VR Plexus: Can Virtual Reality on a Smartphone Improve Neurology Learning Amongst Medical Students?

Maxwell Ng[1], Rohit Malyala[2], He Tian Chen[3], Katherine Kuo[1], Michel P. Rathbone[4], Alexander K. Ball[5], Bruce Wainman[5]

[1] Undergraduate MD Program, McMaster University | [2] Bachelor of Health Sciences Program, McMaster University | [3] Department of Biochemistry, McMaster University | [4] Division of Neurology, Department of Medicine, McMaster University | [5] Education Program in Anatomy, McMaster University

Introduction

- **Stereoscopic virtual reality (VR)** creates immersive three-dimensional (3D) environments
- There is increasing interest in the application of VR technology to **anatomy and physiology education**[1-3]
- The best use of VR technology is for visualizing complex, 3D structures such as the brachial plexus
- **Costly VR equipment** is a monetary barrier to the uptake of VR which directly diminishes its use and stifles innovation[1]
- The following protocol describes a 3D VR production system, designed for **rapid-implementation and financial accessibility**

Objective

To create an **efficient and cost-effective method for developing a student-accessible, virtual reality (VR) resource** to improve anatomy and physiology education.

Protocol

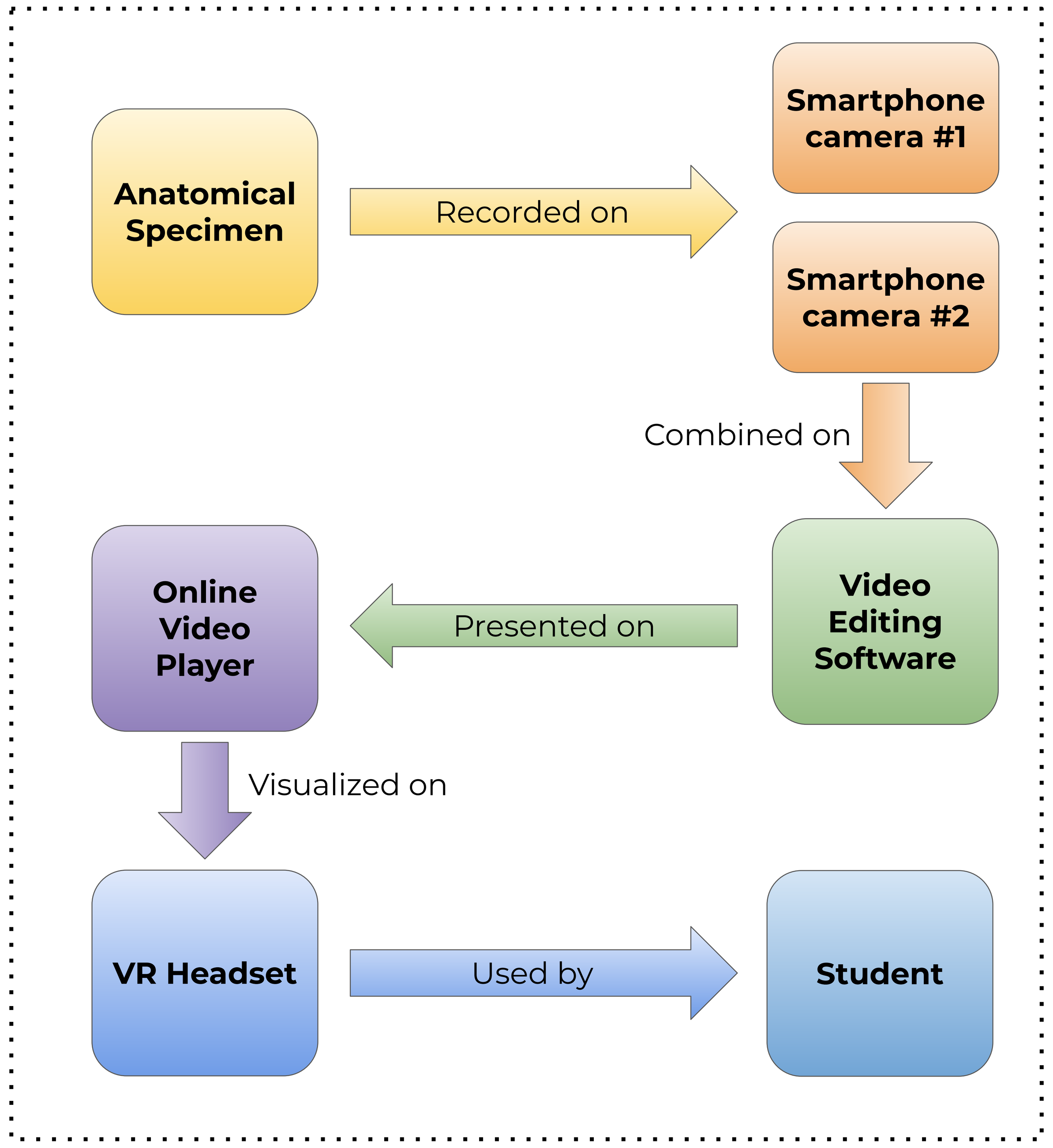

Figure 1 - Production Process
The process of rendering the anatomical specimen in stereoscopic VR. Possible with accessible mobile phones, video software, and low-cost Google Cardboard headsets.

Results

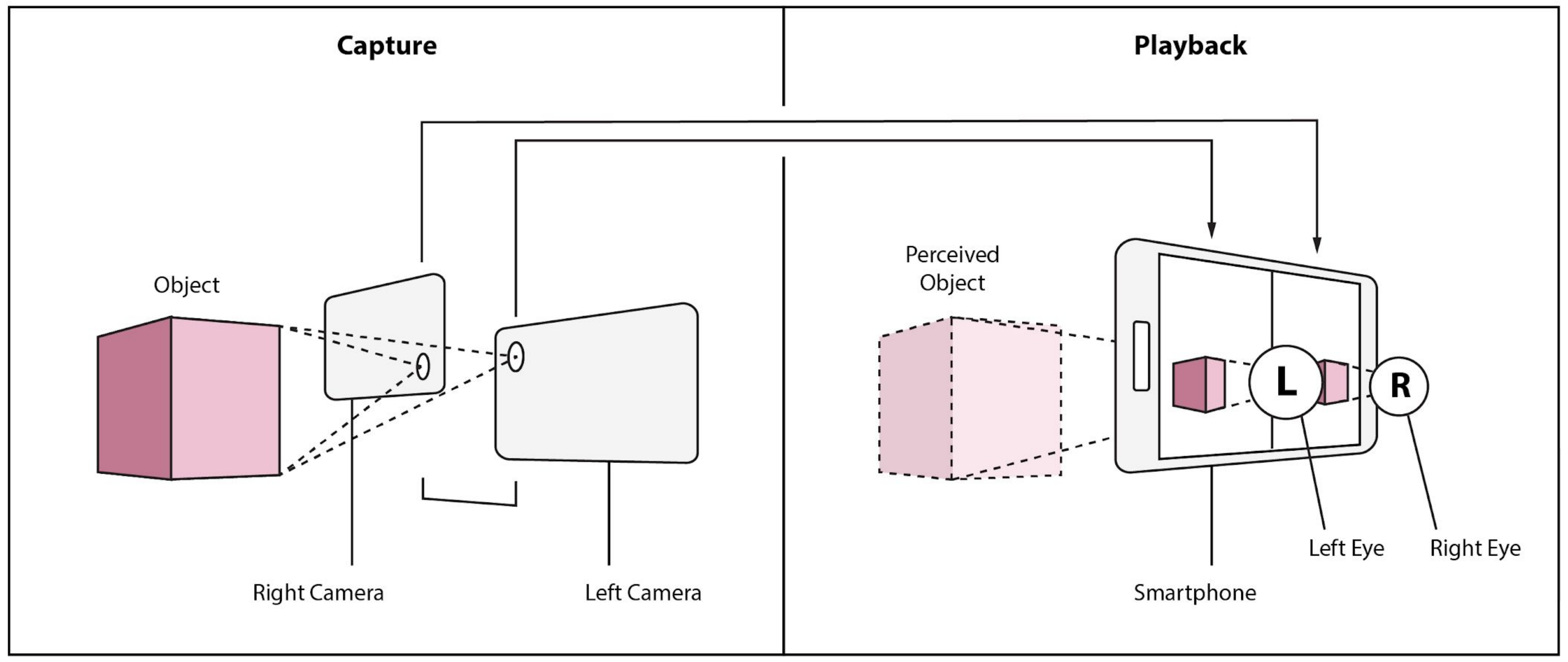

Figure 2 - Virtual Reality Setup

- Stereoscopic videos, filmed on two mobile phones, allow movement of the object and animations for education (e.g., labels, highlights)
- Individual 3D stereoscopic images can be created using a brief video pan of a specimen (not shown) (example application: Camarada)
- The Google Cardboard VR headset is a cost-friendly means for displaying stereoscopic imagery

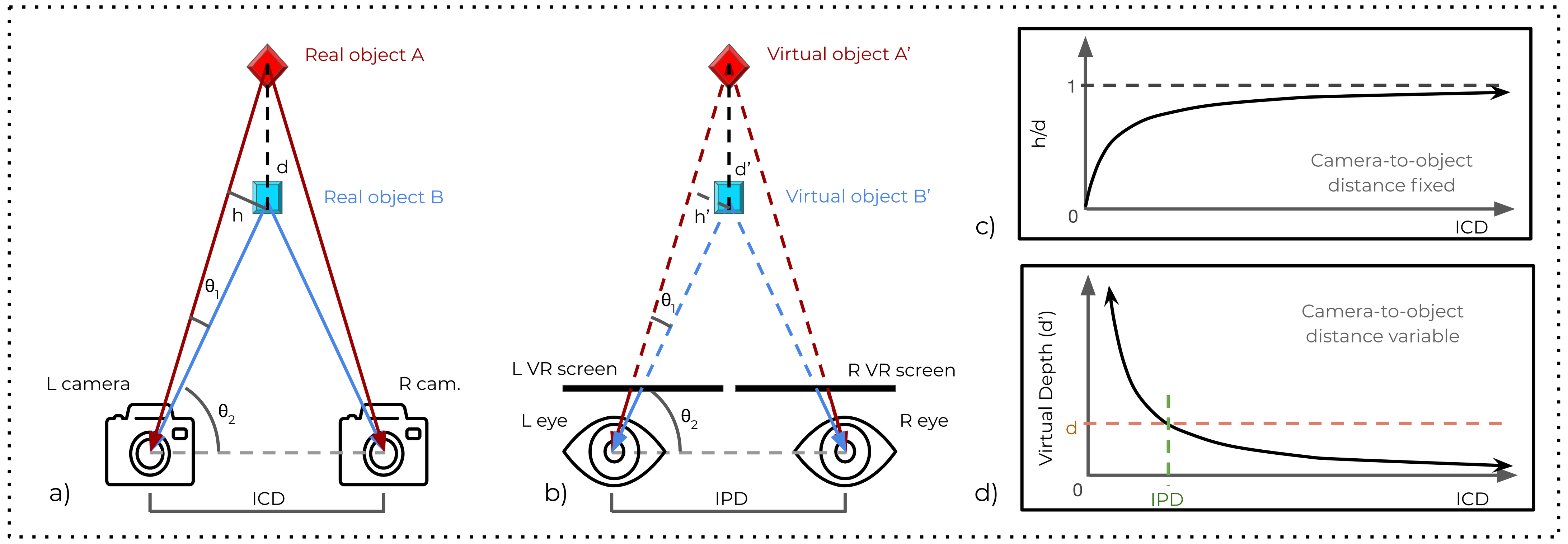

Figure 3 - Models of Visual Depth Perception
(a) Stereo camera setup. ICD = inter-camera distance (distance between lenses), d = real distance between real objects A and B, h = visual projection of d. (b) VR headset setup. IPD = inter-pupillary distance (distance between pupils), d' = user's perceived distance between virtual objects A' and B', d' = visual projection of d'. (c) Mathematical model of visual depth (d') as a function of ICD. (d) Mathematical model of stereoscopic parallax measured as the ratio of h/d as a function of ICD.

- By placing cameras at an ICD similar to IPD, the virtual depth d' will approximate the real depth d
- Stereoscopic parallax (Fig. 3.c): Increasing ICD provides additional lateral and asymmetrical information to each eye, causing a 'pop-out' effect
- Visual size (Fig. 3.d): Decreasing ICD while bringing the cameras closer to the objects (i.e. Real Objects A & B) to keep the angles θ_1 and θ_2 constant can simulate increased visual depth (d')

Discussion

VR Brachial Plexus Module

- Watch the VR Brachial Plexus module on your smartphone by scanning this QR code:

General VR Recommendations

- To change VR depth, the ICD and/or the camera distance to objects filmed can be modified
- Due to different IPD and phone screen sizes between individuals, multiple videos may need to be created to accomodate this variability, with varying distances between left and right videos

Protocol Advantages

- The production process is readily available to many university students and faculties, demonstrating the cost-effectiveness and technological-feasibility of such a system, which allows it to be implemented with numerous anatomical specimens

Protocol Limitations

- Rendering the video side-by-side may change the spacing and size of the video when viewed on phones with different screen dimensions

Conclusions

- It is possible to complete a financially-accessible yet effective smartphone VR process in the interest of teaching medical students anatomy
- This project provides insight regarding the design and use of VR in anatomy and physiology education

Further investigation

- This tool will be used in an upcoming randomized control trial on the effects of stereopsis on neuroanatomy and physiology education
- The effect of modifications of the ICD and camera distance to objects on stereoscopic depth invites further investigation

Acknowledgements

This work was supported by the McMaster University **Education Program in Anatomy**, as well as financial support by the **Michael G. DeGroote School of Medicine, Waterloo Regional Campus, Research Department**.

References

1. Yammine K, Violato C. A meta-analysis of the educational effectiveness of three-dimensional visualization technologies in teaching anatomy. Anatomical Sciences Education [Internet]. 2015 Nov 12 [cited 2018 Aug 16];8(6):525–38. Available from: https://www.onlinelibrary.wiley.com/doi/abs/10.1002/ase.1510
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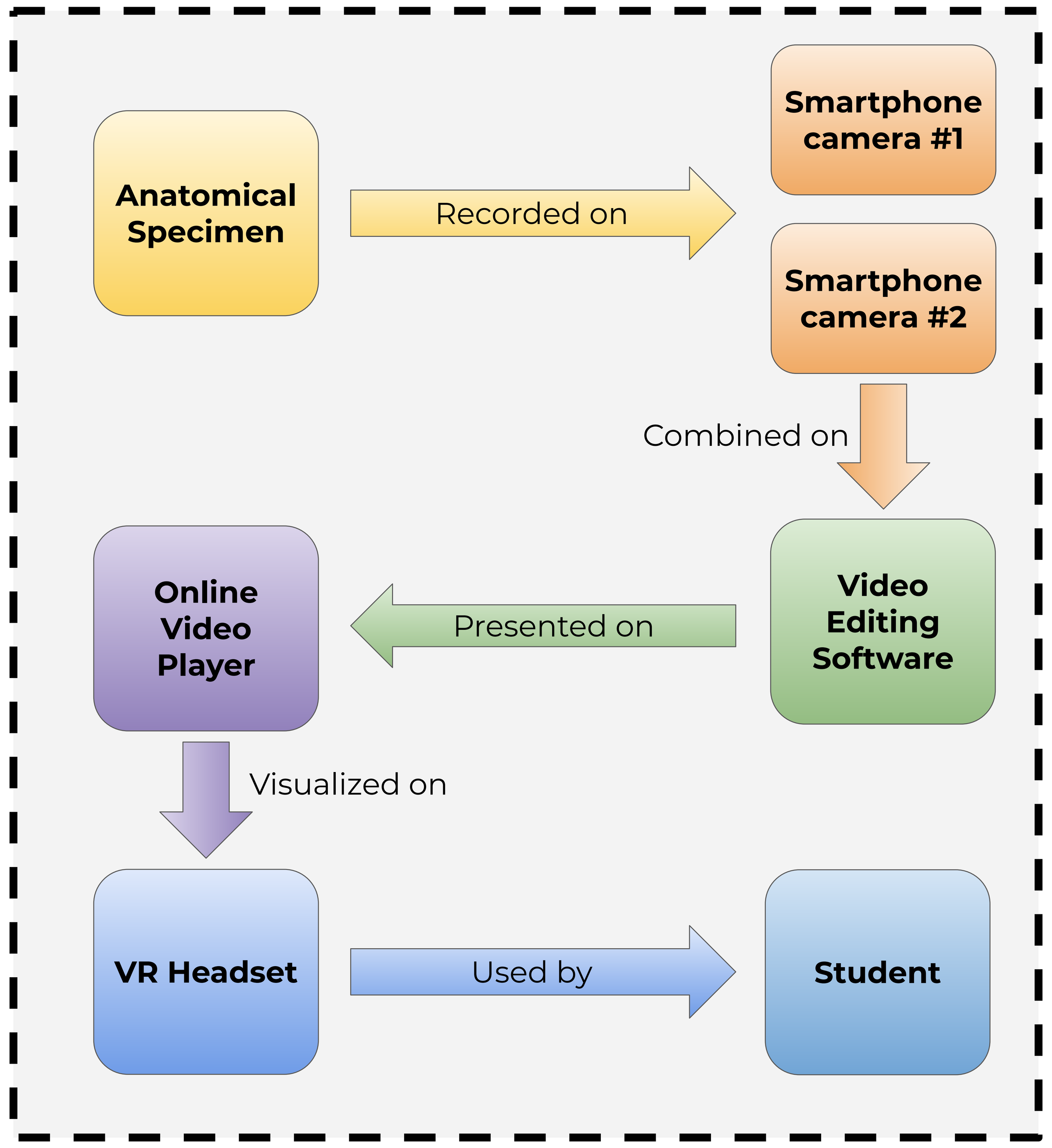

Figure 1 - Production Process
Diagram illustrating the process of rendering the anatomical specimen in stereoscopic VR. Possible with accessible mobile phones, video software, and low-cost Google Cardboard headsets.

Results

Figure 2 - Example Image of Stereoscopic VR Brachial Plexus with Annotation

- Stereoscopic videos, filmed on two mobile phones, allow movement of the object and animations for education (e.g., labels, highlights)
- Individual 3D stereoscopic images can be created using a brief video pan of a specimen (not shown) (example application: Camarada)
- The Google Cardboard VR headset is a cost-friendly means for displaying stereoscopic imagery
- Tests using non-colour matched views (e.g., left eye grayscale, right eye colour) still simulated depth

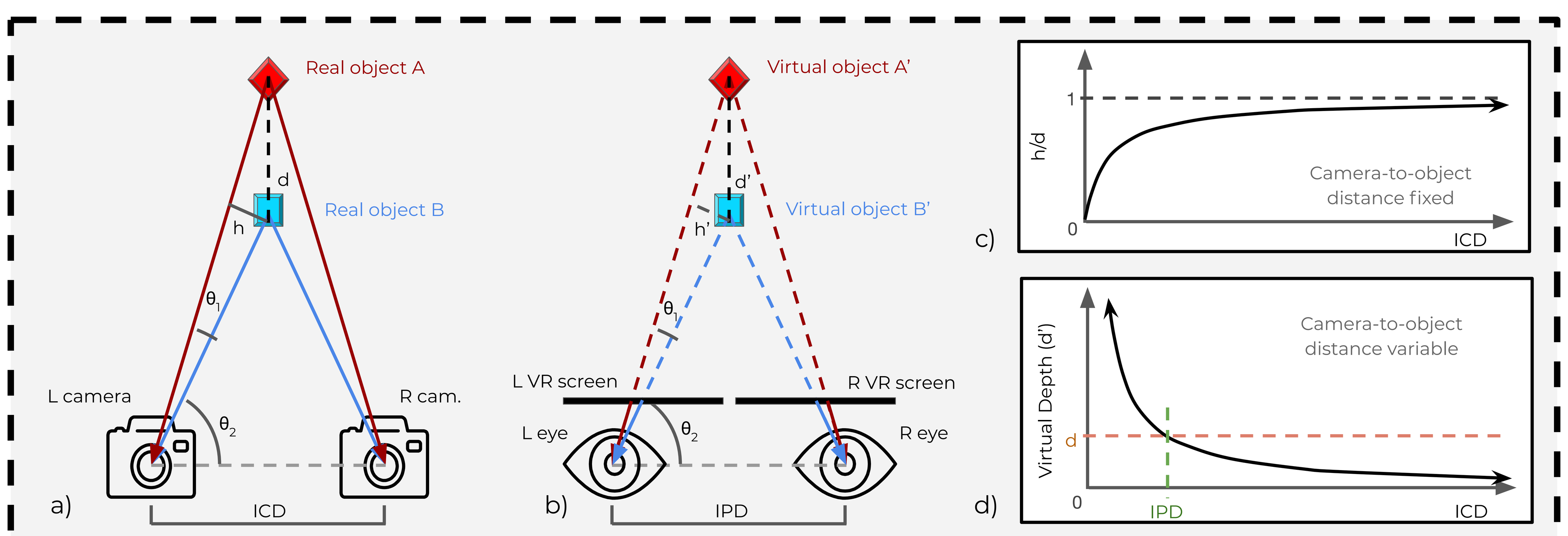

Figure 3 - Models of Visual Depth Perception
(a) Diagram of camera setup. ICD = inter-camera distance (distance between lenses), d = real distance between real objects A and B, h = visual projection of d. (b) Diagram of VR headset setup. IPD = inter-pupillary distance (distance between pupils), d' = user's perceived distance between virtual objects A' and B', d' = visual projection of d'. (c) Mathematical model of visual depth (d') as a function of ICD. (d) Mathematical model of stereoscopic parallax measured as the ratio of h/d as a function of ICD.

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- Visual size (Fig. 3.d): We theorize that decreasing ICD while bringing the cameras closer to the objects (i.e. Real Objects A & B) to keep the angles θ_1 and θ_2 constant can simulate increased visual depth (d')

Discussion

General VR Recommendations
- To change VR depth, the ICD and/or the camera distance to objects filmed can be modified
- Colour matching between the left and right eyes is not critical for the 3D depth effect
- Due to different IPD and phone screen sizes between individuals, multiple videos may need to be created to accomodate this variability, with varying distances between left and right videos

Protocol Advantages
- The production process is readily available to many university students and faculties (e.g., smartphones), demonstrating the cost-effectiveness and technological-feasibility of such a system, which allows it to be implemented with numerous anatomical specimens
- Methods are flexible enough to manipulate key aspects of the VR experience for research purposes (e.g., degree of stereopsis)

Protocol Limitations
- Rendering the video side-by-side may change the spacing and size of the video when viewed on phones with different screen dimensions

Conclusions

- It is possible to complete a financially-accessible yet effective smartphone VR process in the interest of teaching medical students anatomy
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