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Light field imaging: models, calibrations, reconstructions, and applications

Key words: Light field imaging; Plenoptic function; Imaging model; Calibration; Reconstruction

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Background

- Light field imaging not only provides new ideas for obtaining high-quality visual information, but also helps us to solve classic problems in computer vision better.
- Light field imaging can effectively improve the performance of digital imaging, such as DOF, view synthesis, and high dynamic range, as well as increasing the accuracy and robustness of 3D reconstruction, panorama stitching, object recognition, and object tracking in computer vision
- The key technologies in light field imaging can be well extended to particle image velocimetry (PIV), analysis of structure of metallic/nonmetallic materials, and microscopic imaging, which promote the developments in informatics, physics, materials, medicine, and biology.

Main Parts

- Light field imaging models and optical path designs
- Calibration and optimization for light field cameras
- Reconstruction of the physical world using light field cameras.
- Some newest applications from different disciplines based on light field imaging are introduced

Imaging Models

- A light field can be well represented by a TPP model, which results in the accuracy of light field camera calibration. Seven parameters of the TPP model can totally constrain the perspective relationship and scaling between the light field and the 3D structure.
- It is easy to decode light fields from a plenoptic 1.0 camera with a higher angular but lower spatial resolution. The plenoptic 2.0 camera provides a more flexible approach to balance the spatial and angular resolutions in 4D light field.

Calibrations

- In summary, subimage extraction is the premise of light field camera calibration, and it is solved by capturing white images in almost all of the existing.
- So far, most of the works have focused on intrinsic parameter calibration, and there is little work on extrinsic parameters

Reconstruction

- Depth estimation algorithms for the Lambertian surface have been well developed.
- There is no theoretical solution for non-Lambertian surface, and it is still an open issue in light field depth estimation.
- Although the spatial resolution is decreased to trade the angular resolution in light field cameras, the images added from other views provide the probability of recovering high-spatial-resolution images.

Conclusions

- Light field imaging theory is a hot spot in computational photography and brings revolutionary innovations to traditional digital imaging technologies.
- It is necessary to calibrate light field cameras accurately and register multiview light fields to improve both the field of view and depth of field.
- It is possible to fuse multiple depth cues to obtain high-accuracy 3D reconstruction and SR.
- The theoretical outcomes of light field processing will arouse significant revolutions for the core problems in computer vision and promote the applications of light field theory and imaging technology in some important domains