Multi-aperture imaging systems with segmented field of view

F.C. Wippermann, A. Brückner, A. Oberdörster, A. Bräuer, A. Tünnermann

Fraunhofer Institute for Applied Optics and Precision Engineering IOF, Albert-Einstein-Str. 7, 07745 Jena, Germany

** Corresponding author: frank.wippermann@iof.fraunhofer.de*

Abstract Submission for Topical Workshop:

☒ Computational Imaging

☐ Computer Vision and Machine Learning

☐ Large Data in Optics

☐ Virtual/ Augmented Reality

Keywords : miniaturized camera, micro-optics, array-camera, multi-aperture imaging

Abstract

In contrast to traditional single aperture cameras, multi-aperture approaches have advantages in terms of miniaturization, simplicity of the optics and additional features such as depth information and refocusing enabled by the computational manipulation of the system´s raw image data. Independent of their specific working principle, all multi-aperture imaging systems consist of a plurality of channels located next to another, forming an array. The main advantage of multi-aperture imaging systems is the potential of decreasing the total track length, which is highly desired in mobile applications. Typically, the super-resolution principle is applied. Different channels are transmitting the same object field with higher resolution than sampled by the image sensor. The under-sampled image information of the different channels is used to compute an overall image with increased resolution. Different approaches have been suggested. In some systems, each channel transmits the entire field of view; in others, the FOV is segmented (Fig. 1). However, in order to achieve a high quality image, super-resolution algorithms have to be used, which leads to increased computational load and increased energy consumption. This is undesirable especially in mobile applications.

We propose a new layout for array-cameras also enabling reduced z-height and depth mapping capabilities without the need to employ super-resolution techniques. The system is based on a multitude of imaging channels arranged in a row where each channel transmits a different part of the entire field of view. The restriction of the individual channel´s field of view leads to a less complex optical system targeting reduced fabrication cost. The presented concept for miniaturized array-cameras with several megapixels of resolution is targeting high volume applications in mobile and automotive imaging.

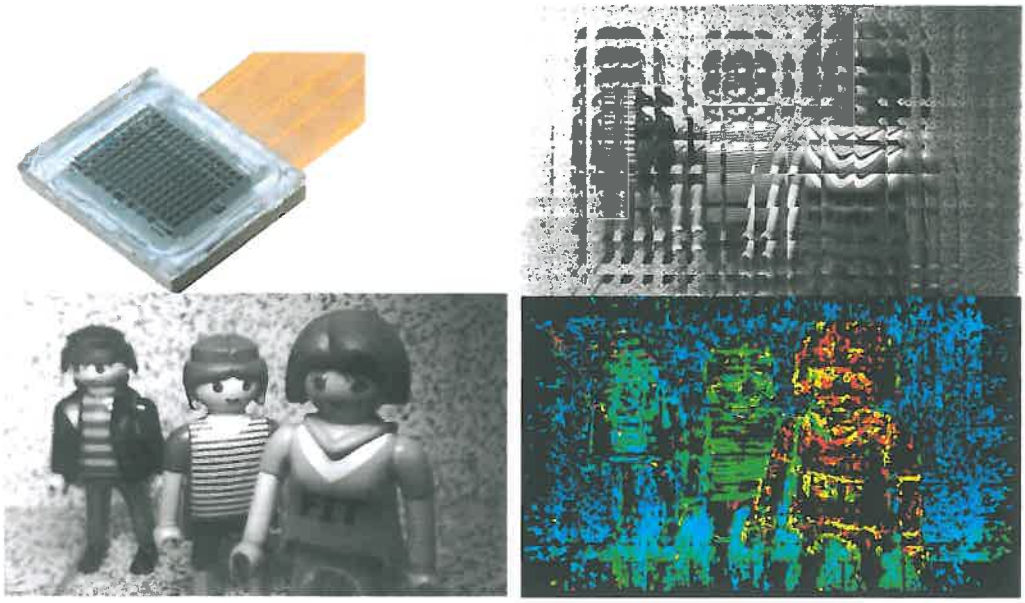

Figure 1: Upper left: 720p-type multi-aperture camera based on super-resolution with a 2D-channel arrangement using refractive freeform arrays. Upper right: Raw image data from the array-camera with segmented field of view. Lower left: Rendered image for close object distance. Lower right: Depth map.

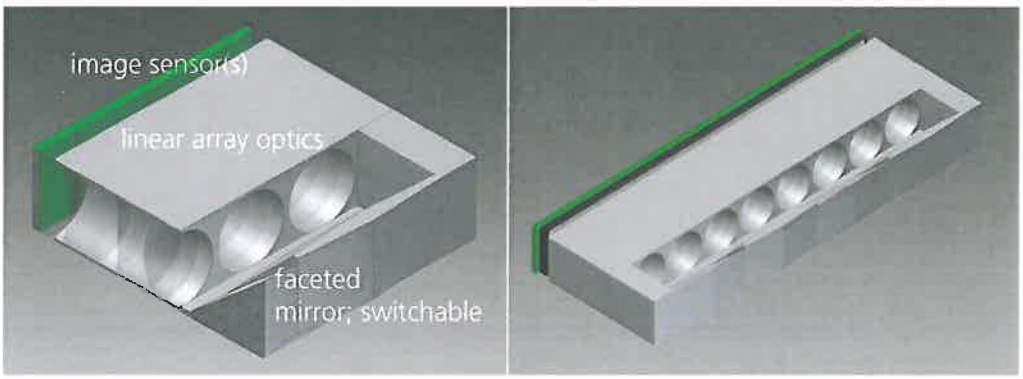

Figure 2: Rendered drawing of the proposed linear array-camera module with reduced z-height und depth mapping capabilities.