THREE-DIMENSIONAL SCENE MEASUREMENT IN THE PRESENCE OF SPECKLE USING SINGLE-CAPTURE DIGITAL HOLOGRAPHY AND IMAGE PROCESSING

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With digital holography one can record and reconstruct real world three-dimensional (3D) objects [1]. The recorded interference pattern includes information about both amplitude and phase of a wavefront reflected from or transmitted through the object. However, some of the hologram capture setups pose a problem for the reliable reconstruction of quantitative phase information. This can be because the twin image, speckle, and/or noise corrupts the reconstructed phase. In such cases, phase unwrapping techniques cannot be used to infer the shape of the object and only the amplitude of the object can be reliably reconstructed and used as the basis for metrology,. Furthermore, for dynamic scenes, one has only one camera frame from which to derive shape information about the 3D scene.

The general class of techniques to extract depth information from the hologram that satisfies these constraints relies on applying a focus criterion to a set of reconstructed amplitudes [2,3]. Its primary disadvantage is that many reconstructions from the hologram are required at different depths. In order to overcome this disadvantage, and still satisfy the earlier mentioned constraints, we introduce an image processing technique based on stereo disparity.

Digital holography can be regarded as a two-stage imaging technique (capture and reconstruction). We introduce a third stage: image processing. Although for the capture stage, we are limited to a single step (camera frame) we can allow ourselves multiple offline reconstruction steps. In this case we reconstruct two different perspectives of the scene and use the stereo disparity (caused by motion parallax) between the two reconstructions to determine relative depth of the objects in the scene. Objects do not need to be in focus for stereo disparity to work, and so a reduced number of reconstructions is possible compared to existing techniques. We can show the effectiveness of our technique using digital holograms of both macroscopic and microscopic real-world 3D objects.

This research received funding from the European Community's Seventh Framework Programme FP7/2007–2013 under grant agreement no. 216105 (Real 3D).

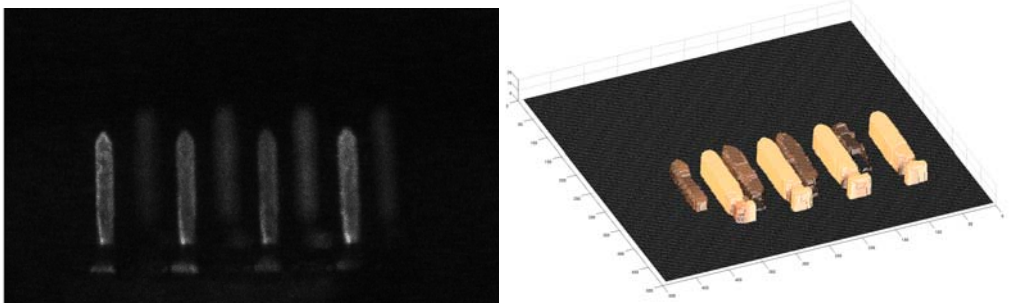

Figure 1: Reconstructed intensity from a hologram, and calculated depth map using stereo disparity

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