

University of Colorado

TECHNOLOGY TRANSFER OFFICE

Method and System for Passive Optical Imaging and Ranging

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Background: Passive Imaging and Ranging

In most situations, when dealing with recovering the three-dimensional structure of an object or a scene, the objects are opaque. There are usually two variables of interest at each image pixel: the surface brightness (reflectance), and its distance from the camera (depth). These two variables (per pixel) are commonly recovered based on two input images. There are several known methods to solve the problem of passive ranging and imaging. These include a variety of techniques for stereo imaging or triangulation in which the images are taken from different viewpoints. By measuring the disparity between the positions of corresponding image points, the distance of the corresponding object point is determined. Another approach is based on defocus blur. The image of an in-focus object point will be sharp while the image of a defocused object point will be blurred. The depth estimate of object points can be based on focus sensing with multiple images. Still other methods for passive ranging use wavefront encoding. None of these methods can achieve super-resolution beyond the depth of field, which is limited by the numerical aperture of the system.

Technology

Investigators at the University of Colorado have developed a novel method and system for passive optical imaging and ranging. In this technique, the distance of objects to an optical system is estimated in conjunction (if so desired) with other parameters such as the object brightness and object transverse position. An optical mask such as a diffractive optical element is placed within the optics in front of a sensor array such as a CCD or CMOS device. The optical mask encodes the three-dimensional response of the system. A particular implementation creates a point spread function ("PSF") that rotates as a function of the object position. The image or images are digitally processed to recover both a depth map of the scene and other parameters such as image brightness. The task of the digital process is to implement an estimation algorithm selected from a variety of methods according to system tradeoffs between processing time and estimate accuracy. The system and method provide depth resolution beyond the depth-of-field limit imposed by the numerical aperture of the system.

Competing technologies are very cumbersome; they typically require two cameras and heavy computation. None can provide depth super-resolution. The novel method developed at the University of Colorado can be implemented with very low cost under mass production.

Potential Applications

- Military ranging systems for acquiring information in the battlefield
- Immersive reality games
- Next-gen automobile 'cruisecontrol'
- Cell phone telepresence
- Microscopy

- Space optics
- Outer-space telescopes
- Camera auto-focus
- Localization of objects in 3D
- Law enforcement (radar/lidar)
- Robotics
- Machine vision

Method and System for Optical Imaging and Ranging. U.S. patent 7,705,970, issued April 27, 2010.