The creation of colored holograms in digital holography

Stefan Hertwig, Johnnes Bühl, Holger Babovsky, Armin Kiessling, Richard Kowarschik

Institute of Applied Optics, Friedrich-Schiller-University of Jena
mailto: oik@uni-jena.de

We show the possibility of creating colored holograms by combineing single-colored holograms at three different wavelengths (633nm, 532nm, 473nm). Thereby, the aim is to achieve a color similar to the original in the reconstructed picture. Additionaly, the reconstructed picture gets speckle-reduced with the help of a multi-imaging technique.

1 Introduction

The digital holography owns already a long tradition [1].

The most important advantages are:

- the absence of chemical ingredients
- the real-time processing
- to stain the reconstructed (gray-scale) images

However, an object is usually shown only in gray scale values (see figure 1).

Fig. 1 *A typical image of an holographic captured object in gray values.*

Nevertheless, in the biological-medical area it would be in particular of some interest to show the specimens in their natural colours. It is an other possibility to receive a false coloured representation, not only for one admission wavelength, but also for several wavelengths to recognize more detailed information from the object.

It is obvious to create a holographic image of the object successively with three wavelengths and to reconstruct the three holograms afterwards. After the post- processing, each of the holograms can reconstruct the object in gray scaled values. If every one of the three single images is dyed in the original color of the laser used to create the hologram, then one can expect as a overlap a multi-colored image corresponding to the original color composition of the object.

2 Experiment

The experimental setup is shown in figure 2.

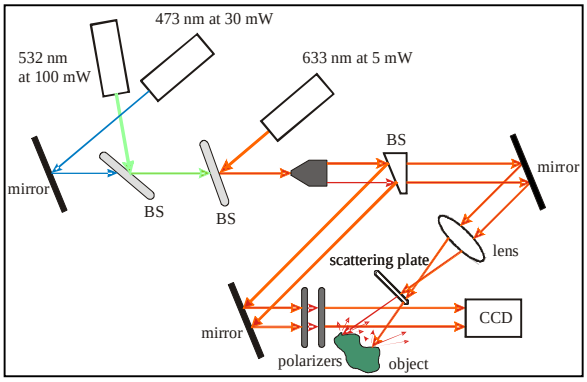


Fig. 2 *Experimental setup to record an object in three colors.*

All 3 lasers are adjusted in a way, that its beams are congruent. To simplify matters, a plane wave was used as reference wave. The polarizers help to adjust the appropriate intensity ratio between the object wave and the reference wave.

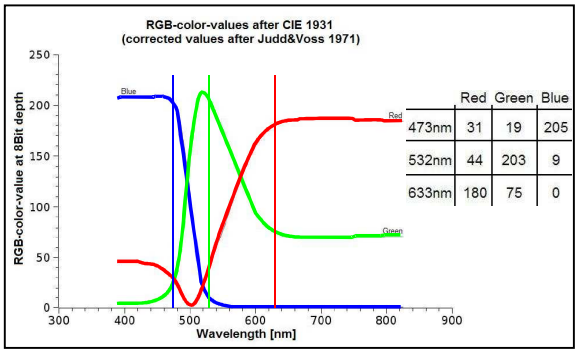
A software package, called Holodeck, was used to carry out the recording of the hologram as well as its reconstruction at quasi real-time (5 - 10 frames/second).

The first results won in this manner (see figure 3) show that it is not sufficient to use the common RED, GREEN and BLUE colours of the RGB-colour table for the visualization of the reconstructed image.

Fig. 3 *The Diddl-mouse, recorded with lasers at wave lengths of λ = 473 nm, 532 nm and 633 nm respectively and superposed with pure RED, GREEN and BLUE of RGB*

Obviously the colours in the combined image do not correspond very good to the real object.

To achieve a more sufficient color compostion, the combinations of colors according to CIE 1931 have to be used. This results in a representation close to reality for the applied laser wave lengths (figure 4).



	Red	Green	Blue
473nm	31	19	205
532nm	44	203	9
633nm	180	75	0

Fig. 4 *Table of values for the used laser wave lengths to get an impression of the laser light close to reality.*

Applying this color distribution (figure 5), one already receives a better impression in color, although nevertheless, the speckle distribution still violates considerably the image.

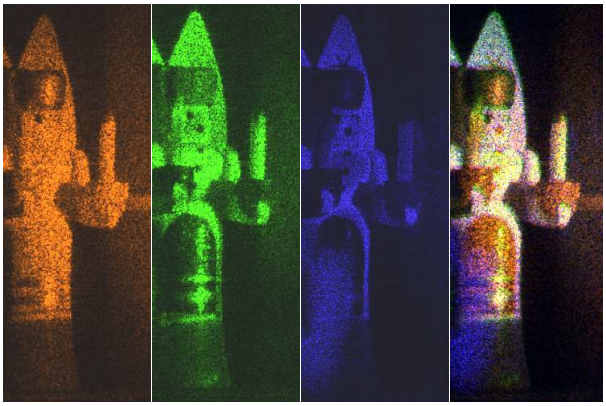


Fig. 5 *The reconstructed and painted holograms in red, green and blue corresponding to the CIA 1931 norm. The speckles still remain.*

However, using a speckle reduction technique described below, the speckles can be suppressed very well, so that figure 6 shows a picture close to reality of the object.

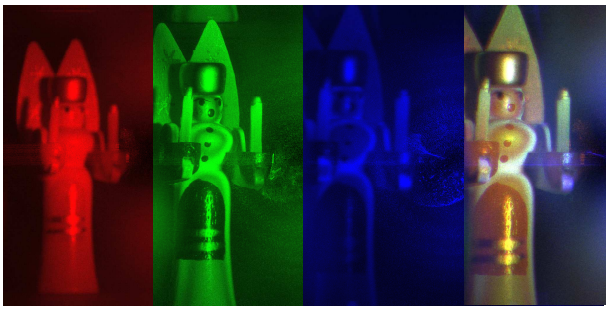


Fig. 6 *The reconstructed and dyed holograms. The speckles were suppressed.*

3 Reduction of speckles

As demonstrated in figure 2, a rotating scattering plate is put in front of the object. In each position of the plate a hologram will be recorded. The speckle pattern in the reconstructed image is strongly related to the position of the scattering plate. Summarizing some images, the speckle pattern will be suppressed without decreasing the spatial resolution.

4 Summary

We could show that with the digital holography colored reconstructions can be won. To achieve acceptable results compared to the object, the color distribution acording to CIE 1931 was used. For a good image quality a reduction of speckles has to be done. In our case the reduction was realized by an averaging procedure.

An even better color impression can be achieved by using more than three colors.

References

[1] U. Schnars, W. Jüptner: Digital Holography, Digital hologram recording, numerical reconstruction, and related techniques (2005) Springer Berlin Heidelberg New York