Detection and Trajectory Tracking in Angry Bird

Beilei Wang(u5870439)
Yunchao Gong(u6329142)
Sirui Li(u5831882)

Group ID 5

Abstract. In this paper, we present a bird detecting and tracking algorithm in real-time video input environment. In our current system, the detecting algorithm is constructed for filtering out expected objects based on HSV values by thresholding operation and component connection operation. In terms of tracking the flying birds, we verify the region of the flying bird using support vector machines (SVM) classifiers which are trained on Histogram of Oriented Gradient (HOG) features.

Keywords: Detecting and Tracking Algorithm, HSV values, SVM Classifier, HOG features

1 Introduction

Angry Birds has been phenomenal successful in all its platforms. The main reason for its immense popularity would be its simple design with barely any instructions. The game screen features the birds to the left while the pig targets are to the right; the basic idea for playing is that the user launch the birds with a sling shot to knock over the pig targets as many as possible. However, to get the physics behind the game and simulate the projectile motion of a flying bird would be a challenging CV (computer vision) problem. Traditional tracking methods usually work under the assumptions of a single frame image or a set of images with the same coordinate and a fixed origin point [?]. Unfortunately, those assumptions do not hold for the real-time video of an Angry Birds video. Consequently, we have combined color thresholding, component connection, SVM-HOG based classification, and polynomial curve fitting approaches to achieve the tracking goal.

2 Related Work

There has been much research on the object detection in videos [?] [?] [?] [?] [?], which investigate the issues like moving background objects and sudden once-off changes. Many techniques have been proposed to address these issues, for example, by classifying background with a Bayes decision rule or combining statistical assumptions with the object-level knowledge of moving objects [?] [?].

In addition to the object detection of videos, another well-studied aspect is the tracking of moving objects. For example, Bastian et al. [?] build upon a state-of-the-art object detector which performs multi-view/multi-category object recognition.

But different from above real-world scenarios, objects in Angry Birds game are not complex. They are stable in terms of color and shape, and there is no unpredictable changes. The works that are most close to ours is the two studies on the color-model-based detection [?] [?]. Our approach of HSV-based detection is inspired by these two studies. However, these two studies do not estimate the trajectory. In contrast, our work proposes a set of rules to detect objects and set the slingshot as the origin point to transform the coordinates for birds based on the new coordinate system.

3 Approach

Our approach contains two main parts: detecting objects according to HSV color space (Hue, Saturation, Value) and tracking birds flying trajectories based on the detected coordinates. All methods are implemented in Matlab.

Given a frame, the detecting process consists of three steps: filter objects based on HSV color model (Section 3.1.1), construct and analyse connected components (Section 3.1.2), and classify similar connected components to extract bird and slingshot using SVM classifier with HOG features (Section 3.1.3). Taking the centroid of slingshot as the origin point, flying trajectories can be estimated (Section 3.2).

3.1 Object Detection

The object "i" is detected and recognized by a sequence of rules $R_i = r_{i1} \cap r_{i2} \cap r_{i3}$ where r_{i1} indicates the color attribute (H, S, V), r_{i2} is area attribute (area range) and r_{i3} is HOG feature. Object "i" in this project can be yellow bird, red bird, blue bird, black bird, white bird and slingshot.

3.1.1 HSV Filtering

Color models are used for describing the specification of the colors, such as RGB, HSV, YCbCr, YIQ, YUV, etc [?]. In computer vision, these models are used for human skin color segmentation [?]. In this work, we use HSV color model since it greatly decreases the size of color and robusts to lighting changes. Especially, hue filtering can segment the specified color [?].

We first use Matlab built-in function "rgb2hsv()" to convert each single frame from RGB to HSV color model. The HSV value of each bird and slingshot can be identified by "impixel()" function. Results are summarised in Table 1 and they are candidates of r_{i1}.

Table 1. Color Attribute r_{i1}

Object i	H Channel	S Channel	V Channel
Yellow Bird	$0.14 < H < 0.20$	$0.50 < S < 0.90$	$V > 0.80$
Red Bird	$H > 0.80$	$S > 0.70$	$0.40 < V < 0.90$
Blue Bird	$0.18 < H < 0.50$	$0.05 < S < 0.79$	$0.36 < V < 0.82$
Black Bird	$0.15 < H < 0.30$	$S > 0.60$	$0.10 < V < 0.50$
White Bird	$0.04 < H < 0.24$	$0.07 < S < 0.21$	$0.78 < V < 0.93$
Slingshot	$0.05 < H < 0.13$	$0.40 < S < 1.00$	$0.40 < V < 0.80$

3.1.2 Component Connection

Figure 1 shows the result frame after applying rule r_{i1} in double image. Pixels in one object are isolated due to the interference of noise. To connect them, we dilate pixels with imfill() and imdilate() functions. Based on our observation, rectangle with size 10*5 is the most appropriate structuring element. Figure 2 is the dilation result. We eliminate some obvious noisy pixels, such as the start button, and it is introduced in Section 4.

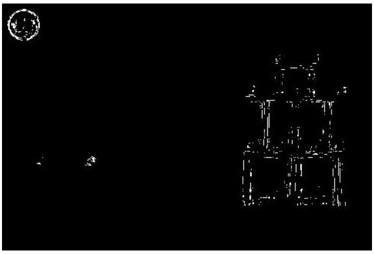


Fig. 1. HSV Extracting Result

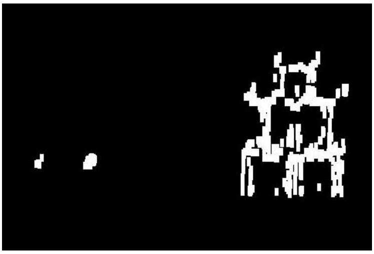


Fig. 2. Dilation Result

To reduce the difficulty of identifying connected components, we preprocess each frame with area constraint, i.e., assigning area (the number of pixels) range to object "i". Table 2 represents rule r_{i2} for each object.

3.1.3 SVM-HOG based classification

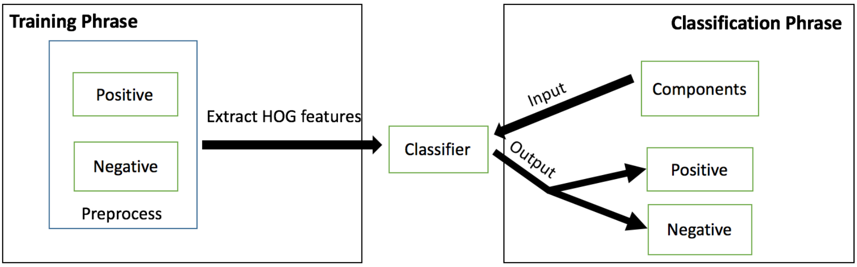
After applying r_{i1} (Color Attribute rule) and r_{i2} (Area Attribute rule), we found noisy components still exist. It is hard to distinguish such noisy components from bird or slingshot components as they have almost identical color and similar area. To address this new issue, linear Support Vector Machines (SVM) is trained on Histogram of Oriented Gradient (HOG) features. SVM classifier with

Table 2. Area Attribute r_{i2}

Object i	Area Range
Yellow Bird	$200 < Area < 520$
Red Bird	$Area < 600$
Blue Bird	$55 < Area < 500$
Black Bird	$Area > 100$
White Bird	$Area > 70$
Slingshot	$Area > 800$

HOG feature was proposed by Navneet Dalal and this method is now complicit in detection across almost every visual classification task [?]. For each object "i", we train a SVM classifier with HOG features. Figure 3 illustrates the overview of our classification method. Because we are only cared about *Is this component bird or slingshot?*, so we trained a binary classifier with either "Positive" or "Negative" output label.

Fig. 3. An Overview of our SVM Classifier with HOG Feature



3.2 Object tracking

To track and estimate flying birds trajectories, the slingshot is set as the origin of the coordinate system XoY, that is, the centroid of the slingshot is regarded as a reference point with coordinate (0,0) once the slingshot is detected in the current frame. Centroid of objects are easy to obtain by using the built-in function "regionprops()". New coordinate s of birds will be transformed based on the following equations:

$$new\_x = bird\_x - slingshot\_x$$

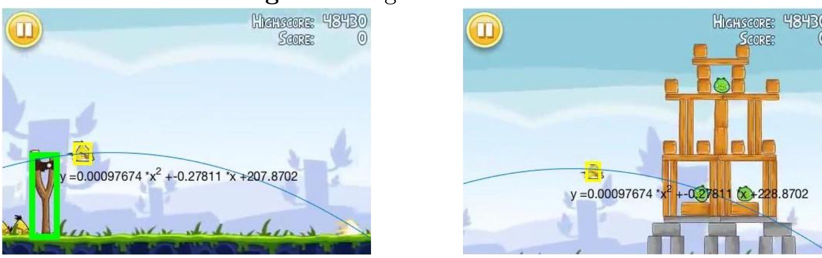
$$new\_y = bird\_y - slingshot\_y$$

For example, the coordinate of the yellow bird in Frame 899 is (105.08, 190.13) and the coordinate of the slingshot is (56.65, 239.27). So the new coordinate of the yellow bird in this frame is (48.43, -49.14) where 48.43 = 105.08-56.65 and -49.14 = 190.13 - 239.27.

Based on our observation and experiment, there are at least 15 frames occuring both slingshot and bird for each kind of bird. We save these new coordinates in a list and apply "polyfit()" function to calculate the quadratic equation for each bird.

As the definition of quadratic equation $y = ax^2 + bx + c$, quadratic term ratio a determines parabola opens upwards or downwards and the degree of curvature. Hence, a will not change with the scale. Figure 4 shows the result of fitting our calculated curve into frames.

Fig. 4. Fitting Curve into Frame



(a) Frame 899 (b) Frame 930

4 Challenge and Improvement

4.1 Detecting Interferent Components

In terms of HSV filtering, when it comes to selecting the ranges of birds HSV values, the grass which is on the bottom of the frame, the stop button which is on the top left of the frame, and the score label which is on the top right of the frame could become interferent components. These interferent components shall be resulted from a similar range of HSV values with the desired bird targets. As is shown in the Figure 5, the grass could be an interferent component in this case.

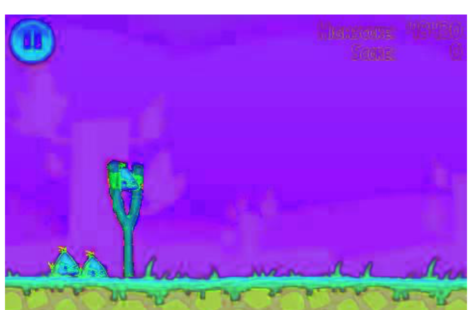


Fig. 5. Interferent Component Example for Yellow Bird

To solve this problem, since these interferent components are on the corners of frame of which the locations remain the same in all frames, they do not impact the projectile motion of the flying birds in the video. Thus, we have come up with the idea of shielding these interferent components, which has been achieved by setting the areas of interferent components 0 in the binary image for all frames, so that only the desired bird targets are labeled as 1 in the binary image for further detecting process.

4.2 Misrecognition

Prior to launching the birds with the slingshot to knock over the targeted pigs, since the range of HSV values of the birds, especially the blue birds, could be similar with that of the slingshot, the slingshot would be misrecognized as birds. Additionally, after releasing the birds, it would also be possible that the pigs and wood bricks are misrecognized as birds as well. The track crosses through these objects and the location of them are changed all time. Hence, in this case, we cannot use the previous shielding method to block these misrecognized components. As Figure 6 demonstrates, the slingshot has been misrecognized as birds.

Fig. 6. Misrecognition Example for Blue Bird

To distinguish birds and other interferents, our team chose to use support vector machine (SVM) to classify them. Initially, the binary filter has been utilized to get the binary image for each frame, where the idealized targets (birds and these misrecognized components) are labeled as 1 while other pixels are labeled as 0. Then, the desired bird targets are cropped into a folder named Positive and the misrecognized components are cropped into a folder named Negative. Consequently, these two folders would be trained by an SVM classifier with HOG features. Thus, in the binary image of each frame, we have output 1 for the flying bird's region, and output 0 for the region of misrecognized components. Due to the real-time video input environment, occasions change for every frame. So, we have traversed more typical frames for each bird and cropped enough training materials for the SVM classify.

4.3 Reference system to track the path

For getting a polynomial curve which indicates the bird's projectile motion, the coordinate system should be built. However, the background for most frames are changing with time. And as for the cases of white birds and black birds, the flying white bird would release an egg bomb which generates a new projectile motion while the blue bird would split into three individuals of which each generates a new projectile motion. Thus, it would be difficult to find a reference system

At the beginning stage of the bird flying, the slingshot exits for most frames where the flying bird is moving relative to stationary slingshot. Thus, we have set the slingshot as the coordinate origin, the horizontal direction as the x axis, and the vertical direction as the y axis. By the calculation of the implementation and coefficients of the previous SVM algorithm, quadratic equations are used to demonstrate the bird's flying path. When the slingshot disappears in the game screen, we adjusted the calculated parametric curve to suit for the birds track since the curve should be a projectile motion curve. For the cases of white and blue birds, as is shown in the Figure 8, we set the coordinate origins on the change points.

Fig. 7. Misrecognition Example for Blue Bird

5 Experiment Results

The video has been divided into six parts based on different birds. Then we recognized and tracked each flying bird frame by frame. Consequently, all the images have been organized to form a new video. The example output frames for each part are shown in Figure **??**.

With regard to recognizing, we have followed the process of setting the threshold of HSV values, transforming the original image for each frame to the binary image, and using the mathematical morphology to train the SVM classifier for each bird so that the interferent components can be removed. The accuracy of

Fig. 8. The example frames of six birds

recognition is over 95%, there are just several birds lost in the beginning of flying as the slingshot disturbs the recognition.

To distinct the bird's color, each flying bird has been covered by the same color box, while the box of the slingshot is labeled as green. The equation of the tracking curve for each flying bird is demonstrated below the corresponding bird. We have assumed each flying path is a one-quadratic equation, and the curve sometimes is not stable because of the zoom between different frames. There will be two special cases when it comes to the blue bird and white bird, since the white bird will release an egg bomb and the blue bird would split three individuals, which will both generate new projectile motion curves. In these cases, we set the change points as the coordinate origins to track the paths.

6 Conclusion and Future Work

A novel CV-based object-detecting and object-tracking algorithm for Angry Birds has been presented in this report. The flying birds are detected with the HSV thresholding operation and the component connection method. False feature matches of flying birds are detected and removed by utilizing SVM classifiers, while true feature machines of those are collected as Mat files. Additionally, the formatted data from those Mat files would be then used for polynomial curve fitting to simulate the projectile motions of the flying birds. For potential further work, some improvements might be developed and applied to realizing the algorithm on videos with zooming background.

7 Learning Outcomes

From the team research project, we indeed have had a brand new experience to construct the computer vision knowledge and theory to a real-world innovative problem. Through the process of completing this project, we have developed some basic techniques in terms of object detection and tracking. Color thresholding and component connection are applied to detect possible object shapes, and SVM classifiers are used as binary classifiers to remove interferent components such as grass and the game page button. Though we have went through some difficulties and disappointment from testing errors, we never give up and attempt to solve the problems.

References

1. Verstraeten, W.W., Vermeulen, B., Stuckens, J., Lhermitte, S., Van der Zande, D., Van Ranst, M., Coppin, P.: Webcams for bird detection and monitoring: A demonstration study. Sensors **10**(4) (2010) 3480–3503
2. Gall, J., Yao, A., Razavi, N., Van Gool, L., Lempitsky, V.: Hough forests for object detection, tracking, and action recognition. IEEE transactions on pattern analysis and machine intelligence **33**(11) (2011) 2188–2202
3. Cucchiara, R., Grana, C., Piccardi, M., Prati, A.: Detecting moving objects, ghosts, and shadows in video streams. IEEE transactions on pattern analysis and machine intelligence **25**(10) (2003) 1337–1342
4. Foresti, G.L.: Object recognition and tracking for remote video surveillance. IEEE Transactions on Circuits and Systems for Video Technology **9**(7) (1999) 1045–1062
5. Liu, J., Luo, J., Shah, M.: Recognizing realistic actions from videos in the wild. In: Computer vision and pattern recognition, 2009. CVPR 2009. IEEE conference on, IEEE (2009) 1996–2003
6. Sivic, J., Zisserman, A.: Video google: A text retrieval approach to object matching in videos. In: null, IEEE (2003) 1470
7. Li, L., Huang, W., Gu, I.Y., Tian, Q.: Foreground object detection from videos containing complex background. In: Proceedings of the eleventh ACM international conference on Multimedia, ACM (2003) 2–10
8. Leibe, B., Schindler, K., Cornelis, N., Van Gool, L.: Coupled object detection and tracking from static cameras and moving vehicles. IEEE transactions on pattern analysis and machine intelligence **30**(10) (2008) 1683–1698
9. Pandey, S., Sengupta, S.: Color detection and tracking from live stream–an extensive survey. International Journal of Computer Applications **168**(3) (2017)
10. Saravanakumar, S., Vadivel, A., Ahmed, C.: Multiple object tracking using hsv color space. In: Proceedings of the 2011 International Conference on Communication, Computing & Security, ACM (2011) 247–252
11. Deswali, M., Sharma, N.: A simplified review on fast hsv image color and texture detection and image conversion algorithm. International Journal of Computer Science and Mobile Computing (2014) 1216–1222
12. Kolkur, S., Kalbande, D., Shimpi, P., Bapat, C., Jatakia, J.: Human skin detection using rgb, hsv and ycbcr color models. arXiv preprint arXiv:1708.02694 (2017)
13. Bristow, H., Lucey, S.: Why do linear svms trained on hog features perform so well? arXiv preprint arXiv:1406.2419 (2014)

8 Peer Review

For this project, our team has meeting every week to review the previous work, discuss the next step and delivery the works. We have good communication and harmonious team relationship. Everyone tried to find creative ideas to solve problems and tried his best to complete his work. I am proud for my team members.

In this project, I have recognized blue and white birds. And because the blue bird will divide to 3 birds in flying. My job is tracking the blue birds and drawing the curve in frames. Beilei Wang has recognized black bird and track black and white birds. Sirui Li has reconized red and yellow birds and track them. When we all finished our parts, our team merged them together and modified it.

For this report, I did the challenge and improvement part and experiment results. Sirui Li did the related work and approach. Finally Beilei Wang finished the left introduction and conclusion parts and modified the grammar.