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RECONSTRUCTION OF THREE-DIMENSIONAL IMAGE FROM COMPOUND-EYE IMAGING WITH DEFOCUS USING RAY TRACING

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Abstract. *A three-dimensional (3-D) image reconstruction method from a compound-eye image degraded by low-resolution sampling and defocusing is proposed. The 3-D profile of a target object is acquired from parallax images captured by a compound-eye imaging system. The compound-eye imaging is modeled by ray tracing to relate the pixels on the 3-D surface of the object to the pixels of an image sensor. The point-spread function of an optical system is estimated by calculating many optical rays passing through the whole area of the pupil of the optical system. This enables us to take into consideration the influence of occlusion upon the point-spread function. A high-resolution 3-D image can be reconstructed by minimizing the difference between the captured image and the image calculated by ray tracing of the modeled composed-eye imaging. The validity of the proposed method is verified by computer simulations and preliminary experiments.*
Keywords: Compound-eye imaging, Super resolution, Defocus-blur restoration

1. **Introduction.** Recently, advanced image acquisition technologies utilizing unconventional optical imaging systems and signal processing are studied actively [1-5]. We have proposed and investigated a compact image-capturing system called a TOMBO (thin observation module by bound optics), which based on compound-eye imaging [6-10]. A compound-eye imaging system has good features, such as thin configuration, deep depth of focus, and three-dimensional (3-D) information acquisition.

Although the resolution of each image acquired by each optical system consisting compound-eye imaging is low, signal processing on the set of unit images enables us to retrieve a high-resolution image. Several techniques for super-resolution image reconstruction can be applied to a TOMBO system to obtain a high-resolution surface model by combining the information of multiple low-resolution images [11-14].

A captured image is blurred by defocusing when a TOMBO system is very close to an object. Such a blurred image can be restored by making a model of the observation process in the high-resolution image reconstruction. One of the major methods for parameterizing the defocusing process is to define a point spread function (PSF) of the optical imaging system for relating an object and an image sensor based on a simple paraxial optical imaging model [15-17]. A PSF derived from the simple model is usually a function of the positions on the object surface and the image sensor. However, a PSF can be changed by