BrightView: Increasing Perceived Brightness in Optical See-Through Head-Mounted Displays

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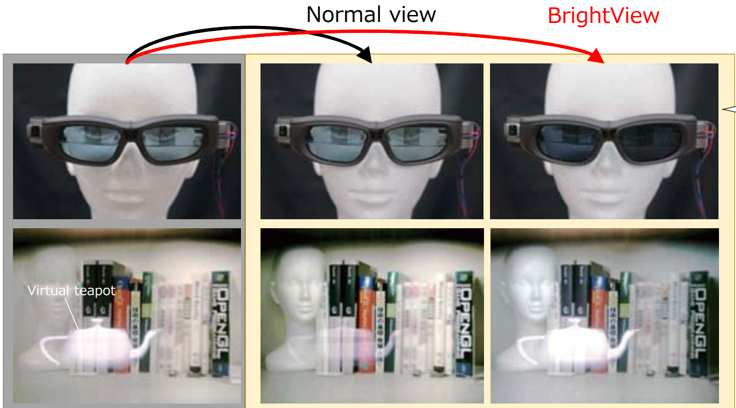
Virtual content on optical see-through head-mounted displays (OST-HMDs) appears dim in bright environments. This poster demonstrates that a liquid crystal (LC) filter can be used to increase the *perceived* brightness of the virtual content. Continuously adjusting the LC filter opacity attenuates the real scene and increases the perceived brightness without being noticed by the user. The results of our psychophysical experiment with 16 participants validate our prototype OST-HMD. Our design could be combined with existing and future OST-HMDs to improve the visibility of the virtual content in augmented reality.

Basic Concept



Dark environment

(a) The virtual teapot appears consistent with the background in a dark environment.

Bright environment

(b) On the other hand, the teapot appears transparent and dim in a bright environment.

(c) By gradually adjusting the transparency, the teapot is perceived as brighter, while the background is perceived as unchanged.

Images (a), (b), and (c) were captured directly through our prototype with a Point Grey Flea3 camera with auto shutter speed.

The illuminance acquired by the illuminometer corresponds to the irradiance of light in the whole FOV. BrightView changes the transparency α based on the irradiance of the real scene.

Similar products vs. BrightView

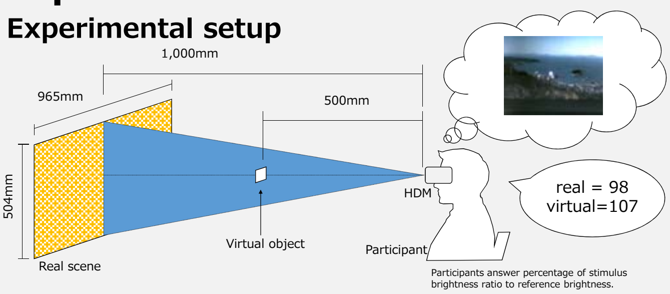
Photochromic lenses
(Seiko Transitions)

Liquid crystal helmet shield
(e-tint Akari AX-11 and TRUSCO TSM20S)

- The basic concept is the same as photochromic lenses and Liquid crystal helmet shield.
- BrightView aims to increase the brightness of virtual objects, not to decrease the brightness of real scene.
- BrightView has the ability to optimally control the transparency according to human visual characteristics and environmental conditions.

Experimental Method

Experimental setup



- **Real Scene:** Real outdoor image shown on a plasma display
- **Virtual object:** White dot
- **Participants:** 16 lab. students (14 males and 2 females (age 20 to 24))
- **Durations:** 5, 10, and 20 s
- **Control condition:** Constant transparency of the LC visor α_s for 20 s
- **Evaluation:** Rate to the reference ($\alpha = \alpha_s$) brightness of 100
- **Total data:** 256 raw magnitudes
  (= 2 targets × (1 control + 3 durations) × 2 times × 16 people)

Hypotheses

- **H1:** After a gradual increase in the opaqueness of the LC visor, users unlikely notice a decrease in the brightness of the real scene ($\epsilon_r > 1$).
- **H2:** After a gradual increase in the opaqueness of the LC, users perceive the virtual content to be brighter ($\epsilon_v > 1$).
- **H3:** If the brightness is adjusted over a longer period, the perceived deviation values become larger.

Visual stimuli

Analysis method

based on Stevens' law

Constant Exponent

$$p = CS^k$$

Perceived brightness luminance

Real scene 0.6 (complex scene)

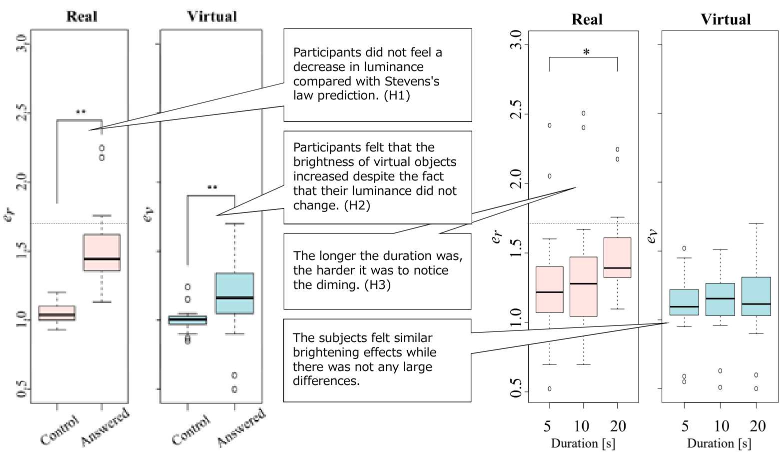
$$p_s = C(\alpha_s S_r)^{k_r} \qquad p_e = C(\alpha_e S_r)^{k_r} \qquad \epsilon_r = \frac{p_e}{\underbrace{p_s}_{100}}\left(\frac{\alpha_e}{\alpha_s}\right)^{-k_r}$$

Virtual object 0.31 (dot)

$$p_s = CS_v^{k_v} \qquad p_e = CS_v^{k_v} \qquad \epsilon_v = \frac{p_e}{\underbrace{p_s}_{100}}\underbrace{\left(\frac{\alpha_e}{\alpha_s}\right)^{-k_v}}_{1}$$

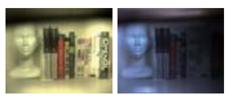
observation evaluation criteria

Results



Discussions

- By slowly declining the transparency, ...
  - Users do not notice the decrease in brightness of the real scene as expected in Stevens' law.
  - Users feel that the brightness of the virtual object is slightly increased.
- The observed effect was not so large because ...
  - The participants may have noticed a change in brightness due to flickering of the liquid crystal.
  - 20 seconds may have been a bit shorter to cause BrightView effect to the participants.
  - The applied voltage range was as narrow as 1.57 V to 3.53 V, because non-uniform pattern in transparency appeared.



1.37V 5V

Future directions

- We plan to formulate real and virtual brightness relationship in our visual perception to effectively control real and virtual light.
- We will investigate effects of dynamic backgrounds and variety of virtual contents comprehensively using better LC visors.