Detecting Astigmatism Condition in Human Eye using VR

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Detecting Astigmatism Condition in Human Eye using VR

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Abstract:

Purpose: A common imperfection in the Human eye curvature may cause blurred vision and near vision. This condition can be clinically termed as **Astigmatism**. If not treated, the blurriness of eyesight may lead to other complications leading to impaired vision for life. We are working towards developing a Virtual Reality (VR) based approach to detect astigmatism condition.

Outcome: As part of this paper, we propose a technique to detect astigmatism condition. The results of this detection are programmed to be used towards our larger goal on developing an end-to-end substantial visual acuity test using VR.

Motivation:

The Eyes are highly developed sensory organs in a human body. However, they are also prone to disorders and diseases. World Health Organization (WHO) fact sheet on blindness and vision impairment estimates that at least 2.2 billion people have vision impairment or blindness [1]. At least a billion among them have vision impairments that can be prevented through early detection [1] .Detection is a major problem in this health crisis. Thus, WHO had come up with a strategic plan called VISION 2020 [2] to eliminate avoidable blindness. Also, studies from researchers in India warn us about the emergence of severe eye disorders due to insufficient care. Early detection is essential for better and planned eye care [3]. These eye issues eventually lead to economic impact on the patients and their families.

Given the importance of detection of eye issues, we started working towards a Virtual Reality based Visual Acuity Test Kit called **VREYE [4],** a low-cost approach to determine and detect

vision disorder. The overall objective of the VREye (split across multiple phases) is to develop a low cost VR device with specific application software that can used for detecting various vision disorders. We currently detect vision disorders like myopia and hypermetropia. However, to accomplish the overall goal of VREYE [4], **Astigmatism** detection is also one of the sub-problems to be solved in a VR Setup. Astigmatism is a common vision condition that causes blurred vision [4]. It occurs when the cornea is irregularly shaped or sometimes the lens has a different curvature inside the eye. (Kaye et al.) Have clinically verified that there is a strong correlation between the Astigmatism of an eye and the degree of myopia (Nearsightedness), i.e., the total amount of Astigmatism in the myopic eye is proportional to the degree of myopia [6]. This clinical evidence [6] motivated us to work towards a setup for detecting the Astigmatism of the human eye using VR as well as the unavailability of 3D depth corrected solutions to build a robust eye-testing setup using VR.

Fan Test in VR:

Clinically, Retinoscopy and Keratometry are the techniques used by Optometrists to measure Astigmatism. They are elaborate and developing a digitized version of these tests is really difficult especially one that caters depth of vision into account. However, the Fan Test is a simplified Astigmatism detection test. It requires the patient to stay 40 cms away from the screen with fan, as shown in **Fig 1.** An optometrist is needed for recording the readings correctly. Our overall goal of VREye is to minimize/negate the need for an optometrist. This is made possible by converting this physical test into a VR setup (which offers a depth of field view as well).
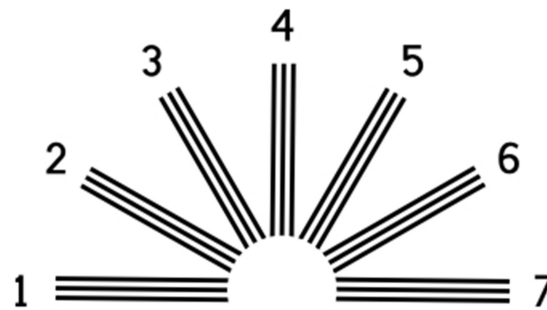

Fig 1. Fan Test Traditional Fan Test contains a series of radiating lines spaced at 10 degrees arranged in the form of sun rays. In the center, there are "V" perpendicular blocks which are mutual to each other. They are rotated through180◦simultaneously.

VR Test Scene Design:

 We designed a VR scene using Unity3D platform. We used Oculus Go VR Headset which offers "Crystal-Clear Optics with Optimized 3D graphics with highest visual clarity". Oculus Go Hand controller is used for user response capture. However, our VR Test Scene is compatible with any available VR Headset and its relevant handheld controller. We placed an Astigmatism fan chart in the middle of the scene with a 360-degree field view around the dark environment. As a result, the participants have a reflex action where in he/she is immediately able to identify a source of light in a dark background. We offer a "Yes" and "No" button on screen as overlay to respond to the queries posed in the VR scene. Although,

not discussed as part of this paper, the application shall eventually be ported to our custom built head mounted device in the later phases of VREye design and developments.

Test Questionnaire, Astigmatism Chart, and user responses are the essential aspects of this VR Scene. Utmost care has been taken in defining seamless flow of events during this test, i.e., the involvement of both the technician (may or may not be an optometrist) and the patient involved in this sensitive activity is kept fairly simple. We followed and applied principles of minimalist design [7] by displaying the results swiftly with fewer interactions with a fixed information display format.
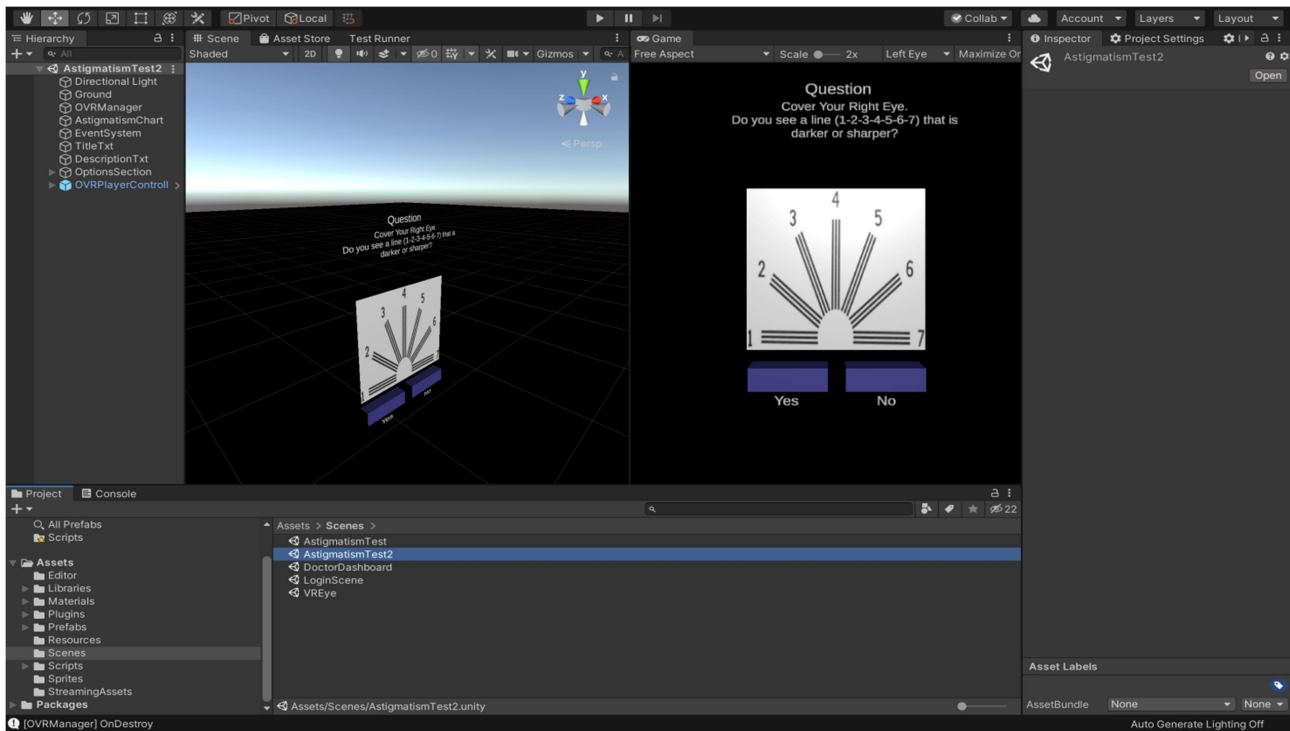

Figure 2. Astigmatism Detection using VR scene

VR Test Work Flow:

The details of test workflow are given below:

1. The technician/user/test subject configures the VR device and chooses astigmatism test. This loads the test assets in VR.
2. The test subject is allowed to join the scene consisting of the astigmatism chart.
3. Fan Test related questionnaire is promoted as an overlay on the screen. The Questionnaire module is flexible for further extension with customization.
4. The test subject now looks at fan chart by covering the left eye without pressing the eyelid. The test subject answers the questions as "Yes" or "No" using a handheld device.
5. The test subject has to repeat the same process while covering his other eye. Covering of the eye is automated within the scene.
6. We store the user responses in a CloudDB for astigmatism judgments. We generate a report card as an outcome of this test for test subject's reference.

VR Fan Test Outcome:

Responses from test subjects lead us to 4 clinically defined indicators that can be used for astigmatism judgment. Table 1 explains the possible outcome based on the input and responses to the Fan Test questionnaire. The patient may be advised for further vision examination by an eye care professional to validate the test result. The primary objective of our VR based astigmatism detection is not to test the degree of severity of Astigmatism but to detect the phenomenon. Our VR Scene will aid any technician (not necessarily an optometrist) to detect the ailment from symptomatic data retrieved from our test task. Such an application will be helpful in countries that have large amount of population but the ratio of eye doctors is rather limited.

	Right	Left
Non-Astigmatic	No	No
Astigmatic	No	Yes
Astigmatic	Yes	No
Astigmatic	Yes	Yes

Table 1. Possible Fan Test Outcome from Right and Left Eye

VREYE Integration:

As part of our ongoing research, we built a test setup for Astigmatism detection of a Human Eye. We are working towards integrating this module with our existing overall eye disorder application – VREye [4]. This integration is for shared eye care testing, which includes myopic, hypermetropic detection and astigmatism detection. The Test kit will be made available to technicians to conduct preliminary detection of the impairments.

Medical Viability:

The American Optometric Association believes that vision tests conducted through an app cannot replace an in-person comprehensive eye examination [8]. However, there are various online eye care test applications available to ease eye care testing. Essilor - a leading eye care solution company, offers an online vision test setup for the general public to understand their current eye health [9] but since Essilor tests are done on 2D apps over screens hence are not a medically viable option. Emerging countries who cannot afford proper eye care testing are trying to utilize the best use of online-based tests that follow medical guidelines proposed by leading medical agencies. Our VREye test kit is being built under similar medical guidelines of optometry to have universal acceptance. Upon detection of an impairment using VREye, the test subjects can be sent to the medical practitioners for further tests. This facilitates detection on a larger scale especially in countries that do not have adequate ratio of eye care experts.

Evaluation Factors:

There are few evaluation factors that need to be considered while conducting this test. For example, clinically dependent factors *age, ethnic group, genetic presence, ocular surgical history, and syndrome related constraints* need to be considered.

Prior research has established a correlation between keratometry and age. Kertometry values gradually increased with *age* [10]. Corneal astigmatism increased over an increase in age.

Most of the astigmatic corneas occur in newborns with the lowest birth weight and lowest post-conceptional age [11]. To address this issue, we plan on including an age constraint while conducting an empirical study on astigmatism detection. Empirical studies have shown that Astigmatism affects populations of different *ethnic groups* differently [11]. The groups of Native American, East Asian, and Asian and Hispanic origin showed high prevalence of Astigmatism. Astigmatic parents may contribute to *genetically developed disorders* in their children [11]. Also, certain types of *Ocular surgeries* in the patient's medical history can contribute to developing asthma [11]. Some *Syndromes* like Down Syndrome, Treacher Collins syndrome, and Spina Bifida are also considered contributing factors towards Astigmatism [11]. Therefore a medical record of the patient can be incredibly helpful in determining Astigmatism. We plan to include these factors while conducting an empirical study on astigmatism detection.

Future Work:

Using our Astigmatism detection setup, we plan on conducting an empirical trial on individual participants to capture their user experience about our VR Scene. Based on the feedback, we shall integrate this test setup with VREye [4] and start running large scale trials on detecting eye disorders for all. Additionally, in parallel we will be building a custom head set (with cost less than USD100) that can be used for VREye instead of the high cost Oculus device.

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