PROJECT 1: FRUIT FINDER

Graham Fuller
Jacob Oakes

Rose-Hulman Institute of Technology
Email: fullerga@rose-hulman.edu
oakesja@rose-hulman.edu

ABSTRACT

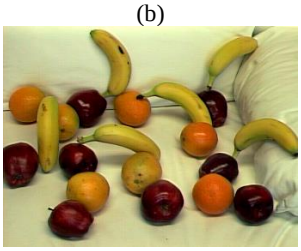
In this study, we honed in on a fruit detection application to classify apples, oranges, and bananas as well as find their sizes and centroids. Our process of accomplishing this included analyzing HSV pixel values and applying a threshold to get a mask for each of the fruit types. These masks were then smoothed by morphological operations such as erosion and dilation. We also included a sub process to fix the problem of green areas of oranges being classified as bananas. For the three images we were able to properly classify every piece of fruit with the exception of two closely placed oranges being clumped together as one.

1. INTRODUCTION

The process of object detection in images plays an interesting role in data analysis today. With this technology, more data can be extracted from pictures such as what objects are in them and the size of these objects. The problem that we have been presented with is finding apples, oranges, and bananas in the pictures found in Figure 1. This problem is interesting because it can be completed with basic color thresholds, but it has the possibly to be expanded and improved upon with other techniques. The challenges of this problem are that the color of each piece of fruit are sometimes widely different. For example, the orange in center of Figure 1c has more green in it than most oranges and is closer to the color of bananas. What makes our proposed solution unique is that it is a process that includes more than just color thresholds. It also contains morphologies such as dilation and erosion, and a sub process to classify green oranges as oranges rather than bananas.

(a)

(b)



(c)

Fig. 1: Original pictures of the fruit

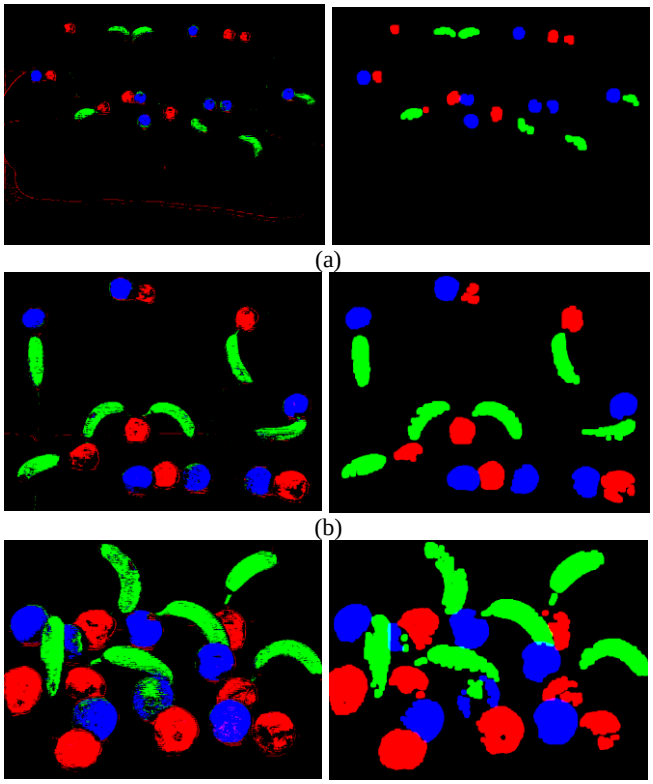
2. PROCESS

2.1 Initial classification using HSV thresholds

The first step that we took was to determine a range of HSV values that would properly classify an orange, apple, and banana. With a little research we were able to find the range of hues for orange, red, and yellow. Then we examined the HSV color values of Figure 1a and found general ranges for saturation and value for the fruits. Some trial and error was used here until a good range was found. The thresholds we found during this initial process can be seen in Table 1. We found that the apples were very dark and almost black in some spots. The shadows around the couch are also near this color. To avoid false positives we set the lower threshold value for apples to be 0.1 rather than something lower. To smooth and better form groups of pixels, we first eroded by a 4x4 pixel square to get rid of small false positive groups. Then we dilated by a disk of radius 6 pixels to close what was just eroded for larger groups of pixels. These morphological operations were performed for all three fruit masks. The results of this attempt can be found in Figure 2. Note that oranges are blue, apples are red, and bananas are green.

Table 1: Initial HSV thresholds

	Hue (°)	Saturation	Value
Oranges	0-40	0.75-1.0	0.5-1.0
Apples	0-20, 120-360	0.4-1.0	0.1-1.0
Bananas	43-100	0.57-1.0	0.5-1.0

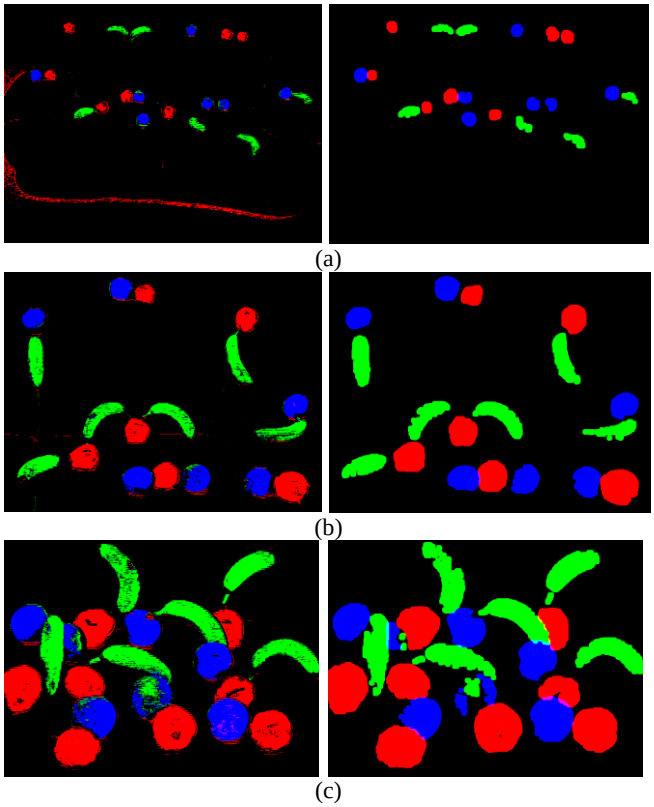


(a) (b) (c)

Fig. 2: Initial fruit classification by pixel on the left and with morphological operations on the right.

Table 2: Improving apples HSV thresholds

	Hue (°)	Saturation	Value
Oranges	0-40	0.75-1.0	0.5-1.0
Apples	0-20, 120-360	0.4-1.0	0.0-1.0
Bananas	43-100	0.57-1.0	0.5-1.0



(a) (b) (c)

Fig. 3: Improving apple classification by pixel on the left and with morphological operations on the right.

2.2 Improving classification of apples

Looking at Figure 2a, there are large gaps in the apples that are not included. These gaps are mostly darker areas that we avoided in our first attempt. To improve our classification of apples we removed the threshold for the value to include these darker areas. The problem that this change created was the same problem we tried to avoid in our initial classification. As you can see in Figure 3a more of the darker area surrounding the couch was included. To compensate for this, erosion of the apple mask had to be increased. A process of trial and error was used until we found that eroding by a 7x7 pixel square was just enough to remove all the false positive apple pixels. Since more was eroded, the dilation for the apple mask was increased to a disk of radius 10 pixels. The morphologies and thresholds for oranges and bananas were left untouched for this attempt. The results of this attempt can be found in Figure 3.

2.3 Improving classification of bananas

Looking at the banana on the far right in Figure 3b and others, we determined that they could be better defined. To improve the shape of the banana, we decreased the banana hue lower threshold to include more greens. In addition we decreased the banana value lower threshold to include the darker areas of the bananas. We changed the dilation of bananas from a 6x6 pixel square to a 4x4 pixel square and then a disk of radius 4 pixels. The idea behind this change was to give the bananas a more defined shape since they are not as spherical as apples or oranges. The results of this attempt can be found in Figure 4.

Table 3: Improving bananas HSV thresholds

	Hue (°)	Saturation	Value
Oranges	0-40	0.75-1.0	0.5-1.0
Apples	0-20, 120-360	0.4-1.0	0.0-1.0
Bananas	38-100	0.57-1.0	0.3-1.0

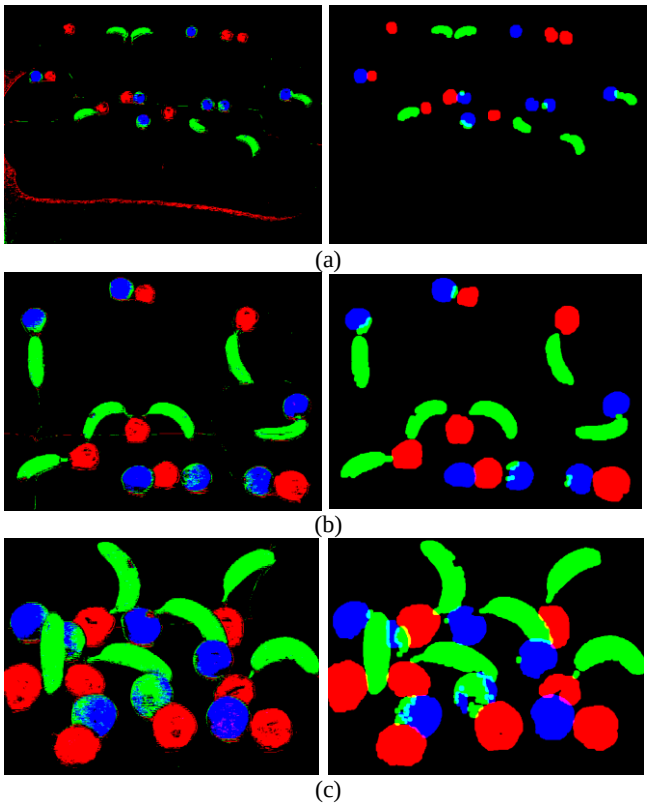


Fig. 4: Improving banana classification by pixel on the left and with morphological operations on the right.

2.4 Improving classification of oranges

In Figure 4c, there were five pixel groups that were classified as bananas that were actually just parts of oranges. These areas were greener than other parts of the orange. The first step we took to fixing this problem was expanding the saturation range of the oranges to include more of the green ranges. A side effect of this change was that more apple regions were included. This was fixed by changing the lower hue threshold of oranges. These changes to the color thresholds included more of the oranges but not enough. In order to properly classify these areas, we created a sub process to rectify this problem. First the morphologies performed on the banana mask were changed again. The banana mask was first eroded by a 6x6 pixel square rather than a 4x4 pixel square. This was increased to make the distinction between the banana and misclassified orange in the center of Figure 4c clearer when we grouped components later in the next step of our sub process. The dilations were also changed to compensate for the increased erosion. They were changed to a 7x7 pixel square followed by a disk of radius 4 pixels. With the now smoothed mask, we were able to find its components using Matlab's built in bwlabel function using a 4 pixel neighborhood. With the components of the banana mask, we were able to find the average banana size in pixels. We then determined that any banana component in this mask that was less than 75 percent of this average could actually be classified as an orange. This approach worked since the average size of bananas was larger than these misclassified regions. The results of this attempt can be found in Figure 5.

Table 4: Initial HSV thresholds

	Hue (°)	Saturation	Value
Oranges	20-40	0.57-1.0	0.3-1.0
Apples	0-20, 120-360	0.4-1.0	0.0-1.0
Bananas	38-100	0.57-1.0	0.3-1.0

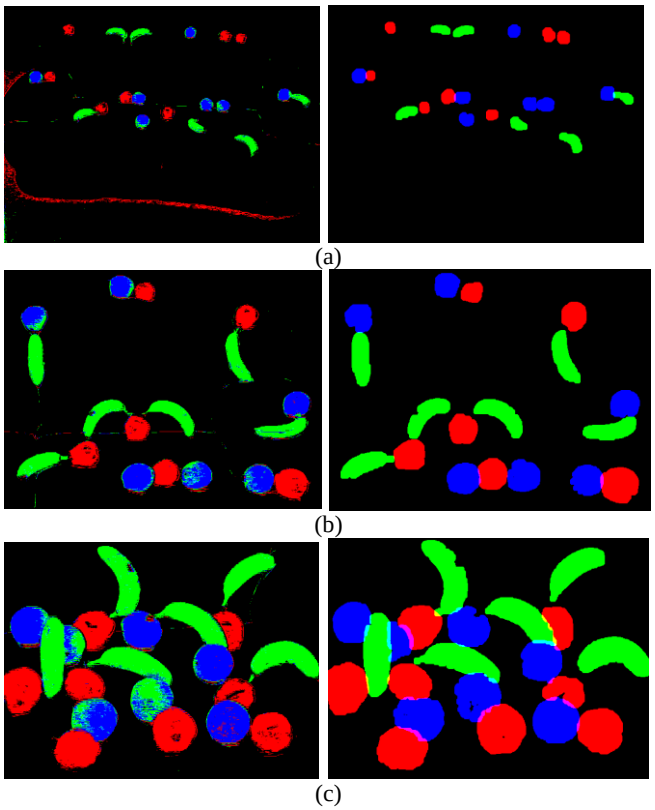


Fig. 5: Improving orange classification by pixel on the left and with morphological operations on the right.

3. RESULTS

Tables 5-7 include the sizes in pixels of the fruit in each image in Figure 6. The centroids are marked and labeled on the images in Figure 6. Note that oranges are blue, apples are red and bananas are green. Each picture has dimensions 480x640 pixels for size comparison.

Table 5: Fruit sizes in Figure 6a

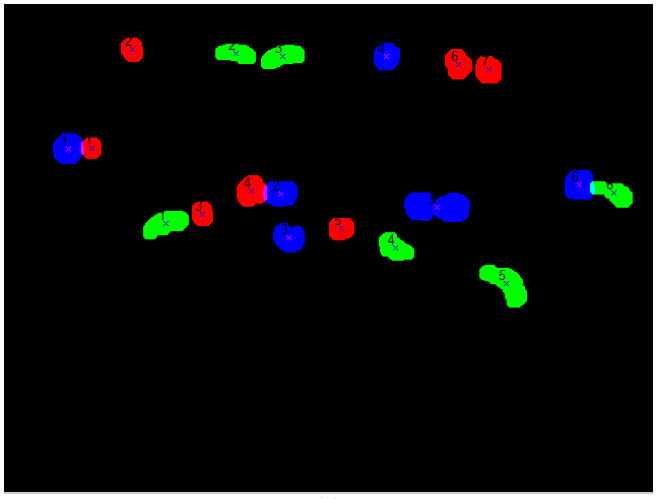
Fruit	Number of Pixels
Apple 1	370
Apple 2	452
Apple 3	449
Apple 4	759
Apple 5	492
Apple 6	645
Apple 7	617
Banana 1	894
Banana 2	641
Banana 3	766
Banana 4	713
Banana 5	1112
Banana 6	720
Orange 1	774
Orange 2	748
Orange 3	718
Orange 4	593
Orange 5	1566
Orange 6	765

Table 6: Fruit sizes in Figure 6b

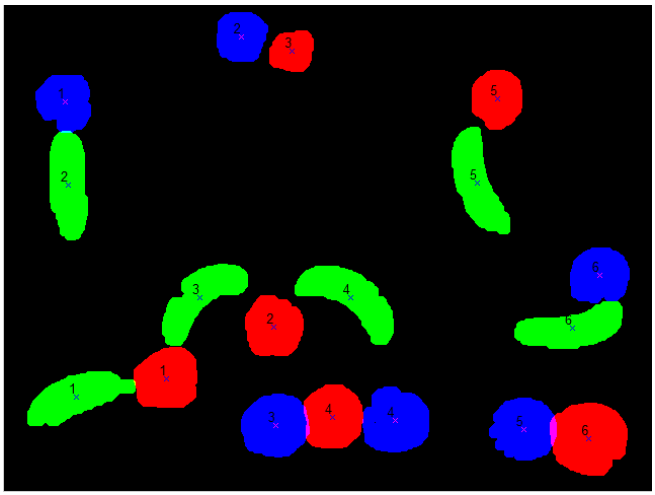
Fruit	Number of Pixels
Apple 1	3167
Apple 2	2829
Apple 3	1491
Apple 4	3081
Apple 5	2386
Apple 6	4396
Banana 1	3375
Banana 2	3355
Banana 3	3226
Banana 4	3605
Banana 5	3323
Banana 6	3269
Orange 1	2470
Orange 2	2078
Orange 3	3393
Orange 4	3446
Orange 5	3238
Orange 6	2682

Table 7: Fruit sizes in Figure 6c

Fruit	Number of Pixels
Apple 1	7009
Apple 2	6984
Apple 3	5185
Apple 4	5576
Apple 5	7773
Apple 6	3827
Apple 7	3777
Apple 8	6769
Banana 1	7825
Banana 2	6899
Banana 3	7249
Banana 4	6588
Banana 5	5570
Banana 6	7477
Orange 1	5208
Orange 2	3275
Orange 3	6774
Orange 4	5460
Orange 5	6756
Orange 6	5689
Orange 7	6941



(a)



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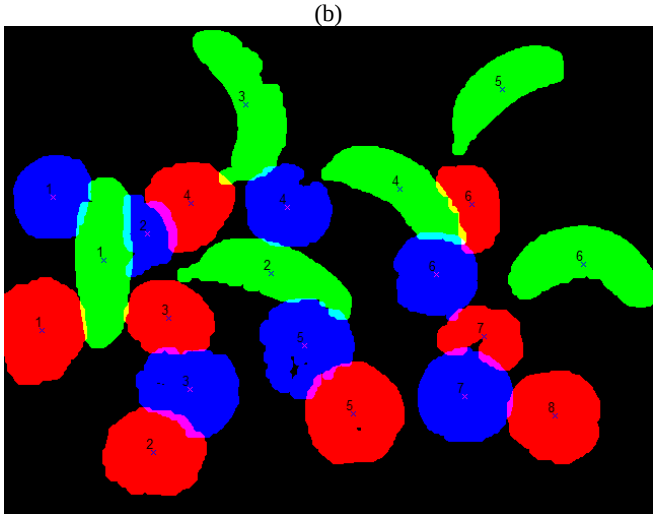

(c)

Fig. 6: Final pictures of masks combined with centroids

3. FUTURE WORK

Our fruit finding process was able to correctly classify every fruit in the three images except for clumping together two oranges in Figure 6a. This could be improved upon by making the size of the structure elements for the morphologies be relative to the average size of the fruits.

The sub process where we switch the classification of a banana to an orange based on the average size works for these images. However, it would not work if the sizes of the misclassified oranges were actually larger than the average banana size. To fix this assumption we would need a better algorithm that takes more into account than just color and sizes of regions. A future improvement would be to include edge detection in some way. Edge detection along with color could also help improve results for large piles of fruit.