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Application of Auto Focus Techniques to Digital Holography with Multiple Illumination Directions.

ABSTRACT - Masterthesis

To measure the surface topography of microscopic objects with optical methods has many advantages: The measurement is fast, non-destructive and has a high resolution. Because of these abilities optical measurement methods are widely used in industry and science.

For example surface profiling with a microscope can be done by scanning mechanically through the focal planes and thus measure the parts of the object, which are in focus. The parts of the different focal planes are put together and the result is an image with all parts of the object in focus. The drawback of this measurement technique is that the number of measurements is equal to the number of focal planes, which is the height of the object divided by the depth of focus of the microscope.

One method to measure an object without scanning is digital holography. The object is illuminated by coherent light and the reflected object wave is superimposed by a reference wave. The resulting hologram contains amplitude and phase information of the object wave and hence of the object surface itself. Reconstructing the hologram numerically results in a complex wave field of the object wave, which contains amplitude and phase information. The phase distribution of the object wave depends on the surface profile. Thus the object surface can be determined by analyzing the object wave phase distribution.

Digital holography can be combined with a microscope to measure the surface profile of a microscopic object without scanning, because it enables numerical focusing. Auto focus algorithms are used to create an image with all parts of the object in focus. One measurement is enough to get the full information about the object surface. Through post-processing of the measurement data the object can be reconstructed completely. This advantage allows fast and precise measurements of microscopic objects.

Since coherent light has to be used to create a hologram, the measurement can be corrupted by speckle noise. Speckles occur when the surface has inhomogeneities in the range of the wave length of the illuminating light. The speckle noise reduces the image quality and is a drawback for the application of image processing techniques like auto focus algorithms.

To reduce the speckle noise the object can be illuminated from different directions and the reconstructed complex wave fields averaged. Experiments showed that the speckle noise can be reduced up to 3 dB if the object is illuminated from 3 directions.

This master thesis investigates the dependence of the speckle noise reduction on the number of illumination directions. Furthermore it is shown how this reduction improves the effectivity of contrast based auto focus algorithms.