Object Detection based on its Colour

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by

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Things which we see are not by themselves what we see... It remains completely unknown to us what the objects may be by themselves and apart from the receptivity of our senses. We know nothing but our manner of perceiving them. [1]

Immanuel Kant

Abstract

For detecting an object based on its colour, initially the colour value is chosen; then we would take a snapshot/frame from a video device, this image is converted to HSV image and then the image segmentation by thresholding is done and converted to a binary image. With suitable threshold values the object is detected. Once the object is detected the centroid of the object is calculated based on the maximum density value and then it will be shown in the resulting image.

Introduction

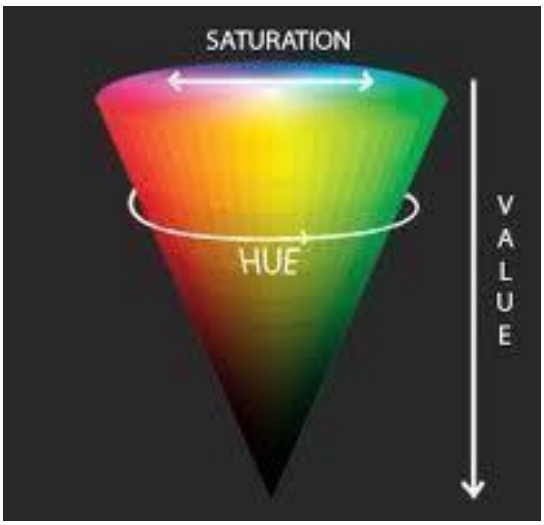
In this world of innovations, where the word 'possible' is being re-defined every day, there have been advances in every field; the field in consideration here is Image Processing. In this field the detection of objects for further usage has its own importance. One way of detecting objects is based on colour.

An image may be defined as a two-dimensional function, $f(x,y)$, where x and y are plane co-ordinates and the amplitude of f at any pair of co-ordinates (x,y) is called as the intensity of the image at that point. When x , y and the intensity values of f are all finite discrete quantities then it's called as a digital image. The field of digital image processing refers to processing digital images by means of a digital computer. [1]

The acquired image would be a RGB image which has integer values from 0 to 255. The value of a colour in RGB can be represented by indicating how much of each of the red, green, and blue is included, i.e. the colour is expressed as an RGB triplet (r,g,b). The main purpose of the RGB colour model is for the sensing, representation, and display of images in electronic systems. [3]

An image in the HSV colour space is closer to the way humans perceive colour. HSV stands for Hue, Saturation & Value, where Hue is the frequency in a visible light spectrum and it represents colour with an angle from 0 to 360 degrees, Saturation indicates bandwidth in the colour space and the

value is calculated from 0 to 1, and Value is the brightness of the colour and this value varies with colour saturation. [4]



Representation of HSV colour space. [4]

Image Segmentation subdivides images into its constituent regions or groups. [1] There are several methods for image segmentation. The simplest one and the one used in this project is thresholding. Thresholding depends upon the intensity values. By selecting the intensity values of the coloured object that needs to be detected and upon checking the intensity values of each pixel in the image and changing their value to one(represents white colour) if the intensity values belong to the threshold range & zero(represents black colour) if they doesn't belong to that range. Thus the resulting image will be a binary image.

Example:

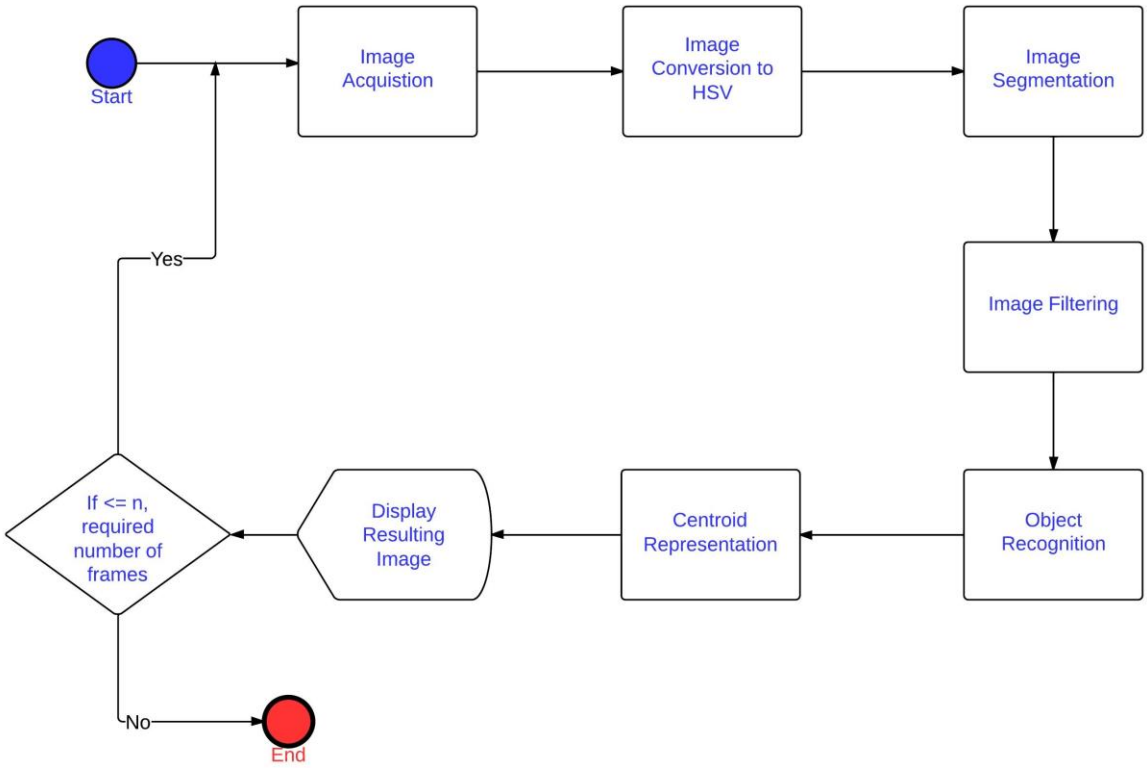
```
if k(x,y,1)>=H1 && k(x,y,2)<=H2
      if k(x,y,2)>=S1 && k(x,y,2)<=S2
            c(x,y)=1;
      end
else
      c(x,y)=0;
end
```

where

- H_1, H_2 and S_1, S_2 represents the range of the intensity values of Hue & Saturation for the colour that needs to be detected.
- K is the image being processed for thresholding
- C is the new binary image created as a result of thresholding.

Methodology

The key stages required in implementing the task, i.e; detection of object based on colour is displayed in the figure below.



Key stages in Image processing for detection of object based on colour and observing its movement.

Image Acquisition:

An image is acquired by taking a single frame from the video of a webcam connected. This Image should be clear with little or no reflective items present in the image, otherwise a problem might arise while reading the colour values from the image.

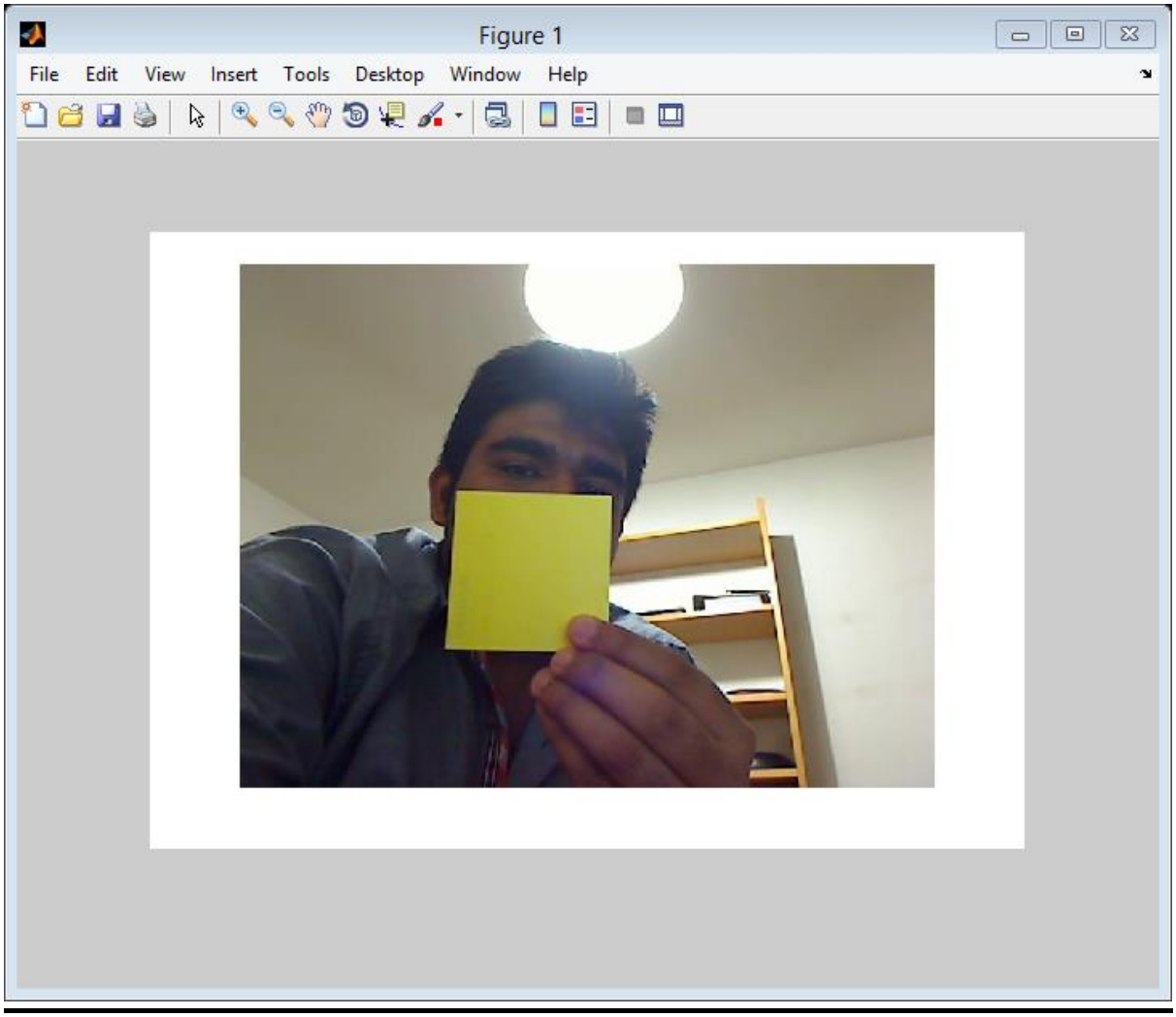


Image Conversion from RGB to HSV:

The image seen below is the result of conversion from RGB to HSV colour space. This conversion is done because HSV image is closer to human colour perception and also because it's easy to detect the required colour in the image with just Hue and Saturation values, as the change in H and S values will be more or less constant compared to RGB values.

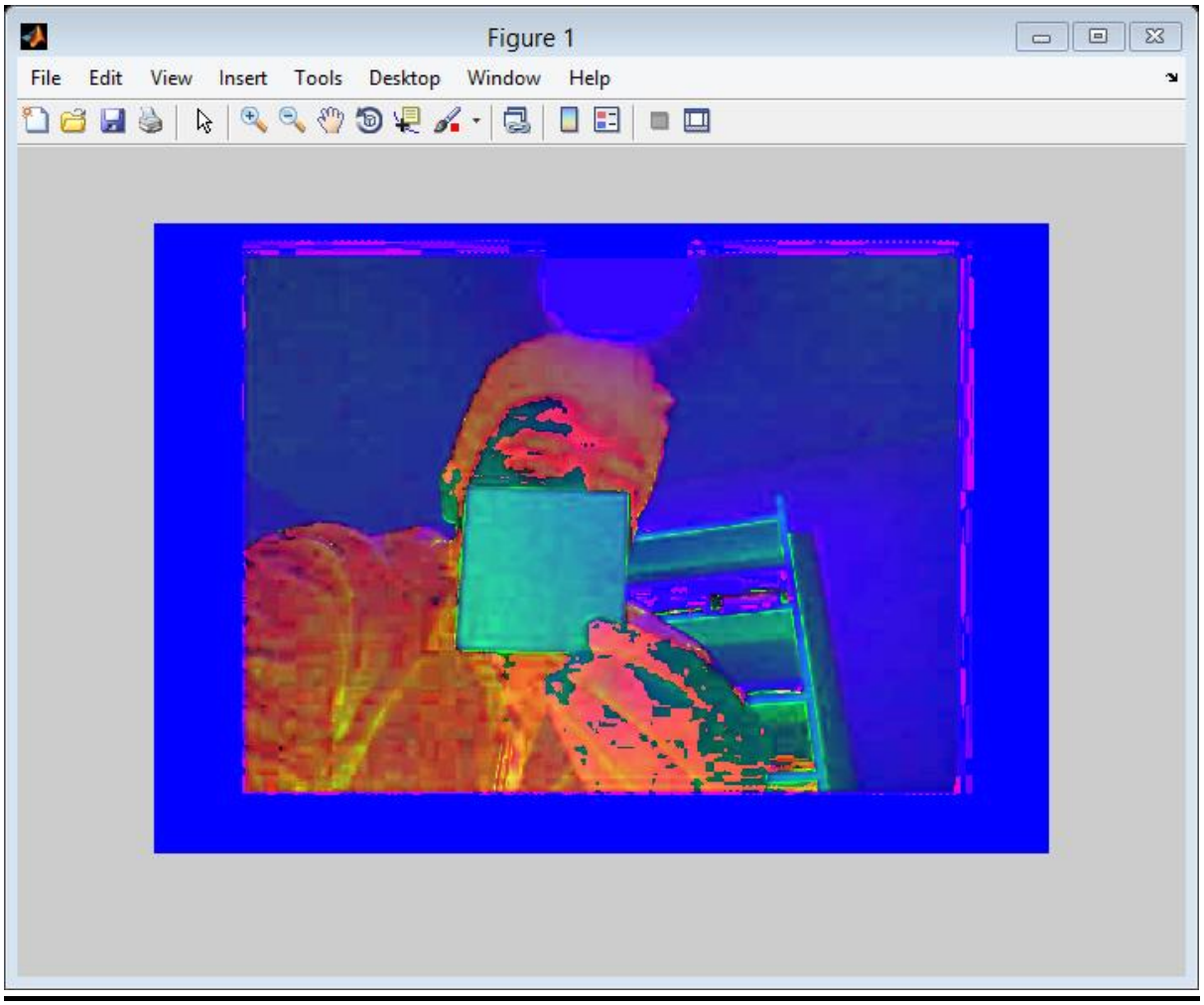
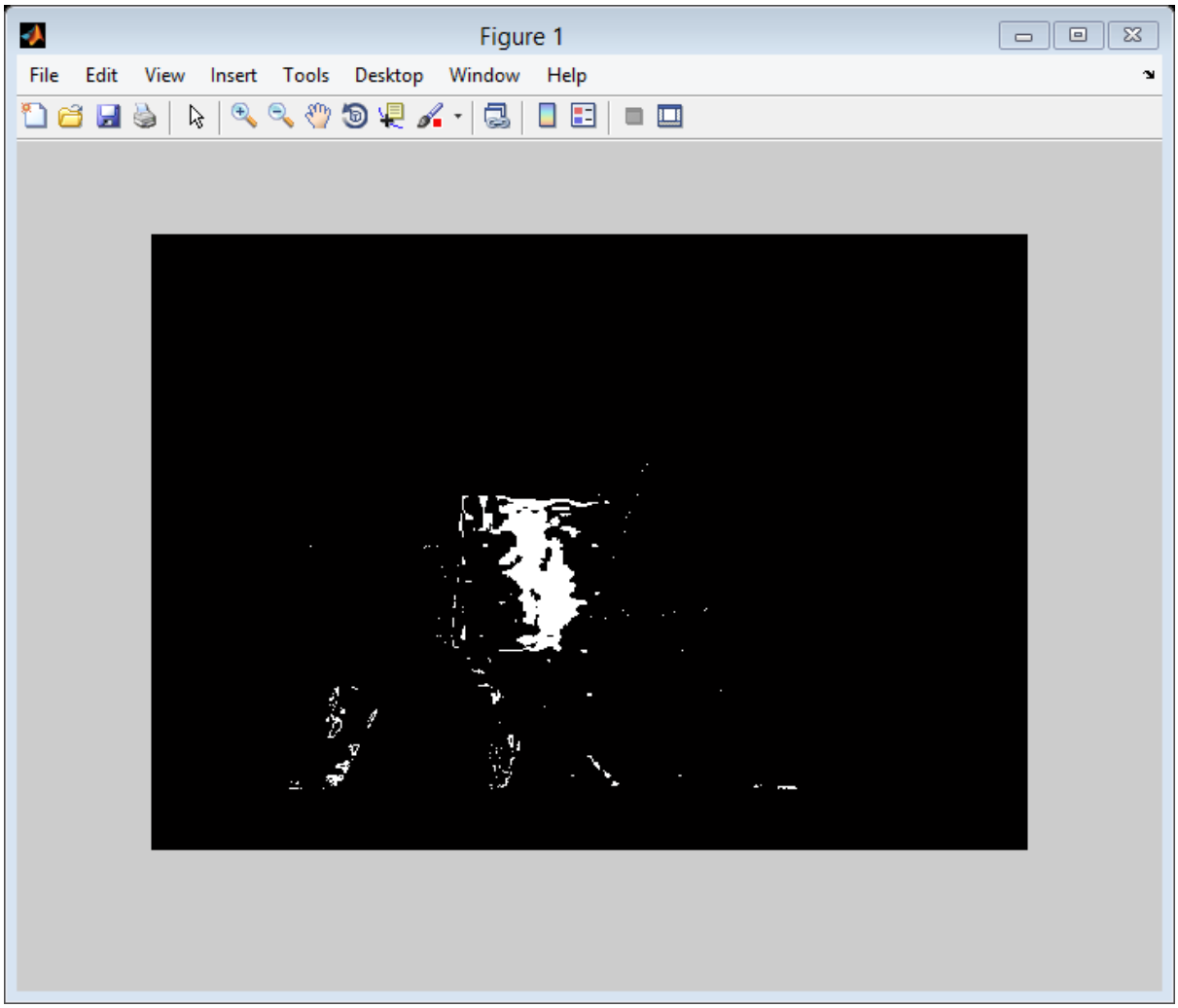


Image Segmentation:

As mentioned in the introduction the method of image segmentation used here is thresholding and the resulting image being binary.

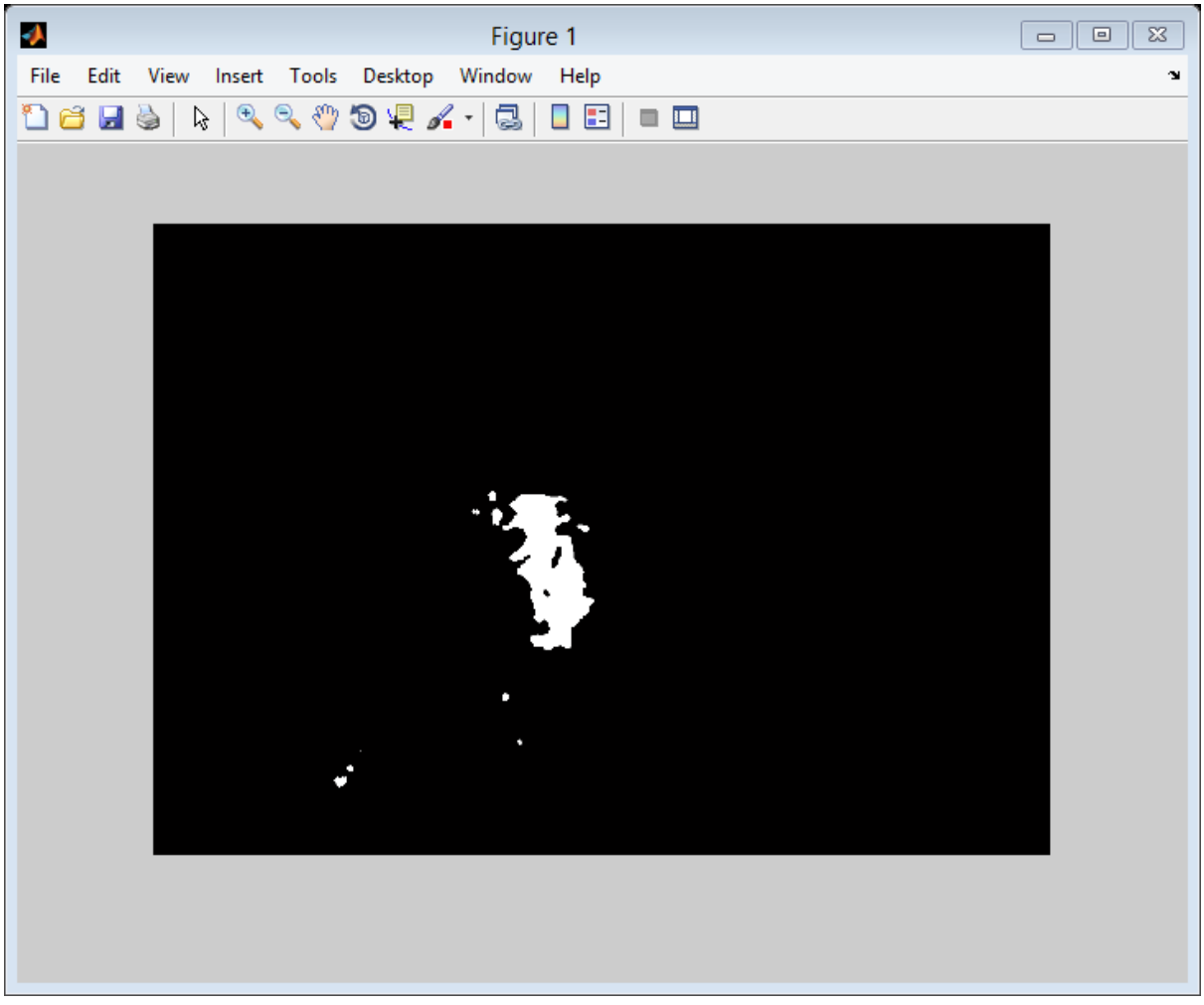


As observed in the image, there is a lot of noise present in the image after thresholding.

Image Filtering:

The filter is used to suppress either the high frequencies in the image, i.e. smoothing the image, or the low frequencies, i.e. enhancing or detecting edges in the image. [2]

The filter chosen here is called a Median filter. As it can be noticed from below image; this kind of filter helps in reducing noise by using the median of the neighbourhood. [2]



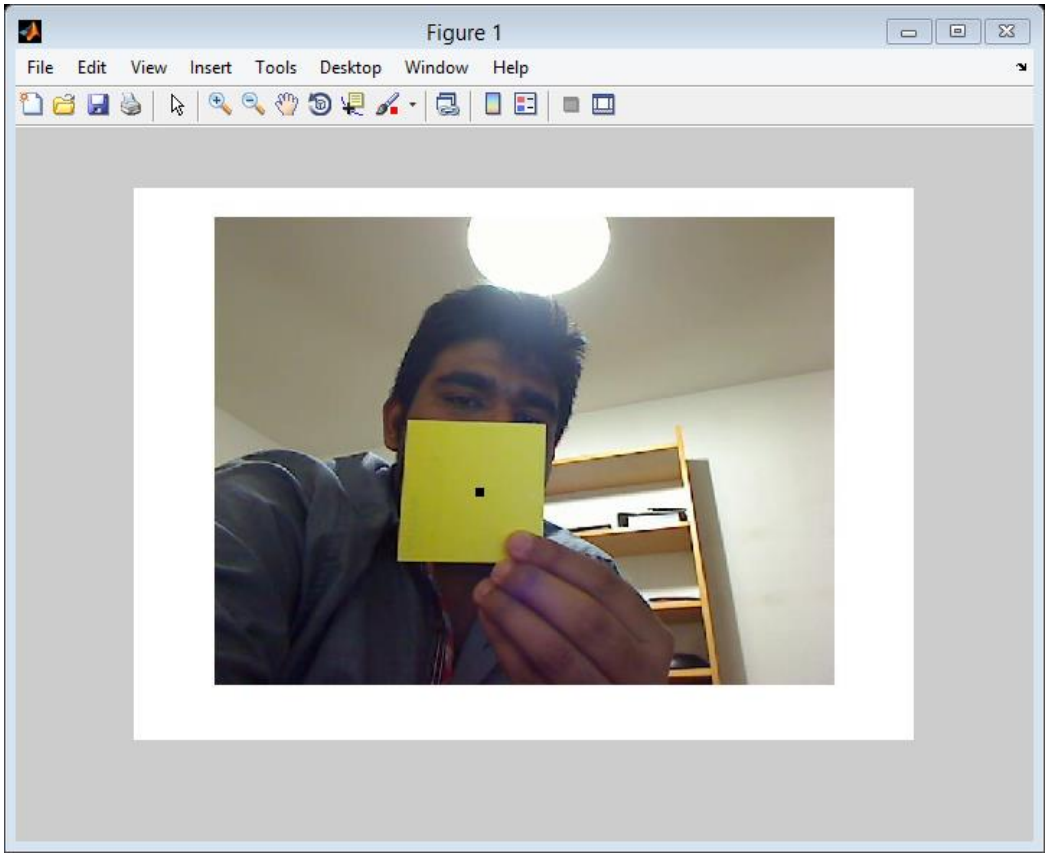
As seen in the image, after the thresholding and filtering only a part of the object is detected. It could be the case of either the range of threshold values or with the lighting constraints while the image is captured.

Object Detection:

Even though the resulting image after filtering shows partial part of the object, this can be considered as the detection of the object of a specific colour.

Centroid Representation:

Centroid of the object is located and displayed by creating a small black dot on the object. Centroid is calculated with respect to the density values of the resulting thresholded image. The mode calculation is done for every coulmn and then the highest peak density of the image is detected. At this point the black dot is created on the originally acquired image at the co-ordinates where the highest density peak is achieved after the mode calculation.



Observing the movement of an object detected:

Object tracking is achieved by taking a number of frames(as many as required) from the video and processing it through all the above mentioned stages sequentially.

Below are the original frames taken at a time interval of 1 second and the final image with object detection being shown. As the object is in motion during the time of capture of frames the intensity values of the object changes because of the varying light intensity on the object. Hence, the centroid(which is determined by the highest colour density value) in the final images change with every frame as the position of the object changes.

Note: Four number of frames are taken for the demonstration of object detection and tracking its movement.


Figure 2
File Edit View Insert Tools Desktop Window Help
Original Image

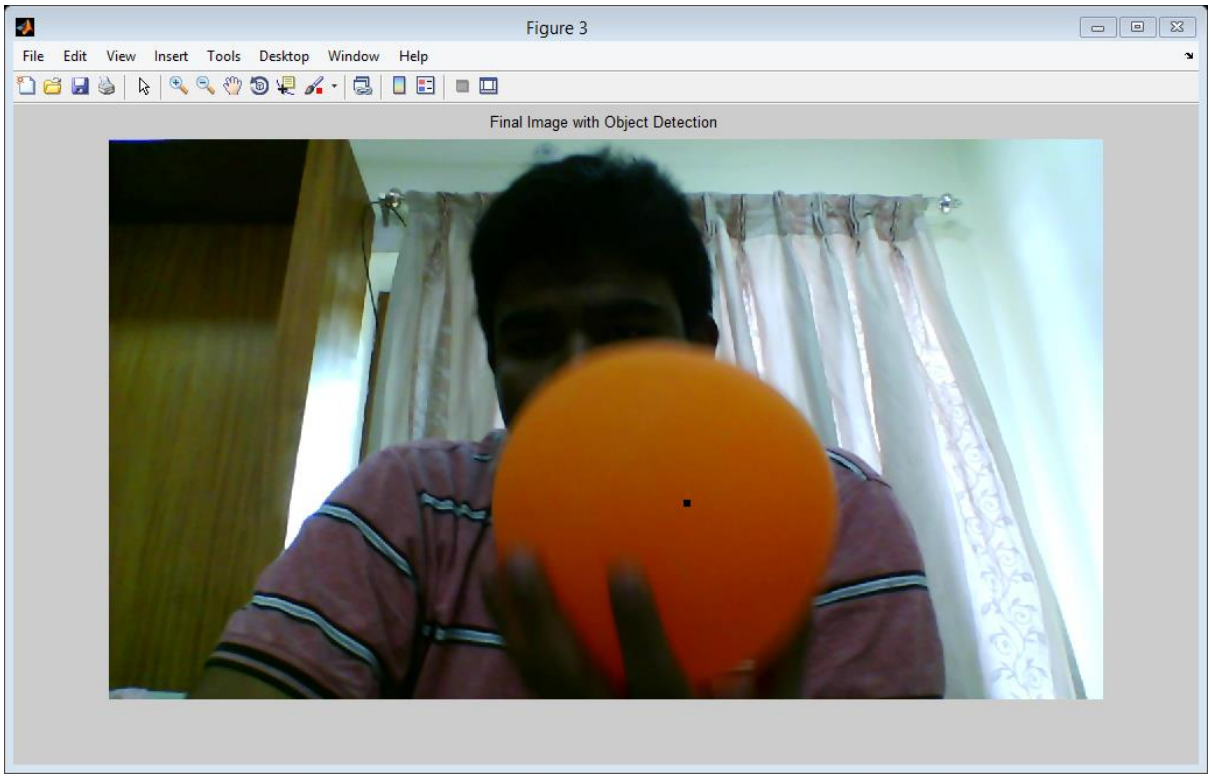


Figure 3
File Edit View Insert Tools Desktop Window Help
Final Image with Object Detection

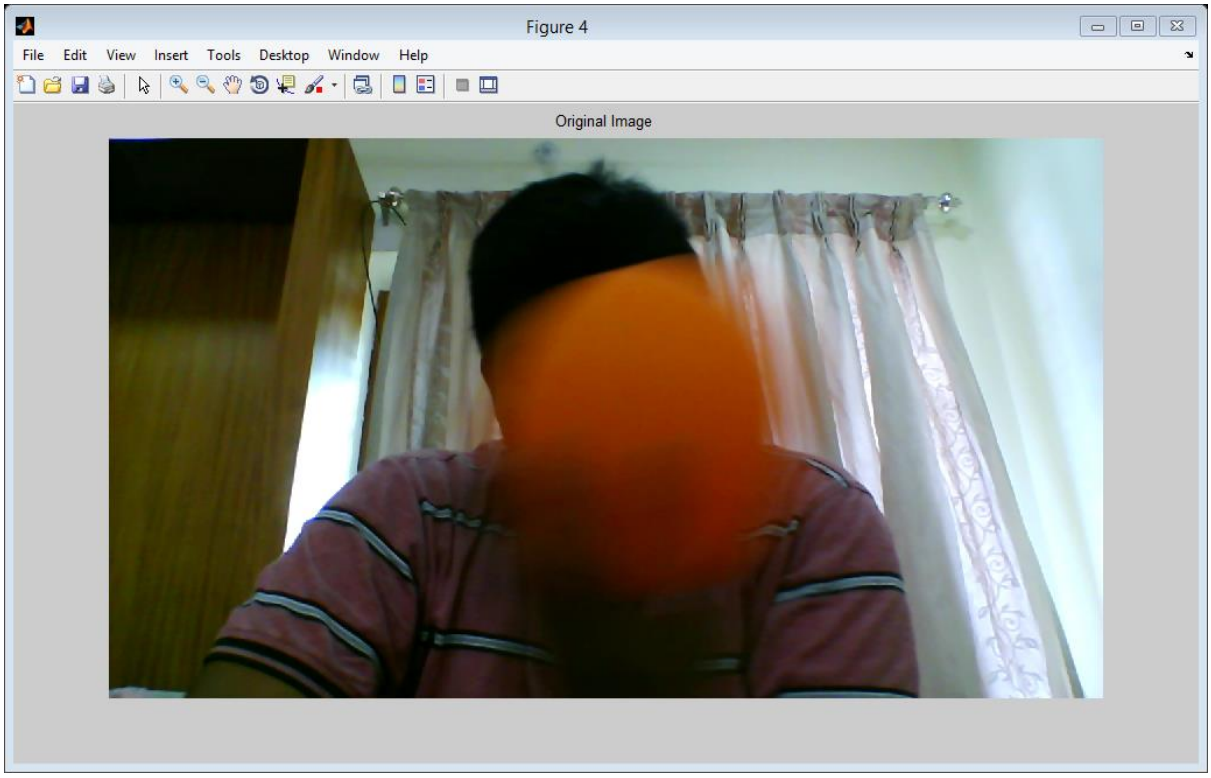


Figure 4
File Edit View Insert Tools Desktop Window Help
Original Image

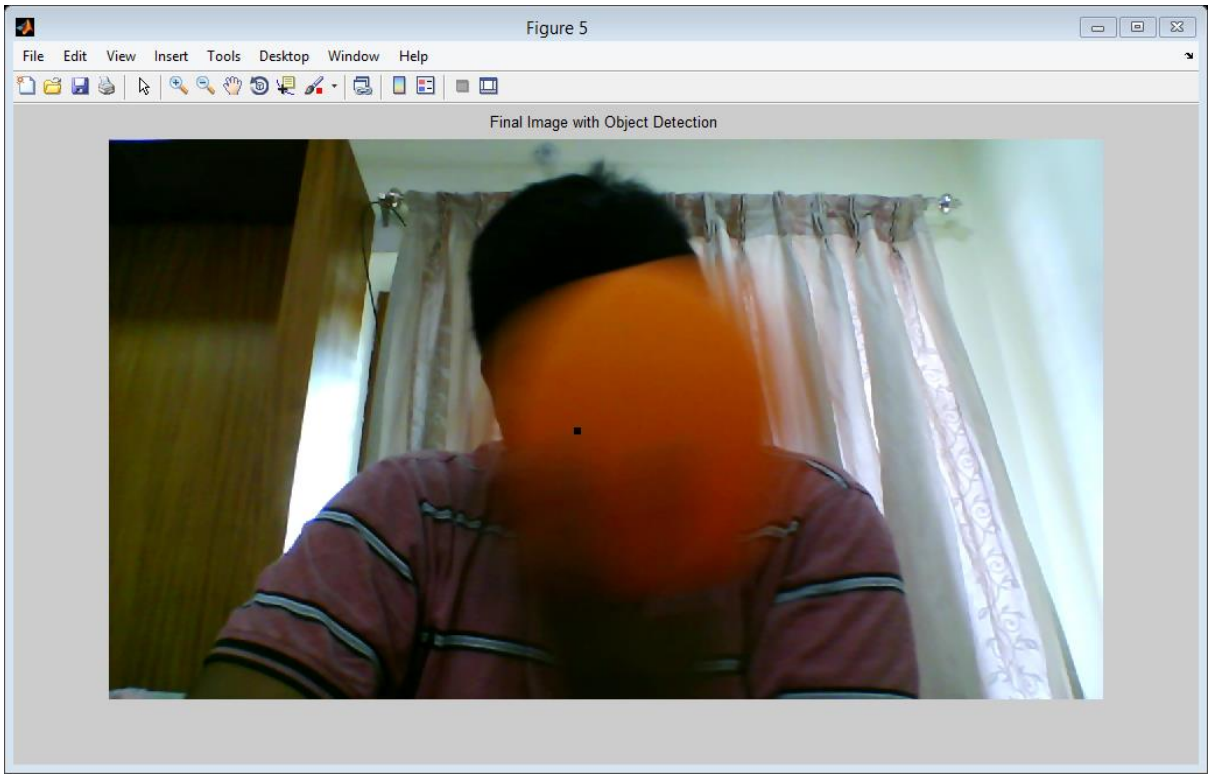


Figure 5
File Edit View Insert Tools Desktop Window Help
Final Image with Object Detection

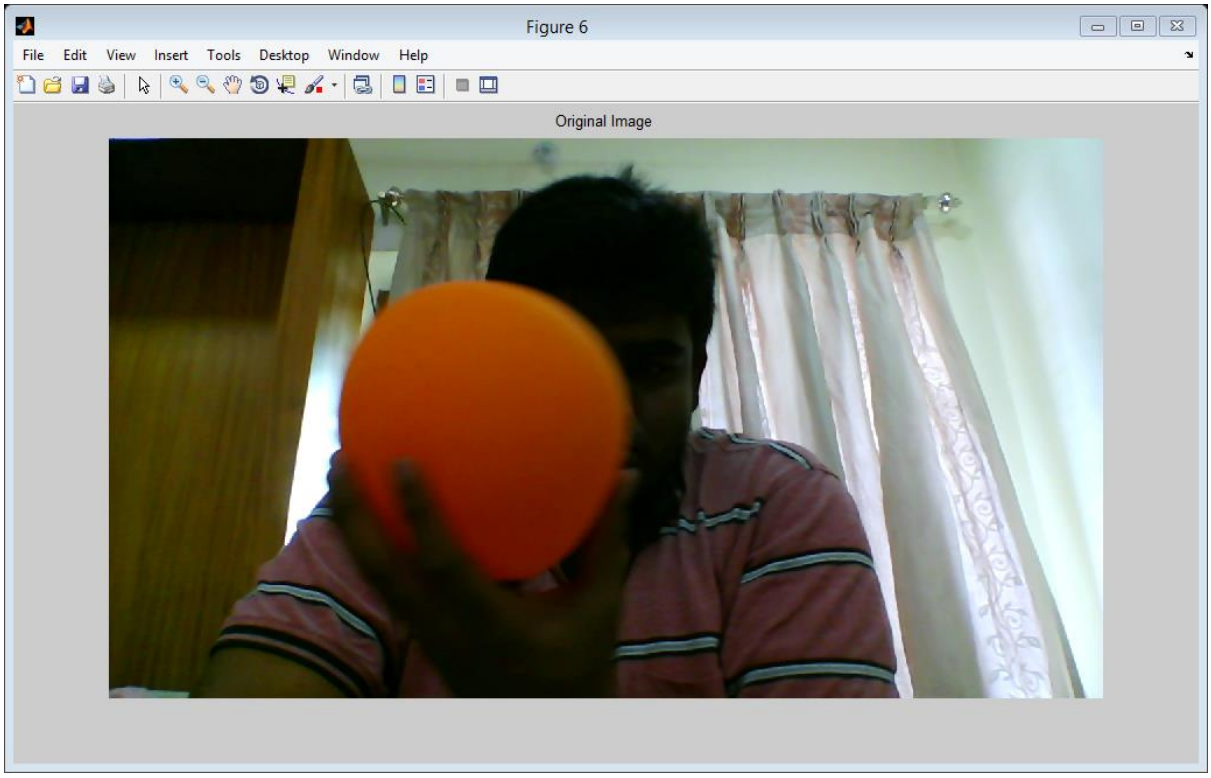


Figure 6
File Edit View Insert Tools Desktop Window Help
Original Image

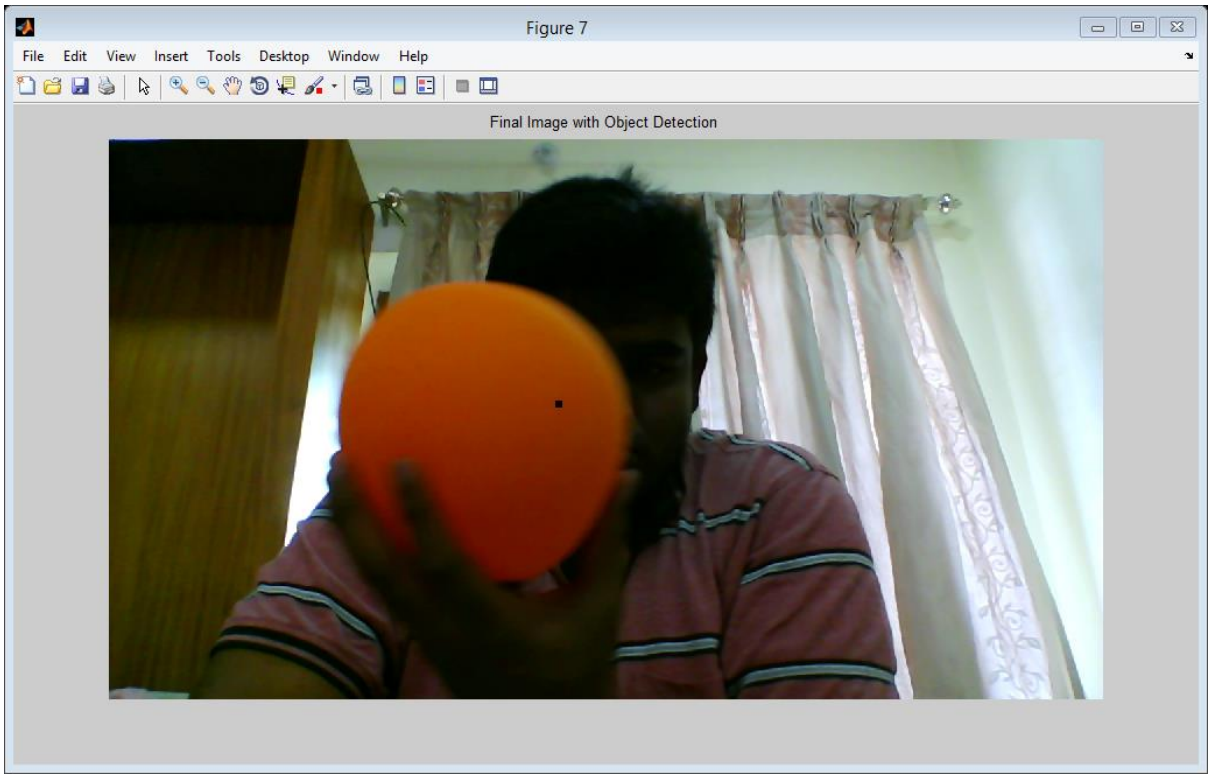


Figure 7
File Edit View Insert Tools Desktop Window Help
Final Image with Object Detection

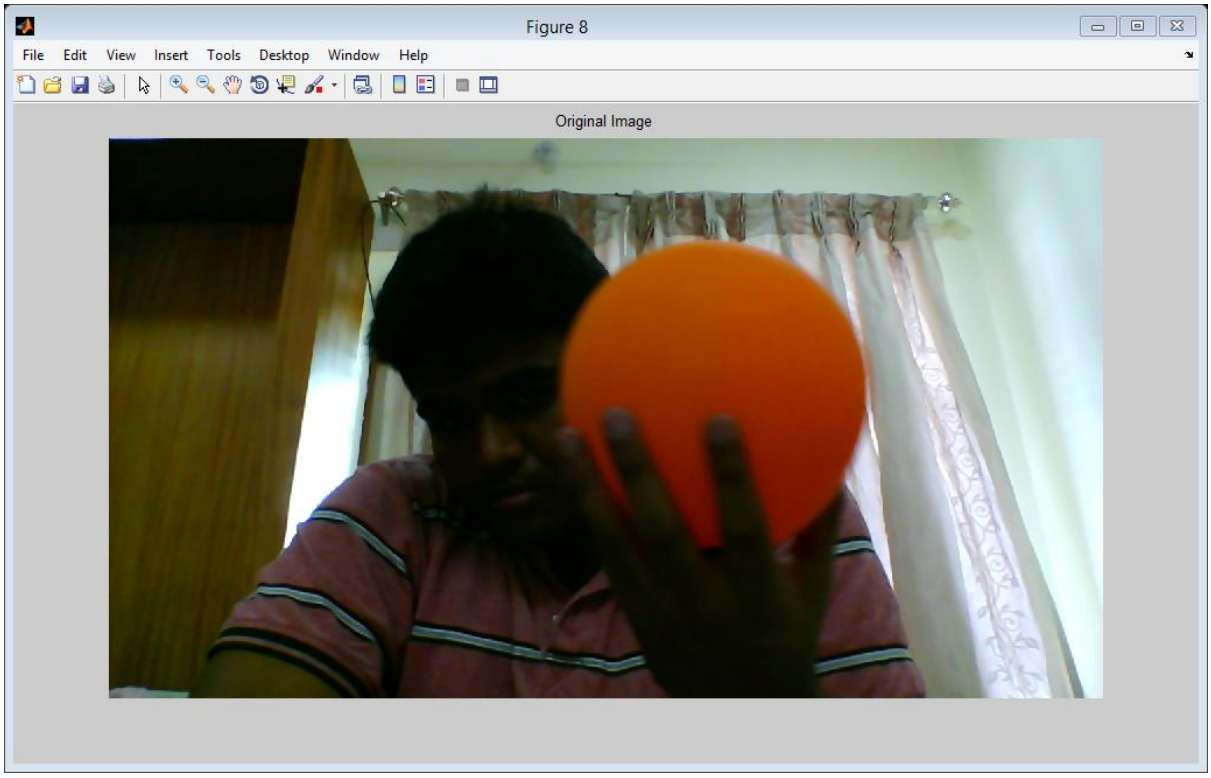


Figure 8
File Edit View Insert Tools Desktop Window Help
Original Image

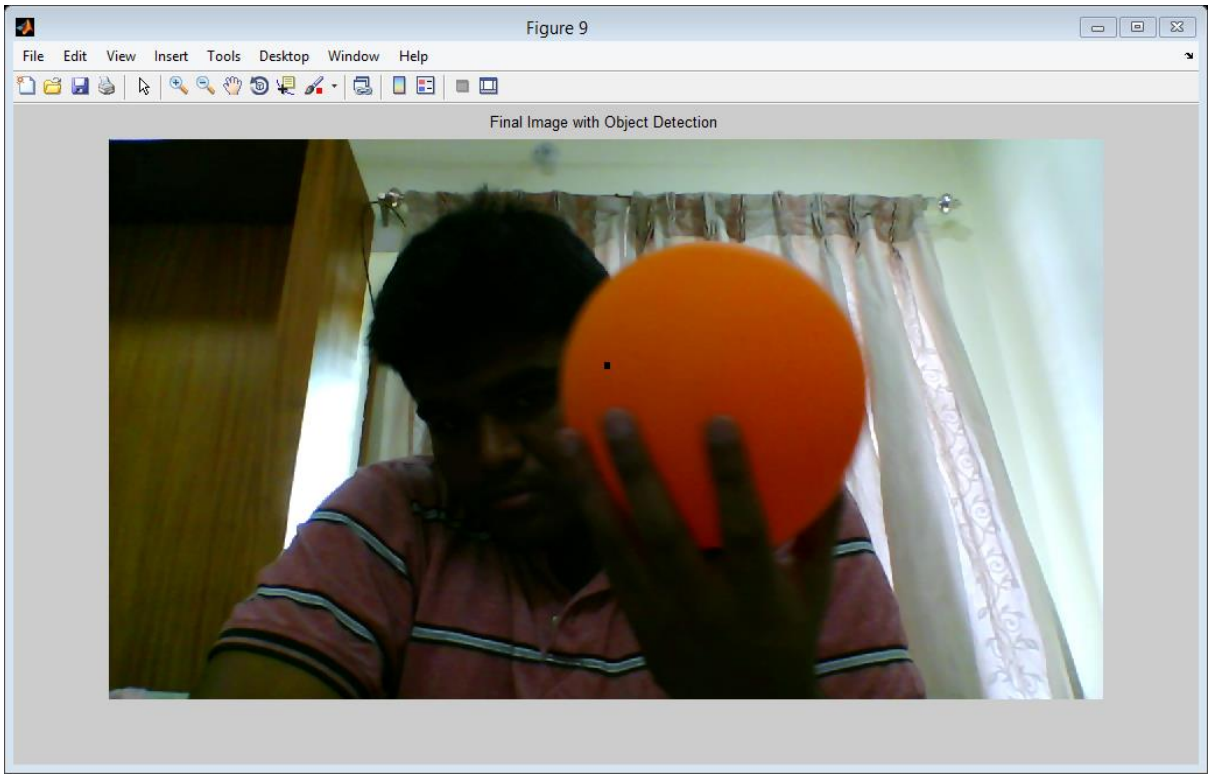


Figure 9
File Edit View Insert Tools Desktop Window Help
Final Image with Object Detection

Limitations & Future Work

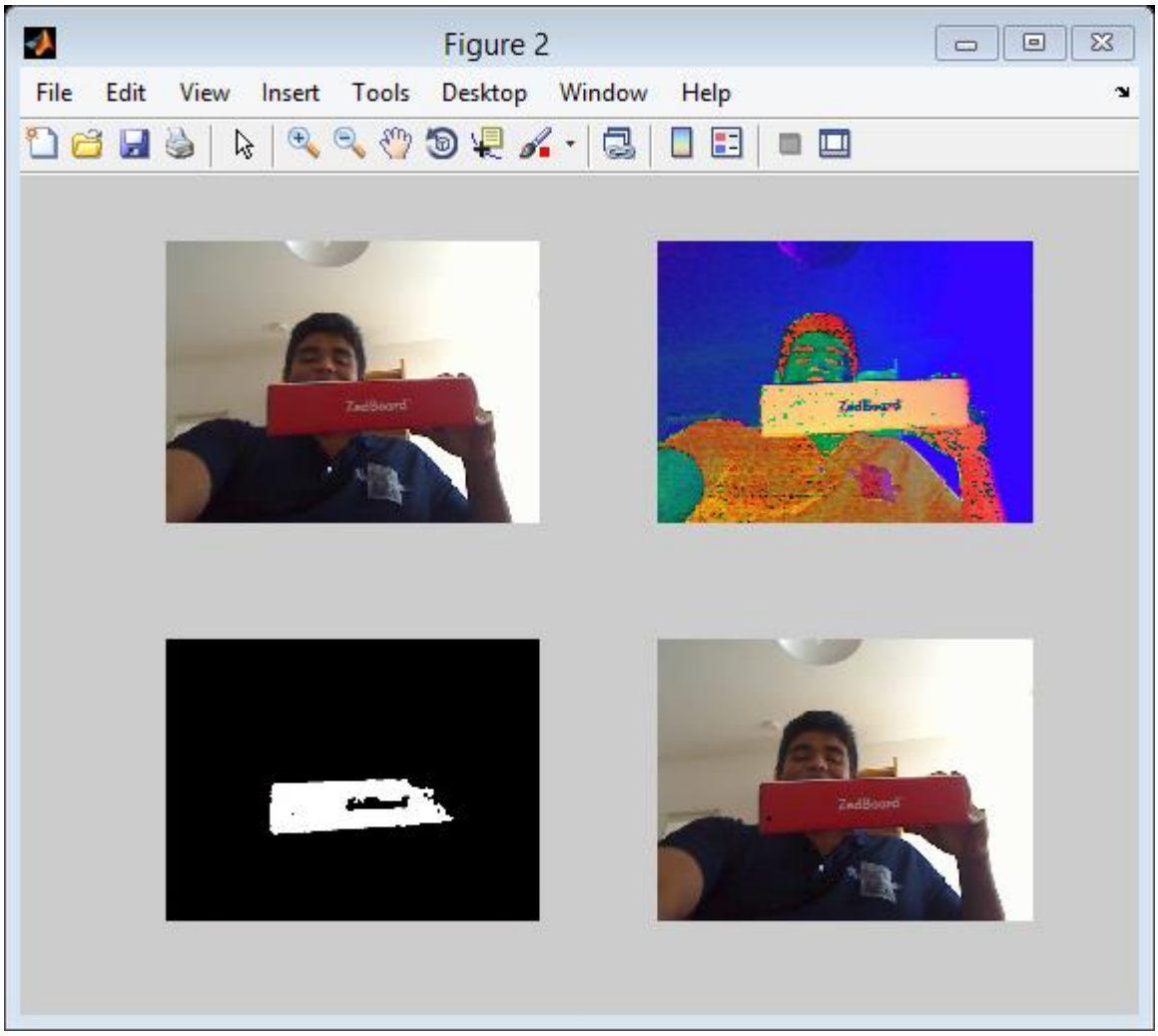
Major limitation of the work done on the object detection by the process explained here is the manual entry of the range of intensity values for thresholding.

So the Future work with this as a base is to implement an automatic way of creating the range of threshold values is by initially taking a snapshot with the object being placed at the left most corner and reading these values and creating a range of these values with some tolerance in the second decimal.

Another improvement that can be done to this project is detecting the object with the input and output being videos, i.e; processing the frames taken out of the video and then combining the output frames with a minimal time interval so that it can be shown as a video.

Conclusions

The task of detecting an object based on its colour and then observing its movement (tracking) is done successfully by converting the acquired image to HSV colour space, then thresholding and filtering is done on the image to detect the object. The centroid based on density values of detected object is found by mode calculation and a black dot is created on the original image at the co-ordinates of the centroid for display. Below is a single frame with a red object and the centroid, where the maximum density value is at its peak.



Bibliography

[1] Gonzalez, Woods. *Digital Image Processing.* Pearson Education International.

[2] R. Fisher, S. P. (2000). *Digital Filters*. Retrieved from http://homepages.inf.ed.ac.uk/rbf/HIPR2/filtops.htm

[3] *RGB color Model - Wikipedia*. Retrieved from Wikipedia.org: http://en.wikipedia.org/wiki/RGB_color_model

[4] Spencer, W. (n.d.). *HSV*. Retrieved from Tech-FAQ: http://www.tech-faq.com/hsv.html