Smartphone-based digital stereovision as an accessible resource for surgical learning

Visão estereoscópica digital via *smartphone* como recurso acessível para o aprendizado em cirurgia

Flavio Mac Cord Medina[1], Alexandre Mendonça de Barros[1], Igor Barbosa Piredda[2]

[1] Universidade do Estado do Rio de Janeiro, Rio de Janeiro, RJ, Brasil.
[2] Hospital Federal dos Servidores do Estado, Rio de Janeiro, RJ, Brasil.

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Corresponding author:
Flavio Mac Cord Medina
Boulevard 28 de Setembro, 77 – Vila Isabel
CEP: 20551-030 – Rio de Janeiro, RJ, Brazil
E-mail: fmaccord@hotmail.com

Institution:
Universidade do Estado do Rio de Janeiro, Rio de Janeiro, RJ, Brasil

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ABSTRACT

Objective: To present a novel, low-cost, and accessible methodology for capturing high-quality stereoscopic images and streaming it in real time to a standard three-dimensional television in a surgical setting, utilizing readily available smartphones.

Methods: Two smartphones were attached to each eyepiece of the surgical microscope using a custom-made adapter. The smartphones recorded the surgical procedure and streamed the video via HDMI cables to a dual-input multi-viewer, which combined the feeds into a single image displayed on a conventional 3D television.

Results: This setup allowed for the real-time viewing of surgical procedures in immersive 3D, providing a cost-effective and accessible alternative to traditional stereoscopic systems.

Conclusion: Utilizing smartphones for capturing and streaming stereoscopic surgical videos can significantly enhance the accessibility of high-quality surgical training materials, making advanced surgical education more widely available.

RESUMO

Objetivo: Apresentar metodologia inovadora, de baixo custo e acessível para a captura de imagens estereoscópicas de alta qualidade e sua transmissão em tempo real para uma televisão tridimensional padrão em um ambiente cirúrgico, utilizando *smartphones* prontamente disponíveis.

Métodos: Dois smartphones foram acoplados a cada ocular do microscópio cirúrgico usando um adaptador feito sob medida. Os smartphones gravaram o procedimento cirúrgico e transmitiram o vídeo via cabos HDMI para um multi-visualizador de entrada dupla, que combinou os vídeos em uma única imagem exibida em uma televisão 3D convencional.

Resultados: Esta configuração permitiu a visualização em tempo real dos procedimentos cirúrgicos em 3D imersivo, oferecendo uma alternativa econômica e acessível aos sistemas estereoscópicos tradicionais.

Conclusão: A utilização de smartphones para captura e transmissão de vídeos estereoscópicos cirúrgicos pode melhorar significativamente a acessibilidade a materiais de treinamento cirúrgico de alta qualidade, tornando a educação cirúrgica avançada mais amplamente disponível.

INTRODUCTION

The landscape of surgical education has been profoundly transformed by video technology, enabling unprecedented levels of detail and clarity in the recording of complex ophthalmic surgeries. Traditional barriers to knowledge sharing and skill acquisition are being dismantled through the integration of digital video recording with surgical microscopes, paving the way for a more collaborative and immersive learning experience.

Video recording in ophthalmic surgery has immense potential to promote improved quality in patient care, training in ophthalmology and research. In Ophthalmology, recording systems coupled with microscopes allow knowledge sharing and assist surgeons in training and preceptors to discuss methods and improve their skills.[1] Surgical techniques have advanced dramatically over the past few decades, as has the ability to record and reproduce these surgeries.[2,3]

Originally, this type of learning was restricted to assistance centers, limited to sharing with service members and those who proposed to visit these places. Recently, the use of the internet, social networks and video streaming has expanded the spread of surgical knowledge in different settings.[4] Currently, with resources accessible from a smartphone or computer with internet access, it is possible to access a wide range of educational content from surgeons from multiple centers.

As part of this technological evolution, the progress in image quality and its capture through stereovision cameras such as Ngenuity® three-dimensional (3D) Visualization System (Alcon Laboratories Inc, Fort Worth, Texas, United States) and Artevo 800 Digital Microscope (Carl Zeiss Meditec AG, Jena, Germany) allow multiple viewers to synchronously follow the surgical act, deepening their anatomical perception of ocular tissues.[5,6] As these modern systems are expensive, the extent of their use is limited.

In response to this challenge, our research explores the potential of smartphones – a ubiquitous and technologically advanced tool – to serve as a practical alternative for capturing stereoscopic surgical videos. This approach not only significantly reduces costs but also enhances the accessibility of surgical training materials, potentially revolutionizing how surgical techniques are taught and learned.

In this article, we describe an accessible and shareable way of capturing stereoscopic images, with an image capture system using smartphones coupled to the optical system of the surgical microscope, recreating the binocular vision of an observer. Our objective was to present a novel, low-cost, and accessible methodology for capturing high-quality stereoscopic images and streaming it in real time to a standard 3D television in a surgical setting, by using readily available smartphones.

METHODS

Two smartphones iPhone 10 (Apple, Inc., Cupertino, California, United States) were attached to each eyepiece of the OPMI Lumera T surgical microscope (Carl Zeiss Meditec, Jena, Germany), using a protective cover attached to a cylinder with a diameter 2mm larger than the diameter of the eyepiece (MedTec, Rio de Janeiro, Brazil) (Figure 1).

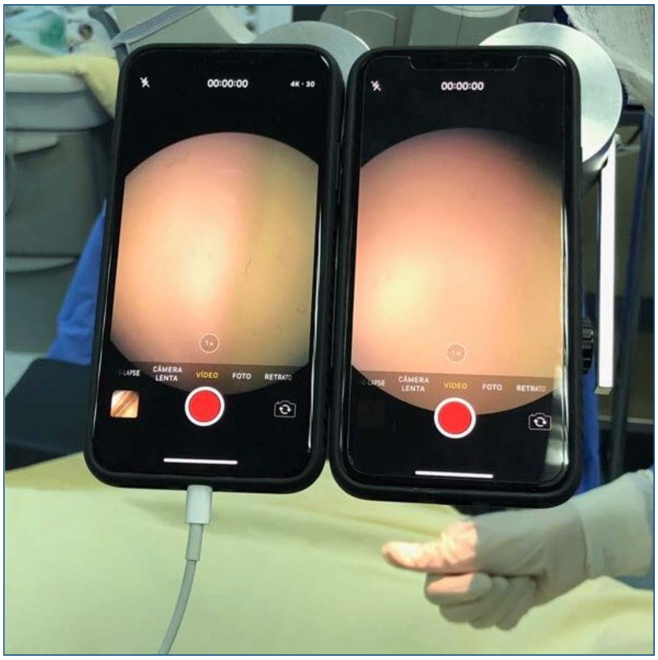

Figure 1. Two smartphones attached to each eyepiece of the microscope.

Figure 2. Observers experiencing live surgery through smartphones streamed in immersive three-dimension on television.

Before the starting to capture, the diopter correction of both eyepieces was checked for zero diopters and then the foci were checked to make sure that the focus of the assistant microscope was the same as the main microscope. Adapters were coupled with smartphones in video mode, positioning so that the circular edges of both optics were clear, and it was verified that both were aligned and leveled, since the difference in rotation impairs the generation of the stereoscopic image.

Capture was started simultaneously to allow conversion to the three-dimensional film without the need for editing. After the start of the capture, the focus lock was performed so that both images remained focused on both smartphones.

Both smartphones, capturing the surgical procedure, were interfaced using HDMI cables with a dual-input (2x1) multi-viewer. This multi-viewer, serving as a crucial intermediary, combined the two separate video feeds into a singular, coherent three-dimensional image. Subsequently, the multi-viewer was connected to a conventional three-dimensional television. This setup enabled spectators to don three-dimensional glasses and immerse themselves in the live surgical operation as if viewing it firsthand from the operating room (Figure 2).

In the editing process, the images were synchronized with time and placed side by side, respecting the respective sides of the footage, using Adobe Premier software (Adobe Systems Software, Dublin, Ireland). The video file can be exported in the .mp4 extension, which can be watched on passive, or active polarized televisions, or even in virtual reality glasses.

A traction retinal detachment surgery for diabetic retinopathy, lasting 6'32'', as an example of the feature produced by the acquisition model, is available at Supplemental Digital Content available at https://www.rbojournal.org/wp-content/uploads/2024/08/VVPP-final-1.mp4 .

The recordings made during the surgical procedures did not interfere with the surgeries. These precautions ensure that the filming process is in full compliance with established ethical standards, without interfering with the effectiveness of the medical intervention.

DISCUSSION

Surgical videos allow not only critical analysis of the surgical technique, but also an objective assessment and are an invaluable medium for surgical education.[7] Suggesting ways to make this happen in a more accessible and low-cost way is also a stimulus to make these instruments even more popular. The practical device, mentioned in this paper, with the use of smartphones and a microscope adapter simulating the binocular vision of a human observer is an agile way to create interaction between surgeon and spectators.[8,9]

The choice for capturing images from iPhone 10 was due to the resolution of its 12 megapixels camera that records videos in up to 4K, optical stabilization capability, autofocus, maximum frames per second (60 FPS) and High Dynamic Range (HDR). Such resources allow the acquisition of high-quality images at an affordable cost.

As for the cell phone adapter for microscope, we used a fixed fitting device specific to the size of the eyepiece, as it is simpler for positioning and centering the smartphone camera, instead of others manufactured for generic devices with recurring adjustment.[10,11] The projection of the stereoscopic image can be performed by several technologies such as anaglyph, passive polarized or polarized active.[6] However, in the reality of vitreoretinal surgery, the applicability of the anaglyph was not possible, as it was not efficient in the red/ blue contrast due to the natural color of the retina and its vessels, losing the quality and differentiation of the tissues.

The projection medium should be decided before capturing the images, as the choice of the resolution of the footage influences the band needed for its transmission and the time and resources spent on its editing and rendering. When capturing and disseminating surgical videos, it is important to take into account the legislation in relation to the protection of patient data, as the recordings and eventual publications of the surgeries are personal responsibility of the teams and surgeons, as well as the informed consent of the patients.[12]

The model presented in this article has demonstrated its efficiency and effectiveness beyond initial expectations. Through innovative use of readily available technology, we have enabled the capture and live streaming of surgical procedures in high-quality 3D, making sophisticated surgical learning tools both accessible and reproducible for our collaborators and a broader audience. This approach facilitates an immersive learning experience, allowing viewers to witness surgeries live as if they were present in the operating room. By leveraging standard smartphones and 3D televisions, we provide a cost-effective alternative to commercially available stereoscopic capture and reproduction methods.

The implications of this research extend far beyond the technical achievement of using smartphones for surgical video capture. By providing a cost-effective and accessible means to produce high-quality, stereoscopic surgical videos, we address a critical gap in surgical education, particularly in resource-limited settings. The widespread availability of smartphones, combined with their advanced camera technologies, presents an untapped resource for medical educators and practitioners.

CONCLUSION

The device highlighted in this manuscript, which employs smartphones attached to a microscope adapter to capture and project images, effectively simulates the binocular vision of an observer. This method offers a dynamic and interactive approach, bridging the gap between surgeons and their audience. Making such advanced capabilities more accessible not only promotes the widespread adoption of these innovative techniques but also significantly contributes to the evolution of surgical education. This strategy not only enhances learning outcomes but also paves the way for these technologies to become a standard in medical training programs.

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