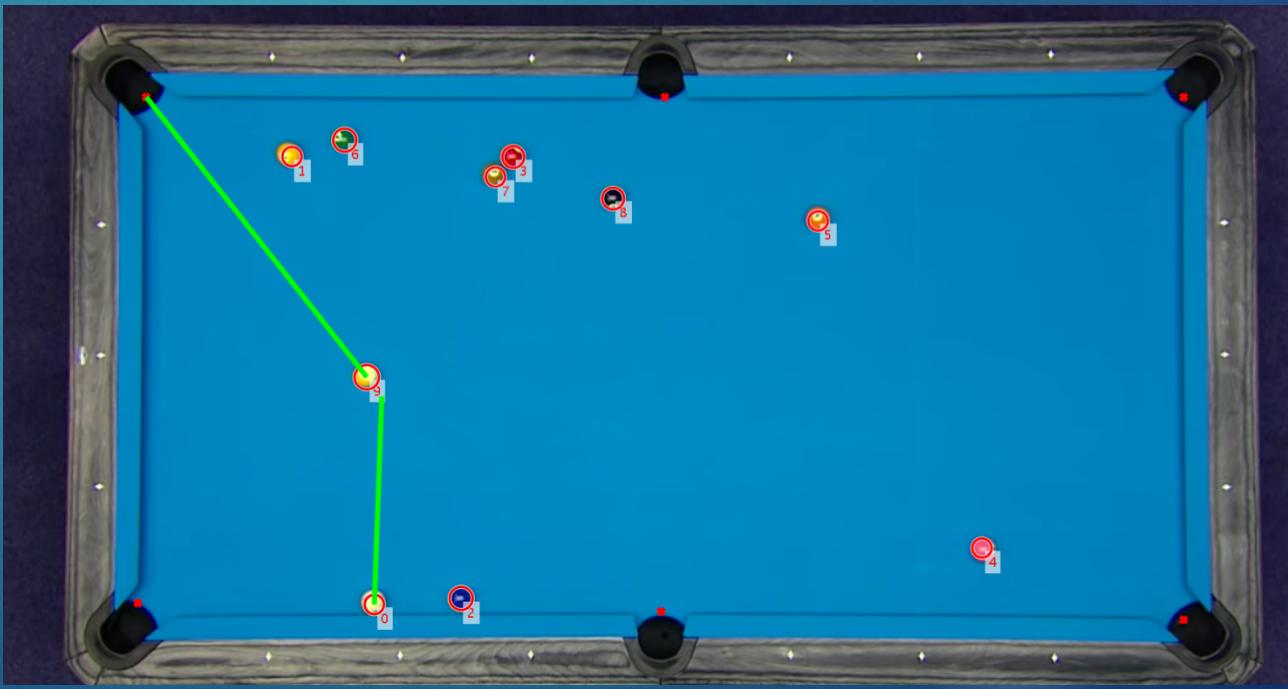


Billiards Identification and Strategy

BY IAN CAIRNS



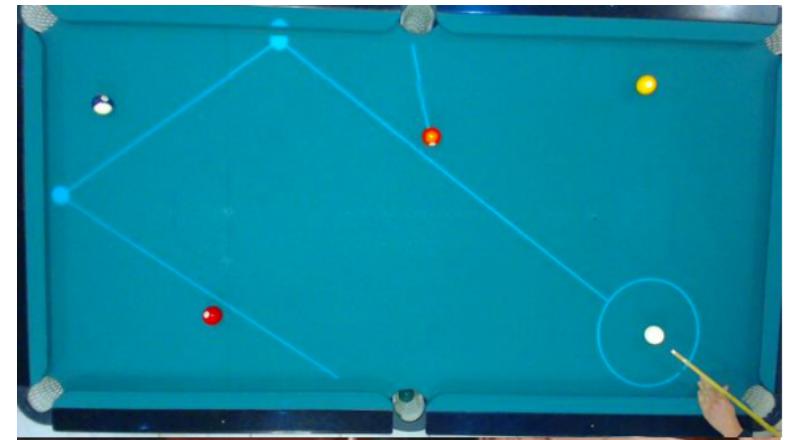
Goals

- ▶ Primary:
 - ▶ Identify Billiards table and find pockets
 - ▶ Find balls on Billiards table
 - ▶ Identify possible shots based on solids or stripes.
- ▶ Secondary:
 - ▶ Allow for a more open-ended image capturing system.
 - ▶ Possibly video
 - ▶ Possibly multiple images stitched together.

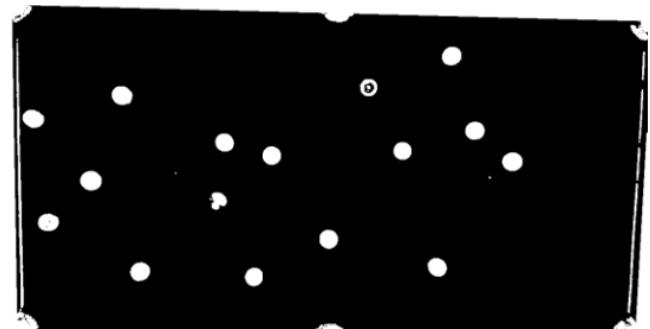


Previous Work

- ▶ I Read About Several Techniques:
 - ▶ Projection system
 - ▶ Glasses
 - ▶ Virtual reality similar to a golf simulator
- ▶ Many use Color Segmentation to find pool table and ball locations
- ▶ Train color models for ball classification

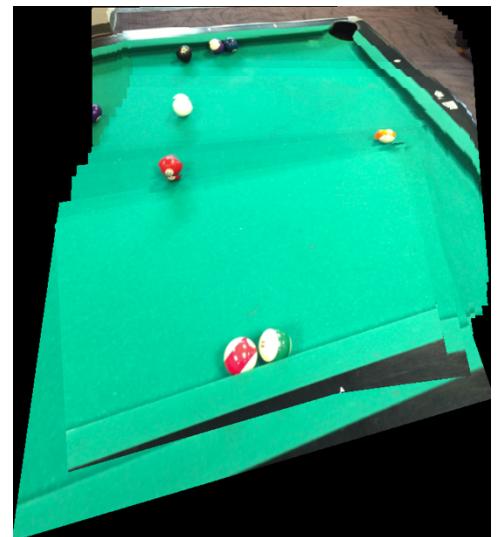
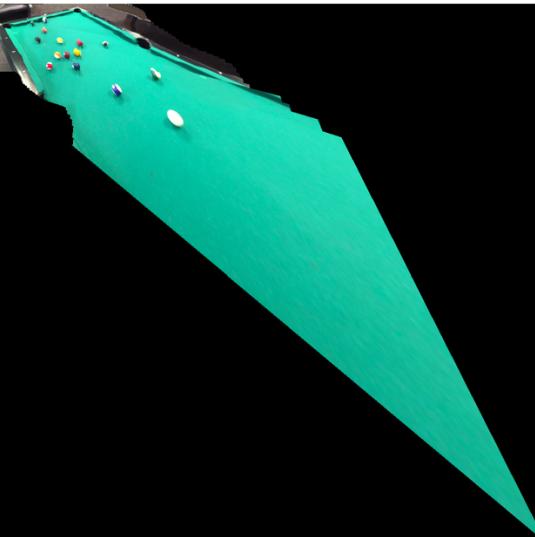


Projection system



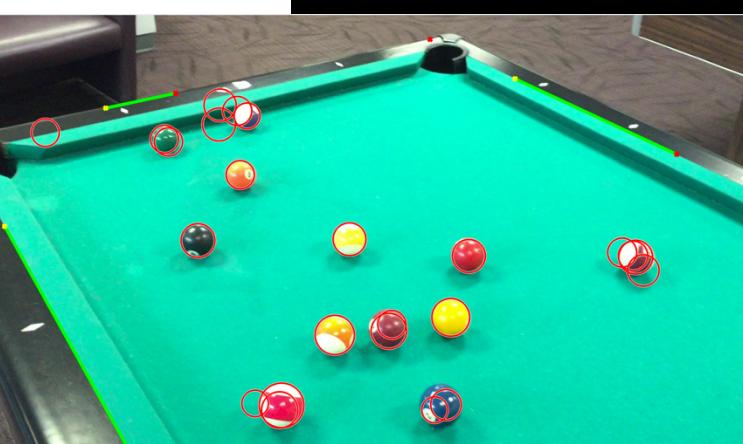
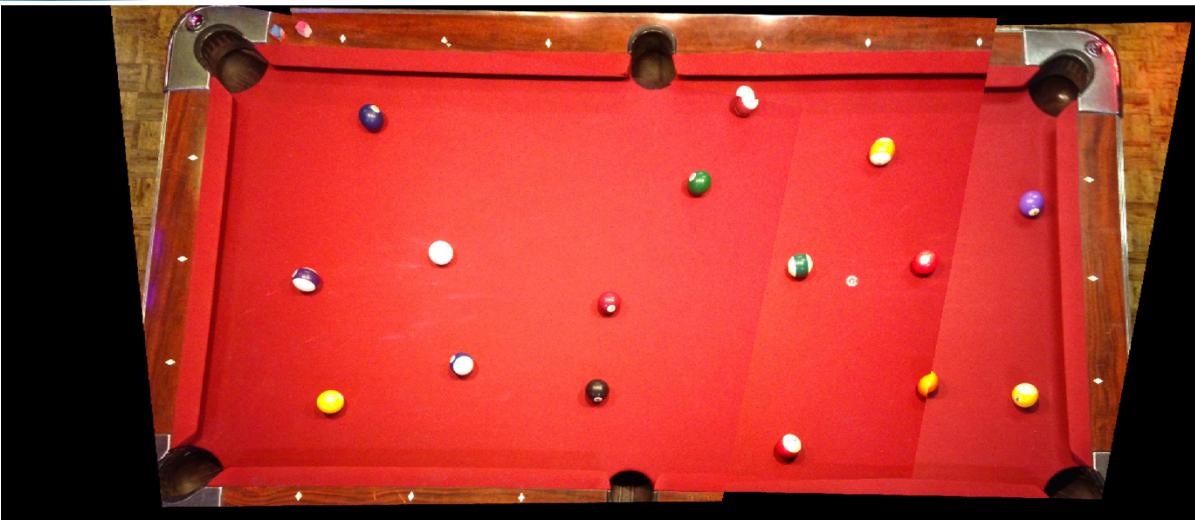
Video Stitching

- ▶ Hard to produce good images
- ▶ Lighting also changes over the course of videos which makes ball classification hard
- ▶ Videos almost always hit a spot where the feature matcher does not have enough similar features.
- ▶ Could be done but would be hard to make robust!



Multiple Photos

- ▶ Hard to create a smooth image to show possible shots
- ▶ Hard to get good position for balls since each frame says they are a little different
- ▶ Change in lighting between pictures makes it very difficult to classify the balls consistently



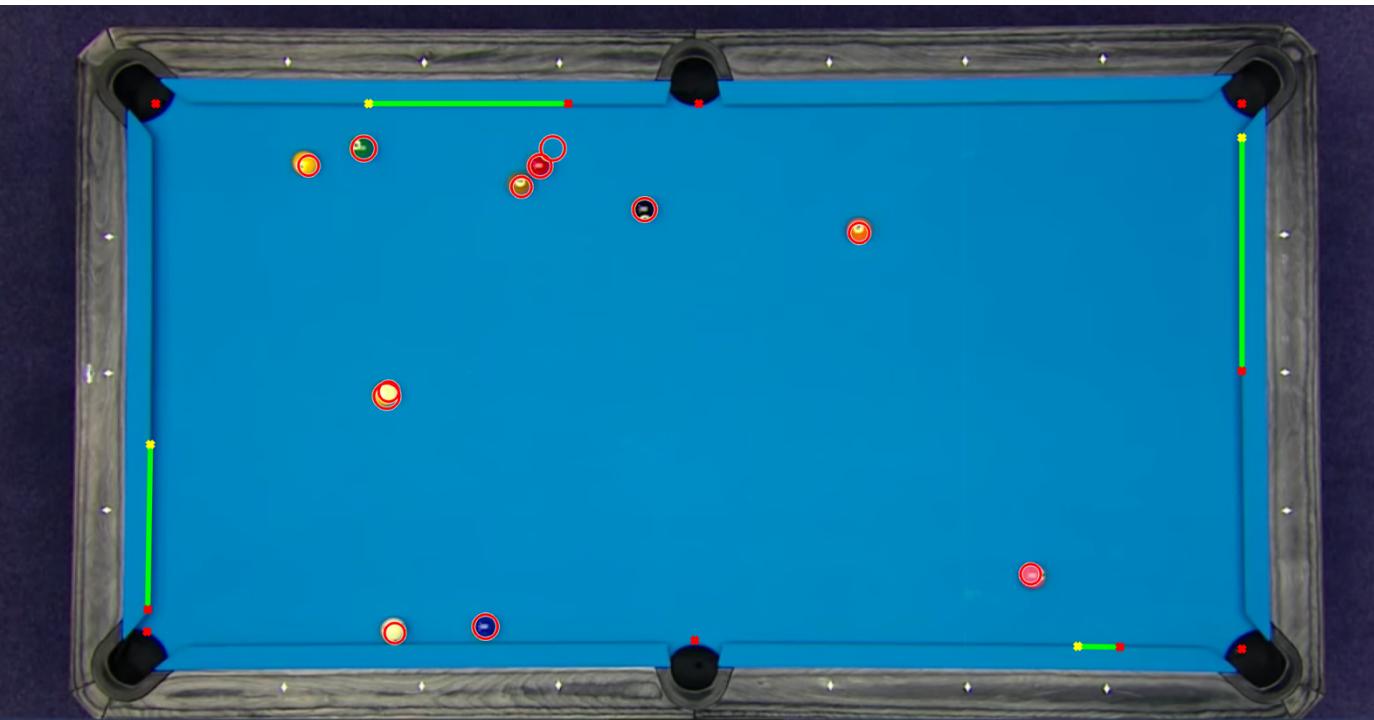
Best/Most Robust Photos

- ▶ Birds eye view of the table.
- ▶ View of the whole table.
- ▶ High quality pictures.
- ▶ Found HD 1080p video of professional Tournaments
 - ▶ Has consistent lighting.
 - ▶ Is a standard and code could be implemented in their broadcast.
 - ▶ Most robust setup.
 - ▶ Could be implemented similar to paper that implemented a projection system with a camera aiming at the pool table.



Initial Attempt

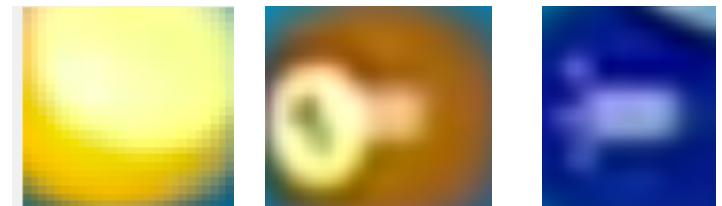
- ▶ Uses Hough Lines to find the table edges
 - ▶ Finds lines closest to center of image that are close to normal with each other
- ▶ Finds four outside pockets
 - ▶ Then the two middle ones based on the long sides of the pool table.
- ▶ Uses Hough Circles to find possible balls
- ▶ All circles outside of the table are discarded.



SVM Classification

- ▶ All circles found on the board are classified by SVM
- ▶ Several bad categories made
 - ▶ Ball 16 = image of the table
 - ▶ Ball 17 = image of table and edge
 - ▶ Ball 18 = image of a pocket
- ▶ Balls that are not actual balls are discarded

Good Images



Bad Images



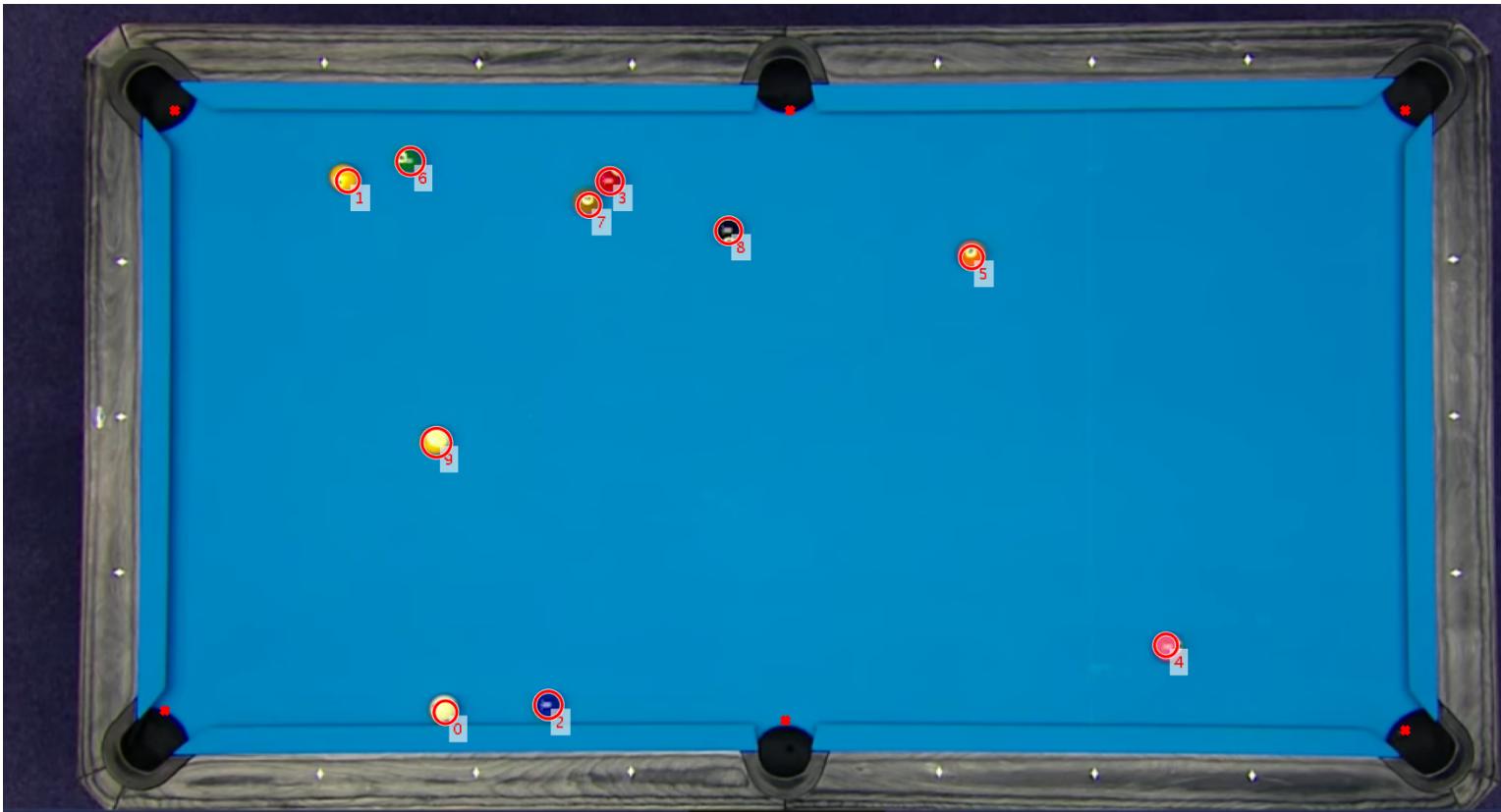
16

17

18

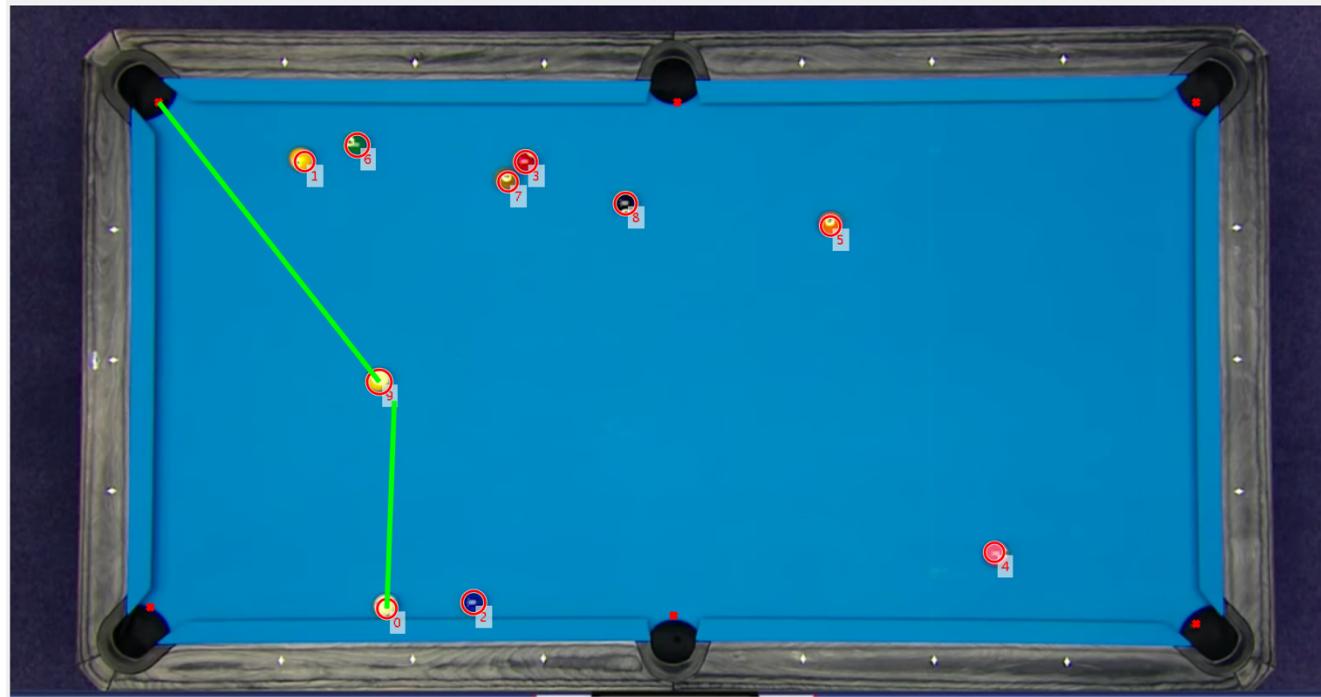
Final Guess for ball locations

- ▶ Balls that are not actual pool balls are dropped
- ▶ Balls that are too close are picked based on the SVM score
- ▶ If multiple balls of the same type are guessed the strongest one is picked
 - ▶ This is mainly used for determining the 8 ball vs pockets.



Shot Prediction

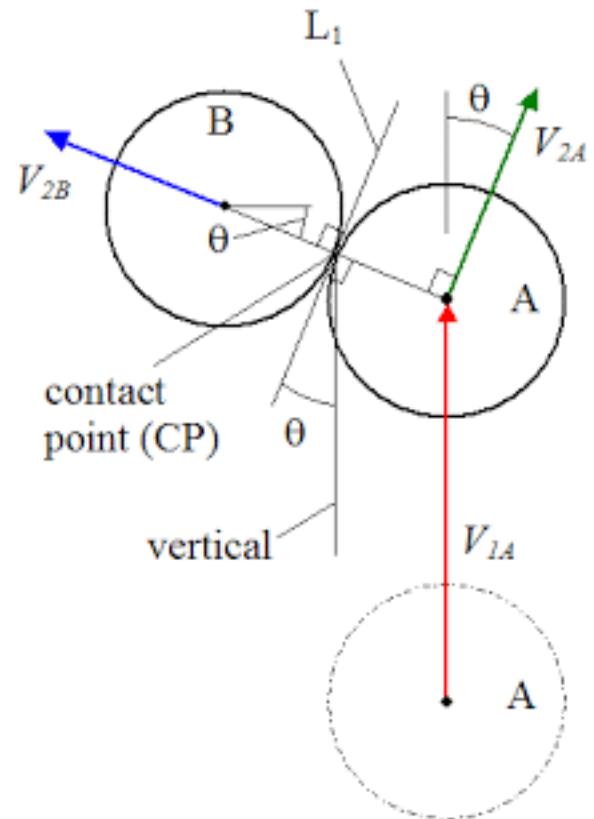
- ▶ Selects closest ball based on solids or stripes
- ▶ Finds pocket that requires smallest angle
- ▶ Calculates the angle the cue balls should be shot at



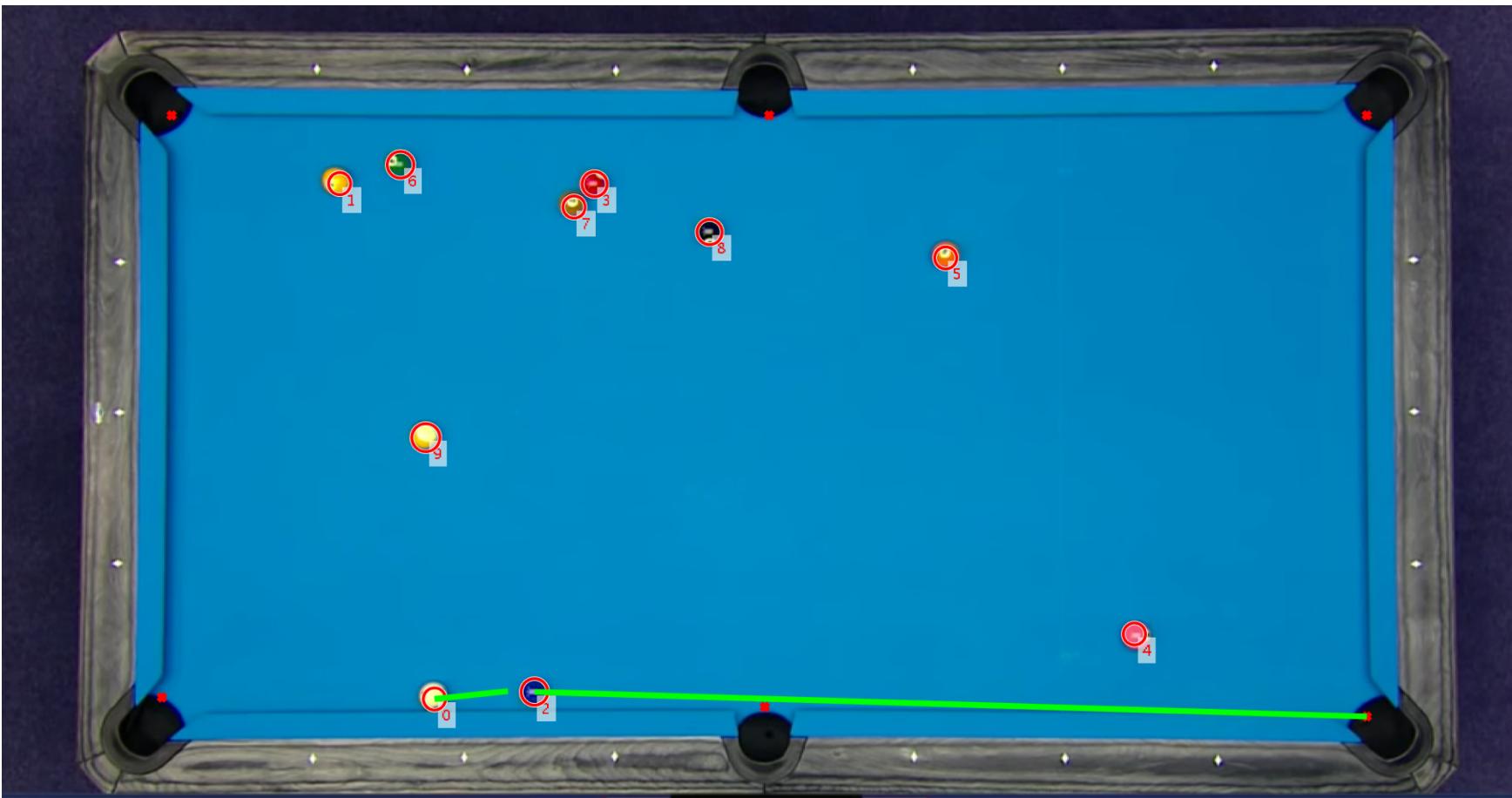
Stripes was picked in this image.

Shot angle

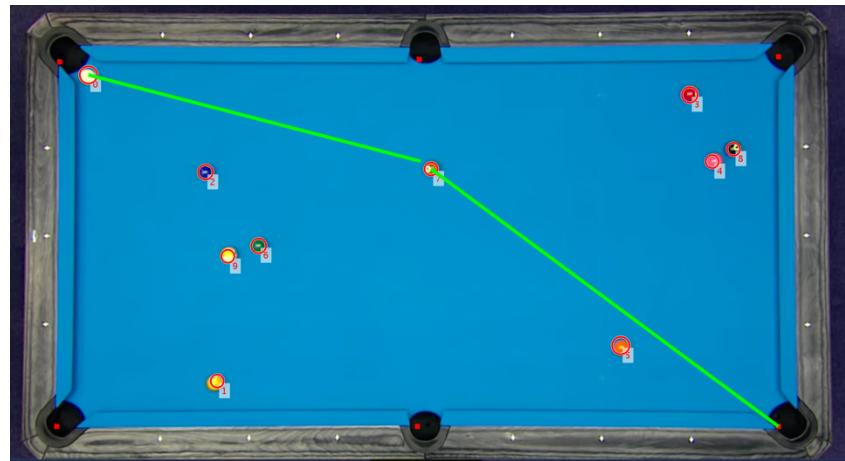
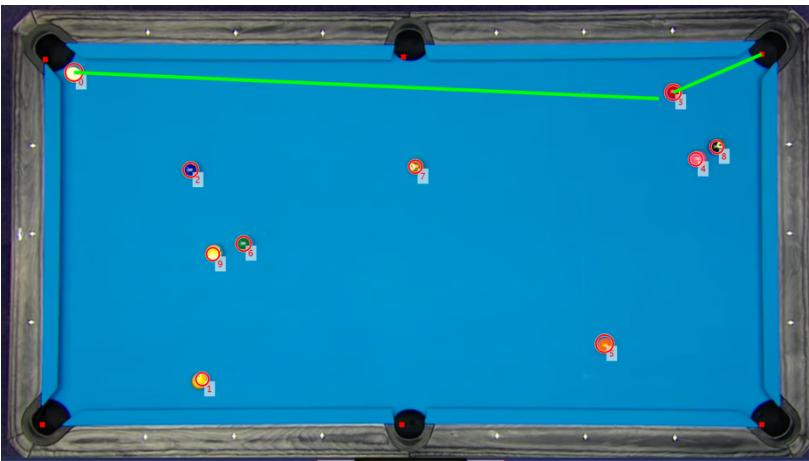
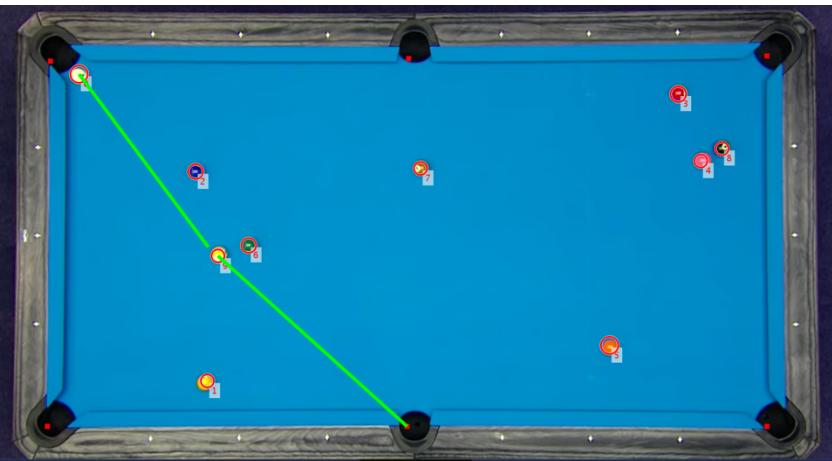
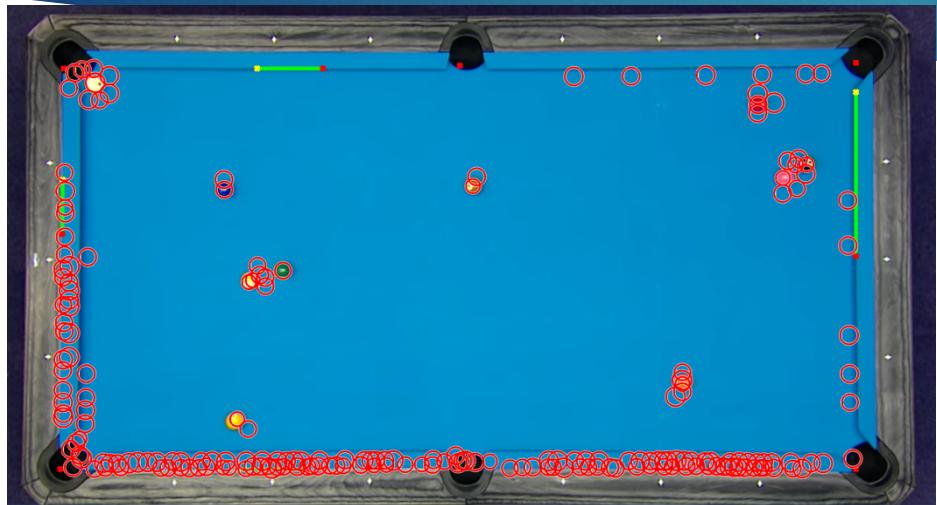
- ▶ Assume no friction between balls
- ▶ Not accounting for spin on cue ball or spin imparted on other balls
- ▶ Aiming for the position 2 radius's away from ball B on the vector ball B needs to go to get in the pocket.



Shot Prediction (Solids)



Another Frame



Conclusion

- ▶ Single Image works the best
- ▶ Hard to implement a video or image stitching especially if positions need to be accurate.
- ▶ Image quality and consistent lighting helps a lot.
- ▶ Table and ball identification works pretty well for professional pool video.

Future Work

- ▶ Make the shot prediction algorithm more complex
 - ▶ Take into account bounces
 - ▶ Check for balls in the way
 - ▶ Make sure ball doesn't hit side of pocket (especially for the middle pockets)
- ▶ Implement with a projection system
 - ▶ Mount camera above table
 - ▶ Mount projector towards pool table
 - ▶ Map possible shots to projector output.

