Classic Methods on Color Based Ball Tracking

Breno Leite
Guilherme Leite
Instituto de Computaão — UNICAMP
Cidade Universitária, Campinas/SP
brenolleite@gmail.com
guilherme.vieira.leite@gmail.com

Abstract

Abstract

1. Introduction

Ball tracking is a classical problem present in a diverse range of applications. Nowadays it is used in sports events to automatically track the focus of the action and game score, it is also widely used in robotics, specially in robocups soccer competitions.

2. Related Work

Related work

3. Methodology

Initially the tracking was done alone by a color detector. Using the color space HSV to select a color range that would create a mask, in this mask every pixel in the range is set to white and everything else black, afterwards two erosions and dilations are applied to reduce noise. The connected components are extracted from the resulting mask, and the largest connected component is selected as a region that contains a colored ball of such range. Every other connected component region with size of at least 30% of the largest one is also selected as another object. Each of these selected regions has a center of mass, the coordinate of this point is used as a rough estimate of the ball's position and is taken as the tracking parameter, later on this information will be called 'tracking position'.

The previous steps should insure the detection of a colored blue, but it can't distinguish between a ball and a cube. The Hough Circle Transform is used in the mask obtained previously, and it tries to fit circles in the mask, using the edges detected by its internal canny filter. To ensure the best fit the parameter SUCH, WHAT SUCH DOES, is started with a value high enough to not find a single circle in the mask, from this high value it is decreased by one until it finds its first circle, the region below this circle is selected as a ball region. This process is repeated until up to K balls are fit. Using Hough Circle Transform the tracking narrows down to track only the roughly rounded shapes in the mask.

Applying the color detection every frame is redundant, add hough transform to that and it becomes expensive and redundant. Hough is applyed every N frame, in each of these frames the position of the ball is corrected and from then it is estimated by the difference of its velocity and direction between two frames. These steps are faster, enabling the overall solution to perform in real time.

LK motion flow is enough to estimate the ball position, but it always depends on the last frame. Add a scenario in which the ball is occluded for more than a couple frame and LK motion will completely lose its estimative. Kalman filter is used to keep up with those scenarios.

4. Experiments

The experiments were designed to stress the effect of each new feature that was incrementally added. A controlled environment was set to perform these experiments, including a blank background, artificial white lighting, fixed camera and three balls of the same size and material, two yellow and a blue one.

Single color detection

The goal was to precisely track a single ball throughout the camera's view.

Two different color tracking

The goal was to track each colored ball throughout the camera's view, not ever mistaking one with another.

Two same color tracking

The goal was to track each ball throughout the camera's view, not ever mistanking one with another, now differentiating between two balls of the same color.

Ball tracking alongside with other shapes

The goal was to track a ball in a setup with many objects with different shapes, but same color as the ball.

Motion flow tracking compared with color tracking

The goal was to compare both solutions, Lucas Kanade motion flow tracking and every frame color detection.

Occlusion tracking

The goal was to compare the LK motion flow tracking and kalman filter tracking, both applied towards a occlusion scenario.

Real world tracking

The goal was to hard test all the features implemented in a real world scenario to avaliate their precision.

5. Results

Single color detection:

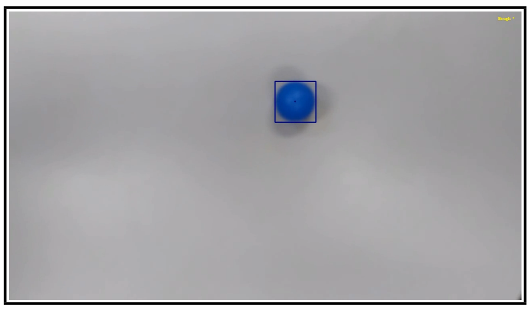

Figure 1. Detection of a colored ball.

The color detection applied to every frame was able to track the ball throughout the camera's view. This solution showed itself insuficient when sme objects were introduced, with different shapes other than of a sphere but same color as the ball.

Two different color tracking:

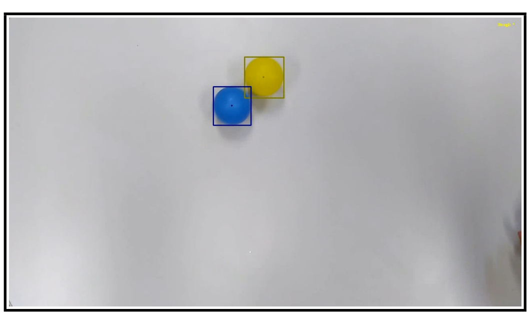

Figure 2. Detection of two balls with different colors.

The fine tunning of the colors enabled the solution to isolate one ball from the other, tracking them throughout the camera's view. This limits the solution to be tunned at every application, indoor and outdoor pocess distinct calibrations.

Two same color tracking:

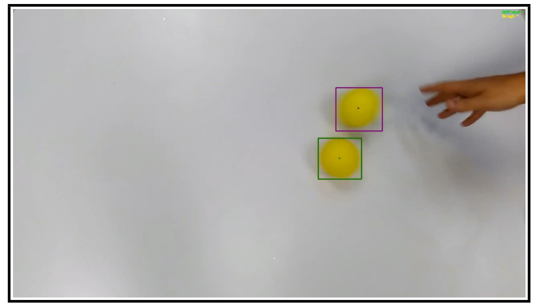

Figure 3. Detection of two balls with the same color.

The size of the connected components regions found in the mask were used the discriminate between the balls, the ratio between the first and second was used and enabled the tracking to work, the solution is limited when the object of interest moves away from the camera and becomes too small to pass the threshold.

Ball tracking alongside with other shapes:

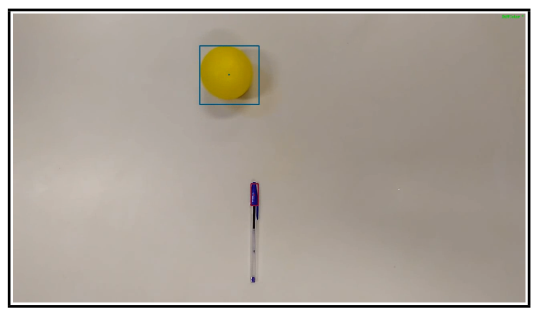

Figure 4. Detection before the Hough Circle Transfom.

As seen in Figure 4 the solution wasn't able to differentiate the ball from the pen top.

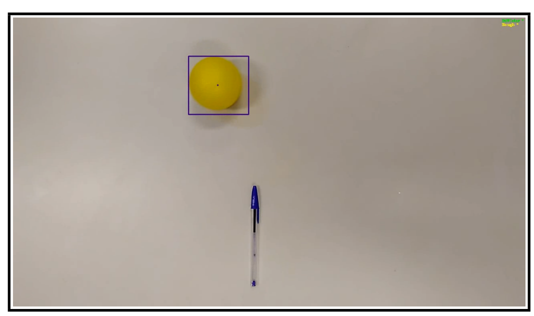

Figure 5. Detection after the Hough Circle Transfom.

In Figure 5 using the Hough Circle Transform the solution was able to ignore the pen top and track only the ball shaped object. This solution is still limited by the time it took to adjust the parameters into differentiate a pen top and a ball.

Motion flow tracking compared with color tracking:

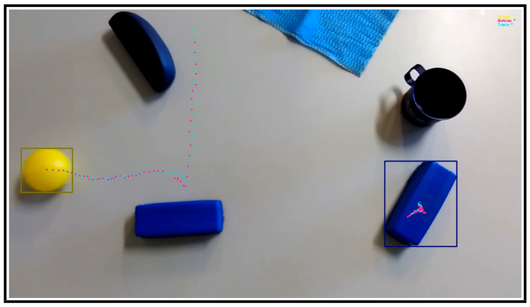

Figure 6. Lucas Kanade motion flow applied every 30 frames.

Using the Lucas Kanade motion flow the solution would only apply the color detection every N frames, this gap between detection speed up the tracking and enabled it to perform in real time (greater than 20 fps). The precision of the tracking depended on the gap size, and this experiment showed that a gap of 30 frames was too large.

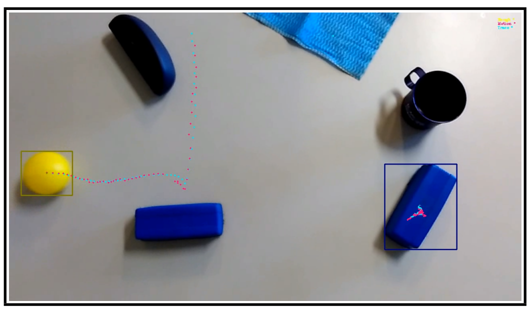

Figure 7. Lucas Kanade motion flow applied every 5 frames.

Using a 5 frames gap the precision of the tracking was close to the color tracking and the solution was still fast enough to operate in real time. Altough this solution couldn't keep tracking of the ball when it was occluded.

Occlusion tracking:

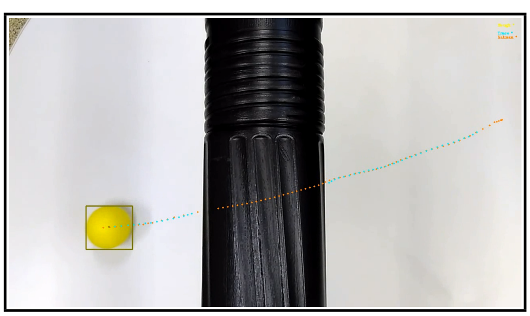

Figure 8. Kalman filter applied to overcome occlusion.

The solution was able to overcome occlusion when the kalman filter was used in such scenarios, since it was able to estimate the ball's trajectory. The filter worked best with low speeds and couldn't estimate a position if the ball changed directions whilst occluded.

Real world tracking:

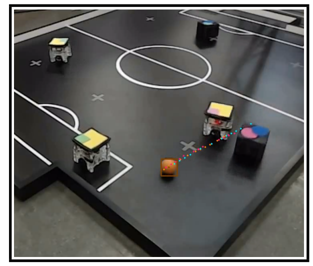

Figure 9. All features applied in a Robocup soccer match.

When applied to a real world scenario the solution can keep tracking up to a point, it fails whenever the ball changes direction while occluded, or when the ball moves too fast.

6. Conclusion

Even though the classic methods were able to track and overcome some of the challenges presented in this report they could't keep their precision in a real world scenario. Some other approaches to detect and track are needed for scenarios like a volleyball match, where the ball is white and the people watching the game are often caught in the camera along side with the game. Other works used deep learning to train a network into detecting the ball, some used a physics model to calculate the parabolic trajectory of the ball and some used completely different clues, like the fact that a baskball player moves differently from the others when he/she pocess the ball.

To go through the classic methods many of the course's topics were covered and applyed, clearing our sights towards their weakness, strenght and how they are applied. It is instigating to think the power that a neural network would have in such context, and realize from other works the vast number of ways to tackle a single problem.

References