Workflow efficiency pilot study of Surgery Viewer©: A secure hands-free intraoperative multimedia interface for Google Glass™

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Abstract

Background: The Google Glass™ heads-up-display system has been adopted by the medical field for applications such as image capture, live streaming and decision support.
Methods: We designed a custom application for Google Glass™ called Surgery Viewer© to capture patient images and securely transfer them to the electronic medical record. Surgery Viewer© was compared to a standard digital camera and an Apple iOS© device using another image capture application. Comparative workflow metrics included timings of image capture and a usability survey.
Results: Ten patients were studied in operating room and wound clinic settings. Average times to log in (Surgery Viewer©, Image Capture™) or turn on (digital camera) were 18.39 s, 9.91 s and 2.11 s for Surgery Viewer©, Image Capture™ and digital camera, respectively. In the operating room, the average times to select the correct patient were 3.06 s, 14.77 s and 4.45 s for Surgery Viewer©, Image Capture™ and digital camera, respectively. Average image capture times were 8.67 s, 7.77 s and 7.60 s for Surgery Viewer©, Image Capture™ and digital camera, respectively. Images captured by Surgery Viewer© and Image Capture™ were instantaneously uploaded to the electronic medical record, but digital camera images took on average 1522 s to be uploaded. In the wound clinic, the average times to select the correct patient were 16.29 s, 7.35 s and 4.63 s for Surgery Viewer©, Image Capture™ and digital camera, respectively. Image capture times were 9.55 s, 5.28 s and 3.47 s, respectively. Digital camera took on average 27,758 s to upload.
Conclusion: Surgery Viewer© performed equivalently with Image Capture™ while digital camera took longer to upload. Users found the application easy to learn with Surgery Viewer© concerns, including log on procedure, ambient distraction from voice recognition, viewfinder perspective and battery life.

Introduction

Capturing surgical images can be challenging. Issues include Health Insurance Portability and Accountability Act (HIPAA) compliance, the sterile field and interruptions in workflow.[1] Current technology is limited to handheld digital cameras (DCs) operated by persons outside the sterile field or cameras mounted to the surgeons' heads. Adjusting camera options such as the field of view, lighting and timing while limiting disruption of the operation can be difficult.

The Google Glass™ heads-up-display system has been tested by the medical field for applications such as image capture, live streaming and decision support. Specifically, its hands-free voice control operating system is appealing to surgeons. However, very few studies have been reported in the literature using Google Glass™ for this purpose.[1–7] Common concerns about its use by physicians include privacy with cloud data transmission, accuracy of data sent and received and its clinical efficiency.

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Figure 1. Google Glass™ Explorer Edition used in this study personally owned by lead author.

This prospective pilot study evaluated the intraoperative and clinic workflow efficiency of a proprietary application written for Google Glass™ to capture images of the surgical field. The application links to the patient's electronic medical record (EMR) and transmits the captured images directly to their record. The study compared this application to another proprietary application for image capture using a cellular phone and to a handheld DC. The study was classified as a quality improvement project with an institutional review board (IRB) exemption as the data and images were de-identified and no patient care interventions were made. In addition, surgical consent forms include permission to use captured images for research and education at our institution.

Methods

Google Glass™ is a monocular heads-up-display unit that presents graphical information to the upper outer corner of the peripheral vision of the user's right eye (Figure 1). The glasses include a 5-megapixel camera, a microphone and speakers using bone conduction technology. Its battery is embedded within the frame while supplemental power and peripherals are connected via a standard micro USB port. Users interact with the glasses using Google™ voice recognition and a touchpad on the right temple frame. Google Glass™ runs on the Android operating system and includes support for Wi-Fi.[8]

In collaboration with the Tiger Institute for Health Innovation™ (Cerner Corporation, Kansas City, MO), we designed a custom application for Google Glass™ called Surgery Viewer© (SV) that allowed the surgeon to use voice commands to capture patient images with remote access to that patient's EMR. Prior to scrubbing into a sterile field, a micro USB Bluetooth dongle was used to pair a wireless handheld keyboard with the glasses. Users logged onto the application using the keyboard then disconnected the Bluetooth dongle. The user's PowerChart™ EMR patient lists were then accessible, allowing one to select the patient

whose images they would capture by swiping through the list using the touchpad. Image capture times for SV included verbally calling up the viewfinder, lining up the shot and verbally capturing the image. Alternatively, one could verbally capture the image without calling the viewfinder. Subsequently, all images captured within the SV application were tagged with the date and time and transmitted to the patient's EMR immediately after capture where they were automatically filed into the Surgical Imaging folder for editing and embedding within patient documentation. Image transfer bypassed local Google Glass™ storage without upload into the Internet cloud.

Another proprietary application in use at our institution is Image Capture™ (IC). This application for Apple's iOS™ operating system allows the user to select a patient from their EMR after logging in with their credentials. Subsequently, all images captured by the IC application are uploaded to the patient's EMR multimedia manager, bypassing local device storage and Internet cloud upload. The application allows the user to select the folder for image storage into the multimedia manager after each capture. The date and time of image capture is also recorded in the multimedia manger. For the purposes of this study, IC was used on iPhone 6 devices with 8-megapixel resolution.

When using a traditional DC to capture images, the first image captured is of the patient's identification label which included their name, date of birth and that visit's identification number. All subsequent images captured by DC were manually associated with the label upon hardwire download via a computer. The downloaded images were then manually uploaded to that patient's EMR multimedia manager and manipulated as explained previously.

This pilot study compared SV, IC and DC in an operating room and in an outpatient surgical wound clinic. All images were captured under similar lighting conditions across all modalities in the clinic and the operating room. In addition to an Explorer Edition of Google Glass™ for the SV modality, an iPhone with flash or iPad running at least iOS 9.0 was used for the IC modality and a Canon 12-megapixel DC with flash for the DC modality. Metrics used to evaluate the success of the pilot study included timings of image capture comparing the three modalities and a system usability survey (SUS) to assess Google Glass™. Other logistical issues were also documented, including intraoperative management of the SV application and Google Glass™ battery life. No power calculation was performed for sample size as this study was not designed to assess statistical significance, but to assess the feasibility of using Google Glass™ and the Surgery Viewer™ (SV) application prior to initiating a larger scale study and purchasing more glasses for the institution.

Results

Average setup times were 2.11 s, 9.91 s and 18.39 s for DC, IC and SV, respectively. These times were equivalent between

clinic and operating room settings as both were performed before the patient encounter; that is, not scrubbed into the sterile field. Ten patients were studied, four in the operating room and six in the wound clinic (Table 1).

Operating room

The average times to select the correct patient were 3.06 s, 14.77 s and 4.45 s for SV, IC and DC, respectively (Table 1). Average image capture times were very similar across platforms at 8.67 s, 7.77 s and 7.60 s for SV, IC and DC, respectively. These were also the times taken to capture the initial patient image with each modality. Alternatively, it took only an average of 4.9 s over 10 independent attempts to capture an image with SV by simply verbalizing the image capture command without loading the viewfinder first. This was done with the SV for subsequent images captured during the case. Significant differences were noted, however in image upload times. While images captured by SV and IC were instantaneously uploaded to the EMR's multimedia manager, the DC images took on average 1522 s to be manually uploaded to the patient's records. This was very user dependent. There were instances early in our study when the Google Glasses™ powered down during a case due to battery power loss. Battery life was not recorded in this study, but one 3- to 4-h case would exhaust the available battery power. This was remedied by a wired supplemental battery pack worn in the surgeon's back pocket as well as software modifications allowing the SV application to sleep, thereby conserving battery power draw from the screen. Rarely, prolonged sleep time allowed the application to close during a case which unfortunately rendered the glasses unusable without physically removing them and logging in again. This was not possible without scrubbing out of the case.

Outpatient surgical wound clinic

In the wound clinic, the average times to select the correct patient were 16.29 s, 7.35 s and 4.63 s for SV, IC and DC, respectively (Table 1). Image capture times were again similar at 9.55 s, 5.28 s and 3.47 s, respectively. Once again SV capture times included verbally calling up the viewfinder to line up the shot and capture the image. As noted in the section "Operating room", it took only an average of 4.9 s to capture images with SV without loading the viewfinder first. Upload times were significantly different with the DC taking on average 27,758 s to upload to the patient's multimedia manager. This was also user dependent. Battery life was not a problem in the clinic setting as the glasses were removed and connected to the micro USB charger in between cases. The SV application did stay open in between most cases; however, prolonged downtime or sleep time did occasionally require reopening the application and logging in with the user's credentials.

Table 1. Comparative timing metrics for each modality and location.

Operating room	SV	IC	DC
Setup time	18.39 s	9.91 s	2.11 s
Patient selection time	3.06 s	14.77 s	4.45 s
Photo shooting time	8.67 s	7.77 s	7.60 s
Upload time	0 s	0 s	1522 s
Surgical wound clinic	SV	IC	DC
Setup time	18.39 s	9.91 s	2.11 s
Patient selection time	16.29 s	7.35 s	4.63 s
Photo shooting time	9.55 s	5.28 s	3.47 s
Upload time	0 s	0 s	27,758.3 min

SV: Surgery Viewer©; IC: Image Capture™; DC: digital camera.
Setup time: Logging in to the application (after phone and Glass™ turned on) or turning on the digital camera. Patient selection time: Selecting the correct patient within the application or capturing their name tag ID number with the digital camera. Photo shooting time: Setting up the shot including positioning, framing and capturing. Upload time: Time from capture to upload to the EMR multimedia manager.

Table 2. Usability survey results.

Question	User 1 (PGY-3)	User 2 (PGY-5)
I think I would use this frequently	5	4
It is unnecessarily complex	2	2
Easy to use	5	4
I would need technical support	1	2
Systems were well integrated	5	5
Too much inconsistency in system	1	1
Most would learn it quickly	5	3
Cumbersome to use	4	3
Confident using it	5	4
Need to learn a lot before using it	1	1

PGY: post graduate year; 1 – strongly disagree, 2 – disagree, 3 – neutral, 4 – agree, 5 – strongly agree.

Usability surveys

Two usability surveys were taken from surgical residents that used SV in the operating room for several cases (Table 2). There was very close reliability in SUS scores between them. Both users found the system well-integrated and easy to use and felt confident using it. They also found the learning curve to be shallow without unnecessary complexity and felt that most would learn the system quickly. Finally, they both would use the SV system frequently. Separate comments by the users focused on the SV log in procedure which required a keyboard and Bluetooth dongle. Suggestions included scanning a QR code with the glasses versus a near-field communication (NFC) solution. They also noted the inability to log back into the SV application while scrubbed using the keyboard. Both users emphasized the need for initial hands-on

instruction by an experienced user. These users and the lead author (S.A.) were impressed by the accuracy of the voice recognition by Google Glass™. Ambient chatter was occasionally perceived as commands by the glasses while the user was speaking to it.

Discussion

Our prospective study quantified the workflow efficiency of a proprietary HIPAA-compliant image capture application for Google Glass™. It is one of the very few studies to compare the application's performance on Google Glass™ with traditional tools such as the DC and the handheld phone using standard metrics. SV's performance was comparable to that of IC with the added benefit of hands-free intraoperative use by the surgeon through their point-of-view. Both SV and IC had clear advantages over DC in terms of workflow efficiency when measured by availability on the multimedia manager. The SV application was a prototype and suffered some glitches that were not completely unexpected. These include logging out during a longer case and occasional application crashes and forced shutdown. Most glitches, however, were easily repaired with software updates. Many of the difficulties with SV were in fact due to the hardware of Google Glass™ itself. This included the user log on procedure which required a wireless keyboard dongle and rendered the application and glasses nonfunctional in the unexpected event of intraoperative application shutdown or logging off. Another difficulty was speaking commands to the application in the operating room while others were also speaking. The user could also not control the image size or zoom without moving closer or farther away from the subject. This was possible in the outpatient clinic setting, but difficult in a sterile operative field.

Future work using Google Glass™ and the SV application would benefit from hardware and firmware upgrades to the camera, battery and wireless input to include voice and keyboards. The camera could also benefit from zoom and high dynamic range (HDR) features which would enhance intraoperative images. The SV application could evolve to include video capture, voice or text annotations and secure live streaming of procedures. The latest iteration of Google Glass™ is currently being tested in several industries including manufacturing and medicine.

Limitations

Our prospective study was only a pilot with a very small sample size of both users and patients. We did not qualify differences in image quality or detail. The patient selection was random depending on their availability in the clinic and operating room. Standardized patient scenarios would help in comparing image quality in the future. Our usability data was limited to S.A. and two residents.

Conclusion

SV performed equivalently with IC while DC took much longer to upload. Users found the application easy to learn and use with some technical concerns about the glasses. These included the log on procedure, ambient distraction of voice recognition, viewfinder perspective and battery life. This was a successful pilot study of a proprietary image capture application for Google Glass™ with quantified comparative metrics not before published in the literature. Hardware limitations with Google Glass™ did limit its effectiveness. Usability surveys of the SV application on Google Glass™ were positive. Further research is warranted.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

Ethical approval for this study was waived by the University of Missouri institutional review board (IRB) as patients already consent to images for quality improvement purposes when signing consent for surgery. No interventions in patient care were made. This study compared image capture methods without patient identification.

Informed consent

Written informed consent was obtained from all subjects before the study. Consent for image capture during surgery was included in surgical consent.

Trial registration

No patient care interventions were made during non-invasive image capture randomization.

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