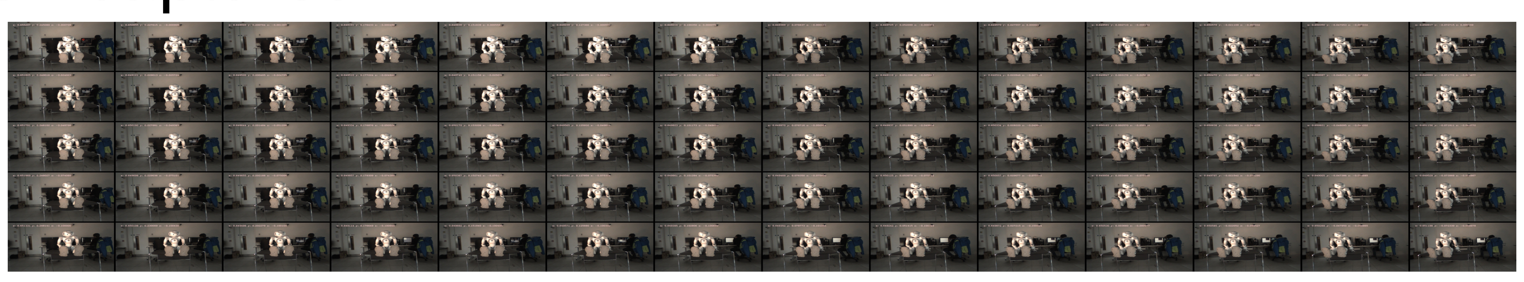
Understanding Light Field Parameterizations

Carson Vogt, February, 2016
Kartic Subr, Alex Belyaev

Introduction

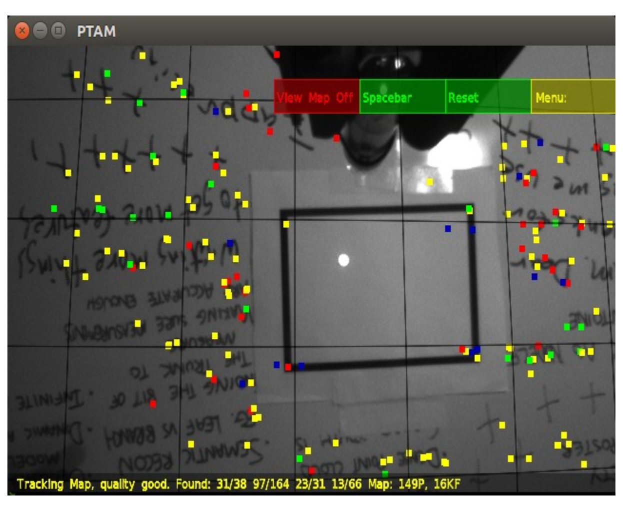
Light fields are a unique way of capturing, storing, and displaying the light from a scene. Derived from the 7D plenoptic function meant to capture all light in a volume, the 4D function describes the radiance of a ray along a line described by two points: $L = f(u, v, s, t)$ Typical methods for capturing a light field are by camera array, or light field camera, which is simply a large image sensor with a micro lens array behind the aperture, allowing for the capture of spatial and angular data.

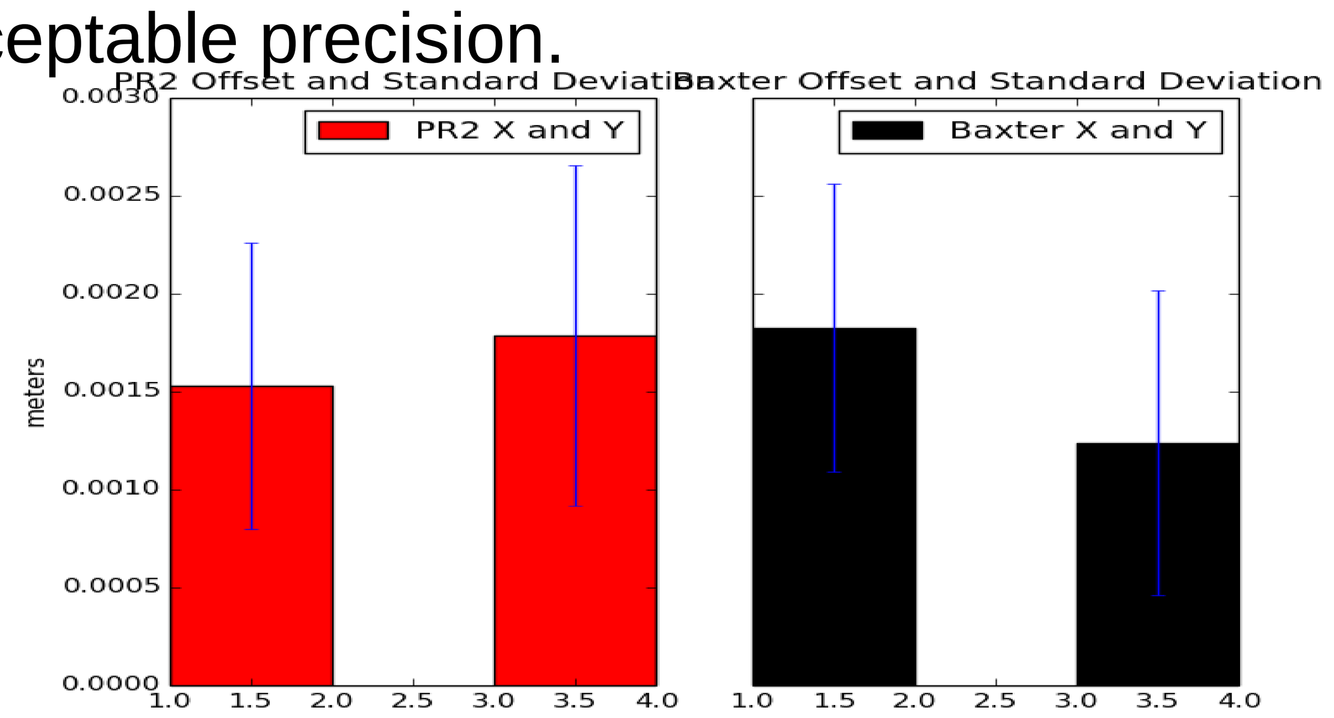
Three parameterizations (shown above) are used to keep a constant depth from a subject when capturing images as individual rays are rarely used. My research at this point seek to analyze the errors in rendering methods associated with each parameterization. I am able to do this due to unique access to robots that can adapt to different parameterization shapes, specifically cylindrical, planar, and spherical. To date, a planar (shown below) and spherical parameterization have been captured.



Experiments

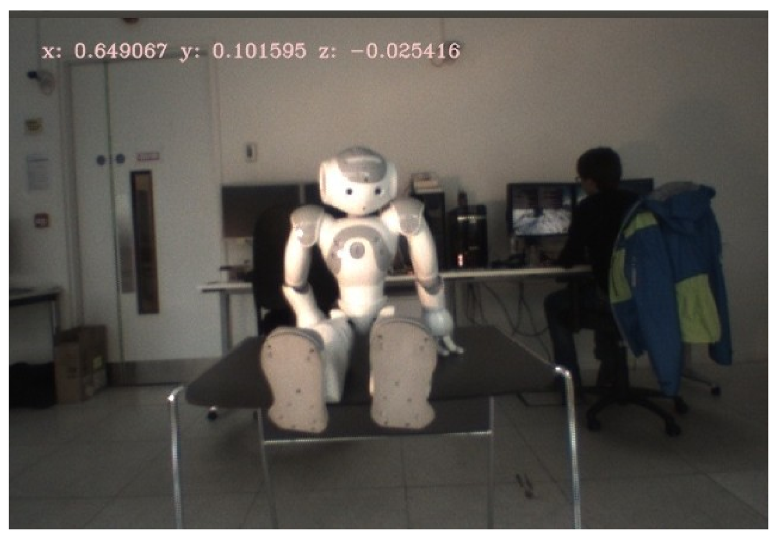
To effectively capture a light field, the location of the camera must be known precisely. Two robots and several Simultaneous Localization and Mapping (SLAM) methods were tested to determine the best platform and localization method to use. The image at the left shows the experiment layout, with the robot moving to specific positions while holding a laser. At each position, an image is captured, and the relative position of the laser within the frame is captured then compared with the robot and SLAM pose estimators. The SLAM method errors were an order of magnitude greater than the robots (PR2 and Baxter). The robot results are comparable and shown below, with acceptable precision.

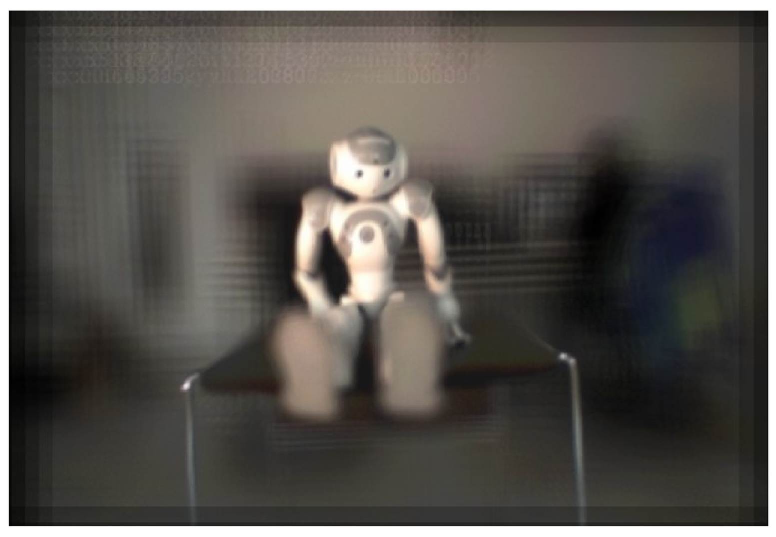


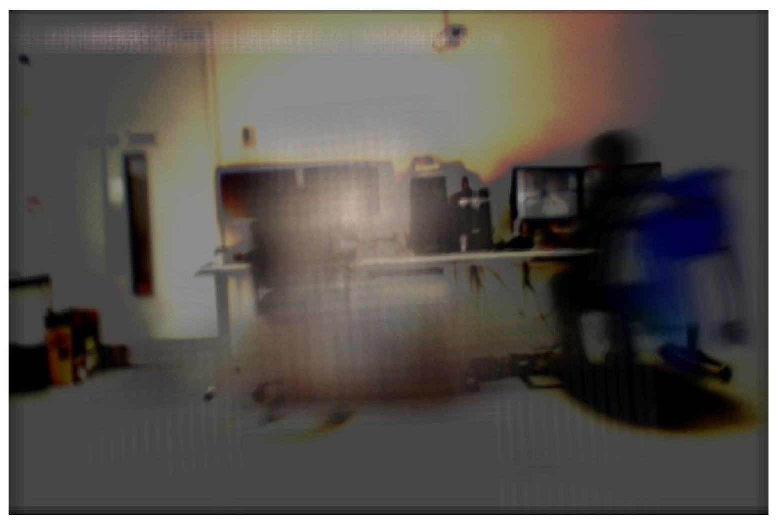


Rendering

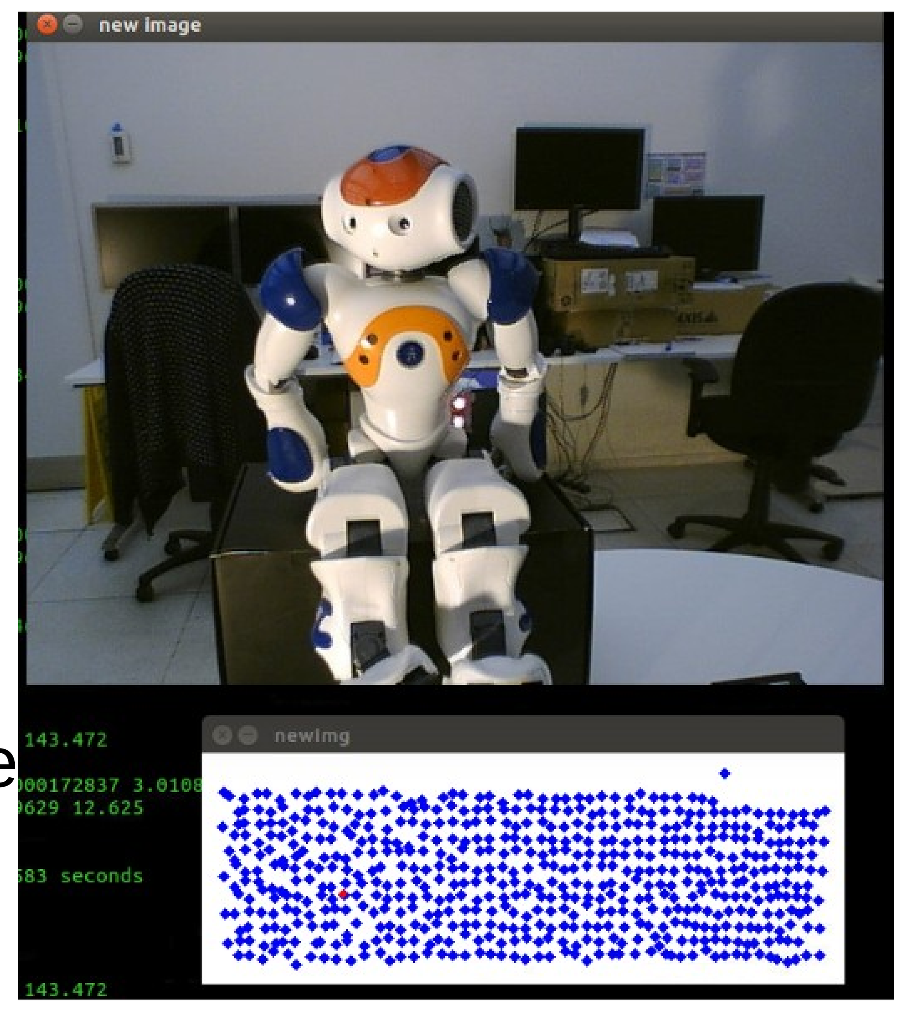
Part of the appeal of the light field is the way in which novel images are displayed. As well, unlike a panorama which can display views in 3D, the light field allows for 6D movement through a scene. Several renderers have been built to best view the captured light fields and make use of some of the unique aspects of the light field data shown in the mosaic in the first column. The first image on the left is the pinhole model of the light field with infinite depth of field. By creating a synthetic aperture, a mobile focal plane is possible, allowing subjects in the foreground to be shown (demonstrated by the second image on the left) or, by increasing the synthetic aperture further and moving the focal plane to the background of the scene, the occlusion may be nearly removed entirely. These images were all captured using a Baxter robot in a planar parameterization.







Using the Baxter again, but with a spherical parameterization, the image on the right shows a pinhole view of the subject and the total number of images captured displayed as individual blue squares. With a constant depth, the 3D spherical coordinates are constrained to 2D angles omitting the radius.



Future Work

With the infrastructure in place to capture and render a light field from each of the common parameterizations, analyses of the resulting images can be completed. With the limited amount of research done on the parameterizations themselves, interpolation methods can be compared on variable density light fields collected of the same subject, which has never been done before. Once this has been completed, and with the adaptability of the robot, other, novel parameterizations may be possible based on the platform being used and the subject under observation.

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