myriad of activities in the operating room is enough for effective postoperative debriefing. Mainly, we identify two limitations of video.

Outside View Only. First, through recorded video of the OR, learners see themselves from the outside, which can be difficult for "reliving" the surgery, and thus to recreate the situation. The way in which we create mental constructs is influenced by the way we perceive and move [3, 22], and traditional displays such as video could therefore be insufficient to accurately transcribe the perception of an event.

Large and Complex Data. Second, there is a large amount of data constantly being produced in the OR. During live action, people access this information selectively, as they can direct their attention towards the area that has the information when they need it. For example, a surgeon can look at a negatoscope hanging on a wall when they want to see a preoperative image, or they can look at the instrument table when making decisions based on the state of the current available tools. Using video to display this data translates into the need for a bigger screen estate to spread the information across the pixels, all being displayed at the same time. However, the complex task of parsing this information requires cognitive resources that the learner should direct towards the debriefing task.

It is relevant, and pressing, to push the boundaries of video and study new technologies for better supporting postoperative debriefing.

3 VR FOR POSTOPERATIVE SURGICAL DEBRIEFING

We believe that VR (Virtual Reality) through HMDs (Head Mounted Displays) can mitigate, if not overcome, these limitations of video for postoperative surgical debriefing. Firstly, because through VR learners can stand in their own shoes and have an *inside view* of the action, reliving the experience from a first person perspective. Second, because the recorded data from the OR can be displayed in the same manner as when it was recorded, therefore it can be accessed in the same way (i.e., looking towards the wall to see the X-Ray hanging) and without requiring unrealistic interaction (i.e., opening a menu and selecting the image).

Our expectation comes from the fact that VR-HMDs has the capacity to provide a immersive experience, that simulations are common in surgical learning, and that the required technologies for recording are readily available.

VR provides immersion. VR-HMD gives a superior spatial awareness though the senses of movement, balance (vestibular sense) and proprioception compared to conventional screens [14]. Authors have found overall positive results from VR in terms of information detection, learning and memory recall ability [14, 18, 23] compared to conventional displays.

VR facilitates reliving experiences. When it comes to replaying moments, 3D recordings and HMDs have been used successfully in the past in other fields, adding an immersive dimension. For example, it has been explored for immersive serious games, where Prasolova-Førland [19] hypothesized that a replay system would enhance students' experiences, enable the creation of tutorials for future students, and that students would benefit from coming back to the recording with additional participants. Also, in debriefing air-to-air combat through replay, Amburn [2] showed that HMDs have the ability to convey situational awareness, and can outperform a console display system.

Simulations are common in surgery. Lastly, the fact that simulations are commonly used in medicine and surgery, means that the concept and technology are not new and can be integrated into the path of medical teaching, even when they include a large amount of information. In their 109 articles literature review, Issenberg [12] found 11 articles that cited that simulators that capture a wide variety of clinical conditions as more useful than those with a narrow range. That is, "*simulations capable of sampling from a broad universe of patient demographics, pathologies and responses to treatment*". Additionally, the authors highlight studies that identified a correlation between effective learning and simulation validity, namely, "*the degree of realism or fidelity the simulator provides as an approximation to complex clinical situations*".

Stereoscopic recordings of the OR are realistic. One of the challenges for carrying out this approach, is the capture of the environment with all its complexity of information. There have been several attempts to create immersive environments based on stereoscopic OR recording. Some aim at preparing the first experience to make it less shocking [13], while others at documenting surgical skills [16, 20, 21]. Stereoscopic recordings can be used to complement existing footage from a 3D microscope and therefore document not only the surgical view but also earlier phases such as the "*opening, approach and closing of the surgical site*" [16]. Those types of recordings are promising as they can improve the feeling of presence when they are used. Furthermore, expert surgeons believed in "*pedagogical interest of this method*" [21] and appreciated 360° view of the operating room [20]. Those recordings can also serve as a base to create interactive simulation and enable users to interact with tools and anatomy [20].

To our current knowledge, some attempts have been made to create pedagogical content from stereoscopic recording of the OR but no research has explored its potential for replay system in a surgical context. Conversely, debriefing systems have not explored yet the potential that immersion can offer.

4 CREATING NEW OPPORTUNITIES BEYOND VIDEO

Beyond mitigating the limitations of video, we believe that VR can open new possibilities for surgical postoperative debriefing.

4.1 Supporting Selective Attention

When multiple sources of video are recorded in parallel, video debriefing requires learners to juggle through the multiple available streams. It is thus challenging to present these different feeds of information in an intelligible way. Matsuda [17] explored an automatic zoom feature to highlight one particular video that embodied the main action, although this was not satisfying for users. VR opens the possibility to keeping sources of information in the same place as where they are located in the OR, and thus learners look towards them intuitively, as they do when they operate.

4.2 External Experts Can (Re)live The Experiences

VR opens the way to providing external experts with the opportunity of living an experience when they did not participate in the first place. Research can focus on this case, to study if the experience gives a closer resemblance to being part of the live action than video, and also to explore if this new types of surgery documentation can help experts give better quality feedback. As this VR experience does not necessarily require learners and external experts to be collocated, it opens the possibility to include experts that are not part of the same hospitals. Remote experts could join the virtual operating room for debriefing and experience first-hand the logistics of another hospital and practices of another surgical team. This could be based on existing telementoring systems such as ARTEMIS [8] that includes avatars, hand avatars, situated telestrations and possibility to add additional video content to illustrate expectations.

4.3 (Re)experiencing Colleagues Perspectives

Immersive debriefing provides an opportunity for surgeon's to "put themselves" in their colleagues' shoes. They can experience action from the perspective of someone else, engender empathy, and enlarge their comprehension of the activity. This unique angle of experience can shed new light on their own understanding of what happened, as it can provide rationale on why someone acted a certain way, for instance by realizing that they did not have access to certain information because of their viewpoint or distance to someone else. This experience may help colleagues build empathy and develop better nontechnical skills, including communication and teamwork practices.

4.4 Dissecting Experiences As They Unroll

Another possibility we envision is for the entire team to get back into situation, replaying the situation from their own perspectives, and stopping the simulation as important milestones are achieved to discuss misunderstanding, switch viewpoints, and propose alternative paths. In this way, it would be possible to recreate conditions of tensions, stress, and time demands, giving a chance to analyze the situation "in-situ".

5 CURRENT STATE OF OUR RESEARCH

We are at the very early states of this research. We are beginning to consider this approach for debriefing. Regarding the application scenario, we are considering the case of anexectomies in gynecology, where there are heavy adherence to the digestive tract. Learning to perform the gestures involved in removing such adherence (adhesiolysis procedures) is complex, involving in-situ decision making from unexpected findings as the procedure advances. It is of interest to relive the adhesiolysis procedures in order to improve learning, as each case is unique.

We do not have yet conducted preliminary studies, as we are studying the technological needs for setting up the research. Participating in this workshop will be of great benefit for us, as it will let us exchange with other participants, and capitalize on their experiences when working with VR HMDs.

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