A NOVEL 3D RECONSTRUCTION APPROACH BY DYNAMIC (DE)FOCUSED LIGHT

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3D Reconstruction has gained increasingly interests and has become one of the most important topics in the field of computer vision. Several methods to recover depth information from 2D images have been broadly developed. However, there is still no unique satisfactory solution for all kind of scenes.

Depth from Focus (DFF) vs. Depth from Defocus (DFD)

Depth from Focus (DFF) is estimated by searching for the best focused point from a large number of collected images with an small incremental steps of geometric parameters (focal length, object distance, etc.),

Depth from Defocus (DFD) is computed by evaluating the local blur difference between each point from at least two defocused images.

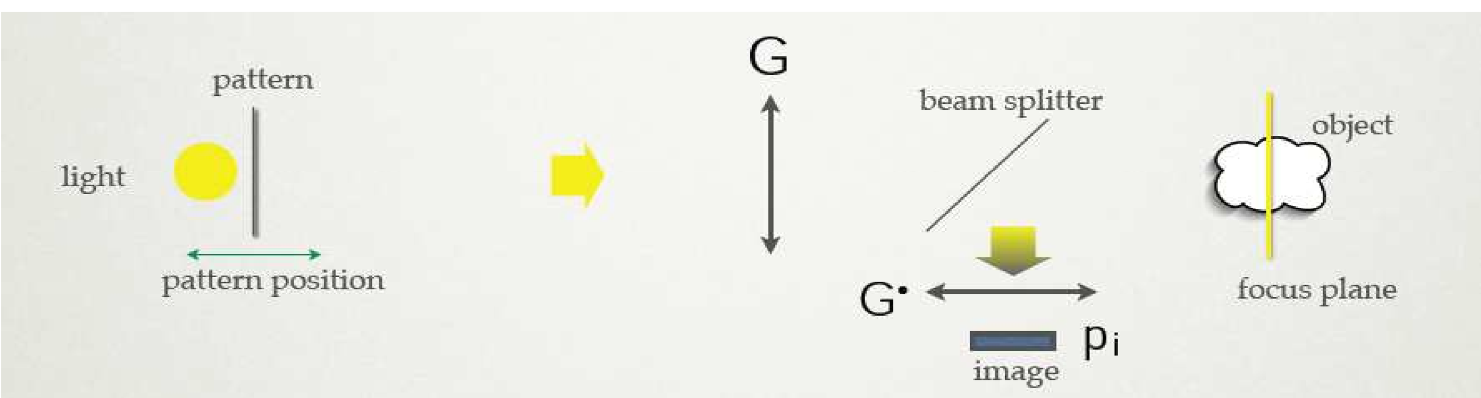
Our Proposed Method

Depth from dynamic (de)focused Light is a novel active 3D recovery method based on local blur estimation.

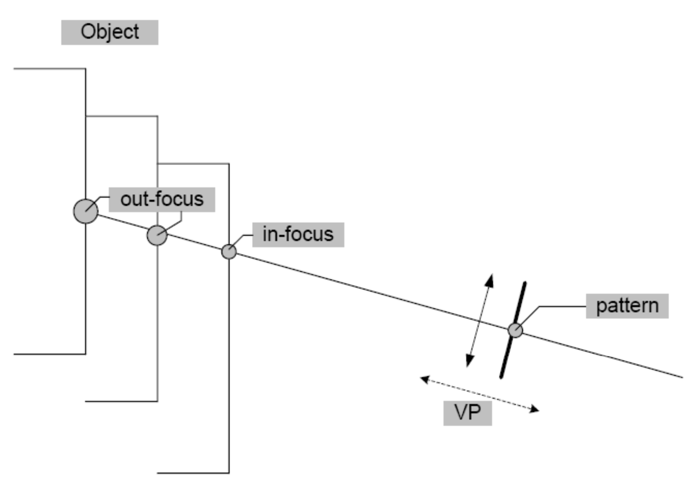
- The method combines both depth from focus (DFF) and depth from defocus (DFD) techniques.
- Projected light pattern images are acquired within certain focused ranges similarly to DFF approach while the focus measures across these images are calculated for depth estimation by using DFD manner.
- The imaging system is specifically constructed to keep the whole object sharp in all captured images. Optimized illumination pattern is projected on the object in order to force strong dominant texture on the surface.

Methodology

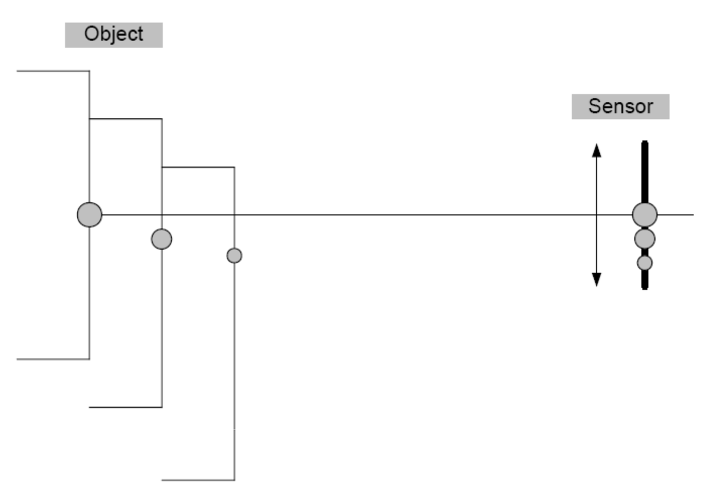
Given sufficient number of images captured with different depth of field, the depth can be recovered by calculating resulting blur levels (spread parameter) among them and compare to their pre-defined relationship and ground truth. In addition, dense illumination pattern is projected on the object in order to force strong dominant texture on the surface as well as to improve the overall optical system and reconstruction quality.



The optical setup can be considered into two systems



Defocus System
(From video projector to object)



Imaging System
(From object to the sensor)

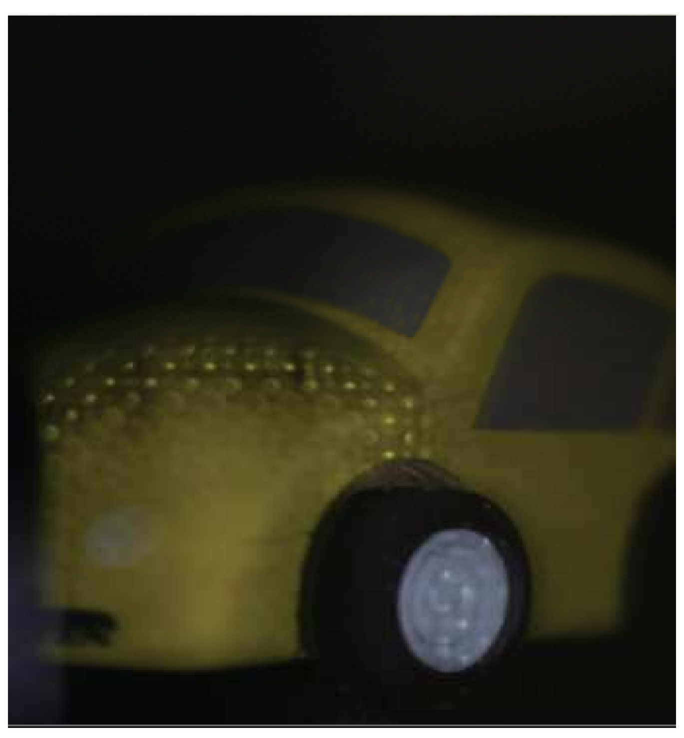


Image Acquisition
- Obtain n images from n Video projectors

Blur Selection
- Choose only k smallest blurs from n images

Overlapping Pixels Determination
- Search for the intersecting area from selected blurs

Point Spread Function (PSF) Calculation
- Define the PSF for each k blurs

Spread Parameters Computation
- Fit PSF to a 2D Gaussian

DEPTH Estimation
- Match spread parameter relationship to pre-defined ground truth depth

Expectation

In this new approach, it promises superior 3D reconstruction in term of accuracy and robustness compared to other DFD methods and has less computational extensive than DFF scheme. Moreover, unlike the tradition approaches such as stereo and triangulation methods, the problems associated with occlusion and correspondences have been overcome.

Effective depth estimation requires theoretical analysis and experimental investigation on three main influenced factors:

- Optimized illumination pattern:
  - ensures that all scene points have the same dominant texture, maximize the spatial resolution, and accuracy of computed depth.
  - compromises between pattern density and the spaces of neighborhood patterns (sufficient for depth recovery and avoids confusion from overlapping)
- Accurate preliminary depth estimation: derives from the assumption that the Point Spread Function (PSF) is a 2D Gaussian.
- Magnification variations: magnification due to projection's displacement caused shifting and scaling of light pattern. This problem can be overcome by determining the intersected pixels appeared on the object and only taking them into consideration for further computation.

Conclusion

We present the demonstration of a novel local blur estimation based on structure of light and the investigation on their benefits over other 3D recovery methods. The method improves the established Depth from Defocus (DFD) by using additional focus information during the image acquisition process.

In order to retrieve precise depth estimation, we addressed few influenced factors that have major effect to the final 3D reconstruction including optimized light pattern, accurate preliminary depth estimation, and magnification issue.

References

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