A Tool to Support Surgical Quality Assessment

Marco A. Hudelist, Bernd Münzer, Sabrina Kletz, Klaus Schoeffmann
Klagenfurt University
Universitätsstrasse 65-67
A-9020 Klagenfurt, Austria
Email:{marco,bernd,sabrina,ks}@itec.aau.at

Heinrich Husslein
Medical University of Vienna
Währinger Gürtel 18-20
A-1090 Vienna, Austria
Email:heinrich.husslein@meduniwien.ac.at

***Abstract*—In the domain of medical endoscopy an increasing number of surgeons nowadays store video recordings of their interventions in a huge video archive. Among some other purposes, the videos are used for post-hoc surgical quality assessment, since objective assessment of surgical procedures has been identified as essential component for improvement of surgical quality. Currently, such assessment is performed manually and for selected procedures only, since the amount of data and cumbersome interaction is very time-consuming. In the future, quality assessment should be carried out comprehensively and systematically by means of automated assessment algorithms. In this demo paper, we present a tool that supports human assessors in collecting manual annotations and therefore should help them to deal with the huge amount of visual data more efficiently. These annotations will be analyzed and used as training data in the future.**

I. Introduction

Laparoscopic surgeries demand highly trained psychomotor skills of the performing surgeon as they directly influence the overall performance of a surgery. It has been shown in the literature that surgical errors occur frequently during a surgery due to its nature as high-performance, high-risk undertaking, which is subject to human error and adverse events [1], [3]. As such errors are often not obvious to the operating surgeon, they may go unnoticed during the actual surgery, thereby preventing the opportunity for improvement in future cases. Therefore, over the years medical experts have proposed to perform error analysis and managing surgical errors in order to improve patient safety [6], [2], [5].

A recent approach in this context is the *Generic Error Rating Tool* (GERT) [1]. It defines four error modes as well as nine generic surgical tasks, according to laparoscopic surgery, during which these errors could occur. These tasks and error modes are collected by an inspecting surgeon in a checklist and finally rated to assess the performance of the operation.

The main problem, however, is that there is currently no support by special multimedia tools for the surgical quality assessment process. Inspecting surgeons have to use a simple video player and external checklists (on paper or electronically) to visually revisit the surgery and watch its video recording entirely again. This is extremely time-consuming and error-prone itself, and is additionally hindered by the fact that the video archive increases with each day, resulting in an extremely large amount of video data, whereas even a recording of a single surgery can be several hours long.

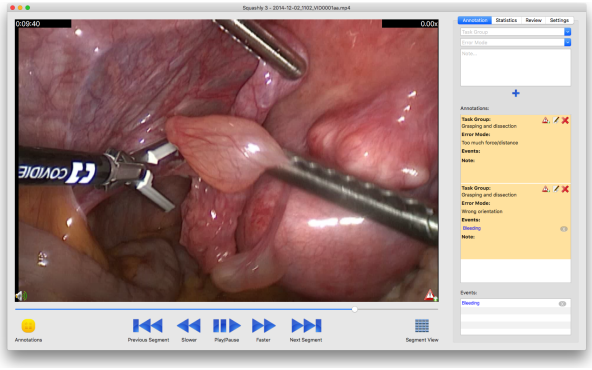

Fig. 1: User interface of the proposed tool for surgical quality assessment (video playback mode).

Therefore, in this paper we present a collaborative effort with a medical expert in surgical quality assessment to improve the current situation by providing users with a powerful and tailored software solution for this task. This work is an early step to obtain manual ratings from users, which should be used as training data in the future to partially automatize the quality assessment task. This will enable comprehensive and systematic quality assessment for each and every procedure, which is truly a big data problem.

II. User Interface

The user interface consists of three parts: (a) a *content area* at the top left, (b) a *navigation area* at the bottom and (c) an annotation area on the right. Figure 1 illustrates the UI layout.

a) Content area: This area is used for content inspection and therefore occupies the largest space of the screen. By default, it displays a video player that fills the entire space. Alternatively, the user can switch to a *segment browsing mode* that shows a decomposition of the video into segments with a uniform duration (e.g., 10 seconds), as illustrated in Figure 2. This mode is useful to get an overview of the entire video and enables the user to quickly find specific scenes. The third mode provides annotation search and filtering functionality. The user can specify search criteria like target group, error mode and note text. The matching segments are then displayed as thumbnails in the content area.

b) Navigation area: This area offers custom controls for the different modes of the content area as well as links to

Preprint of the paper to appear in the IEEE Proceedings of the Third International Conference on Multimedia Big Data(BigMM 2017), Laguna Hills, CA, USA, April 2017

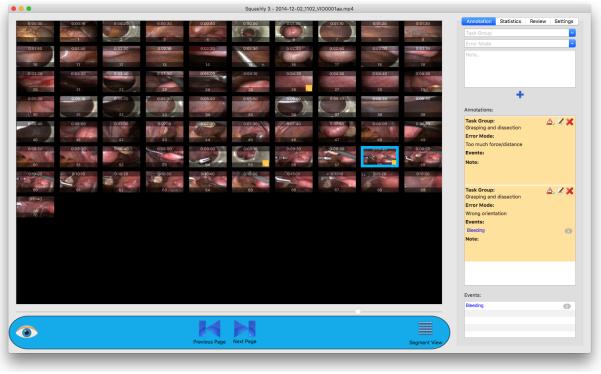

Fig. 2: Segment browsing mode.

the alternative modes (video playback, segment browsing and annotation search/filtering). In video playback mode, buttons for play/pause, fast forward/rewind and next/previous segment are displayed. Every click on the fast forward/rewind buttons increases or decreases the playback speed by steps of 0.25 (where 1.0 is normal speed). Furthermore, frame-by-frame navigation can be accomplished by using the arrow keys when the video is paused. The segment navigation buttons (next/previous) are used to jump between annotated segments.

c) Annotation area: In this area users enter their annotations – therefore it can be considered as the core of the system. Every user input (annotations and settings) is automatically saved, i.e., there is no need for the users to explicitly save their current status. The annotation area consists of four tabs: Annotation, Statistics, Review and Settings.

The *Annotation* tab is used to add annotations to the currently displayed segment. An annotation consists of:

- A task group according to GERT [1]: (1) abdominal access, (2) use of retractors, (3) use of energy devices, (4) grasping and dissection, (5) cutting, (6) transection and stapling, (7) clipping, (8) suturing, and (9) use of suction.
- An error mode according to GERT: (1) inadequate use of force or distance (too much), (2) inadequate use of force or distance (too little), (3) inadequate visualization, and (4) wrong orientation of instrument or dissection plane.
- An optional free text note.
- Optional links to events, whereas an event is defined as "*an action that may require additional measures to avoid an adverse outcome*".

Annotations can also be edited or deleted. Moreover, the tab shows a list of existing annotations, which is updated automatically when a different segment is entered during playback. The list entries serve as links to the corresponding positions in the video, i.e., when the user clicks an entry the video player re-positions accordingly. The same linking feature is also implemented for events.

The *Statistics* tab displays aggregated information about the surgery, e.g., the total amount of annotated errors, number of errors per task group, or error types per task group.

The *Review* tab is used to perform an overall rating of the procedure as a whole. First, the user has to enter a name

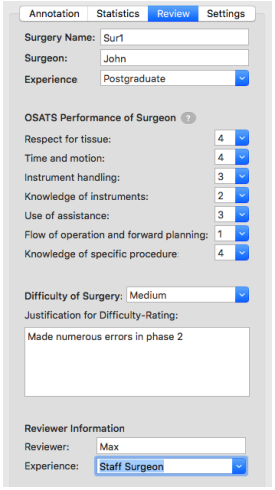

Fig. 3: Assessment of a surgery according to OSATS [4].

for the procedure, the name of the executing surgeon and his experience level. To rate the overall performance, the OSATS metric is used (*Objective Structured Assessment of Technical Skills* [4], see Figure 3). Finally, users can define the overall difficulty of the surgery, a justification for their difficulty rating, as well as name and experience level of themselves as reviewers.

The *Settings* tab allows adjustments of the systems behavior. This also includes video import and export of the annotation data. Furthermore, the list of available task groups and error modes can be modified. By default, this list complies with GERT, but it can be customized to satisfy every users needs.

III. Conclusions

This demo presents a first step towards computer-aided surgical quality assessment and will help surgeons to more efficiently inspect and annotate video recordings of their surgeries. It includes specific annotation features according to established assessment methods, such as OSATS and GERT. Moreover, it includes efficient video content navigation features to allow for quick navigation in large video archives.

References

[1] E. M. Bonrath, B. Zevin, N. J. Dedy, and T. P. Grantcharov. Error rating tool to identify and analyse technical errors and events in laparoscopic surgery. *British Journal of Surgery*, 100(8):1080–1088, 2013.

[2] E. N. de Vries, M. A. Ramrattan, S. M. Smorenburg, D. J. Gouma, and M. A. Boermeester. The incidence and nature of in-hospital adverse events: a systematic review. *Quality and Safety in Health Care*, 17(3):216–223, 2008.

[3] M. MA. The power of video recording: Taking quality to the next level. *JAMA*, 309(15):1591–1592, 2013.

[4] J. A. Martin, G. Regehr, R. Reznick, H. Macrae, J. Murnaghan, C. Hutchison, and M. Brown. Objective structured assessment of techn. skill (osats) for surgical residents. *British Journal of Surgery*, 84(2):273–278, 1997.

[5] R. Rosenthal, H. Hoffmann, K. Dwan, P.-A. Clavien, and H. Bucher. Reporting of adverse events in surgical trials: Critical appraisal of current practice. *World Journal of Surgery*, 39(1):80–87, 2015.

[6] J. M. Rothschild, C. P. Landrigan, J. W. Cronin, R. Kaushal, S. W. Lockley, E. Burdick, P. H. Stone, C. M. Lilly, J. T. Katz, C. A. Czeisler, and D. W. Bates. The critical care safety study: The incidence and nature of adverse events and serious medical errors in intensive care*. *Critical Care Medicine*, 33(8), 2005.