

3-D Camera Calibration

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A 3-dimensional camera can sweep across a scene and render the scene, with color, onto an attached computer. Depth information is gathered from the scene from lasers that are attached at a distance to either side of the camera. The laser rays intersect at points on the image plane. Based on the location of these points, depth information is calculated and used to render the scene.

One of the many challenges in creating this 3-dimensional camera is the calibration of the lasers. Before any useful information can be extracted from the laser points, the location and orientation of the lasers must be known. Traditionally, calibration was performed by using a checker board pattern with known dimensions onto which the lasers were fired. The entire process took anywhere from one to two hours after all calculations were made. An alternative approach to the traditional calibration technique is panning the camera across a flat wall for a few seconds and the calibration would be performed on-the-fly. It was our goal both to determine if it is possible to perform the calibration in such a way and if so, to actually write the calibration algorithm.

We have approached this problem using vectors in the camera coordinate system (where the camera is the origin). When the camera swings back and forth along a flat wall, a particular laser's image will move only in either direction along a straight line. This "epipolar" line can be extracted easily from a few frames. Using the data collected and the epipolar lines, we try to find the set of parameters that cause all laser points to intersect upon the same plane. Once these parameters are found, we know we have the proper calibration of the camera. Much of our time was spent determining how the distance from coplanarity when one parameter was incorrect. Due to measurement error, this scenario is likely in practical applications. Minimization techniques were used to restore the erroneous parameter to its correct value.

We have determined that it is possible to perform the calibration using the presented method. We have constructed Matlab functions to generate where the lasers points would appear based on a given wall and laser configuration. We also have functions to return the error value for incorrect parameters. Alex Thaman created and modified the Matlab functions and worked on function minimization, Lance Alexander constructed the graphs and worked on minimization, and Matt Schmidt created most of the Matlab functions. All members contributed to the equation solving and algorithm design.

Future work will address remaining issues in the error value. The error value that is returned from the functions is not a meaningful value. The only conclusions that can be drawn from the error result is that if $error1 < error2$, then the parameters used to arrive at $error2$ are further from coplanarity than those used for $error1$. This is the only information needed to arrive at the correct value for the parameters, but it would be helpful to know the meaning of the error value. Additionally, a C function will be

created that takes data from a couple frames as input and returns the calibration for all the lasers.