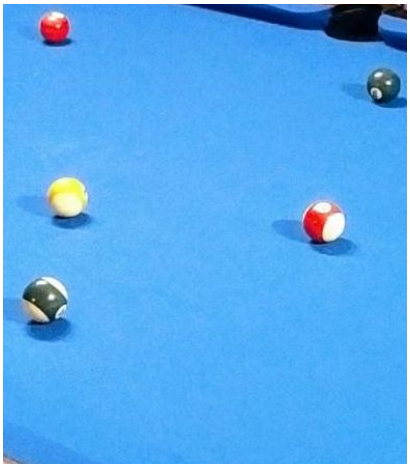
Pool Table Image Analysis

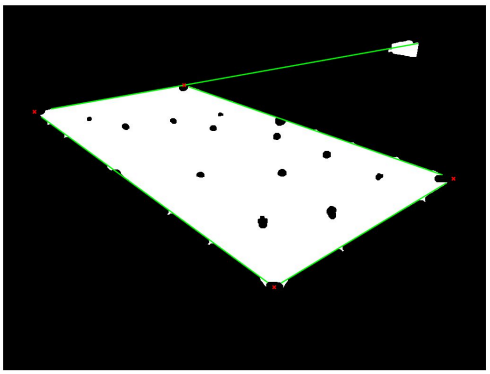
The goal of this project is to extract a model of ball locations from a picture of a pool table. These pictures can be extracted from a video or taken with a camera, and may be angled to the side and rotated, as long as certain assumptions are met. This model can then be used for a variety of other purposes, once it has been extracted from the image.

Due to the methods of computer vision, certain constraints must be met. The entire table surface must be included in the image, or else the four point projection cannot be properly applied. It should also take up a significant portion of the picture and be centered. The background must be a different color from the table, otherwise the four table edges and corner points will not be found. Balls cannot be clustered or obstructed too much. Shadows with hard edges can be a problem, but are handled fairly well using the color similarity magnitude method. Unevenly illuminated table surfaces can also pose a problem, especially with glare, but this is also handled well with color similarity. Table vanishing points cannot be in the picture; this confuses the corner detection.

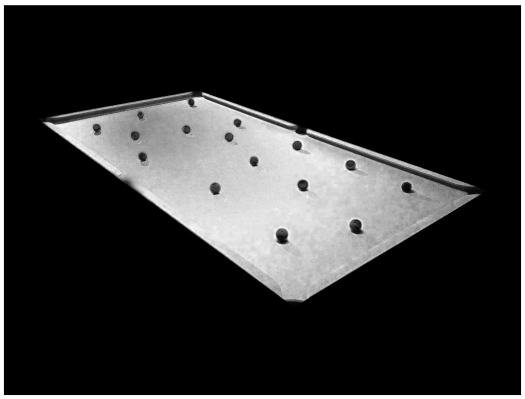
Starting with our assumptions, the first task is determining the table surface color. Cropping the image with a given percentage off the top, bottom, and sides will result in the table color taking up the majority of the image. A histogram analysis on the HSV channels is then performed. The peaks of all three channels provides the most common color. Using this common color, a color similarity analysis is performed, which weights the hue channel much more than saturation or value channels. A threshold of 70% similarity is used to find a rough shape of the tabletop.

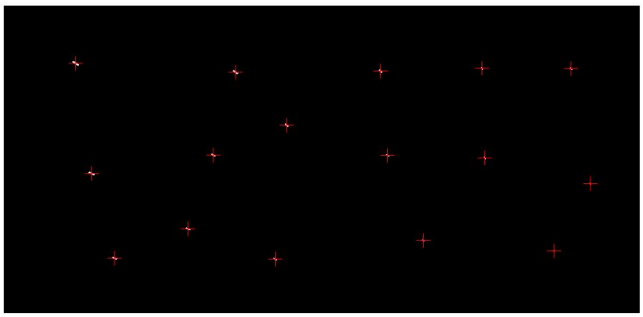


The image from the previous step is morphologically closed, in order to better isolate the table surface shape for line detection. Hough peak detection is then used to find the four most voted lines. Hough line detection returns the coordinates of the start and end points of the lines. With these points, simple math is used to find and compare the slopes and intercepts to return a set of intersections, representing the four corner points of the table. Intersections which appear outside the image are discarded.



In order to detect the balls, an image of the table is masked using the four detected corner points, and the color similarity magnitude is calculated as before. The ball center points are then found using Hough circle detection. These points are geometrically transformed into lines, using the corner points. Connected component analysis is used to determine the centroid of each line, being the final locations of each ball in the model. The final step recreates the board using the table color as the background and balls represented by black circles located at the detected locations, as a simple application of the model.





Due to time constraint, solutions to some of the problems were not implemented. The process is unable to distinguish between striped and colored balls. This can be solved by performing a histogram analysis on the HSV channels near each of the detected ball centers. Balls which are clustered or obstructed cannot be identified very well, which would require more advanced artificial intelligence techniques to be used. The vanishing point problem is a special problem involving geometry. Although some preprocessing is done to decrease the effects of

shadows, dark shadows can still be misclassified as a ball. A “smarter” table surface color detection could be used, instead of naively cropping the image and finding the most common color.

Despite some limitation, the proposed solution is able to consistently extract the positions of the balls. The code can potentially be improved to take video and be able to select multiple frames to create a more accurate representation of the board. The code can also be expanded upon to generate a 3D model representation of the table, generate a game shot history, or suggest the best possible shot given certain parameters.