**Exploring the effect of finer sampling in object space on light field images generated by polarized light ray tracing of birefringent objects.**

A graph of a diagram

Description automatically generated

116µm = (17•6.5µm/60)•63

A group of gray blocks

Description automatically generatedA grey and white cross-like structure

Description automatically generated A diagram of a box with a cross

Description automatically generated

hedgeHog2\_GT.h5 hedgeHog4\_GT.h5

I created the same object that I call hedgeHog with two different resolutions for rasterizing the volume. The voxel size on the left corresponds to the size of a microlens projected into object space (17•6.5/60=1.84µm), hence the volume array of 15 voxels in X-direction, 63 voxels in Y- and Z-direction corresponds to a physical volume size of 27.6µm by 116µm by 116µm.

The object on the right, hedgeHog4 embedded in the same volume, is rasterized by one third of the microlens diameter, hence the array rasterizing the same volume is 3 times as big in every direction.

The actual object is composed of birefringent bundles or rods that extend from the center of the volume to the corners of a cube. The rod-diameter is one microlens diameter and its length is 9.2µm or 5 microlens diameters. Its birefringence is 0.01 and the optic axis runs parallel to the rod-axis. The empty volume in the center of the object corresponds in size to one microlens diameter cubed.

The images above on the right illustrate the finer resolution afforded by the smaller voxel size compared to the coarser sampling on the left of the same object.

The next page shows the retardance light field images of the object, using a super-sampling number of 1 for the left object array and SS=3 for the right object array:

A black and white background with many dots

Description automatically generated A black and white background

Description automatically generated

hedgeHog2 retardance LF image SS=1 hedgeHog4 retardance LF image SS=3

Both light field images were generated with the Streamlit interface using the same optical settings, shown below, except for the super sample setting. Therefore, the images have the same dimensions and the same overall appearance, but they differ significantly, especially near the center of the pattern.

The TIFF files of the retardance and orientation light field images and the h5 files of their respective ground truth volumes are available in the objects/bundles directory in our GitHub repository.

**Optical settings:**

Number of microlenses: 31

Pixels per microlens: 17

Number of voxels per microlens (supersampling): 1

Magnification: 60

NA of objective: 1.2

Wavelength of light: 0.55 µm

camera pixel size: 6.5 µm

refractive index of medium: oil n=1.35

When reconstructing the volumes based on their simulated light field images, i.e. retardance and orientation image, the results are very different, as can be seen on the next page.

**Reconstruction based on “measured” retardance and orientation image for hedgeHog2:**

hedgeHog2 has 8 bundles placed symmetrically to the volume center [31,31,8] and bundles extending to the corners of a cube; intended for super sample=1

A diagram of a graph

Description automatically generated

**Reconstruction based on “measured” retardance and orientation image for hedgeHog4:**

Same object as hedgeHog2, but sampled with a three times bigger sampling rate; intended for super sample=3

A diagram of a number of different colored squares

Description automatically generated

A more congenial representation of the ground truth and reconstructed volumes are shown on the next page.

A couple of rectangular boxes with a red and grey star

Description automatically generated A couple of rectangular boxes with red and gray screws

Description automatically generated

hedgeHog2 ground truth volume, SS=1 hedgeHog4 ground truth volume, SS=3

A black and grey objects

Description automatically generated A black and red square

Description automatically generated

hedgeHog2 reconstructed volume, SS=1 hedgeHog4 reconstructed volume, SS=3

In both cases, the reconstructions are quite off from the (ground) truth. While the SS=1 reconstruction succeeds in placing most of the birefringence into the rods of the hedgeHog, the distribution is fairly wide and the orientation lines are very noisy, even in the rods.

hedgeHog4 reconstruction places most of the retardance into the nominal focus plane of the light field setup. Curiously, though, there is also some retardance that is placed correctly into the rod locations and the orientation lines in the voxels located inside rods are more consistent in their orientation parallel to the rod axes, compared to the hedgeHog2 reconstruction.

Based on the total loss versus iteration number on previous page, I don’t expect much improvements with higher iteration numbers.

The h5 files of the reconstructions are also available on GitHub.