# Principal Component Analysis

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## 1. INTRODUCTION

Principal component analysis can be used to classify data that is seemingly grouped. Data can be processed so that each individual component can be identified as unique through various methodologies. The method used in this implementation utilizes double thresholding for background deletion. Each continuous object should then be identifiable as a unique entity. PCA can then be applied to classify each object. The center of mass for each object can be used to identify the center of the object.

After constructing a covariance matrix for an object, the major and minor axes an ellipse can be computed. The orientation of the ellipse can be determined by obtaining the eigenvalues. Each object can then be classified using the data available. In this implementation, the data is used to identify the types of fruits in an image.

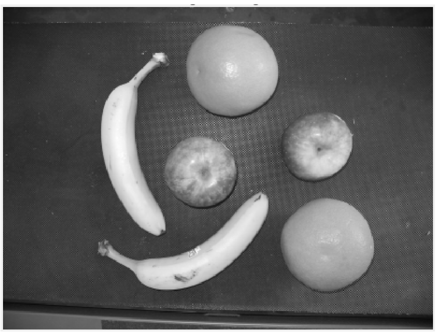

**Figure 1: Original Image**

## 2. METHODOLOGY

### 2.1 Bananas

Bananas are identified by computing the eccentricity of the matched ellipse. If the eccentricity of the object is between .94 and .98 with an appropriate length, then it is assumed that the respective fruit is a banana.

### 2.2 Apples & Oranges

Oranges are classified according to size. Since it is highly probable that the fruits will be of different sizes under different circumstances, the sizing of the fruits needs to be dynamic. This is achieved by computing the sizes of the fruits using the distance formula.

$$\textbf{Length} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

**Figure 2: Distance Formula**

The sizes of the fruits are then stored in a array associated with another array of the following format: `[[major_x, major_y, minor_x, minor_y]]`. Every object with a radius below one standard deviation of the mean is culled. Objects that are larger than average are deemed to be oranges. The rest of the fruits are classified as apples.

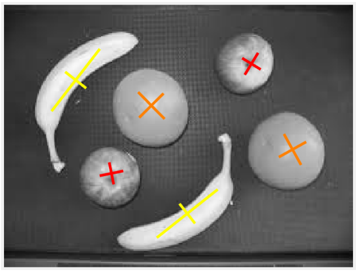

**Figure 3: Fruit 1 Image classified with PCA.**

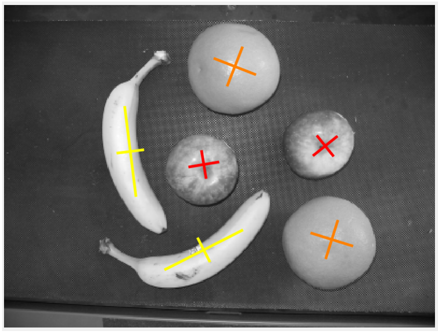

**Figure 4: Fruit 2 Image classified with PCA.**

# 3. RESEARCH APPLICATIONS

## 3.1 Thesis

Physical therapy patients are prescribed rigorious exercise regimens as a part of their post-op recovery. It is essential that the patients perform these exercises accurately in order to ensure that additional injury does not occur. It is not feasible for many patients to meet their therapist on a regular basis, however, PT feedback is necessary for a speedy recovery.

In order to address this, my thesis entails constructing a computer vision solution for patients that can be performed using a standard smartphone camera. This application can be used to analyze a patients range of motion while performing their PT regimen, offering real time feedback to the patient and meaningful data to the therapst without any additional doctor-patient interaction.

## 3.2 Problem

The application uses OpenCV is track points of interest on the patients body throughout the exercise. In it's current implementation, there are three points of interest: original head, head, and waist. Throughout the exercise, the head is tracked to determine the patient's range of motion. This is performed by the following steps:

1. The current frame is captured.
2. The frame is converted to grayscale.
3. The frame is smoothed with a gaussian blur.
4. The difference is taken between the previous and current frames to identify motion.
5. The double threshold is taken of the difference image.
6. The lines in the threshold image are dilated.
7. The original head location is identified by matching a haar-cascade classifier if it is the first frame. The original point of interest is set at this location.
8. The point of interest is updated if it exists in an identified contour.

## 3.3 PCA Solution

PCA can be used to update the location of the head each interval. The contours of the point of interest within on head distance can be identified. The center of mass for each contour can then be used to match an ellipse of the head contours.

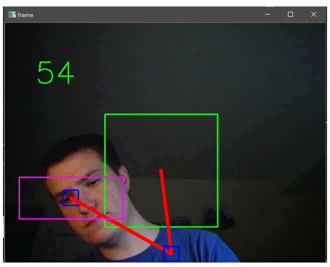


**Figure 5: Pink box of ellipse boundaries with centroid.**

The center of the head can then be used to infer the location of head's centroid. This is currently implemented in my thesis and successfully tracks the head.