Multilayer holographic augmented reality with digital micromirror devices: content pipeline and system implementation

Executive summary

Most augmented and virtual reality devices currently available rely on stereoscopy to present 3D information to users. However, stereoscopy has certain limitations, including the issue of vergence-accommodation conflict. On the other hand, holographic displays have the potential to fully control the amplitude and phase of a light field, allowing for visualizations that closely resemble natural vision. Additionally, holographic displays can project multiplane scenes, where different information is presented to the user's eyes depending on their focus position. However, there are several challenges that need to be addressed in order to fully realize this potential.

The main challenges are related to the need for fast and accurate methods to encode a target scene into a hologram, as well as the availability of suitable devices to modulate a light field with the resulting holograms. Current high-performance holographic displays use phase-only holograms combined with liquid crystal on silicon spatial light modulators (LCOS-SLM). However, these devices are expensive and limit the potential applications of holographic display techniques. An alternative option is the use of digital micromirror devices (DMD), which are more affordable but limited to binary amplitude modulation. Due this limitation, most existing high-performance hologram generation methods were developed for phase only holographic displays and are not suitable for projection using a DMD. Despite these limitations, recent advances in fast propagation methods and binary amplitude hologram generation with binarized neural networks show promise in overcoming these challenges.

In this project, we aim to leverage the latest advancements in hologram generation to develop a holographic display based on a digital micromirror device, as well as a binary amplitude hologram generation pipeline that takes advantage of the high speed offered by DMDs compared to LCOS-SLMs. Specifically, our intention is for the prototype system developed during the project to serve as a test platform to demonstrate the capabilities of new binary amplitude hologram generation methods, as well as the potential of holographic augmented reality in general. Moreover, by highlighting the potential of digital micromirror technology in holographic displays, we hope to lower the entry barrier for many applications, such as optogenetics, superresolution microscopy, and holographic tweezers, which have traditionally relied on expensive LCOS-SLM-based solutions.