VR-Phore: A Novel Virtual Reality system for Diagnosis of Binocular Vision

by

VUDDAGIRI SAI SRINIVAS, Kavita Vemuri

in

2021 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)

Report No: IIIT/TR/2021/-1

Centre for Others
International Institute of Information Technology
Hyderabad - 500 032, INDIA
March 2021
VR-Phore: A Novel Virtual Reality system for Diagnosis of Binocular Vision

Sai Srinivas Vuddagiri†
IIIT Hyderabad
Kavita Vemuri†
IIIT Hyderabad
Male Shivaram
University of Hyderabad
Rishi Bhardwaj
University of Hyderabad

ABSTRACT
Binocular vision (BV) is the result of fusion between inputs from each eye to form a coherent image. BV anomalies are evaluated using different diagnostic tests and instruments. One such instrument is the Synoptophore, which evaluates three grades of BV. This equipment though efficient has certain limitations like ambient light while testing, bulky and expensive. We propose VR-Phore, application of a VR head-mounted display for diagnostics based on principle of the haploscope similar to Synoptophore. The proposed system addresses the limitations of Synoptophore with added advantage of a software platform to incorporate testing modules for a range of clinical conditions.

Index Terms: Virtual Reality—Synoptophore—Binocular Vision—Health-clinical Diagnosis;

1 INTRODUCTION
Binocular vision (BV) is achieved by combining similar inputs from both the eyes to form a single coherent image [2] and has three grades/levels of processing namely simultaneous macular perception, fusion and stereopsis. This is essential for depth perception. Absence or degradation in BV is manifested as accommodative problems, vergence problems, suppression, amblyopia (lazy eye), and strabismus. In most standard vision tests on children, BV is rarely tested rigorously and hence is not diagnosed early for effective intervention [1]. The Synoptophore has been used for diagnosis and intervention of BV and related disorders. Assessment of grades of BV are done using HAAG-STREIT UK Synoptophore Slide Catalogue [3]. The device works on the haploscopic principle of each eye being shown a separate visual space by the division of a single physical space (see Fig. 1b) and binocular stimuli (dioptic, dichoptic) is achieved by placing same or different images in front of each eye. The instrument (see Fig. 1a) is bulky, requires expertise and expensive, thus not accessible to smaller vision care centers. We present VR-Phore, a virtual reality (VR) HMD based application tool for BV diagnosis. Our VR based application proposes a solution to address some of the problems mentioned. The system designed works on the same principles as functioning in the Synoptophore, to ensure clinical acceptance. The field-measurements conducted are comparable to the Synoptophore.

2 METHODOLOGY
2.1 Synoptophore
A patient is seated in front of the Synoptophore and asked to look into the eye-tubes by anchoring the forehead and chin on a rest (see Fig. 1a). The image slides or fixation targets (see Fig. 1b) as per the conditions being tested are inserted into the slide holders on either arms of the device so that each eye sees a different image. The slides are glass with pictures painted on them and retro-illuminated by an incandescent bulb. The tubes are adjusted by the examiner (objective) and by the patient/participant (subjective, self-report). A number of conditions are tested using this device, important are the three grades of BV for diagnosis of binocular vision.

2.2 VR-Phore
When a participant views an image through Synoptophore the incident ray reflects from a mirror and falls perpendicular to the eye. To achieve the required condition a participant can adjust the subtending angle of the stimuli thus creating a deviated incident ray. The deviated ray also reflects from the mirror and falls on the eye at an angle of deviation A from the original incident ray. VR-Phore follows similar working except for the reflecting mirrors. The angle subtended by the image on the eye is adjusted to be similar to the Synoptophore setup. Participant adjusts the stimuli to achieve the required condition subtending an angle (equal to the angle A in Synoptophore) with the incident ray (see Fig. 2).

The Oculus Rift (a division of Facebook Inc), a head mounted device (HMD) is used. The VR content was simultaneously streamed to a desktop screen, mirroring the user’s real time viewing angle; allowing the examiner to monitor the procedure and intervene if required.

The application developed in Unity 3D game engine used the
RESULTS AND CONCLUSION

The angle of deviation measured in the Synoptophore (left panel) and in the VR-Phone (right panel). (Fig. 2)

The schematic of the angle of deviation measured in the Synoptophore (left panel) and in the VR-Phone (right panel). (Fig. 2)

The schematic of the angle of deviation measured in the Synoptophore (left panel) and in the VR-Phone (right panel). (Fig. 2)

The angle of deviation of simultaneous perception observed on Synoptophore ranged from 1.5 - 6 degrees (Mean = 2.76, SD = ±1.14), while on VR-Phone ranged from 0.35 - 5.59 degrees (Mean = 2.34, SD = ±1.21) (see Fig. 4a). The angle of deviation of fusion observed on Synoptophore ranged from 2-14 degrees (Mean = 3.33, SD = ±1.47), and on VR-Phone ranged from 1.23 - 9.47 degrees (Mean = 3.08, SD = ±1.47) (see Fig. 4b).

Pearson correlations were estimated on the measurements from the Synoptophore and VR-Phone of the participants having normal or lower corrected values to normal vision. Simultaneous Perception values showed a positive correlation of 0.59 (at p < 0.05, lower bound CI at 95% = 0.335; upper bound at CI of 95% = 0.766), coefficient of determination value \( r^2 \) is 0.3494 and \( p \) value is 0.000093 which is significant at \( p < 0.01 \). While fusion measurements showed a positive value of 0.53 (at p = 0.05; lower bound CI at 95% = 0.262; upper bound CI at 95% = 0.718), coefficient of determination value \( r^2 \) is 0.2777 and \( p \) value is 0.0004 which is significant at \( p < 0.01 \).

The results from VR-Phone with the preliminary participant set is encouraging as a possible system for diagnosis and also for intervention. By using the standard Synoptophore Slide Catalogues as stimuli for the dichoptic vision, we have validated the system.

3 RESULTS AND DISCUSSION

Data was collected from 41 non-clinical subjects (Age range = 17 – 31 years; Mean = 21.51, SD = ±3.15, 11 female participants) with normal or corrected to normal vision. The simultaneous perception and fusion tests were conducted on the Synoptophore and VR-Phone (see Fig. 4). The angle of deviation of simultaneous perception observed on Synoptophore ranged from 1.5 - 6 degrees (Mean = 2.76, SD = ±1.14), while on VR-Phone ranged from 0.35 - 5.59 degrees (Mean = 2.34, SD = ±1.21) (see Fig. 4a). The angle of deviation of fusion observed on Synoptophore ranged from 2-14 degrees (Mean = 3.33, SD = ±1.47), and on VR-Phone ranged from 1.23 - 9.47 degrees (Mean = 3.08, SD = ±1.47) (see Fig. 4b).

Pearson correlations were estimated on the measurements from the Synoptophore and VR-Phone of the participants having normal or lower corrected values to normal vision. Simultaneous Perception values showed a positive correlation of 0.59 (at \( p < 0.05 \), lower bound CI at 95% = 0.335; upper bound at CI of 95% = 0.766), coefficient of determination value \( r^2 \) is 0.3494 and \( p \) value is 0.000093 which is significant at \( p < 0.01 \). While fusion measurements showed a positive value of 0.53 (at \( p = 0.05 \); lower bound CI at 95% = 0.262; upper bound CI at 95% = 0.718), coefficient of determination value \( r^2 \) is 0.2777 and \( p \) value is 0.0004 which is significant at \( p < 0.01 \).

The results from VR-Phone with the preliminary participant set is encouraging as a possible system for diagnosis and also for intervention. By using the standard Synoptophore Slide Catalogues as stimuli for the dichoptic vision, we have validated the system.

4 CONCLUSION

With the demonstration of the VR-Phone we hope to provide a more economical, sustainable and easily accessible system to diagnose binocular vision and extend it to interventions in future. By configuring the camera asset in Unity 3D engine to show different images to each eye, we have extended the use of VR HMD to applications requiring dichoptic vision. The motivation is to establish screening camps with VR-Phone at remote and underprivileged areas to diagnose binocular vision in addition to the standard vision screening on a larger set of people.

REFERENCES

