Rubik’s Cube Auto-Reconstruction

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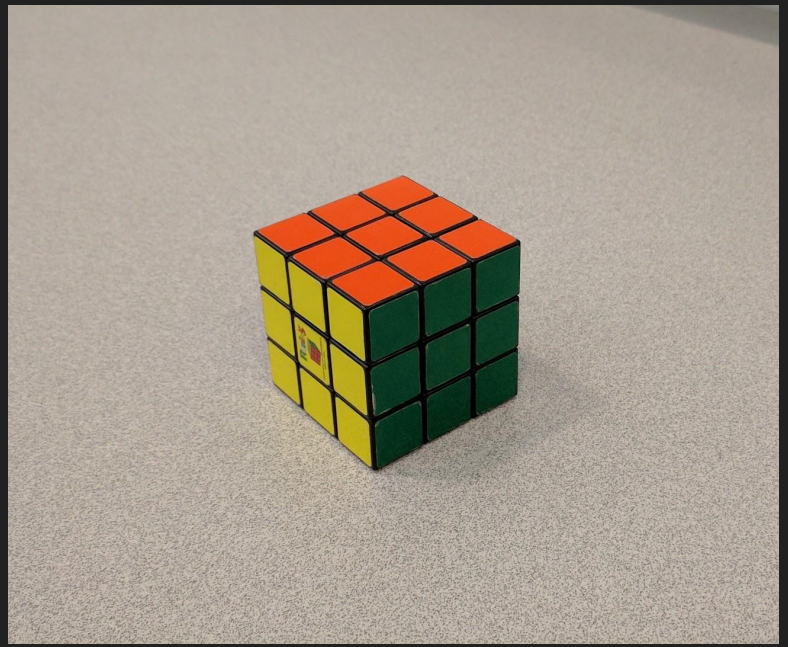
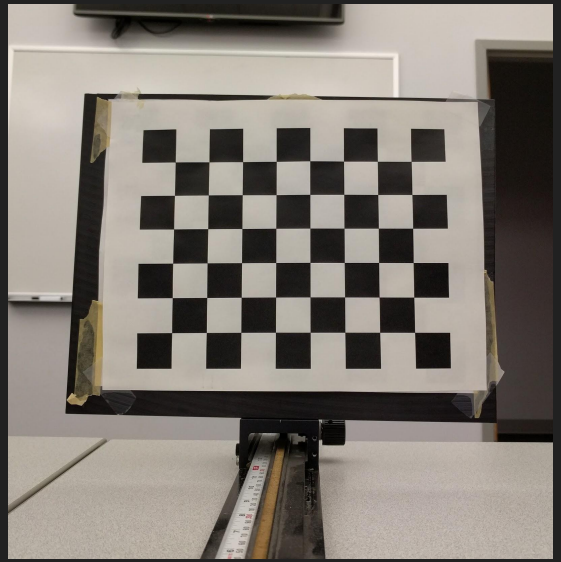
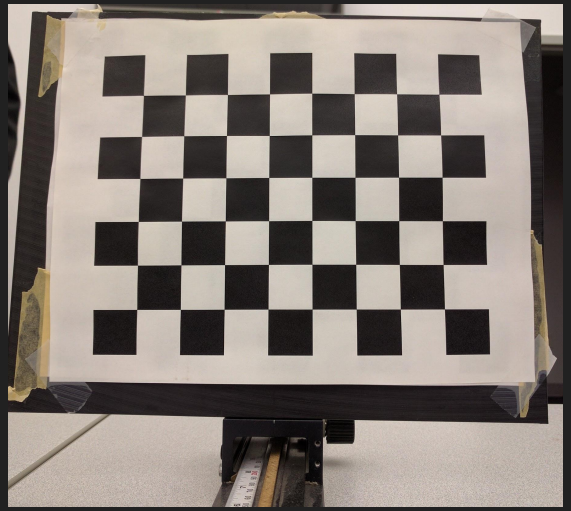
Why a Rubik’s Cube?

We chose to use a rubik’s cube for our automated reconstruction because it is a cube is a very easy shape to model. Furthermore, the clear divisions between tiles allow for easier automatic detection of edges and corners.



Pictures of a calibration checkerboard were taken to calculate the camera calibration matrix





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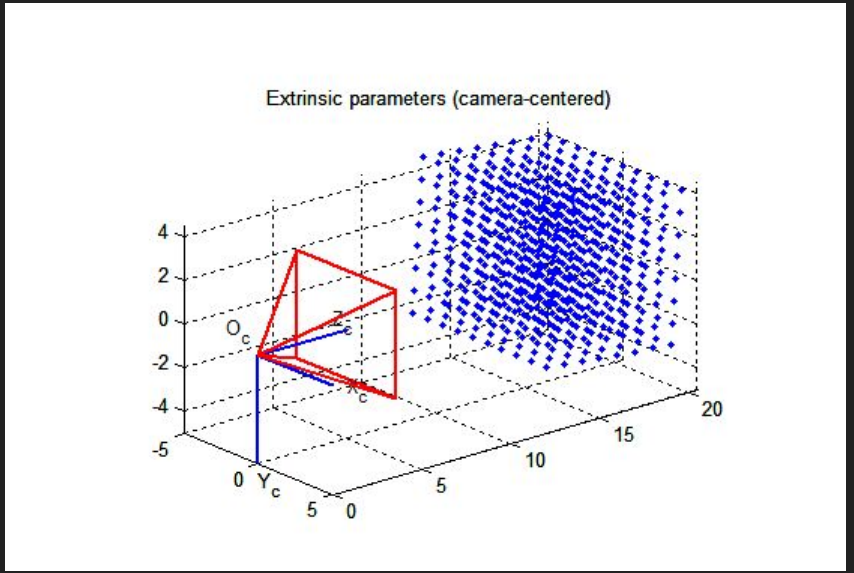
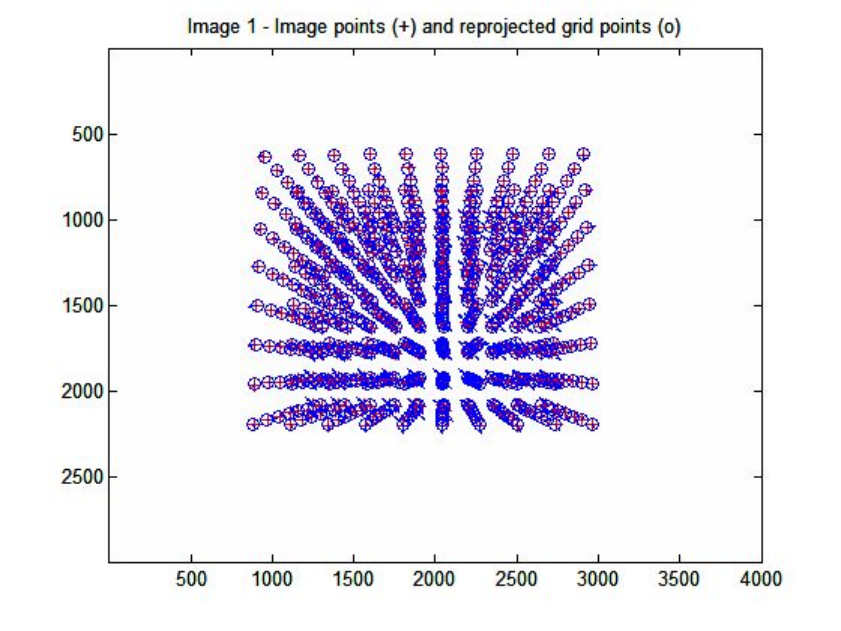
Using the calibration toolbox

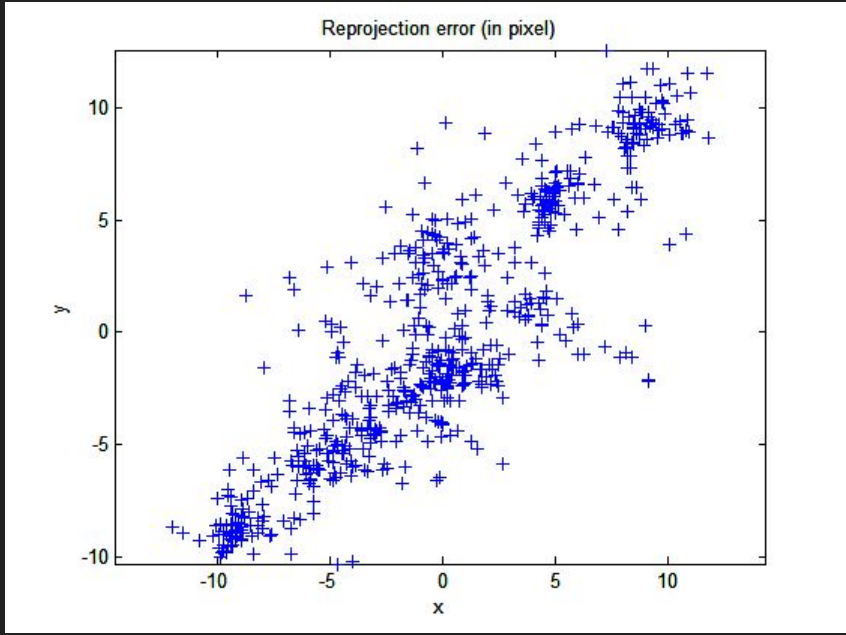
Images were loaded in the calibration toolbox. With some user input corner detection extracted 3D points for each image.



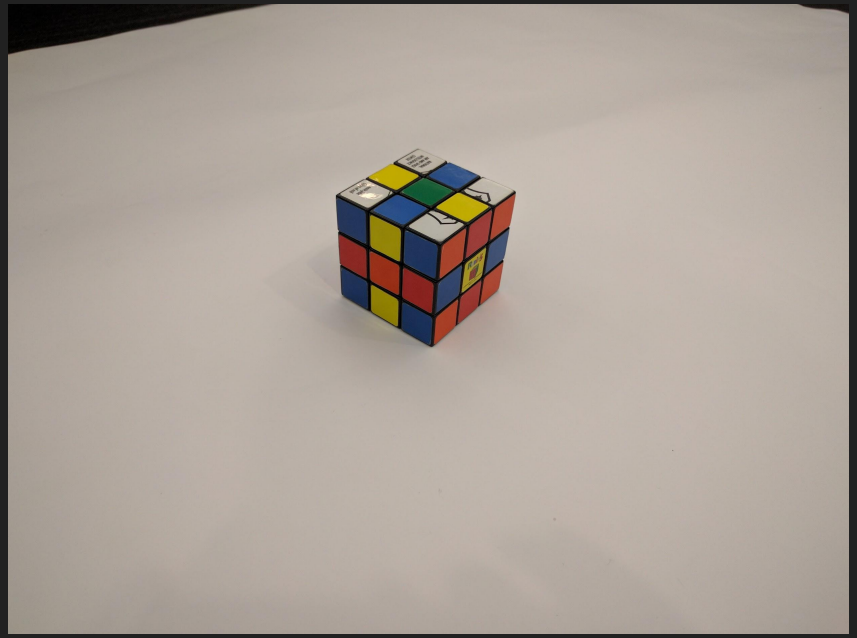
3D visualization of calibration points across 8 images

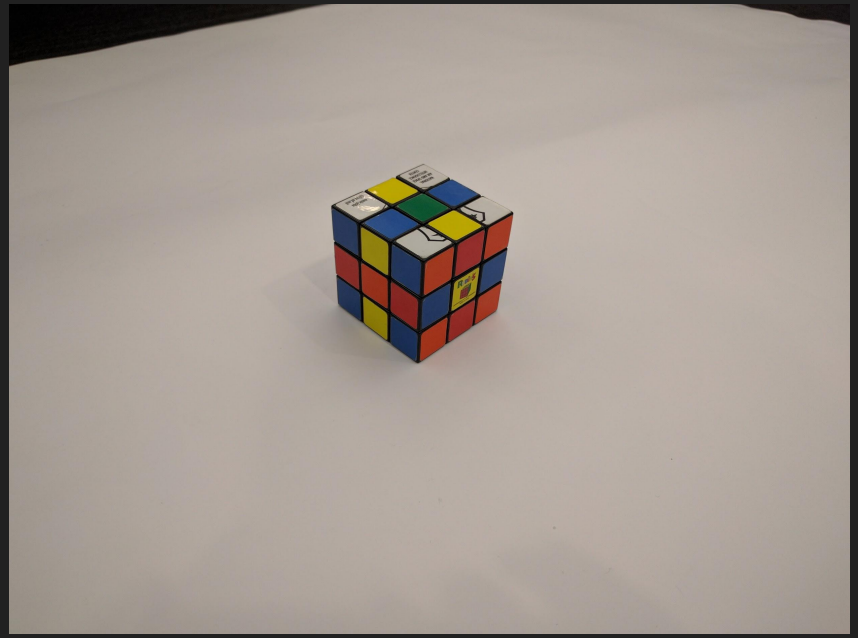
Autocalibration results





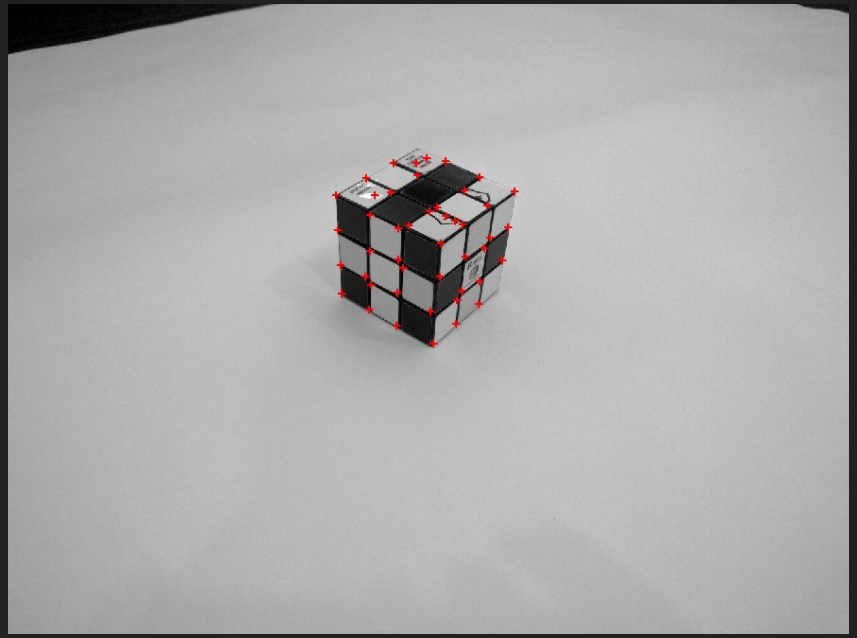
Original images taken with calibrated camera on white background.

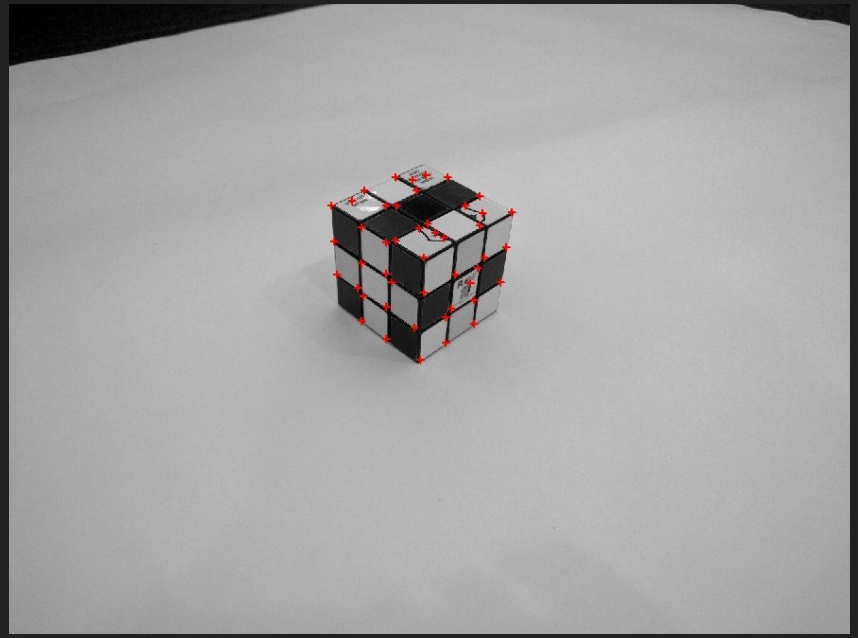




Cubes were scrambled to prevent excessive uniformity during grayscale conversion

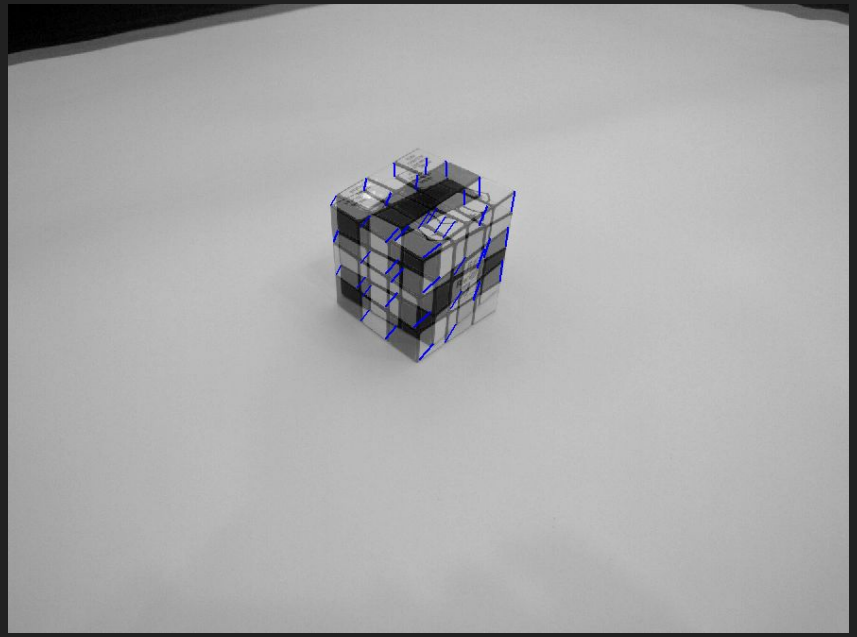
Extracting harris corners for RANSAC after grayscale conversion and subsampling



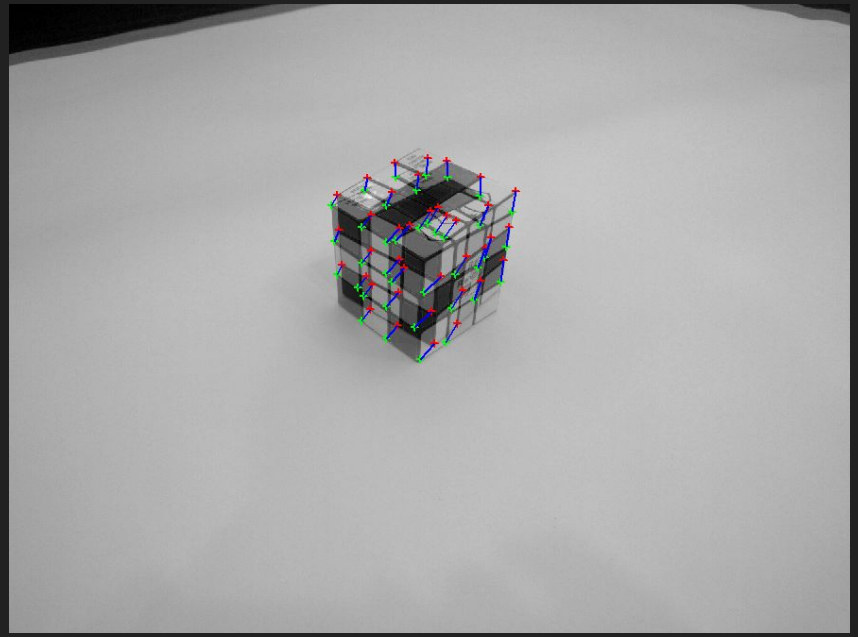


Inlying matched feature points using RANSAC matching

The images are shown overlaid, with relevant points shown matched between the two images

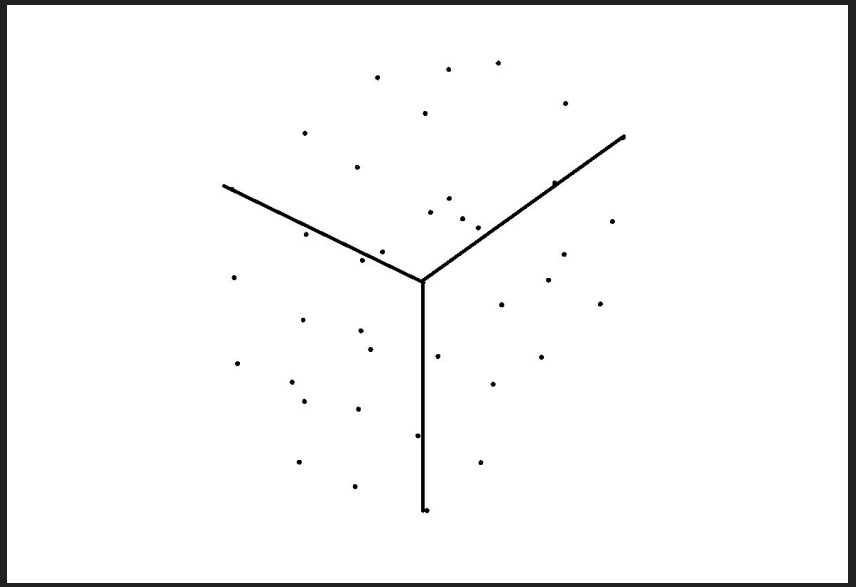


Left: potential matches



Matches chosen by inlying matched feature points from RANSAC.

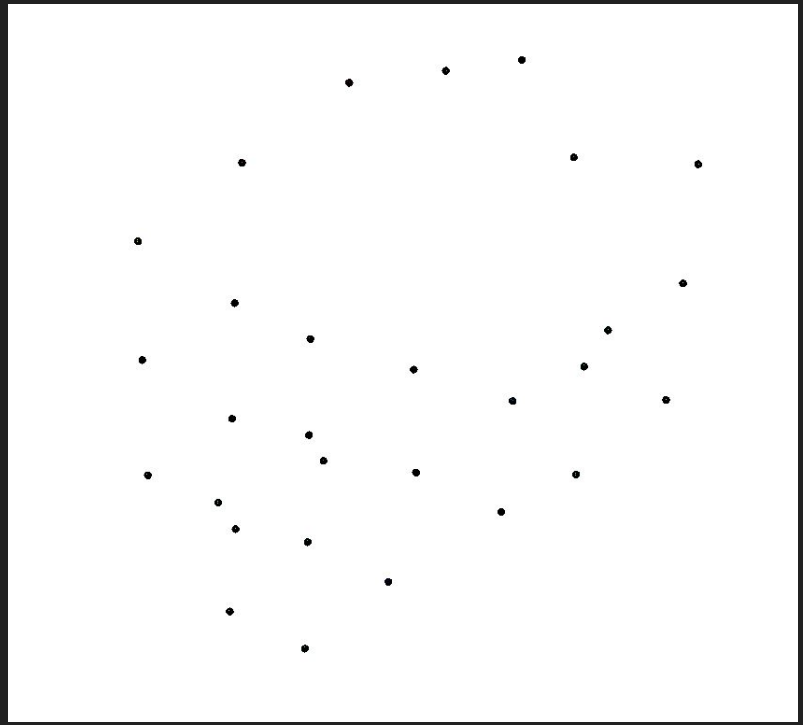
Real image beside to 3D point map



Lines have been added afterwards to show approximate position of edges

RANSAC to find inliers as points on a single plane

Error in the estimation of a 3D plane was calculated from the squared error in order to amplify the sensitivity of error. This error was used in the RANSAC method to estimate 3D planes. The RANSAC identified plane points were converted to 2D space so that we could gather both the indices of a convex hull for the plane. We were also able to extract the proper order of the indices from this method, because the convhull function returns the indices of points in a counterclockwise direction. Extraneous points points were discarded in preparation to assign vertices to polygons. This process was repeated twice in order to extract all relevant sides.



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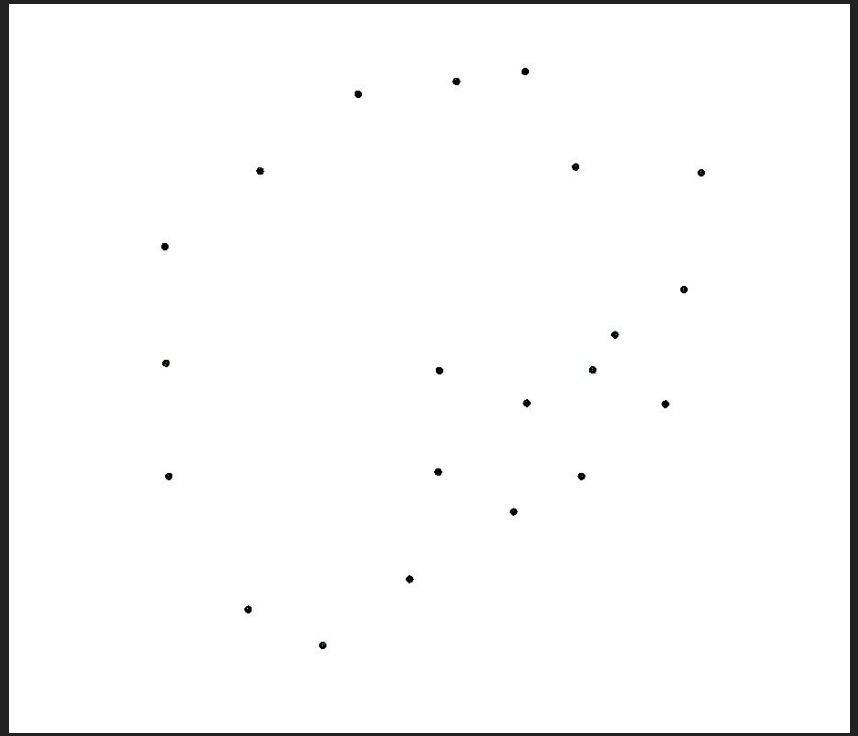

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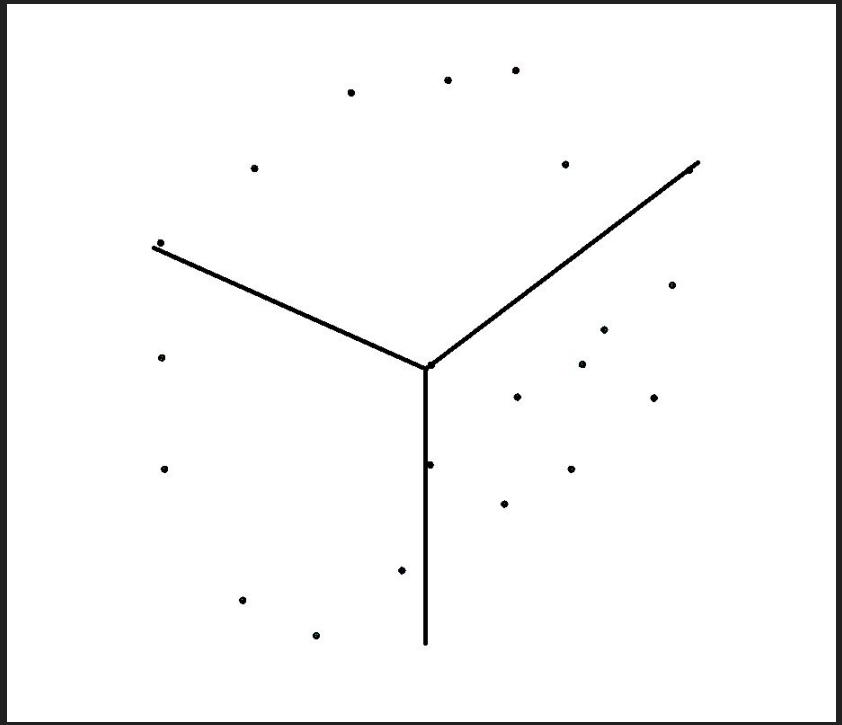
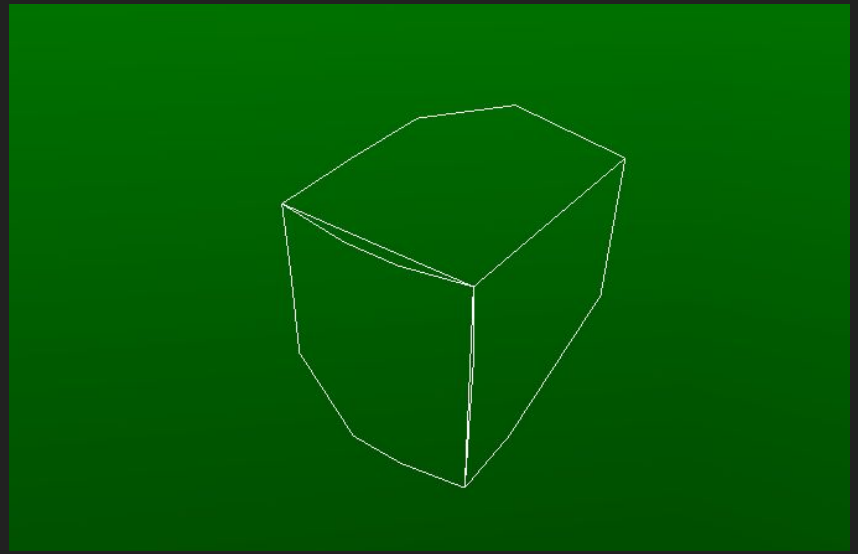


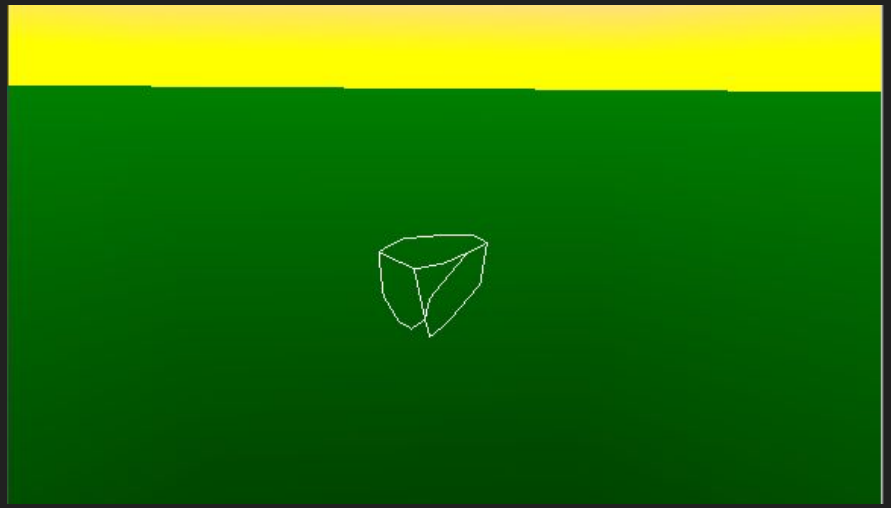
Creation of Models

After recreating planes out of the convex hull points, a wireframe model of the Rubik's cube was constructed.

Some models were better than others: Due to a certain degree of randomness in the RANSAC method, only two runs produced a model with a correctly identified corner



Error with Detection



These models demonstrates a random fault from the RANSAC method to be able to fully comple complete a mesh over the model

Tweaking the threshold for determining outliers a lot produced correctly recovered models