<u>Project Report</u>

Eyebrow Recognition Using MatLab

CSE4019 - Image Processing

Submitted by:

18BCE0933 - Atharva Joshi

19BCE0994 - Shruti Garg

19BCE2060- Punit Middha

School of Computing Science and Engineering

VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

FALL SEMESTER 2020-21

Submitted to :- Dr. Akila victor

CONTENT

ABSTRACT

A fundamental challenge in face recognition lies in determining which facial characteristics are important in the identification of faces. Surprisingly, however, one rather prominent facial feature has received little attention in this domain: the eyebrows. In fact, a significantly greater decrement in face recognition is observed in the absence of eyebrows than in the absence of eyes.

Detection of facial landmark features is an initial step in facial expression recognition. Detection of eyebrows can aid the detection of the remaining facial features as eyebrows are relatively more stable across changing facial expressions.

In this project, a compute-efficient eyebrow detection algorithm has been used which provides us with detected eyebrows and also their width. It even calculates the distance between the eyebrows. We have used the computer vision toolkit in matlab for identifying and detection purposes. It helps us to identify the facial features in our image. The method has also been shown to be computationally less complex.

INTRODUCTION

Detection of facial features is an important step in facial expression detection and face recognition. The facial expressions are analyzed by combining the individual facial muscle movements measured by a combination of action units (AUs) based on the FACS (facial action encoding system). In facial expression recognition, an initial estimation of the facial features is first obtained for face alignment. In geometric feature-based methods for extracting facial features for expression analysis, the shape and location of the landmark facial features are extracted . In appearance-based methods, image filters are used to extract the facial features. In both of these methods, the detection of landmark facial features is a basic step.

Eyebrows may serve as high-contrast lines that give the appearance of the brow greater clarity and emphasis, and their associated musculature allows for sophisticated, often involuntary gestures that may be discerned from a relatively large distance. As such, the eyebrows appear to play an important role in the expression of emotions and in the production of other social signals, and they may also contribute to the sexual dimorphism (ie sexual differentiation) and even the aesthetics of faces.

Among the facial landmark features, i.e. eyebrows, eyes, nose and mouth, eyebrows are considered relatively more intransient. For instance, eyes and mouth appear different when open and closed, but eyebrows remain relatively more stable in appearance. Even under changing expressions, eyebrows are observed to show lesser variation in appearance compared to eyes and mouth. In general, eyebrows along with head gestures are used as promising indicators in the detection of emotional states. Apart from being distinctive features, eyebrows are also used as a frame of reference for obtaining the rest of the facial features.

It is observed that the algorithms proposed for eyebrow detection are intended for achieving high precision and robustness, but involve complex computations. This can become a bottleneck in realization of the algorithms on an embedded platform, where resource constraints have to be met. This motivates the need for a computationally efficient algorithm for eyebrow detection. We have tried to provide a compute-efficient and robust method to detect the eyebrow in this project.

<u>REQUIREMENTS</u>

MATLAB - MathWorks - MATLAB & Simulink

We have to install the *tools* written as follows :-

- *Computer vision toolkit* in matlab
- *Image processing toolkit* in matlab
- *Statistics and Machine Learning Toolbox*
- Input images for testing.

PROPOSED METHODOLOGY

The proposed algorithm is based some unique properties of the eyebrows that are retained in spite of changes in facial expressions, which are listed as follows:

(a) on scanning the face from top, eyebrows are most often the features that show the first prominent transition from light → dark intensity at the upper edge of the eyebrow followed by a transition from dark → light intensity at the lower edge of the eyebrow.

(b) the right and left eyebrows will be of similar length and thickness that are within a certain range defined with respect to the width and height of the face.

(c) the separation between left and right eyebrows in the y-direction will be within specific bounds in spite of slight variation in roll of the face.

(d) the difference in intensity between the region enclosed within the eyebrow and the region just above the eyebrow.

The proposed method comprises **two** main steps.

The first step involves extraction of possible eyebrow edge candidates by taking advantage of property (a) as listed above.

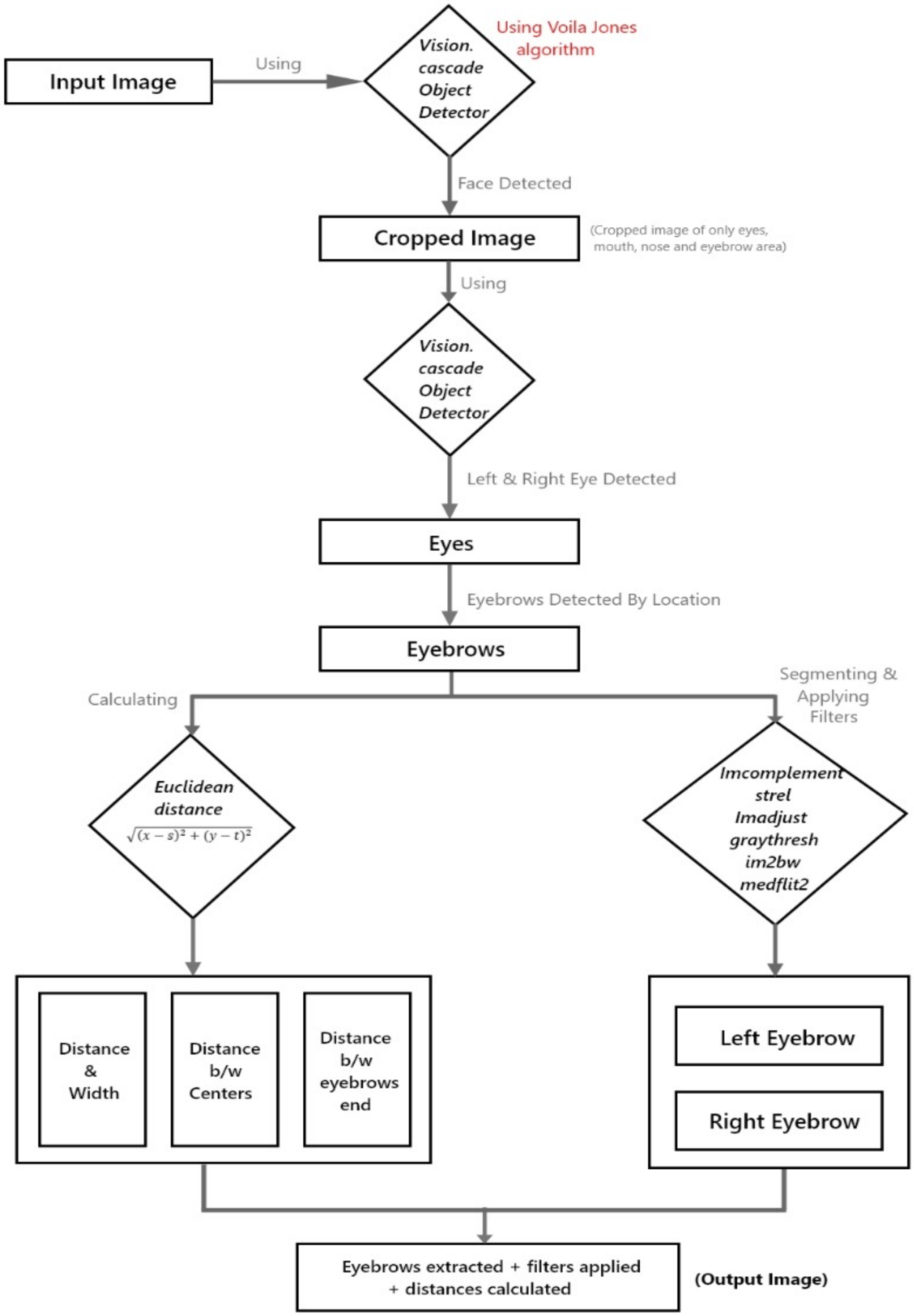
The next step is a filtering step that uses the properties (b) to (d) to detect the correct eyebrow candidates from the pool obtained from the first step.

The two steps are performed in an iterative fashion so that the algorithm is robust to varying surrounding conditions, features on faces and facial expressions.

WORKING OF THE PROGRAM

1. Our first step is to read the input image. The input image should contain a face.
2. After reading the image, face detection will take place using vision cascade command and the excess part except the face will be removed. Thus, we will get a cropped out image of our face only.
3. Then we will recognize the eyebrows with the help of the eyes and also by contours and create a rectangle around both the eyebrows.
4. After detecting the eyebrows we will calculate the distance between the eyebrows and also the length of both eyebrows. Comparing them will provide us with the accuracy of our algorithm.
5. Moreover, we will also recognize the eyes with eyebrows. This will help us to know the location of detected eyebrows.
6. Now, we have recognised our eyebrows(object) in the image. The next task is to segment the eyebrow from the face.
7. The segmented image of the eyebrow goes through image enhancement so that we can get a clear required image of our object i.e the eyebrow.
8. So for the enhancement purpose, we have used the following filters:
   - incomplement
   - strel
   - imadjust
   - greythresh
   - im2bw
   - medfilt2
9. After these steps we will get our expected output image containing the detected eyebrows from the face and also its specifications like length of eyebrow and distance between eyebrows(both between centres and ends).

ARCHITECTURE DIAGRAM



Input Image : Image containing a face.

Expected output : Detected eyebrows image with its specifications (width , distance).

LITERATURE REVIEW

1. A biological perspective of Viola-Jones face detection

   Thomas M. Murphy; Randy Broussard; Ryan Rakvic; Robert Schultz; Hau Ngo

   Human face detection in digital images and videos is a mature technology, yet its operational performance is generally sub-optimal. Any improvement would be beneficial in many applications. Some computer vision approaches to object recognition, including face detection, have begun to achieve impressive levels of accuracy and robustness, yet lack a clear connection to known cortical constructs. This motivates investigations of biologically-inspired techniques. The mechanisms by which contour shapes, and in particular faces, are represented in cortex and the means that neural models and computer vision algorithms can more closely approximate these are examined.

2. Face Detection Based on Viola-Jones Algorithm Applying Composite Features

   Wen-yao LU; Ming YANG

   Viola-Jones' face detection algorithm was jointly proposed by Paul Viola and Michael Jones. Although it realized face real-time detection to some extent, its false detection rate is not low. Because the block features in the Viola-Jones algorithm can't handle purely rigid objects, such as chopsticks and cups, so if there are rigid objects in the face image, Viola-Jones' face detection algorithm is prone to generate false detection of faces. In this paper, we propose to apply the composite features based on Viola-Jones algorithm to improve the above problems, and prove the feasibility of this method through experiments.

3. A Compute-Efficient Algorithm for Robust Eyebrow Detection

   Supriya Sathyanarayana; Ravi Kumar Satzoda; Suchitra Sathyanarayana; Srikanthan Thambipillai

   Detection of facial landmark features is an initial step in facial expression recognition. Detection of eyebrows can aid the detection of the remaining facial features as eyebrows are relatively more stable across changing facial expressions. Existing eyebrow detection algorithms in literature involve complex computations and are not suitable for direct porting on to embedded platforms. In this paper, a compute-efficient eyebrow detection algorithm has been proposed and tested on three standard databases with an average detection rate of 96%. The method has also been shown to be computationally less complex compared to the state of the art.

4. Eyebrows localization for expression analysis

   Laura Florea; Raluca Boia

   Automatic detection of human face features plays a significant role in expression recognition and human computer interaction. Human eyebrows shape has good specificity and stability, hence precise localization outlines a series of threads for face expression analysis. This paper will introduce a simple method for eyebrow localization. The determined positions allow geometrical extraction of the upper face area, which will be further investigated for expression recognition.

5. Facial expression video analysis for depression detection in Chinese patients

   QingxiangWanga1HuanxinYangb1YanhongYu

   Emotional state analysis of facial expression is an important research content of emotion recognition. At the same time, in the medical field, the auxiliary early screening tools for depression are also urgently needed by clinics. Whether there are differences in facial expression changes between depressive patients and normal people in the same situation, and whether the characteristics can be obtained and recognized from the video images of depressive patients, so as to help doctors detect and diagnose potential depressive patients early are the contents of this study. In this paper, we introduce the videos collection process of depression patients and control group at Shandong Mental Health Center in China. The key facial features are extracted from the collected facial videos by person specific active appearance model. On the basis of locating facial features, we classified depression with the movement changes of eyes, eyebrows and corners of mouth by support vector machine. The results show that these features are effective for automatic classification of depression patients.

6. Redundancy Reduction in Face Detection of Viola-Jones using the Hill Climbing Algorithm

   In this study, we improved Viola-Jones face detection using Hill Climbing algorithm in order to reduce the redundancy rates. Viola-Jones's algorithm has succeeded in determining the best face scale factor, but it produces a non-comparable face window that leads the redundant face detection. Hill Climbing algorithm which is one of the local search family, is proposed to serve the local-maxima which represents a set of faces that has been selected from redundant data. We have evaluated and compared the accurate, accurate and recall tests the performance of the proposed method using LFW dataset. Traditional Viola Jones achieves accuracy up to 77% and the proposed method achieves accuracy up to 85%. The two sets of values concluded that the proposed method reduce the redundancy problem.

7. Real Time Drowsiness Detection using Viola Jones & KLT

   Technologies are developing day by day, sector for road transport implement new technologies for the welfare of people all over the world, even though the number of road accidents had increased day by day. Studies say that there are many reasons for these accidents but one of the main reasons is the mistake made by the driver, due to drowsiness or any other reason. The proposed methodology helps to detect whether the driver is drowsy or not. The violajones algorithm is used to detect the face and eyes. After detection, using Kanade Lucas Tomasi (KLT) the detected part is tracked. The eyeballs are detected using hough transform. Two conditions are set to analyze the drowsiness if the conditions are satisfied the system will raise the alarm to alert the driver. The alarm got stopped only if the driver awake from the drowsy situation. The proposed system was simulated using MATLAB 2017a. The result was analysed by testing 55 samples in real-time. The accuracy of the proposed system is 96.3%. The accuracy was analysed using the parameters like True Positive, True Negative, False Positive, False Negative. The method helps to reduce the number of road accidents and the proposed system does not need any physical contact with the driver so it is quite easy to implement

8. Lip Biometric Authentication Using Viola-Jones and Appearance Based Model (AAM) System

   The lip biometric system focuses on the uniqueness of the parameters of the lips as a useful feature to distinguish similar-looking people. Data gathering includes five identical twins, ten similar faces, and ten dissimilar faces of still face-front images of subjects with neutral expressions were used to examine the efficiency and performance of the system. Different lighting conditions measured in flux under various distances have been characterized. The system employs the Viola-Jones algorithm for face detection and the

Active Appearance Model (AAM) for lip extraction. An 87.5% accuracy resulted in using lips for human identity.

9. The Effect of Bicubic Interpolation on Viola-Jones and Principal Component Analysis in Detecting Faces and Helmet Wearers

Face detection plays an important role in various applications such as face recognition, object tracking and also computer-human interaction. An efficient face detection algorithm is needed to apply this. In this paper, Viola-Jones is used not only to detect faces, but also to determine the position of the sub-window which will be carried out in the detection process of Helmets. Bicubic Interpolation plays an important role in scaling and improving detection accuracy. Helmet detection is done by conducting a training process using Principal Component Analysis which is done after the face is detected successfully. The test results show that the accuracy of using the original image is at 92.537% for face detection and 78.125% for helmet detection. But in images that have gone through the stages of bicubic interpolation and histogram equalization, accuracy can reach 95.522% for face detection and 82.8125% for helmet detection.

10. Detection of Pterygium Disease Using Forward Chaining and Viola Jones Algorithm

Eyesight is one of the most important senses for human life. Because only with our eyes, we can see and know the situations and conditions that occur around us. If there are problems or disorders that happen in our eyes, then we will feel uncomfortable and there are several diseases that can reduce the quality of vision and can cause blindness. In this project the author will be make an application to detect Pterygium eye disease based on the early symptoms that have been felt by the patient and find out how severely the patient affected by Pterygium disease with different levels. The stages used to determine the level of Pterygium disease is by filling all the symptoms by the patient in the application using Forward Chaining method and using an image segmentation process with Viola Jones Algorithm. The results of using the Viola Jones algorithm that have been processed using this application have an accuracy rate of 76% by testing 50 images and the results of the images detected are 38 images, in addition there are some images that are not detected and there are some images that are not detected.

CODE

```
%Detect eyebrows, find distances and width
clc

%read image:
I = imread('1.jpg');
I = imresize(I, [244, 244]);

%Face detection:
 FDetect = vision.CascadeObjectDetector;
 FaceSegment = step(FDetect,I);
 imgFace =
(I(FaceSegment(1,2):FaceSegment(1,2)+FaceSegment(1,4),FaceSegment(1,1):FaceSegment(1,1)
+FaceSegment(1,3),:));
 mappingLeft = FaceSegment;
 mappingRight = mappingLeft;

 subplot(3, 2, 1);
 imshow(imgFace);
 hold on;
 title('Cropped image(FACE)');

 %To detect Left Eye
 EyeDetect = vision.CascadeObjectDetector('LeftEye');
 Eye=step(EyeDetect,imgFace);
 LeftEye  = Eye(1,:);

 %To detect Right Eye
 EyeDetect = vision.CascadeObjectDetector('RightEye');
 Eye=step(EyeDetect,imgFace);
 RightEye = Eye(2,:);

%To detect Left Eyebrow
 LeftEyebrow   = LeftEye;
 LeftEyebrow(4) = (LeftEyebrow(4)/2) - 4;
 LeftEyebrow(3) = LeftEyebrow(3);
 LeftEyebrow(4) = uint8(LeftEyebrow(4));
 LeftEyebrow(3) = uint8(LeftEyebrow(3));
 mappingLeft = mappingLeft + LeftEyebrow;

%To detect Right Eyebrow
 RightEyebrow  = RightEye;
 RightEyebrow(4) = (RightEyebrow(4)/2) - 4;
 RightEyebrow(3) = RightEyebrow(3);
 RightEyebrow(4) = uint8(RightEyebrow(4));
```

```
RightEyebrow(3) = uint8(RightEyebrow(3));
mappingRight = mappingRight + RightEyebrow;

subplot(3, 2, 2);
imshow(imgFace);
hold on;
title('Detected eyes and eyebrows');

for i = 1:size(LeftEye,1)
  rectangle('Position',LeftEye(i,:),'LineWidth',2,'LineStyle','-','EdgeColor','r');
end

for i = 1:size(RightEye,1)
  rectangle('Position',RightEye(i,:),'LineWidth',2,'LineStyle','-','EdgeColor','r');
end

for i = 1:size(LeftEyebrow,1)
  rectangle('Position',LeftEyebrow(i,:),'LineWidth',2,'LineStyle','-','EdgeColor','g');
end

for i = 1:size(RightEyebrow,1)
  rectangle('Position',RightEyebrow(i,:),'LineWidth',2,'LineStyle','-','EdgeColor','g');
end


%To show the left eyebrow as a figure:
BW = processEyebrows(imgFace, LeftEyebrow);
[startlx, stoplx, startly, stoply, contourL] = findContours(BW, mappingLeft);
widthL = findWidth(contourL);
subplot(3, 2, 3);
imshow(I); hold on
plot(contourL(:,2),contourL(:,1),'g','LineWidth',1);
plot(startlx, startly, 'o');
plot(stoplx, stoply, 'o');

%Calculate distance and width of left eyebrow:
distance = num2str(pdist([startlx, startly; stoplx, stoply], 'euclidean'));
t1 = strcat('Distance= ', distance, '    Width=', num2str(widthL));
title(t1);


%To show the right eyebrow as a figure:
BW = processEyebrows(imgFace, RightEyebrow);
[startrx, stoprx, startry, stopry, contourR] = findContours(BW, mappingRight);
widthR = findWidth(contourR);
subplot(3,2,4);
```

```
imshow(I); hold on;
plot(contourR(:,2),contourR(:,1),'g','LineWidth',1);
plot(startrx, startry, 'o');
plot(stoprx, stopry, 'o');

%Calculate distance and width of left eyebrow:
distance = num2str(pdist([startrx, startry; stoprx, stopry], 'euclidean'));
t2 = strcat('Distance= ', distance, '    Width=', num2str(widthR));
title(t2);

%Calculate distance between the centres of eyebrows:
subplot(3,2,5);
imshow(I);
hold on;
midPointRX = (stoprx + startrx)/2;
midPointRY = (stopry + startry)/2;
midPointLX = (stoplx + startlx)/2;
midPointLY = (stoply + startly)/2;

distance = num2str(pdist([midPointLX, midPointLY; midPointRX, midPointRY], 'euclidean'));
t3 = strcat('Distance between centres(eyebrows) =', distance);
title(t3);

plot(midPointRX, midPointRY - 4, 'o');
plot(midPointLX, midPointRY - 4, 'o');

%Calculate distance between the ends of eyebrows:
subplot(3,2,6);
imshow(I);
hold on;

distance = num2str(pdist([startlx, startly; stoprx, stopry], 'euclidean'));
t4 = strcat('Distance between ends(eyebrows)=', distance);
title(t4);

plot(startlx, startly, 'o');
plot(stoprx, stopry, 'o');


%2nd figure:
figure;

%Enhancements on left eyebrow :
LimgEyebrow =
(imgFace(LeftEyebrow(1,2):LeftEyebrow(1,2)+LeftEyebrow(1,4),LeftEyebrow(1,1):LeftEyebro
w(1,1)+LeftEyebrow(1,3),:));
```

```
subplot(4, 3, 1);
imshow(LimgEyebrow);
title('Left eyebrow');
IM1 = imcomplement(LimgEyebrow);
subplot(4, 3, 2);
imshow(IM1);
se = strel('disk', 10);
afterOpening = imopen(IM1, se);
subplot(4, 3, 3);
imshow(afterOpening);
IMG = IM1 - afterOpening;
subplot(4, 3, 4);
imshow(IMG);
K = imadjust(IMG, [0.1 0.20], []);
subplot(4, 3, 5);
imshow(K);
level = graythresh(K);
BW = im2bw(K, level);
subplot(4, 3, 6);
imshow(BW);
BW = medfilt2(BW);

%Enhancements on right eyebrow :
RimgEyebrow =
(imgFace(RightEyebrow(1,2):RightEyebrow(1,2)+RightEyebrow(1,4),RightEyebrow(1,1):Right
Eyebrow(1,1)+RightEyebrow(1,3),:));
subplot(4, 3, 7);
imshow(RimgEyebrow);
title('Right eyebrow');
IM2 = imcomplement(RimgEyebrow);
subplot(4, 3, 8);
imshow(IM2);
se = strel('disk', 10);
afterOpening = imopen(IM2, se);
subplot(4, 3, 9);
imshow(afterOpening);
IMG2 = IM2 - afterOpening;
subplot(4, 3, 10);
imshow(IMG2);
L = imadjust(IMG2, [0.1 0.20], []);
subplot(4, 3, 11);
imshow(L);
level = graythresh(L);
BW = im2bw(L, level);
subplot(4, 3, 12);
imshow(BW);
```

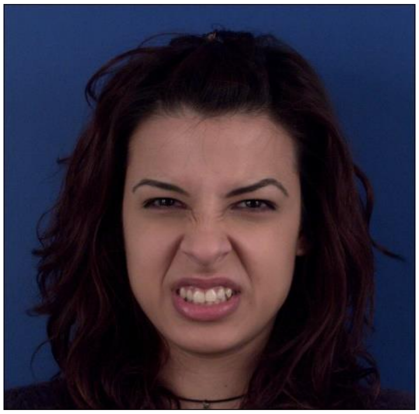
```
 BW = medfilt2(BW);


%Store the distances in an excel sheet:
add=6+11*(i-1);
p1=strcat("D",num2str(add));
xlswrite('123.xlsx',t1,'Sheet1',p1);

add=7+11*(i-1);
p2=strcat("E",num2str(add));
xlswrite('123.xlsx',t2,'Sheet1',p2);

add=8+11*(i-1);
p3=strcat("F",num2str(add));
xlswrite('123.xlsx',t3,'Sheet1',p3);

add=9+11*(i-1);
p4=strcat("G",num2str(add));
xlswrite('123.xlsx',t4,'Sheet1',p4);


%%
 %User defined Functions:

 %detect contours
function [startx, stopx, starty, stopy, contour] = findContours(BW, mapping);
    [m, n] = size(BW);
     flag=0; r=0; c=0;
    for(i=1:m)
        for(j=1:n)
            if(BW(i,j)==1)
                r=i;
                c=j;
                flag=1;
                break;
            end
        end
        if(flag==1)
            break;
        end
    end

    contour = bwtraceboundary(BW,[r c],'E',4,Inf,'counterclockwise');
    [s1, s2] = size(contour);
    for(i=1:s1)
       contour(i,2) = contour(i,2) + mapping(1,1) - 2;
```

```
        contour(i,1) = contour(i,1) + mapping(1,2) - 2;
    end

    startx = contour(1,2);
    stopx = contour(1,2);
    for(i=1:s1)
        if(startx > contour(i,2))
            startx = contour(i,2);
            starty = contour(i,1);
        end
        if(stopx < contour(i,2))
            stopx = contour(i,2);
            stopy = contour(i,1);
        end
    end
end

%find width of eyebrow
function width = findWidth(contour)
    MAX = max(contour);
    MIN = min(contour);

    y = (MAX(1) + MIN(1)) / 2;

    [s1, s2] = size(contour);
    distance = 0;
    for(i=1:s1)
        if(contour(i,1) < y)
            for(j=1:s1)
                if(contour(j,1) > y && contour(i,2) == contour(j,2))
                    if(distance < (contour(j,1) - contour(i,1)))
                        distance = contour(j,1) - contour(i,1);
                        disp('Distance: ' + distance);
                    end
                end
            end
        end
    end
    width = distance;
end

%process eyebrows for contour detection
function BW = processEyebrows(imgFace, Eyebrow);
 imgEyebrow =
(imgFace(Eyebrow(1,2):Eyebrow(1,2)+Eyebrow(1,4),Eyebrow(1,1):Eyebrow(1,1)+Eyebrow(1,3
),:));
```

```
 IM1 = imcomplement(imgEyebrow);
 se = strel('disk', 10);
 afterOpening = imopen(IM1, se);
 IM = IM1 - afterOpening;
 K = imadjust(IM, [0.1 0.20], []);
 level = graythresh(K);
 BW = im2bw(K, level);
 BW = medfilt2(BW);
end
```

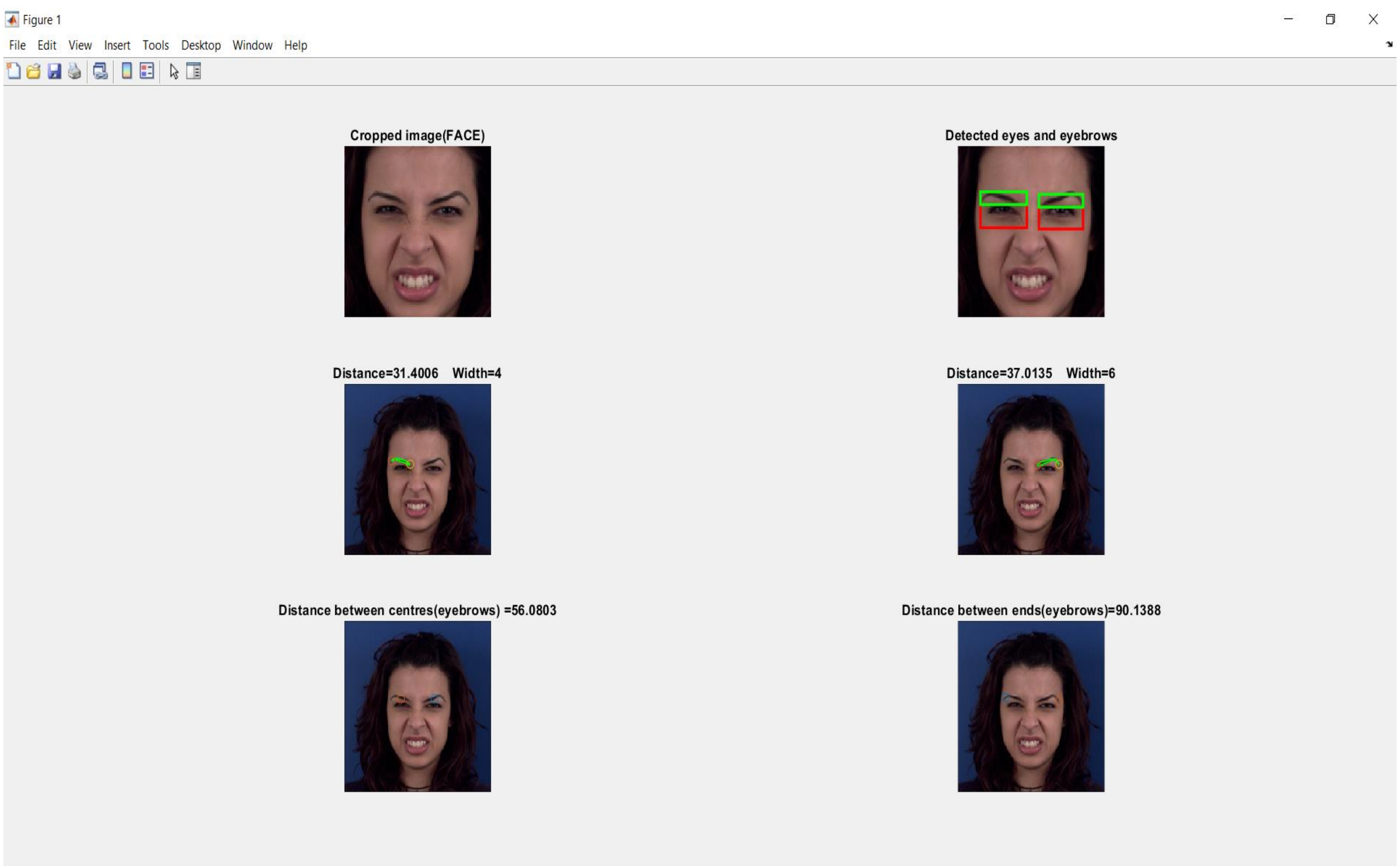
RESULT

1. Input image

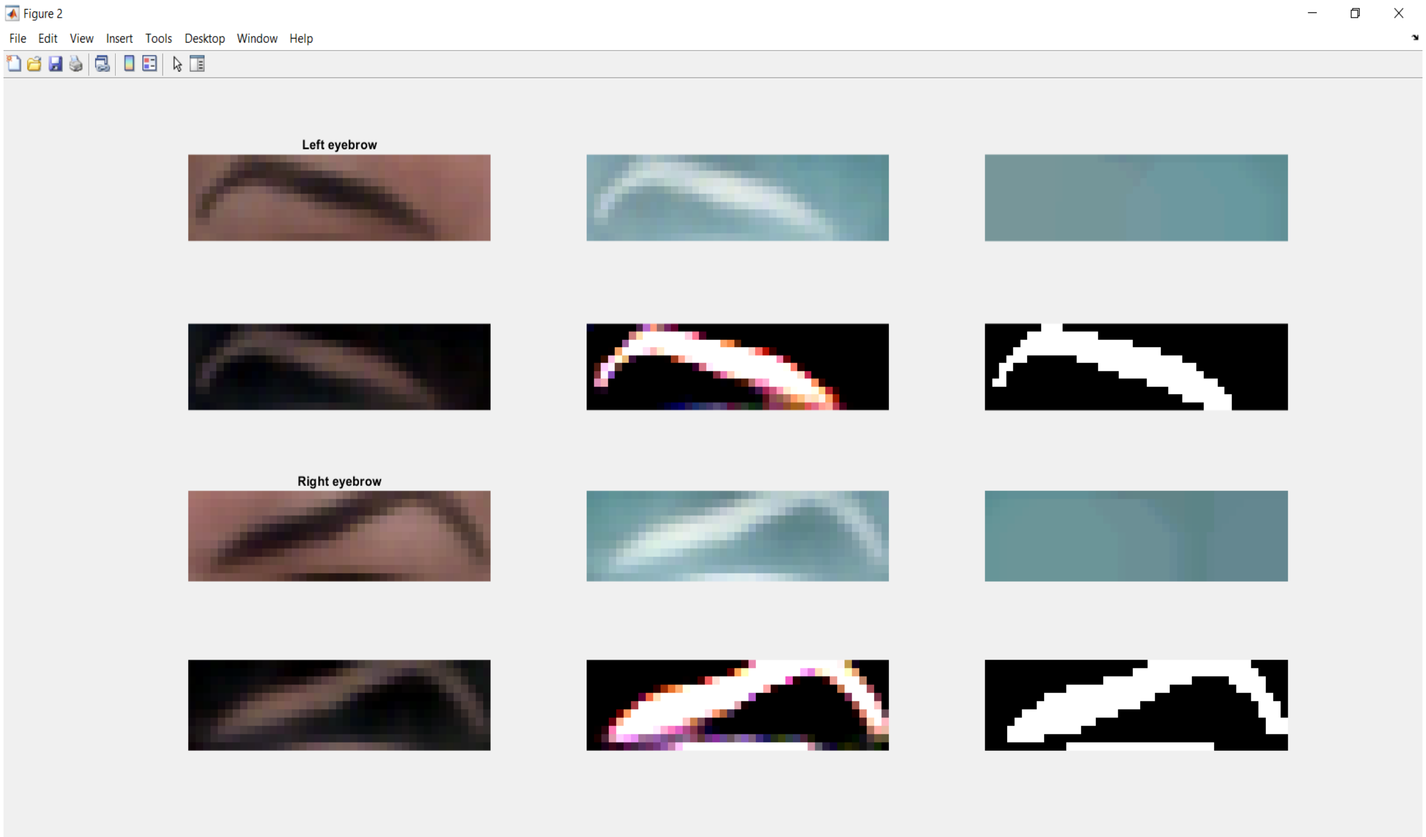


Output:

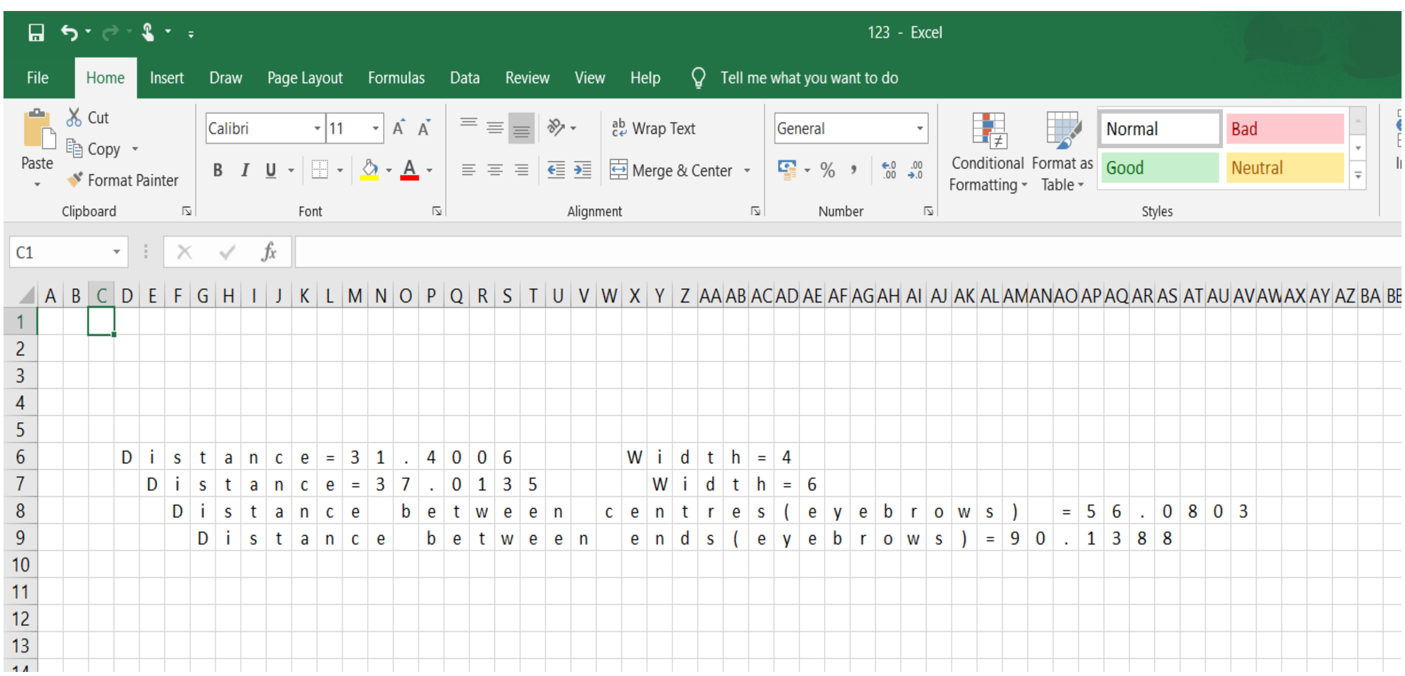
- Figure 1



- Figure 2



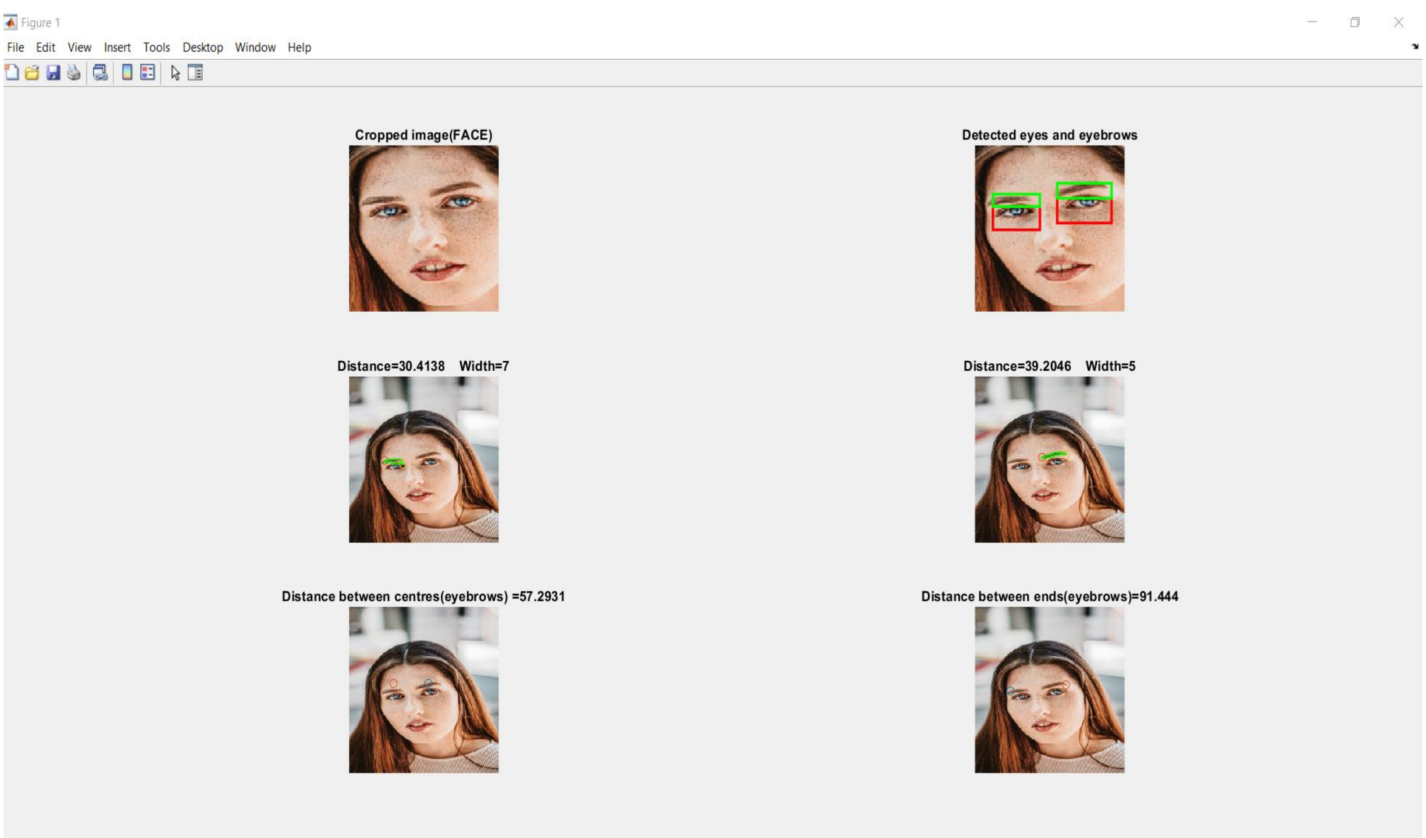
Excel sheet:



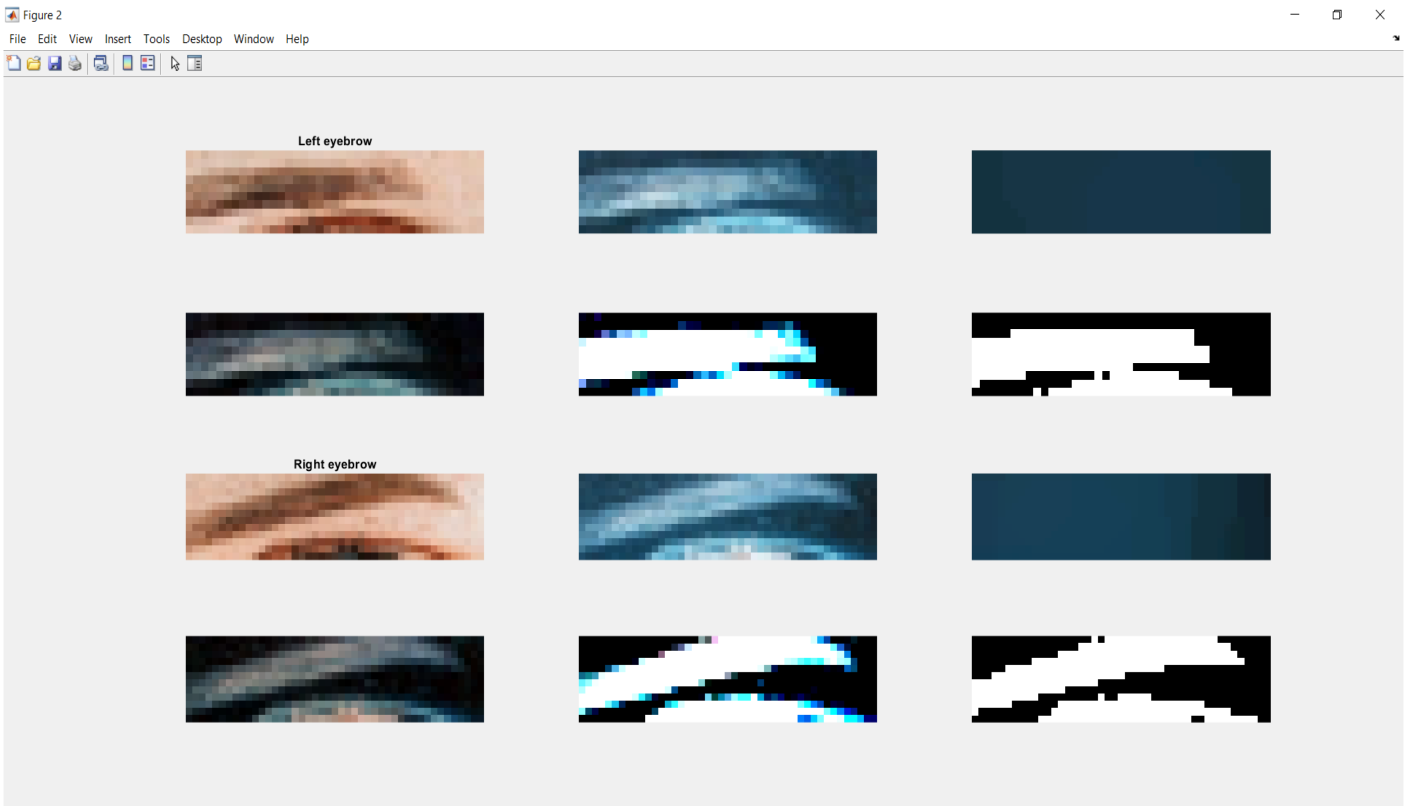
2. Input image

Output:

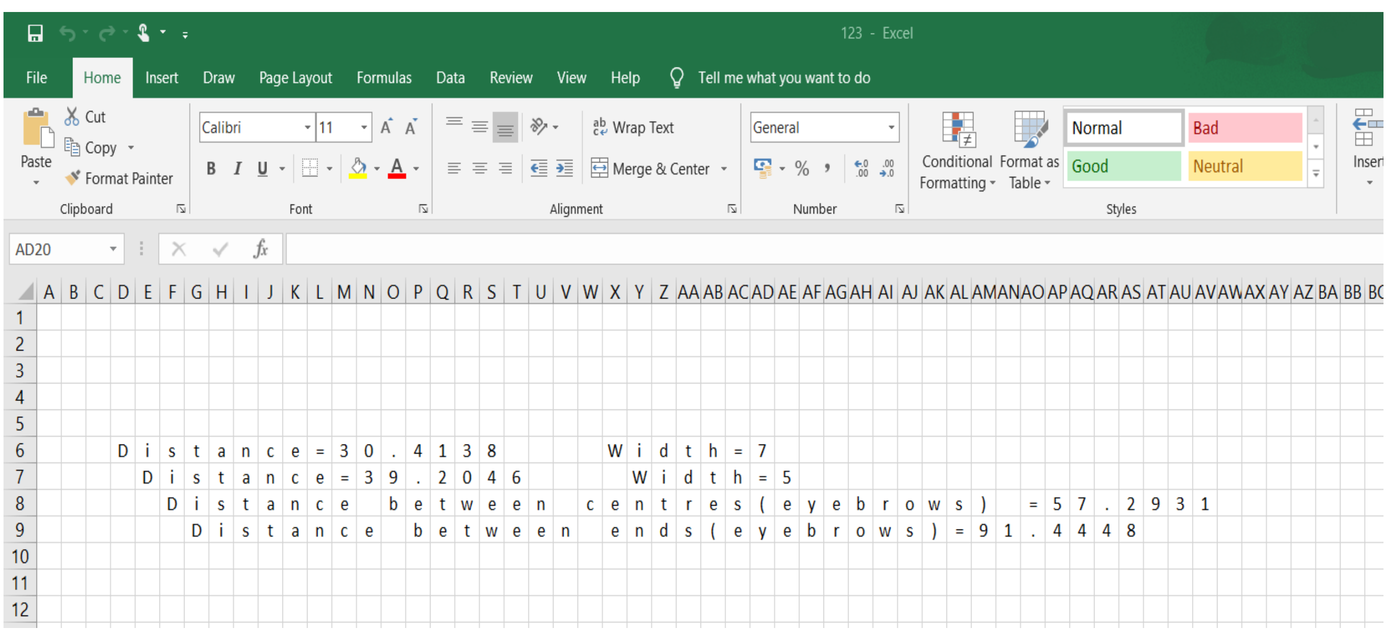
- Figure 1



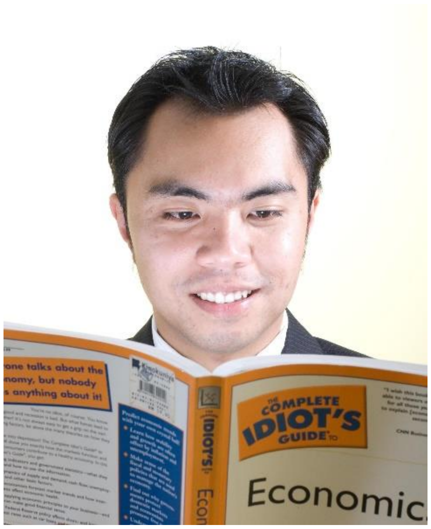
- Figure 2



Excel sheet:

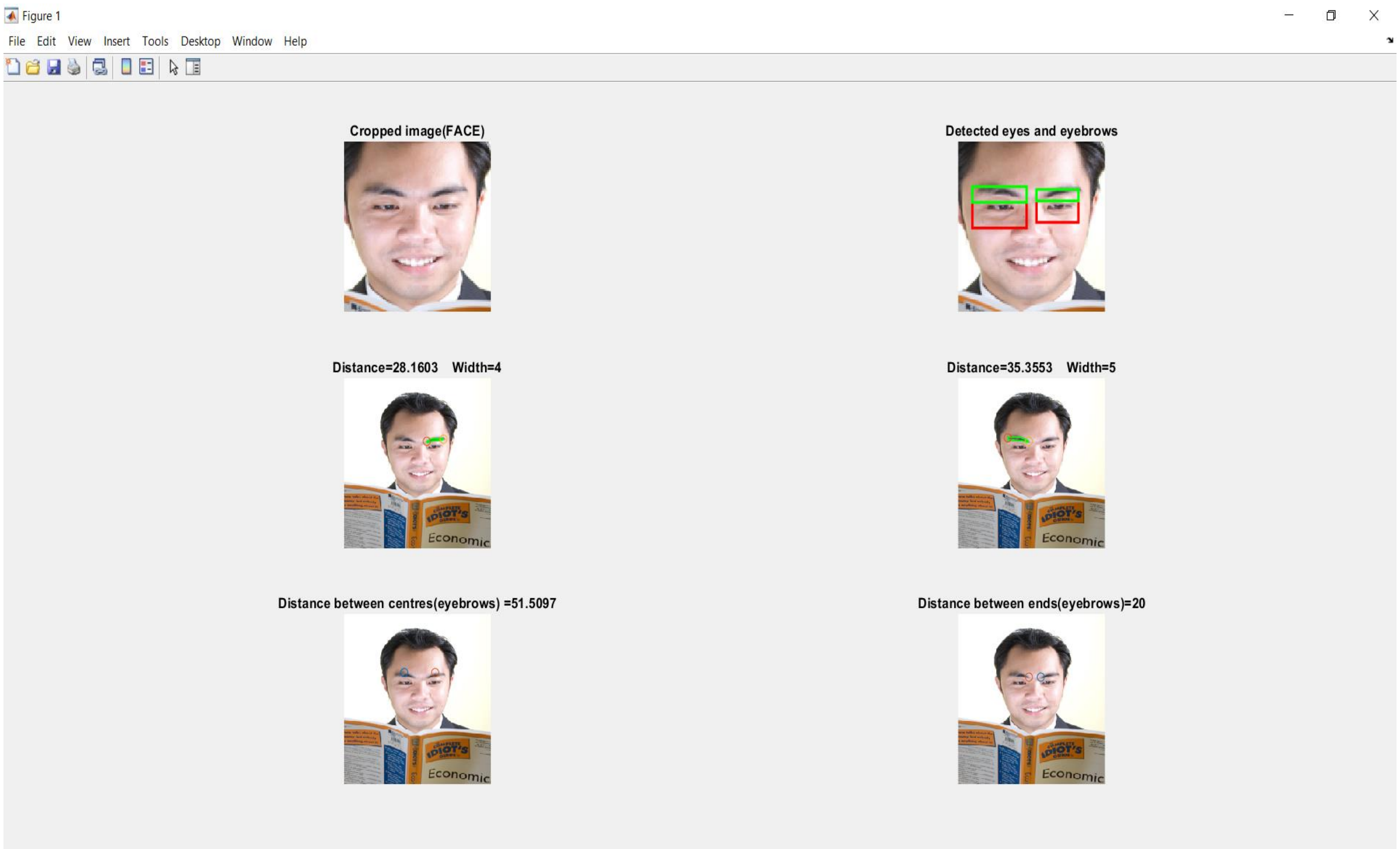


3. Input image

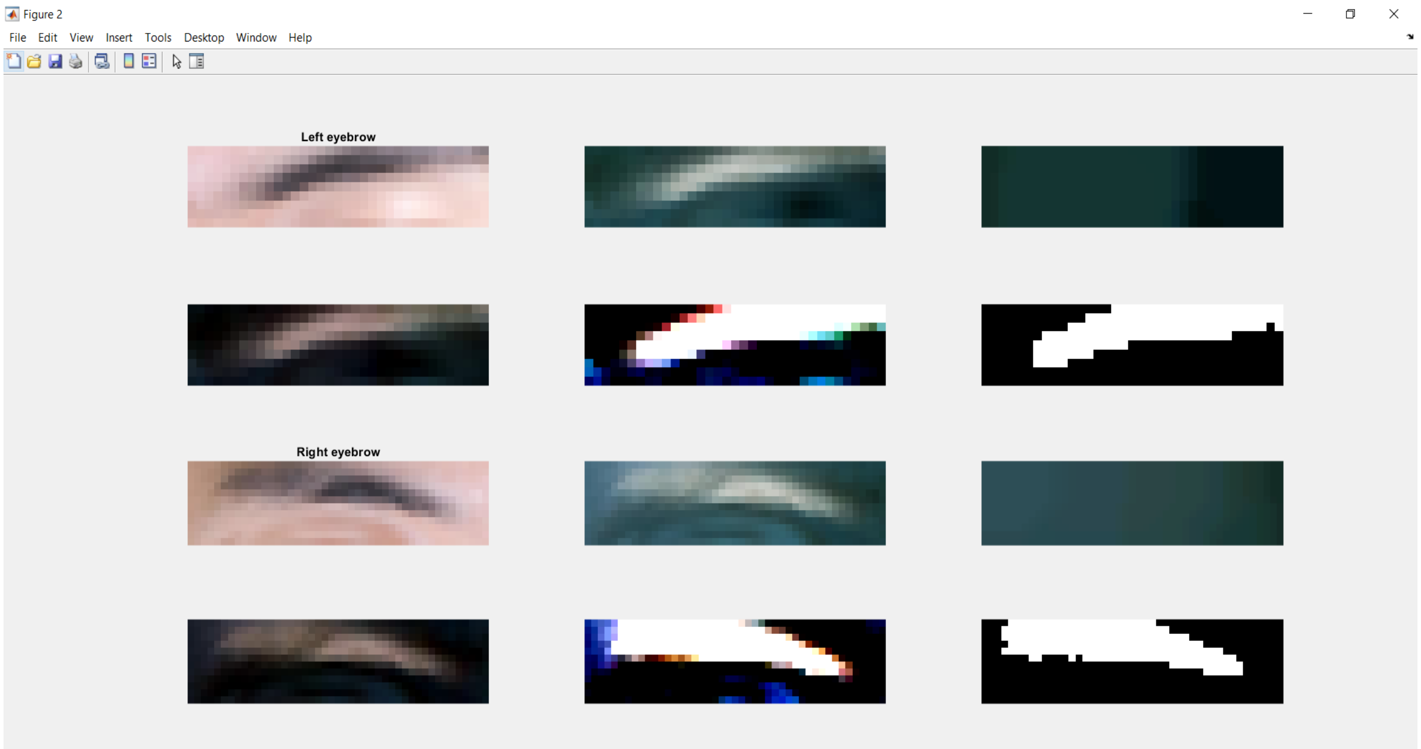


Output:

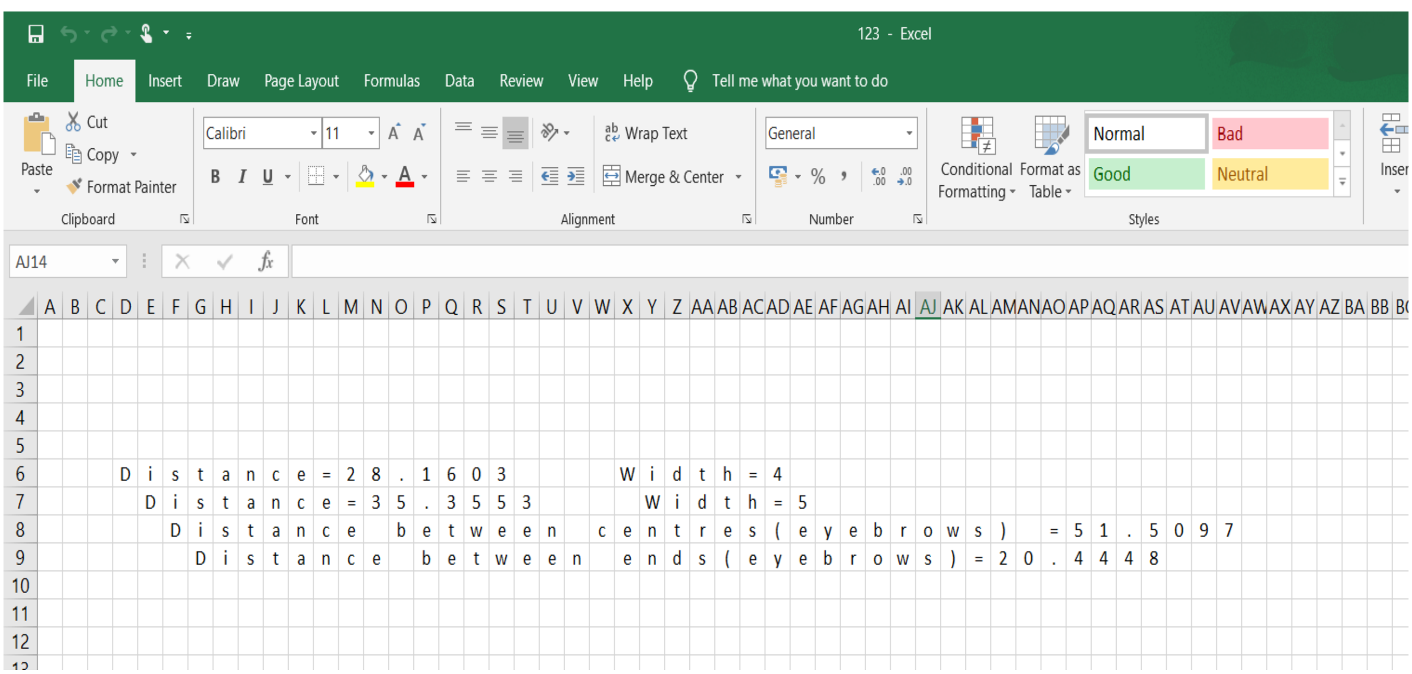
- Figure 1



- Figure 2



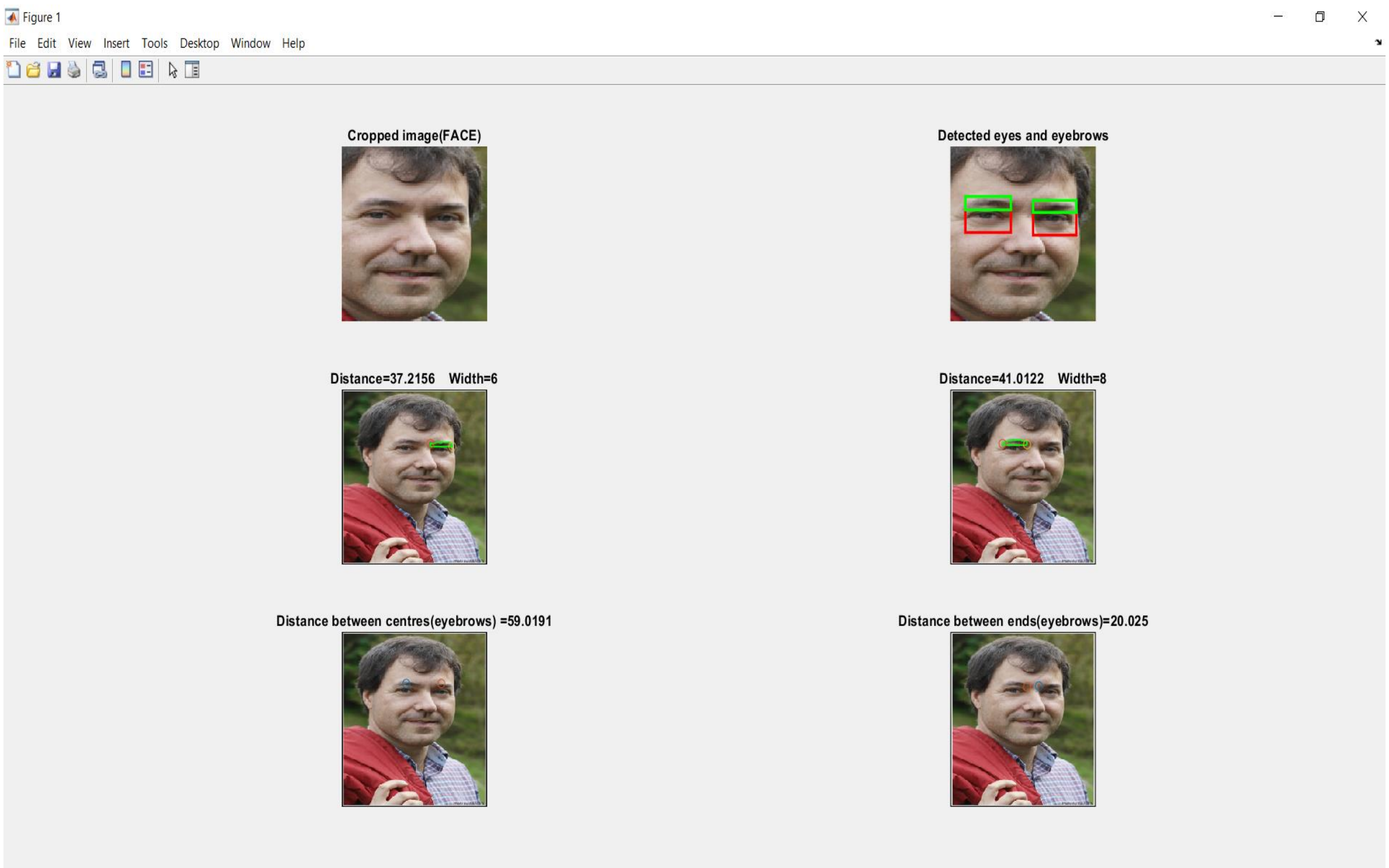
Excel sheet



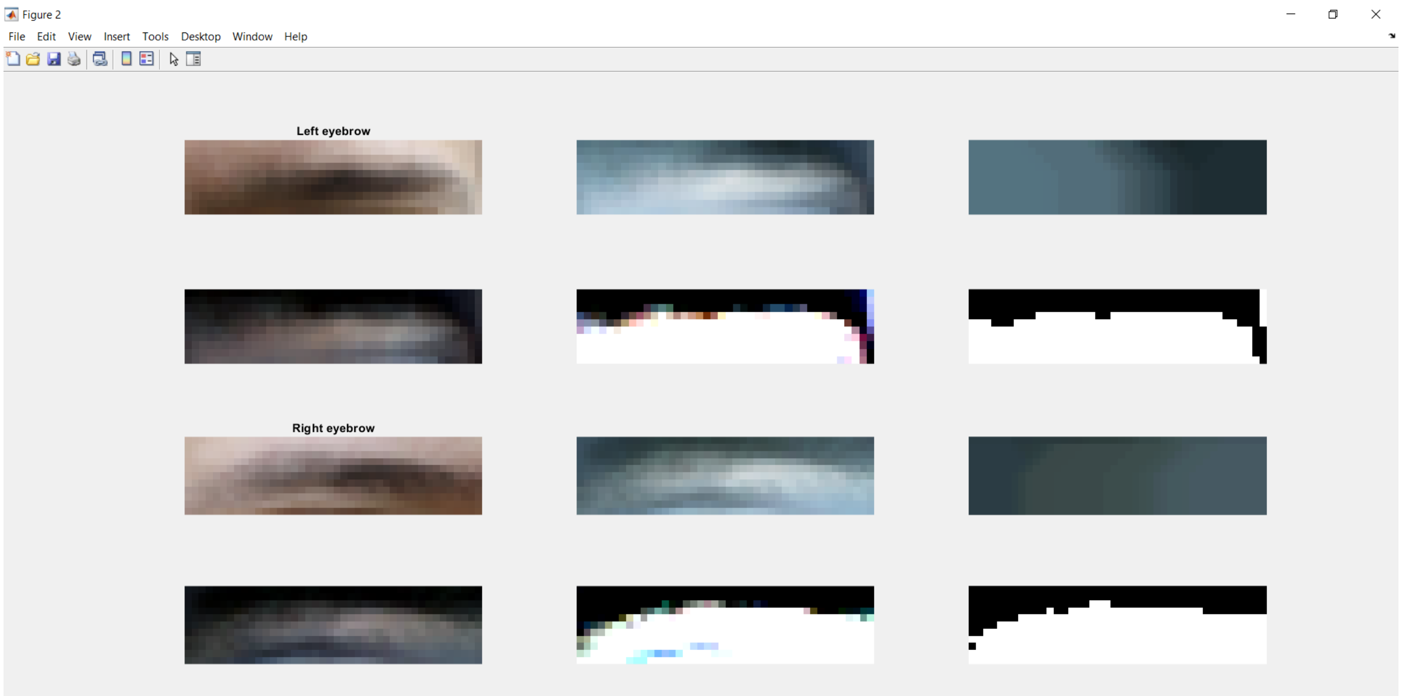
4. Input image

Output:

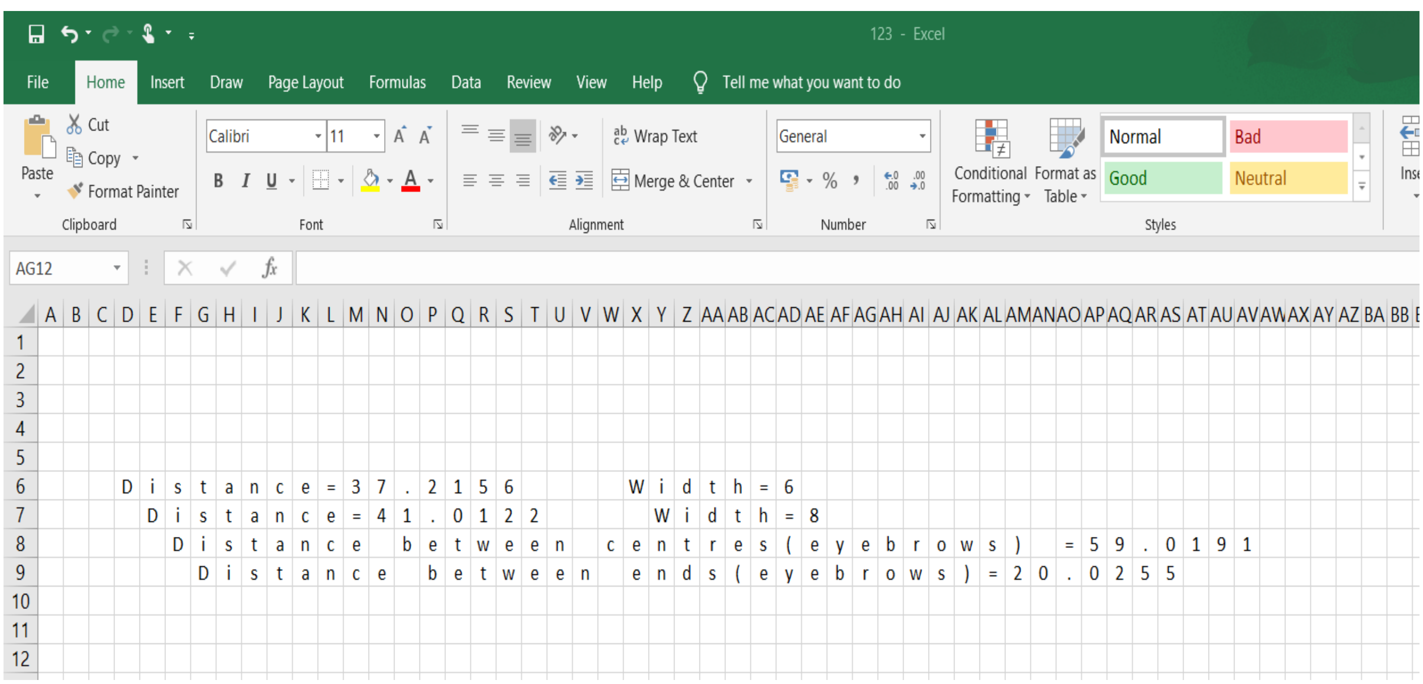
- Figure 1



- Figure 2



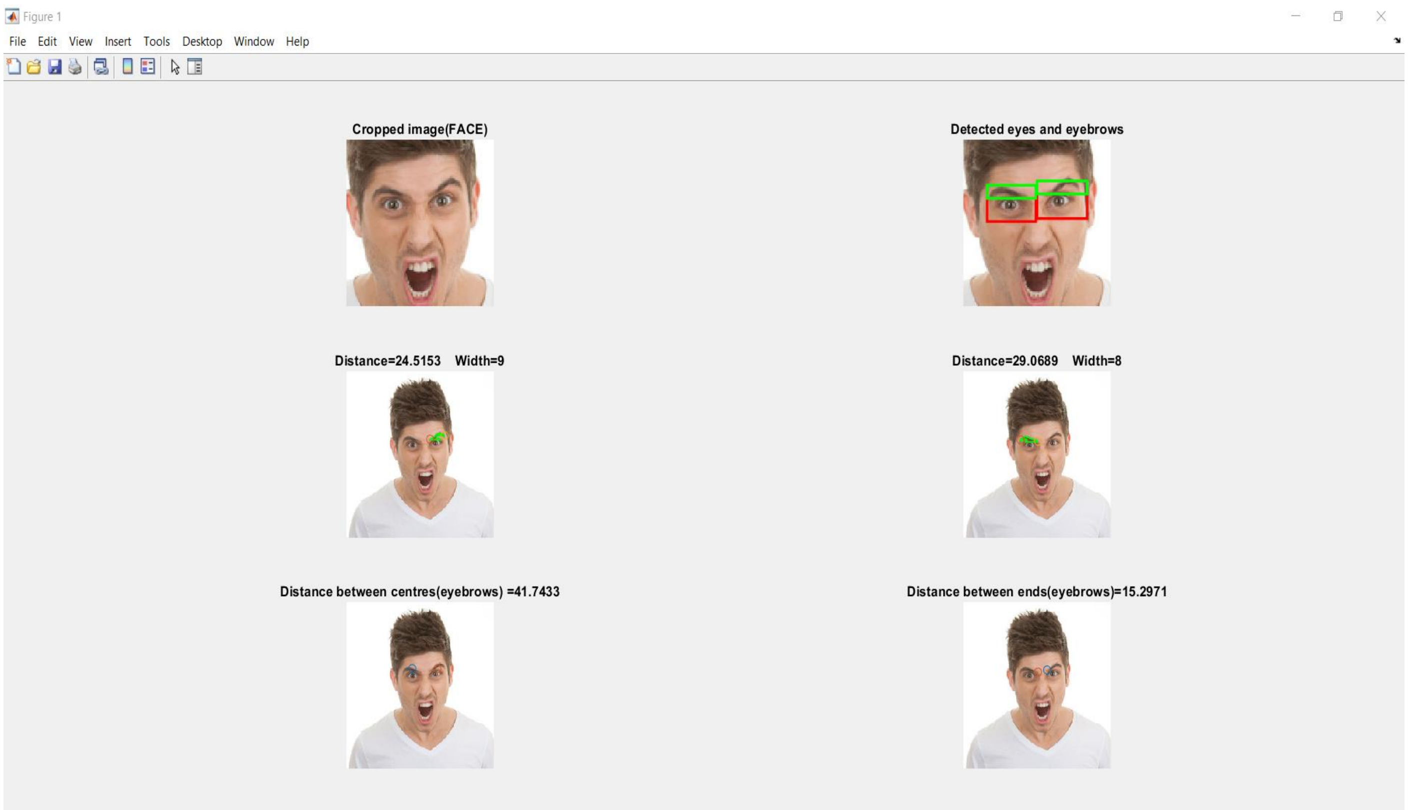
Excel sheet



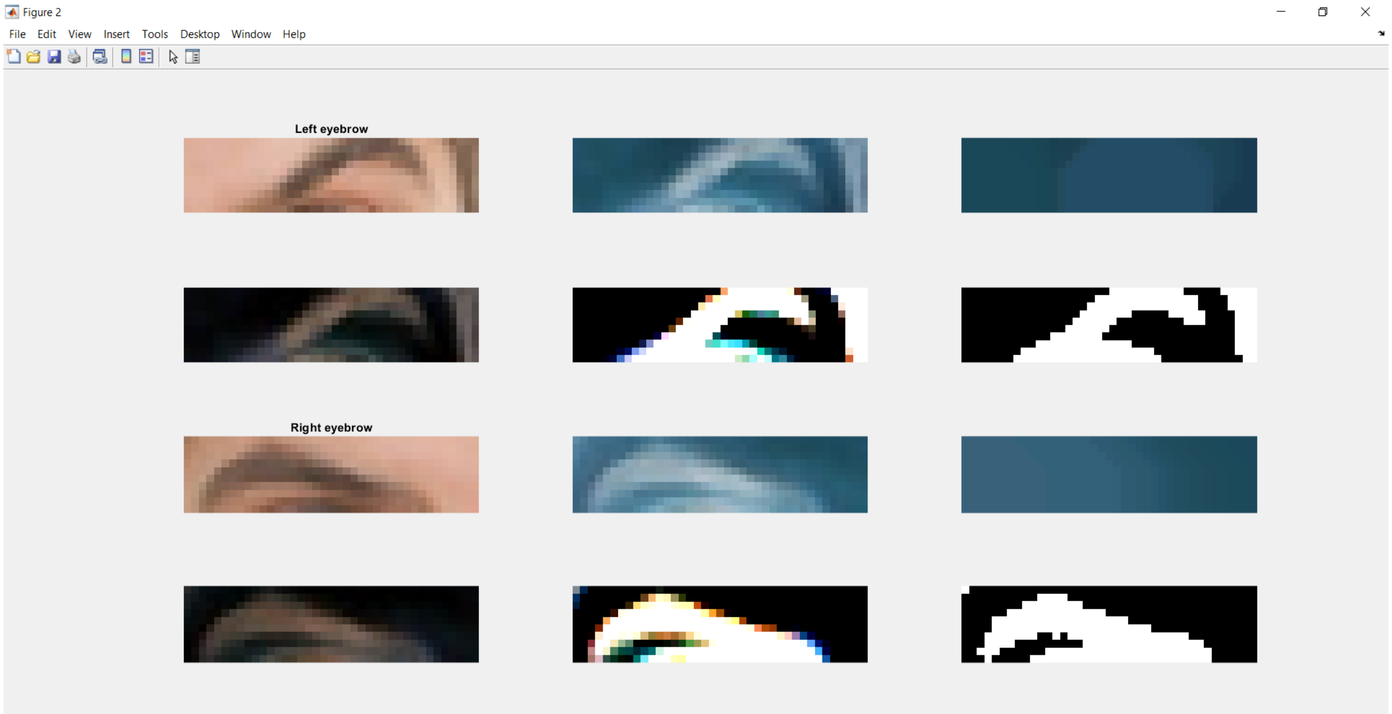
5. Input image

Output:

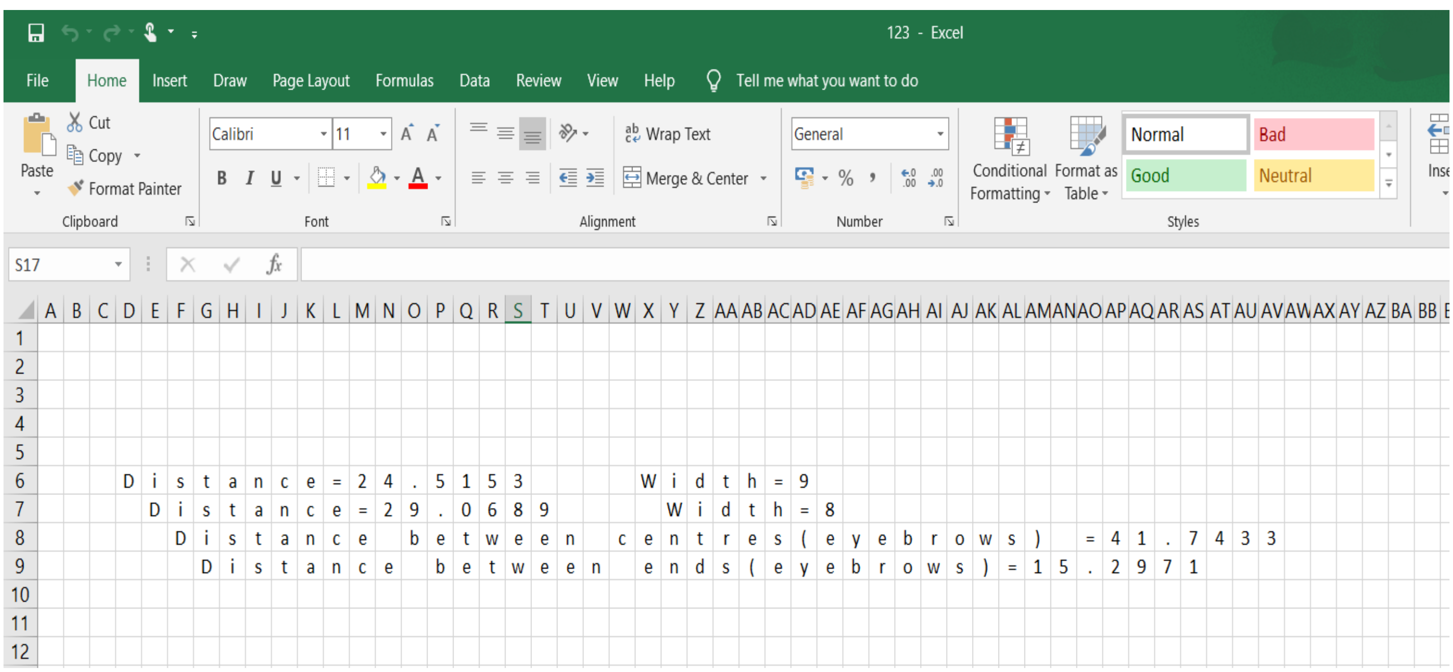
- Figure 1



- Figure 2



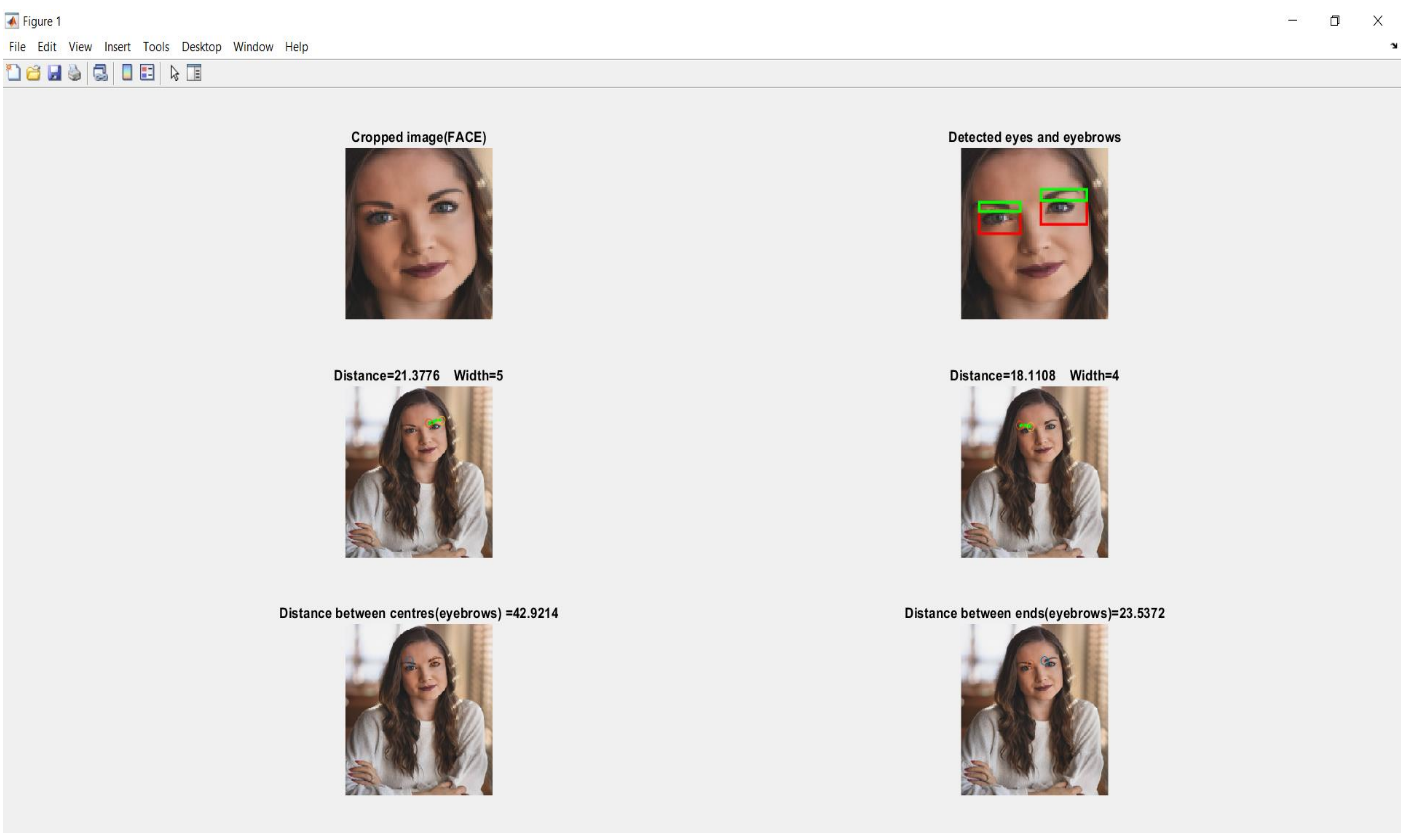
Excel sheet



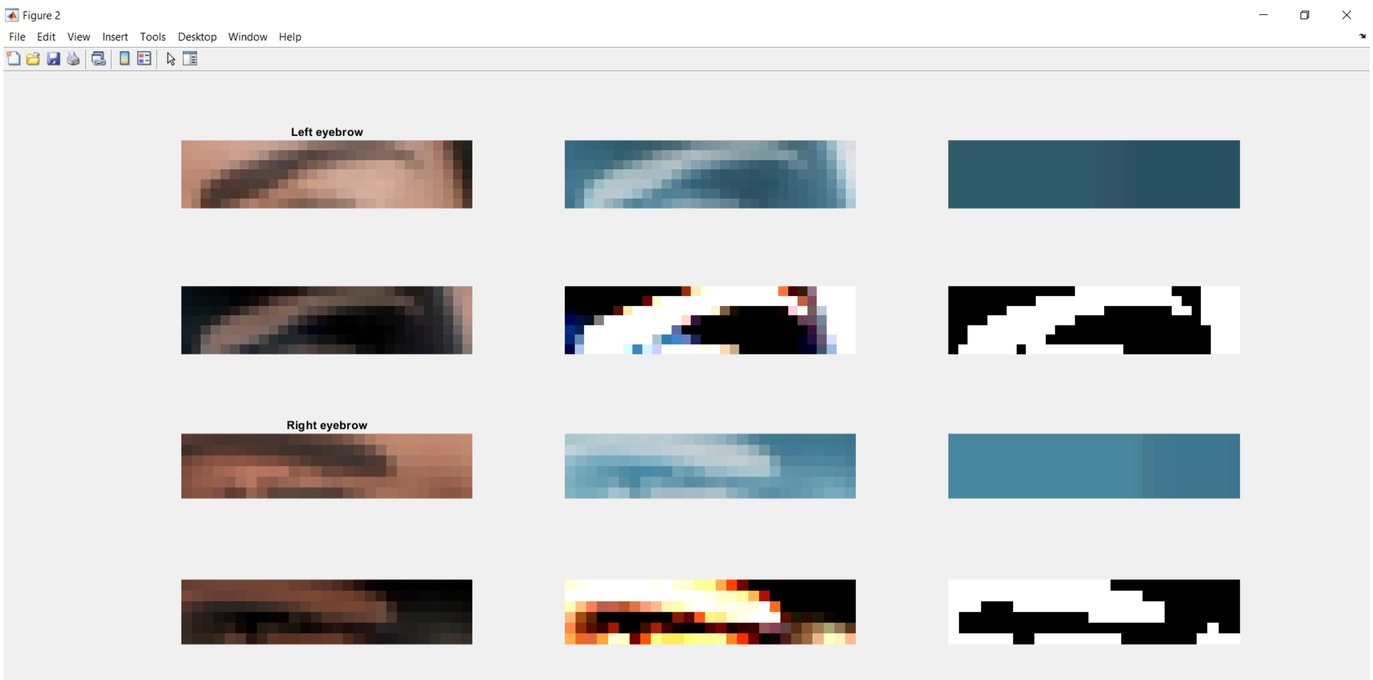
6. Input image

Output:

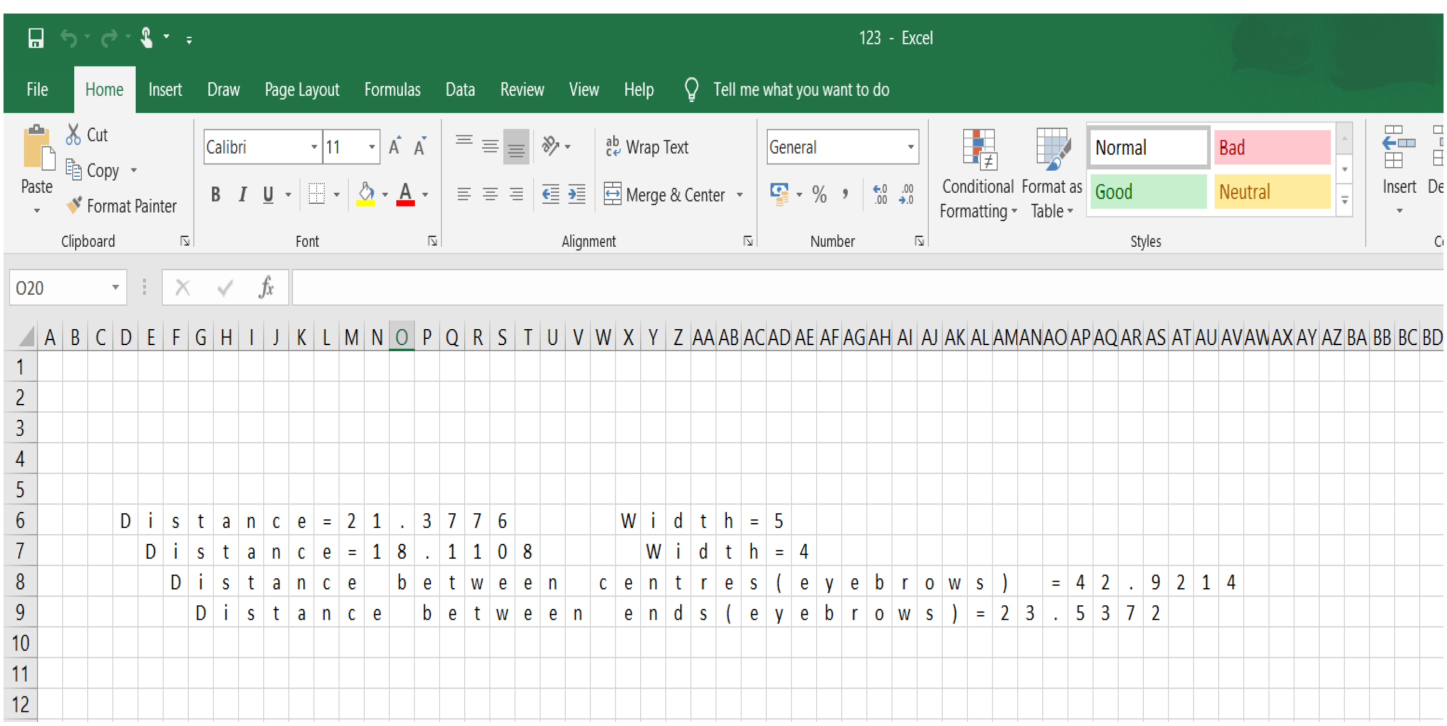
- Figure 1



- Figure 2



Excel sheet



DISCUSSION OF RESULTS

From the above results for 6 input images we can observe the following:

- **Figure 1:**

  - The first image shows the cropped image of the face from the original image.
  - The second image shows the detected eyes and eyebrows in green and red rectangle boxes respectively.
  - Third image shows the outline of the left eyebrow and also calculated its Euclidean distance and width.
  - Fourth image shows the outline of the left eyebrow and also calculated its Euclidean distance and width.
  - The fifth image shows the centers of both the eyebrows and the distance between them.
  - The sixth image shows the ends of both the eyebrows and also the distance between them.
  - We can observe that the distance and width of both the eyebrows are close to each other thus showing the correctness of our output.
  - Moreover the centers and ends are also detected properly.

- **Figure 2:**

  - The six images show various enhancement functions and filters on the segmented images of eyebrows. These filters/functions are listed below in order:
    1. *incomplement*
    2. *strel*
    3. *imadjust*
    4. *greythresh*
    5. *im2bw*
    6. *medfilt2*
  - In the last image we can see a clear output of the eyebrows.

- The **excel sheet** stores all the Euclidean distances that we calculated in figure 1.

CONCLUSION

So with the help of the *computer vision toolkit* and the predefined function **vision cascade object detector**, we were successfully able to detect the eyebrows from the input image of the face.

We also calculated the euclidean distance of eyebrows and also the distances between the eyebrows to provide more accuracy to the detection.
Finally we segmented our image and used various enhancement techniques to enrich our output with more precision and clarity.

Thus we conclude that through this project we have developed an algorithm to detect eyebrows which can be very useful for expression reading and other applications as stated below in future work.

FUTURE SCOPE

Other than improving the time and space complexity of our program we can extrapolate it to livestreams and video imaging as well. Eyebrows and facial features will be able to be detected in real time.

This is especially important for crime fighting purposes. Suspects can be easily matched with already existing databases and thus can be found quicker. Eyebrow detection techniques can also be used to diagnose and help treat mental ailments.

Apart from this we can extend this to surveillance applications, monitoring patient conditions.

REFERENCES

1. T. M. Murphy, R. Broussard, R. Rakvic, R. Schultz and Hau Ngo, "A biological perspective of Viola-Jones face detection," 2014 Spring Symposium: From Lab to Life: Field Based Applications of MEMS & NEMS (MAMNA), Baltimore, MD, 2014, pp. 1-4, doi: 10.1109/MAMNA.2014.6845234.
2. W. LU and M. YANG, "Face Detection Based on Viola-Jones Algorithm Applying Composite Features," 2019 International Conference on Robots & Intelligent System (ICRIS), Haikou, China, 2019, pp. 82-85, doi: 10.1109/ICRIS.2019.00029.
3. S. Sathyanarayana, R. K. Satzoda, S. Sathyanarayana and S. Thambipillai, "A Compute-Efficient Algorithm for Robust Eyebrow Detection," 2014 IEEE Conference on Computer Vision and Pattern Recognition Workshops, Columbus, OH, 2014, pp. 664-669, doi: 10.1109/CVPRW.2014.101.
4. L. Florea and R. Boia, "Eyebrows localization for expression analysis," 2011 IEEE 7th International Conference on Intelligent Computer Communication and Processing, Cluj-Napoca, 2011, pp. 281-284, doi: 10.1109/ICCP.2011.6047881.
5. http://www.sciencedirect.com.egateway.vit.ac.in/science/article/pii/S1047320318302761?via%3Dihub
6. F. N. Sitorus, Y. Manihuruk and G. F. Panggabean, "Implementation of Viola-Jones Algorithm for Object Detection Using FPGA," 2019 International Conference of Computer Science and Information Technology (ICoSNIKOM), Medan, Indonesia, 2019, pp. 1-6, doi: 10.1109/ICoSNIKOM48755.2019.9111611.
7. F. R. Basthomi et al., "Implementation of RFID Attendance System with Face Detection using Validation Viola-Jones and Local Binary Pattern Histogram Method," 2019 International Symposium on Electronics and Smart Devices (ISESD), Badung-Bali, Indonesia, 2019, pp. 1-6, doi: 10.1109/ISESD.2019.8909430.
8. D. R. Castillo Salazar, H. F. Gómez Alvarado, C. B. Guevara Maldonado and L. Lanzarini, "Object detection application and Viola Jones algorithm for the development of a database in Alzheimer's patients," 2019 14th Iberian Conference on Information Systems and Technologies (CISTI), Coimbra, Portugal, 2019, pp. 1-7, doi: 10.23919/CISTI.2019.8760869.