Light Field Vision for Transparent Object Recognition

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論　文　内　容　の　要　旨

The object recognition task in computer vision system is to detect or identify objects in an image. It is an important part of the artificial intelligent systems to know their working environment, and to decide what they can do or cannot do. Transparent object cannot be well recognized by conventional methods that only use the appearance information since the appearance of a transparent object dramatically changes when the background varies. In this work, the author uses a light field camera to observe the visual information of the environment. The light field camera can record light rays from every direction through every point in the 3-Dimensional (3D) world. The captured light field data can help the computer vision system recognize the 3D world more easily, even for the transparent object.

Because the applications require to know the relationship between the recorded light rays and the 3D world, camera calibration is an essential step for the light field acquisition. After calibration, camera parameters are known and ray geometry can be understood. In this thesis, the author propose a calibration method for a camera array and a rectification method for generating a light field image from the captured raw images. The proposed camera array calibration approach is a two-step algorithm consisting of closed form initialization and nonlinear refinement, which extends Zhang's well-known method to the camera array. More importantly, the author introduce a rigid camera constraint whereby the array of cameras is rigidly aligned in the camera array and utilize this constraint in the calibration. Using this constraint, the calibration process is much faster, and the calibration results are getting more accurate in the experiments.

After obtain the known geometrical information of the captured light field, special features can be extracted from the light field. The feature extracted from the light field image have more advantages than conventional features. A background-invariant feature which is called the light field distortion (LFD) feature is proposed. The LFD feature comes from the transparent object is very different from that comes from the Lambertian object because the linearity in the light field space is different. The light field linearity (LF-linearity) can be used for measuring the likelihood of a point comes from the transparent object or not. And the occlusion detector is designed to locate the occlusion boundary in the light field image.

Recognizing the object category and detecting a certain object in the image are two important object recognition tasks, but previous appearance-based methods cannot deal with the transparent objects. The proposed methods in this thesis overcome previous problems using

the novel feature extracted from a light-field image. Transparent object categorization is performed by incorporating the LFD feature into the bag-of-features approach for recognizing the category of transparent object. Transparent object segmentation is realized by solving the pixel labeling problem. An energy function is defined and Graph-cut algorithm is applied for optimizing the pixel labeling problem. The regional term and boundary term are from the LF-linearity and occlusion detector output. Light field datasets are acquired for the transparent object categorization and segmentation. The results demonstrate that the proposed methods successfully categorize and segment transparent objects from a light field image.