CHAMPACA. COMPUTER-GENERATED HOLOGRAPHY: APODIZATION MASK WITH PHASE AND AMPLITUDE CONTROL

3D cinema has long been accepted as a natural part of living in the modern world – what's more, they don't meet our expectations anymore. The known issue lies in the convergence-accommodation conflict, which means that while we're watching 3D movies, our eyes focus on a plane of the screen, while the images are seen on a different distance. Most of us know well both the message delivered by the three-dimensional projection of princess Leia from the Star Wars saga, and Star Trek's Holodeck - scientists, strongly believing that the ideas created by fiction writers could be mirrored in reality, have been working for years on various new technologies that would meet our high expectations.

One of the possible paths considered by the scientists is computer-generated holography. With the use of sophisticated devices, called spatial light modulators or, in short, SLMs, it is possible to display real three-dimensional images, that are exactly the same as images we observe in the real world. In the effect, the eyes focus at the same distance that the projected images are observed (which means that the convergence-accommodation conflict is resolved), and what's more, we observe the parallax, as well. Parallax is a phenomenon of seeing different sides of an object depending on the point of observation.

It is worth noting that computer-generated holography is not a completely new field of science. First mentions of its possibility were published as early as in the '60s, however only nowadays it is not only possible to create spatial light modulators containing millions of pixels of micrometer size (that's smaller than the thickness of a hair!), but also to calculate computer-generated holograms in real time, which enables projection in 60 Hz, that is, from human's perspective, completely smooth. That doesn't mean, however, that the promising technology is now ready to be introduced to the market, there are still many challenges computer-generated holography has to face. One of them is the presence of replicated images in the reconstruction of a hologram created with the use of an SLM, called higher diffraction orders. It is undesired not only due to the loos of efficiency and energy, but also because of the need to occlude such additional images. The ideal solution would include finding a method of reduction of such higher diffraction orders that enables redirection of light from them back to the desired areas of hologram reconstruction.

The search for such a method is the substance of this project. We will take a closer look at masks that can be applied to each pixel of the spatial light modulator, adjusting their shape and, at the same time, the information they display (the phase). Research shows that it can lead to suppression of higher diffraction orders while, at the same time, amplifying the main image. Finding a perfect mask is, however, complicated. While in the case of adjusting the pixel shape previous research found a working solution, the search for an optimal mask isn't finished. When it comes to adjusting the phase, this task exceeds the possibilities of classical computing.

Whenever the classical computation methods fail, the scientists learn to employ neural networks, which work especially well in areas where the complexity of a problem is too high for classical algorithms. This project will include creation and training of new neural networks that will help us cross the limits of classical computation methods.

The goal of this project is not only to find a theoretical solution of the described problem, but also to fabricate a mask which could be then experimentally applied to the spatial light modulator, and to confirm whether the obtained results align with what was previously predicted in theory. If the additional images in the reconstruction of a hologram are reduced, the project will be successful.

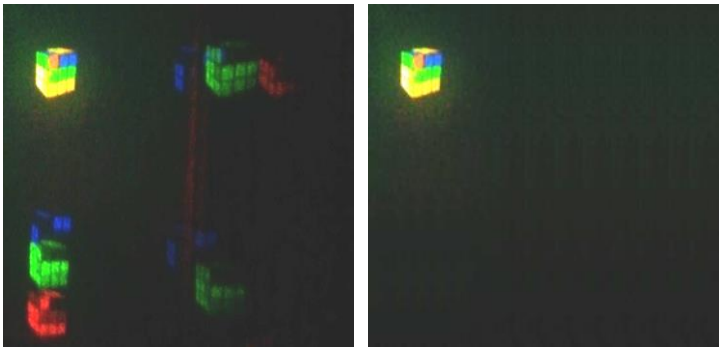

Fig. Left: hologram reconstructed with an SLM device; main image visible in the top left corner. Right: the desired effect.