The use of smart glasses in healthcare – review

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ABSTRACT

Nowadays technical innovations appear rapidly. One of new possibilities is smart glasses – wearable computing devices wore as standard glasses.

Although most smart glasses were not initially targeted at healthcare, they have been already implemented in multiple different medical applications across different specialties. In general such devices can be utilized whenever a screen or external monitor is already required. Head mounted displays can be implemented for very basic purposes such as education, simulation, live streaming of visualized data (i.e. vital signs, imaging studies, tests results, etc)., to more interactive functions such as video recording and digital photo documentation, for telemedicine, telementoring and many others. Ultimately smart glasses would implement artificial intelligence engines in the daily clinical practice and several other promising application for the future. Digital health is already growing exponentially, and with no doubt, the market for smart glasses in healthcare will grow accordingly in the very near future.

The aim of this paper is to analyze current possible applications of smart glasses in patient care as well as the advantages and drawbacks of this kind of devices in everyday clinical practice.

BACKGROUND

Smart glasses are wearable computing devices that are web-connected and enable to transmit multiple types of data and project it in field of vision. Smart glasses can be used in many ways. They offer most functions of a standard computer but in this case, head - mounted displays can react on voice comments, eye movements, gestures or simple tactile commands. In general, a hands-free system can be particularly useful in medical practice where oftentimes practitioners are hands busy, sometimes even in the sterile field. Smart glasses provide augmented or virtual reality in addition to wearers' environment. They can be used for recording, streaming video, teleconferences, data transmission, telementoring and in education process, among others.

Glass by Google has been one of the most widely known types of smart glasses since it was released to a selected market in 2013. It has high wearability, a wireless platform, and runs in a well-established android system. It is almost non obtrusive in human -to- human interaction. Other devices such as Epson Moverio BT-200 or Atheer Lab DEV kit have yet limited applicability in clinical settings because of law wearability (cables), lack of friendly operative system, big sized front-end, obstructive human-to-human interaction and even cost. The advantage of Google Glass over other head-mounted display is also simple learning curve. All of the glasses provide virtual or augmented reality (VR/AR) in see-through screen as an addition to real milieu.

New on the market device called HoloLens by Microsoft holds much promise for future applications. It is one of the first holographic computer using holographs appearing "in front" of the user to provide virtual or augmented reality in real-time. Holographs are integrated with the real world. The device is head -mounted display wore like helmet/glasses.

Smart glasses were not primarily targeted at healthcare but doctors and health providers around the world are finding new exciting possibilities in wearable technology. They believe that wearable technology can improve clinical outcome and patient care. Soreon Research predicts that smart wearables in healthcare market will grow from USD 2 billion in 2014 to 41 billion in 2020 with annual growth rate of 65 %. [1]

Yu et al. published results of the survey among glass users in healthcare. Majority of them were male, assistant professors in United States but other markets grow very fast. [2]

In the literature there are several examples of current implementation of smart glasses in medical practice as well as in education and various possibilities for the future.

DISCUSSION

Numerous of studies and surveys have been conducted on smart glasses in healthcare. The majority of them review the most popular head-mounted display – Google Glass.

Smart glasses can give the clinician information such as patients' data, vital signs or imaging studies results within their field of vision so the clinician can use it simultaneously with performing other tasks or procedures. This can be very helpful in all kinds of interventions when doctor or nurse needs to be focused on the procedure. It helps to avoid looking at different screens or stepping away from the patient in order to look for test results.

O.J. Muensterer researched Google Glass in Children's Hospital. [3] He was wearing the device for 4 executive weeks constantly and used it in different situations in a typical clinical day many times for withdrawal of patient data. He kept a diary on advantages and drawbacks of it. The battery life, ergonomics, audiovisual quality and other aspects were assessed. In this study wearing Glass was well tolerated by the user. Also patients and their families had positive response to it.

Vorraber et al. tested Google Glasses during interventional radiology procedures – 3 angioplasties. They collected opinions on the device from participating radiologists. [4] The authors formulated hypothesis that projection of patient data and consolidation of all kinds of parameters in the monitor within the radiologist/surgeon field of vision results in a reduction of number of head movements to look at different screens, improvement of efficiency and awareness of the physician performing the procedure. In their study interventionists completed a survey in which they told that they fully relied on Glasses and did not need to look at different monitors to check the vitals. The opinion of users was that Glasses improved concentration and supported multi-tasking. Huang et al. came to the similar conclusion concerning spatial awareness of a smart glasses user. [5] There is no evidence that it might have negative impact on it. The concept of imaging tests results projecting onto smart glasses screen during the procedure was used by Wu et al in the study of ultrasound-guided central venous access with the use of Google Glass. [6] The results of the study was that Google Glass user comparing to person performing standard procedure had less head movements but it took longer to gain the access. It might be attributable to the fact that majority of users were not familiar with the technology before.

Google Glass can be used during surgery not only for data visualization or video recording. Another interesting and very helpful application is using smart glasses for surgical safety checklist. At Doctors 2.0 & You 2014 Conference dr. Homero Rivas from Stan-

ford University presented his experience with surgical safety checklist prior to operation with the use of Google Glasses. In his study surgeons were 74% less likely to skip life-saving steps using the checklist. It showed that Google Glasses can improve efficiency of surgical safety checklist.

There is great interest in impact of smart technology on education. Smart glasses can be widely used in teaching whether it is constant telementoring for example through the procedure or using virtual reality for learning.

Newly introduced HoloLens by Microsoft can help medical students to learn anatomy in 3 dimensions using holographic images. [7] The pilot study was conducted in Case Western Reserve University and Cleveland Clinic. The device enables students not only see the anatomical structures in 3D but also work on holographic mannequins and interact with them. That provides better understanding of human anatomy than learning from two dimension graphics in a book. The students had very positive response to this method of education.

Mentioned earlier, Dr. Homero Rivas from Stanford University was one of the first surgeons implementing augmented reality in surgical lab for teaching purpose. In his experiment surgeon could see the procedure he was about to perform step by step projecting in his field of vision. [8]

Dickey et al. developed application for Google Glasses helping to train urology residents using augmented reality during surgery (in this case inflatable penile prosthesis placement). [9] Google Glass presented the procedure step by step and also provides interaction between trainee and specialist. The residents had overall very good experience with the technology and were likely to use it in the future. It shows that smart glasses can be successfully used in training process.

Telementoring – another interesting application for smart glasses, allows students or residents to perform some procedures on a patient by themselves while being constantly monitored by senior doctor. There is an example of study with using Google Glass in cardiology residents and fellows during training in different possible cardiac scenarios. [10] It can help trainees to gain independence and self – confidence. This method can also be used to record students' actions and their evaluation as some studies showed. [11]

Jeroudi et al. investigated the accuracy of electrocardiogram interpretation with the use of Google Glasses. [12] They compared interpretation of 10 ECGs by viewing it on Google Glass screen, photograph taken by Google Glass, paper ECG and its picture taken by camera. Although in their study users were dissatisfied of an image of electrocardiogram comparing to paper version or standard picture they were pleased with the concept. This paper shows new application for Google Glass but also how it needs improvement. Similar study showed that Google Glass is sufficient tool for interpretation of coronary angiograms recorded by it which supports telemedicine. [13]

Google Glass can also help to share information concerning patient whether it is asking for a consult in one center or consulting specialists around the world. [14]

The device can put clinicians together in a teleconference to discuss live case, take and send photos or videos, help to retrieve medical information in no disruptive manner. Preliminary assessment of those functions was conducted by Widmer et al. [15] The research team tested sending and retrieving visual medical records such as pictures of the skin as well as CT and MRI images to define whether Google Glass can affect the accuracy of results. As they showed despite some minor disadvantages Google Glass can potentially help in decision making and improve patient care.

Authors from Yale University were trying to asses if Google Glass and teleconferencing can be helpful for healthcare providers performing triage during mass accidents and emergencies. [16] In their study the team of paramedics communicated with an off-site emergency medicine specialist using Google Glass. They found out that still there are some obstacles. Using Google Glass took longer than standard triage but the device did not decrease performance. It can be helpful in the future with some technical development.

The concept of smart glasses can empower patients in sense of interaction between them and the clinic or other patients, telemedicine, simplifying hospital or outpatient visits among many other functions. [17] Virtual Reality displayed on glasses screen can also directly help in patient treatment for example in pain management. Maani et al. in their study randomized burn victims (wounded soldiers) to receive standard pain medications during debridement of the wound or get distracted by virtual reality during the procedure. [18] Then Graphic Rating Pain Score was measured. Patients reported significant less pain during wound cleaning while distracted by VR.

Researchers are also trying to evaluate possible advantages of using smart glasses by patients with chronic diseases. For example applications allowing patients with Parkinson's disease to motion tracking, voice and visual clues or recognition of objects. In the Netherlands patients with Parkinson's disease answered online survey in which they were very enthusiastic about this technology helping them with everyday activities. [19]

There is also possible use for wearable technology in pharmacy for example for drug delivery tracking or checking medications prior to delivering them to the patient which can increase safety and also in education and in medication preparing process. [20]

Although smart glasses can be very helpful and have great potential for the future use there are some drawbacks and aspects that need to be worked out in the future.

There are some technical aspects that can lower the performance and usability such as poor camera image preventing from wider use in telemedicine, short battery life, memory limits, wearability and others. There is also major concern over patient confidentiality. The important issue that could inhibit progress and innovation is sensitive data storage and transmission problem. Glasses explorers and e-health specialists around the world are debating how to improve security of this type of wearables.

The Glass Development Kit for Google glasses enables the device to work in local network (for example hospital network) rather than via internet which can help to protect sensitive data such as patients digital documentation.

Other thing preventing from general use of smart glasses are legal regulations. In developed countries it is necessarily to consider use of the device in treatment or diagnostic process (FDA approval, CE mark). It is widely known that development and innovations come first, than applications and legal regulations. With rapid technical growth and many new devices on the market (not necessarily targeted in medicine and healthcare only) legal process of approval needs to be more effective.

CONCLUSIONS

It seems that wearable technology such as smart glasses have potential to improve effectiveness of healthcare and education. Improvements of devices as well as new specific applications will allow for smart glasses to be used in different aspects of patient care.

Although medical practitioners are evaluating smart glasses benefits in various situations still some more studies need to be conducted and legal regulations established. Also numerous technical obstacles have to be eliminated to make smart glasses more efficient in everyday practice.

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TAB. 1. CURRENT APPLICATIONS OF SMART GLASSES IN HEALTHCARE

Area of application	Examples
Reading data	Vital signs, test results
Telementoring	Education, consultations
Video recording	Life streaming of procedure, telecon-ferences, video records for digital documentation
Workflow, documentation	Digital patient history, consultations, emergencies, drug delivery tracking
Patients empowerment	Used in chronic diseases, telemedi-cine, patient connection
Education	Augmented reality, telementoring, trainees evaluation
Other	Safety checklists

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