Interactive Simulation WS 15/16
Project Proposal

EYES - Exchange Your Vision Simulator

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1. MOTIVATION

Eye diseases have been an issue throughout all the human history. In the beginning the focus layed on their treatment. This task is reasonably well solved for many diseases and since Virtual Reality (VR) is more and more pushing into the consumer market, it could be broadly used for education and thus prevention of eye diseases. For example, the risk of suffering from retinal detachment can be greatly reduced if the signs are recognized early and a doctor is consulted. Therefore, educational software can be used. In addition, people would hopefully visit a doctor earlier if they already experienced a good simulation of a severe state of a disease, before they actually are in a severe state. Other applications could be testing designs of consumer products like packaging or traffic signs or other signs at public places.

Although there are many simulations available already, they usually work on still 2D images, 2D video streams or static 3D scenes[1] and don't have any game component. Moreover, more sophisticated simulations are probably not easily available for public use and implementing a simulator using Unity3D in terms of an *eye disease asset set* wrapped into a small game could be interesting for a broad audience.

2. CONCEPT

The user should be able to experience different types of eye diseases, including early as well as severe stages in order to understand when to consult a doctor and why. Hopefully, this gives people better judgment on when to visit a doctor as well as the courage to do so, if they experience the symptoms of a particular disease.

There will be at least the first 6 different eye diseases in Table 1 either to choose from in every task or appear at least once in the game.

Possible tasks could be based on reading (visual acuity), distinguishing objects (color), and navigating in everyday environments (limited field of view). This may be realized required for cooking, working at a line in a factory sorting screws or similar things, using public transport or driving a car (at night), food shopping, going to the pharmacy getting the right medication, find hidden object given written hints, or board/care games.

[1]All these statements are based on our brief research. There might still be game-like applications out there… somewhere.

Ideally the chosen tasks would be individual levels which depend on each other and will tell a small story, like car driving → food shopping → cooking. The user can either choose the disease for the level himself or a random disease is selected in the beginning. The chosen disease should become worse over the time (within one level or across levels) but, if possible and accurate (neglecting the time), the user should also be able to slow down the process or even heal the disease completely. Therefore he/she has to take the appropriate measures for the specific disease.

3. TECHNICAL ASPECTS

In order to convincingly convey the topic, using a VR device like the Oculus Rift or an mobile phone / Google Cardboard combination would be beneficial to the project.

Vinnikov *et. al.* [VAS08] developed a Gaze-Contingent-Display in order to evaluate the users eye direction and adept the displayed images in real-time. Because the effects of eye diseases follow the eye movement, i.e. are static with respect to the eye coordinate frame, they achieved more realistic results in comparison to rendering gaze-independent images. A consumer solution is under development by the German company SensoMotoric Instruments (SIM) which provides an gaze tracking solution update for the Oculus Rift DK 2 [Sen15; Geu14]. According to their website they also provide an integration into various VR engines, including Unity3D, available making it especially interesting for this project.

The gaze-direction would be useful to accurately simulate the vision fields and would also be an interesting human interface for the game mechanics.

As described in [VAS08] and [BM08] effects like blurry or distorted vision, floaters, and reduced field of view can be efficiently implemented by using fragment shaders. The individual properties of the shaders and how to decompose the individual diseases into different shaders (re-usability) is subject to the first research block. But since this appears to be a very well researched topic, we're confident that we won't run into any major difficulties.

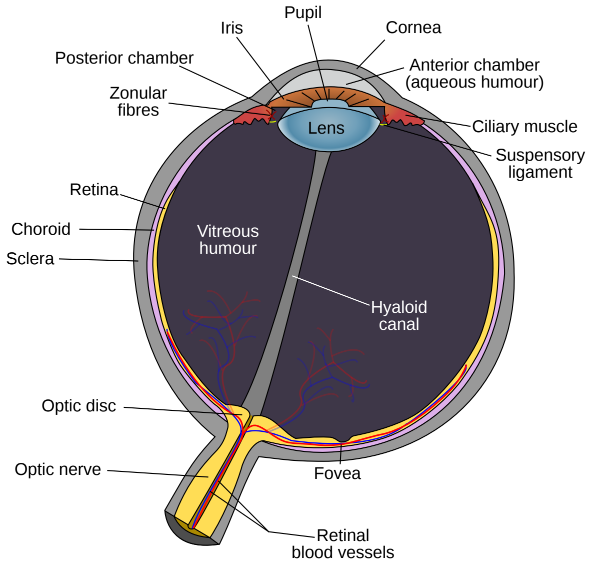

Figure 1: Scheme of the human eye.

Glaucoma
Sudden eye pain, blurred vision and loss of vision especially in the outer regions.

Cataracts
Blurred vision especially in the center region.

Diabetic Retinopathy
Black spots in the view.

Color blindness
Some colours appear indistinguishable.

Achromatopsia
(Almost) No color sensitivity at all.

Myopia / Hyperopia
Commonly known as nearsightedness and farsightedness respectively.

Kreatoconus
The cornea deforms into a conical shape. Multiple ghost images may be visible, arranged in a chaotic pattern, the vision becomes blurry, and visual acuity decreases at all distances. Poor night vision, photo-phobia, and eye strain are additional symptoms.

Nyctalopia / Hermalopia
High difficulty to see in relatively low and bright light respectively.

Retinal detachment / Posterior vitreous detachment
Flashes of light, very brief in the extreme peripheral region. Sudden increase in the amount of floaters. Slight feeling of heaviness in the eye.

Table 1: Eye diseases

4. TIME-LINE

The dates behind the categories are the due dates.

- Research - 15. Nov. '15
  - What kind of eye diseases are most common?
  - Find some suitable tasks.
  - Are there simulators like this available?
  - How to implement custom camera projections in Unity?
  - How to interface with the Oculus Rift?
- Implementation - 1. Jan. '16
  - Create scenario/level 1
  - Implement the first disease
  - Implement the other diseases
  - Create another scenario
  - Create menu
  - Integrate Oculus Rift
- Testing - 11. Jan. '16
- Report - 18. Jan. '16
- Presentation - 25. Jan. '16

References

[BM08] D. Banks and R.J. McCrindle. "Visual eye disease simulator". In: *7th International Conference on Disability, Virtual Reality and Associated Technologies (ICDVRAT 2008)*. 2008, pp. 167–174. URL: http://centaur.reading.ac.uk/14969/.

[Geu14] Megan Geuss. *Why eye tracking could make VR displays like the Oculus Rift consumer-ready*. ars technica. June 4, 2014. URL: http://arstechnica.com/gaming/2014/06/why-eye-tracking-could-make-vr-displays-like-the-oculus-rift-consumer-ready/ (visited on 10/28/2015).

[Sen15] SensoMotoric Instruments. 2015. URL: http://www.smivision.com/en/gaze-and-eye-tracking-systems/products/eye-tracking-hmd-upgrade.html (visited on 10/28/2015).

[VAS08] Margarita Vinnikov, Robert S. Allison, and Dominik Swierad. "Real-time Simulation of Visual Defects with Gaze-contingent Display". In: *Proceedings of the 2008 Symposium on Eye Tracking Research & Applications*. ETRA '08. Savannah, Georgia: ACM, 2008, pp. 127–130. ISBN: 978-1-59593-982-1. DOI: 10.1145/1344471.1344504. URL: http://doi.acm.org/10.1145/1344471.1344504.