Frameless

Volume 1 | Issue 1 Article 23

2019

Color and Object Appearance in Augmented Reality

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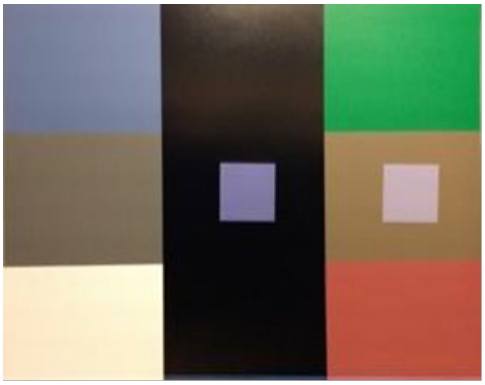
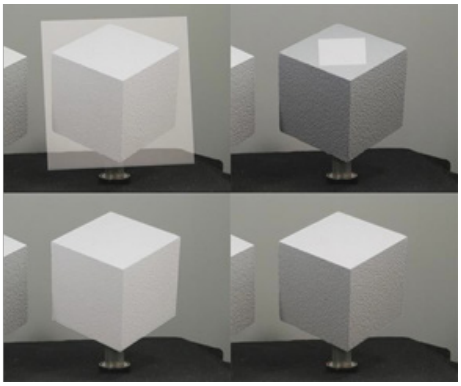
INTRODUCTION

This presentation will summarize recent work on the visual perception of color appearance and object properties in optical see-through (OST) augmented reality (AR) systems. OST systems, such as Microsoft HoloLens, use a see- through display system to superimpose virtual content onto a user's view of the real world. With careful tracking of both display and world coordinates, synthetic objects can be added to the real world, and real objects can be manipulated via synthetic overlays. Ongoing research studies how the combination of real and virtual stimuli are perceived and how users' visual adaptation is affected; two specific examples will be explained.

MIXED COLOR APPEARANCE

OST AR systems generally provide the user with an optical mix of foreground (virtual) objects and background (real) objects, which





Left: example of a color appearance experiment with virtual color patches (small squares) overlaid upon different real, printed colored backgrounds. Right: example of an lightness manipulation experiment with real cubes showing different styles of overlays, from poorly-aligned to physically-accurate.

means the background bleeds through the foreground and distorts its color. Further, viewers perceive the transparency of the foreground objects and discount, to some extent, the bleed-through of the background. We performed color matching experiments to uncover how viewers make simple color matches; for example, in the figure above (left), viewers were asked to adjust the color of the small square on black background to match the appearance of the other small square. Many combinations of foreground and background provide data to test and improve color appearance models. This work is ongoing, looking at more complex stimuli than simple squares of color.

OBJECT MANIPULATION

In order to convincingly manipulate object appearance, viewers must accept a plausible optical mix of foreground and background. A classic concept of veiling luminance says that an overlay, or veil, of light can be discounted by viewers, and that the true color or lightness of objects behind can still be correctly identified. This must be overcome in AR to convey the impression of manipulation of object properties. We have recently experimented with object lightness, using real cubes with AR overlays in a variety of sizes and alignment. Preliminary results show that these differences affects how viewers perceive object lightness, which is related to discounting the overlay.

CONCLUSION

The complex interplay of real-world lighting and objects with virtual-world rendered lighting and objects means that predicting what viewers perceive is challenging. Optical blending, cognitive discounting, and mixed adaptation are currently under study. Existing models of color appearance and adaptation need verification and likely updating to accurately describe what is seen; once updated, such models can be inverted to allow AR systems to present viewers with robust, predictable color and appearance.