CSCE 681 600: SEMINAR REPORT 7

Name: Rohan Chaudhury

UIN: 432001358

23rd February 2022

Paper Citation: Kangsoo Kim, Austin Erickson, Alexis Lambert, Gerd Bruder, and Gregory F. Welch. 2019. Effects of Dark Mode on Visual Fatigue and Acuity in Optical See-Through Head-Mounted Displays. In Symposium on Spatial User Interaction (SUI '19), October 19–20, 2019, New Orleans, LA, USA. ACM, Association for Computing Machinery, New York, NY, USA, Article 9, 1–9. https://doi.org/10.1145/3357251.3357584

1. SUMMARY:

a. Problem Statement:

The authors in this paper have examined the impacts of dark mode schemes of color in OST-HMDs (optical see-through head-mounted displays) where distinctive "additive" light model indicates that: (1) Bright graphics are visible (2) Dark graphics are transparent. "Dark Mode" or light-on-dark color schemes, are becoming increasingly popular across a broad range of screen technology and application domains. People who work on a computer for long hours, especially in low-light conditions, prefer to switch color scheme on the screen from "dark text on a light background" to "light text on a dark background" due to apparent advantages to their visual characteristics. In this paper, the authors have presented the results of a human-subject investigation in which they tested a regular and inverted color mode against various physical backgrounds and lighting circumstances. Their findings demonstrate that dark mode graphics on OST-HMDs improve visual acuity, fatigue, and usability.

b. Proposed solution:

The researchers anticipated that Augmented Reality annotations on OST-HMDs, which include light or dark foreground colors on a dark or light background, could affect users' visual sharpness and tiredness. They address and explore these problems using the Microsoft HoloLens as an example in this study. In a human subject investigation, they requested participants to read AR annotations in various color modes and to perform visual acuity tests with AR annotations in various backdrops and lighting situations. Participants' visual preferences, fatigue, and acuity were evaluated by the authors. They assessed the following questions: (1) When using OST-HMDs, whether users prefer standard or dark mode color schemes. (2) Whether dark mode color schemes with OST-HMDs provide subjective or objective benefits in terms of visual fatigue and sharpness. (3) Whether users' preferences are in line with the modes' benefits or drawbacks.

The authors had asked 19 people without any vision defects to read a certain text in augmented reality on a HoloLens OST-HMD, perform visual acuity tests, and score their subjective experience, visual fatigue, and preference for these modes of vision. The authors utilized the Unity game engine and connected it with the HoloLens to render the visual stimulus. They picked AR textual annotations with either black text on a white background or white text on a black background that

was recognized as "holograms" in the laboratory area. Four reading passages were constructed by the authors using "Pearson Test of English Read Aloud Practice Questions". They also created an augmented reality version of a popular visual acuity test chart, which is distinguished by circles with a missing component on one of the four sides. Black circles on a white backdrop or white circles on a black background made up the chart. The following were the two visual mode conditions that were considered: (1) “Light Mode”: On the HoloLens, a positive contrast mode was used in which the foreground was black and the backdrop was white. (2) “Dark Mode”: a negative contrast mode was used with the foreground white and the backdrop black. The other variables used in the experiment are as follows: (1) Physical Lighting (Low Light, Hight Light) (2) Physical Background (Chromatic Distortions, Lightness Distortions, Uniform). After performing the series of tests on the 19 participants the following measures were taken: (1) Visual Acuity of the participants which corresponded to the mistakes made by him/her when he/she was reading the chart (2) Visual Fatigue which was collected from the participants using questions on a 7-point Likert scale (3) Usability of AR annotations collected from the participants using a questionnaire (4) Preferences of the participants with respect to the two modes of vision in various light and background conditions.

c. Results:

From the results of the experiments, the authors found that the subjects had much better visual acuity than in light mode and were also able to complete considerably more rows on the test chart in the dark mode without any mistakes. The authors also found that the visual fatigue of the participants was much lower for the dark mode when compared with that of the light mode. They also found that there is an improvement in the usability of Augmented Reality annotations when using dark mode and that the participants preferred dark mode more than light mode. The responses collected from participants gave the indication that the reason for such preference was because the participants perceived an increase in visual comfort and ease to read with the dark mode.

2. CRITIQUE:

a. Pros:

- **i.** In recent times optical see-through head-mounted displays are becoming very cheap and accessible to everyone. This research on how dark mode affects the visual characteristics of a human being will help us a lot in maintaining eyesight conditions by efficient use of the dark mode feature.
- **ii.** The paper does show an in-depth of the previous and related work in the same field which helps a lot to connect the current work as a continuation of the previous work.
- **iii.** The experiments for the purpose of measuring visual acuity, visual fatigue, usability, and preferences were well designed and a correct choice for this purpose.

b. Cons:

- **i.** The paper is a study of existing modes on the visual characteristics of an individual and no new methods of improvement to the ailments were suggested.
- **ii.** The experiments were targeted only for an additive light model and the authors have stated that these results might not hold true for other kinds of displays.
- **iii.** The number of participants in the research was very less (only 19). This can lead to biased results.

iv. The participants in the experiment might also have been biased towards using dark mode before even starting the experiment because there were some frequent users of dark mode amongst the participants.
v. The types of experiments performed to get the results were less which can also lead to biased results.

3. FOLLOW UP:

a. The research can be carried out with a larger number of participants to remove the possibility of the results being biased.
b. Research can be carried out with OST-HMDs on related chromatic differences, as well as further investigation of the vision modes with other kinds of VR displays.
c. Their results can lead to a better understanding and development of AR vision technologies and also in technologies centered around low light conditions.