Edge Detection and Thresholding

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***Abstract*—In recent years, edge detection and thresholding have been put to use in an extremely wide range of situations. When the medical profession is deemed to have a thresholding, it is comparable to a situation in which there will be three outputs in order to treat a disease: something that cannot be cured, something that is pretty sure of, and something that is not perfect. This project includes edge detection and thresholding algorithms. First, we constructed Hough Transform utilizing the Marr-Hildreth filter to determine image edges and lines. We extended Otsu's approach to two thresholds. Then used Otsu's single threshold approach has we will be performing two-class classification in order to determined edge map detection. Automatic thresholding of grey-level images was used to determine 2-D image entropy, and the results are compared to 2-level Otsu's approach. Finally Pal and Pal's local joint entropy methods, Global, local and joint relative entropy methods have been implemented.**

I. Introduction

Thresholding creates a division in the image that results in two distinct groups. In which we look for grey levels to use as dividing lines between levels. Above a certain threshold value, we perceive something to be in the foreground, while below that value, we consider it to be in the background. Therefore, the histogram of an image is calculated in order to determine the threshold. We can see from this that thresholding is quite similar to computers in that it only gives the values 0 and 1 and cannot mix the two values together.

If we plot the histogram of an image, the image will become darker; therefore, we will need to make it brighter. The grayscale of an image can differentiate between two different parts with the background subtraction. In the global thresholding we need to calculate the reliable mean and variance where we group entire images into 2 clusters. The best possible threshold is used to separate images using background and foreground. Edge detection is used to produce 2 edges one is foreground and one background. From the fundamental concept of Entropy which is in Information Theory which means there is uncertainty i.e., anything that is not determined or there is no prediction. Since there is no element of uncertainty, we will calculate an image's histogram where the entropy of an image is determined by using a kernel matrix.

There are many methods involved in order to perform thresholding and edge detection methods where some of them can be known in the remaining sections of this report.

II. Selection of Images

If you try to load images from the folder that we have downloaded, you will notice that the accuracy has been compromised. Therefore, I need the images that are contained in the Image Processing Toolbox itself. First and foremost, we will verify that the user has the Image Processing Toolbox installed. In the event that the user does not have the toolbox installed, the following message will appear: "Sorry, but you do not seem to have the Image Processing Toolbox. Do you want to try to continue anyway? "The user said "No" then exit.

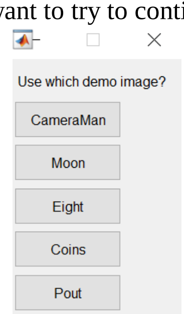


Fig:GUI for selction of images.

Fig: GUI window opens for the Image Selection with the images Cameraman, Moon, Eight, Coins, and Pout.

Then a graphical user interface with Use which demo image?', 'Cameraman', 'Moon', 'Eight', 'Coins', 'Pout' appears. In order to read an image in a grayscale demo image of the type that is typically used with MATLAB. We will Determine where demo folder which works with all versions. Then, load a grayscale demo image from the MATLAB standard library. Find the location of the demo folder is supported by software versions R2013b and before, w when we finally locate the folder, we get the complete filename, with the path appended to the beginning. We will check to see whether the file already exists. If the file does not exist or we were unable to locate it in that location, then we will look via the search path for it. Still didn't find it notify the user with a message that says that "Error: the image does not exist in the search path folders".

If the image is found, then we are able to read it, and the image will be displayed in axes1 if it is found.

III. GUI IMPLEMENATION

If you try to load images from the folder that we have downloaded, you will notice that the accuracy has been compromised.

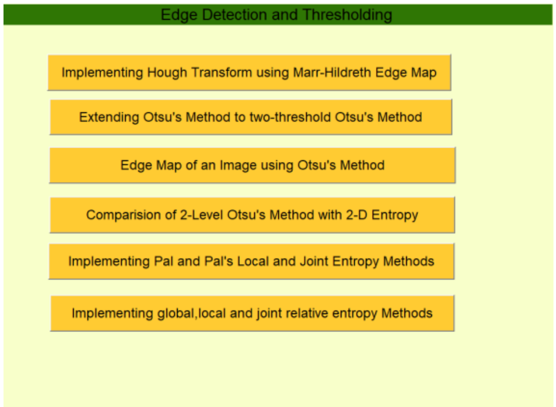


Fig: GUI Implementation for performing Edge Detection and Thresholding methods

Firstly there will be a primary graphical user interface (GUI) where the user can interact with all of the questions that appear in this window. Each time the user clicks on the button, the application will take them to a different implementation. For instance, the implementation of the Hough transform is triggered whenever the user clicks on the Implementing Hough Transform while using the Marr- Hildreth Edge map. This prompts the Hough transform to be displayed. And the same goes for the rest of the other implementations.

IV. Hough Transform

The Hough Transform is a method of feature extraction that can recognize fundamental shapes inside an image. These fundamental shapes include circles and lines. It makes use of the images that were generated by the edge detection operators; despite this, the edge map is disconnected the vast majority of the time. As a direct consequence of this, the Hough transform is applied in order to re-establish the connection between the several edge point subsets that have become separated.

During this implementation, we took several images and then used a filter to make them look smoother.

```
gfilter= [0 0 1 0 0;
 0 1 2 1 0;
1 2 -16 2 1;
0 1 2 1 0;
0 0 1 0 0];
```

After that, locate the points in the image where the zero crossings occur, as this is where we determined the output threshold of an image sensor. Then we have taken the threshold value has 110 and determined the output image of Marr-Hildreth displayed on axes 2.

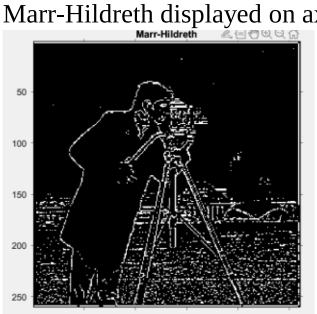


Fig:Marr-Hildreth Edge Filter

Using the Hough feature available in Mat lab, the Standard Hough Transform (SHT) of the binary image BW is computed by using the Hough (BW) function. The Hough function's primary purpose is to identify line segments. This is a parametric representation of a line, and the function uses it as follows: rho = x*cos (theta) + y*sin (theta). The function gives back two pieces of information: rho, which is the distance along a vector that is perpendicular to the line from the origin to the line, and theta, which is the angle in degrees that is formed between the x-axis and the vector. The SHT, also known as H, is a parameter space matrix that has rows and columns that correspond to rho values and theta values, respectively. This matrix is also returned by the function.

The Resthr is then passed with the RhoResolution has 0.5, Theta has -90:0.5:89.The resultant image is adjusted and rescaled and displayed in axes3. Then find the peeks of the image by Resthr and then find the Hough lines of the image. Then the image is over imposed with the Hough lines shown in the
axes4.

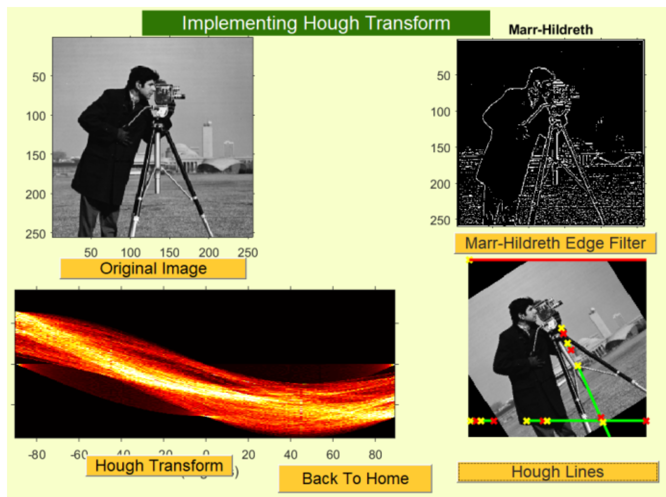


Fig: Implementation of Hough Transform

V. TWO THRESHOLD OTSU'S METHOD

We first load an image and convert it to grayscale, and then we need to define how we want to approach this multi-thresh. Typically, we just use one split, and values that were greater than that split became white, and values that were lower became black. You can think of this multi-thresh as adding in more channels to split over, and now we'll have two arbitrary values.

Things greater than the highest value becomes white, things between the two values are gray, and things lower than our bottom value become black. We have our Otsu method thresholds and we have white in the very bright spots gray intermittently interspersed here and then black in the other regions that's a triple split but it's only using two values as I have specified here.

We will be quantizing the image off of the threshold that we create. The threshold becomes a matrix of multiple values that goes into the quantize function, and we get out zeros ones twos threes depending on how many splits we do. I'm just centering these around zero so we have zero being black pixels to start, and then I need to scale those between 0 and 1 so we can make an image.

Determine a global threshold T using Otsu's approach. The Otsu approach minimizes intraclass variation to establish the threshold for black and white pixels. Use global threshold T and imbinarize to convert a grayscale image to binary. Here the split we will be using has 2 and the resultant image is shown in Otsu's method.

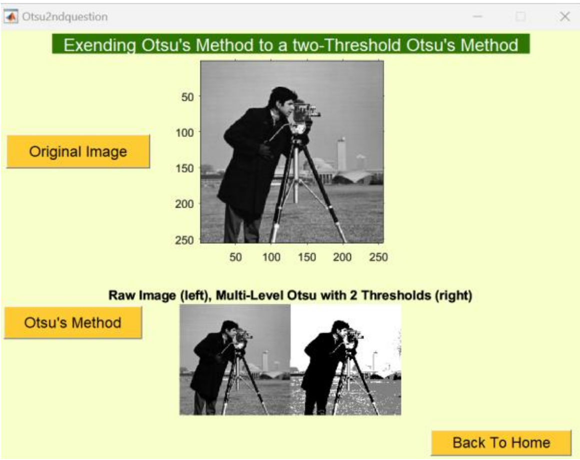


Fig: GUI Implementation of a Two-Threshold Otsu's Method

VI. Edge Map of an Image Using Otsu's Method

In this we have considered cameraman Image has shown in the axes1 and according to the Otsu method, the image is then split into 16 different level histograms.

```
>> edgemap
Threshold obtained by using Otsu method
            0.333333333333333
```

Fig: The value of threshold that was achieved by performing the Single Otsu Method

Fig: Image obtained by performing single Otsu Method

Through the utilization of an Otsu threshold and the subsequent conversion of an image into binary values. Whenever we use the Otsu approach, the matrix that we work consists of both 0-background and 1-foreground.Both the background and the foreground of the image can both be seen in the final product.

Variations in points from 0 to 1 or 1 to 0 can be used to produce an edge map with the help of this method since it takes into account the transition from foreground to background, which is an edge. Therefore, in order to discover the filled binary image, we need to fill the holes inside the image and link the points. Axes 3 displays the final image that was produced by the process which is a black image with white boundary lines is employed in order to locate the edge map for the binary filled image shown in axes 4.

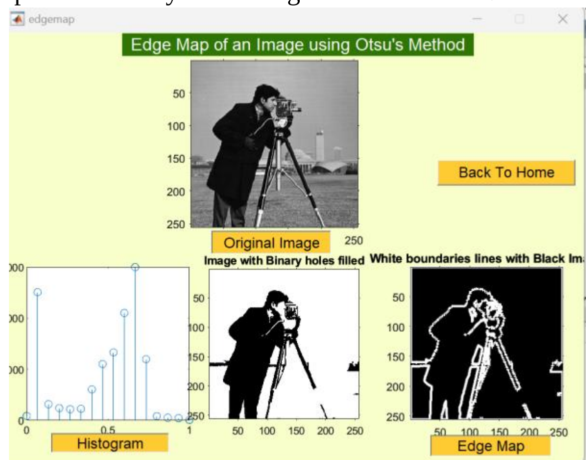


Fig: GUI Implementation of Edge Map of an Image using Otsu's Method

VII. Comparison of Two Level Otsu's Method to 2-D Entropy

In the paper automatic thresholding of grey-level images using 2-D entropy I observed that when compared to Otsu's method. Following the implementation of the methods, it was observed that the intensity and variance of the gray levels within the image are used by Otsu's method in order to determine image thresholds.

We take into account that the window width is 21, that the kernel is calculated, and that the kernel is then passed through the image in order to perform the histogram utilizing hist2d. In order to determine the 2-D histogram of an image, we first take into account that the window width is 21, and that the kernel is calculated which is displayed on axes 2.

In the first step of this process, the grayscale level of the image and the levels are both calculated. This level is passed in order to binarize the grey level image which can be observed in axes 3. The Otsu technique threshold is calibrated using the threshold, which has a value of 2.The multi-level threshold's achieved threshold, is quantized, and the segmented image may be observed. This image is the multi-level threshold's image, and it is presented on axes 2 of the graphical user interface (GUI).Converting the N-D arrays into a single column is the first step in calculating the gray level of an image. Then Convert to unit8 for the most efficient computation of the histogram. The histogram provides a count of the locations at which we discover the highest value of sigma b squared. The maximum may span across multiple bins; hence, it is important to take an overall average of the places.

In Abutaleb's method, "2-Dimensional Entropy-Based Approach," the average of gray-level and the PMF value of neighboring pixels are calculated, and then the entropy-approach is applied.

The maximum value that is acquired has values of NaN, which indicates that sigma squared is composed entirely of NaN, in which case we return the value 0.

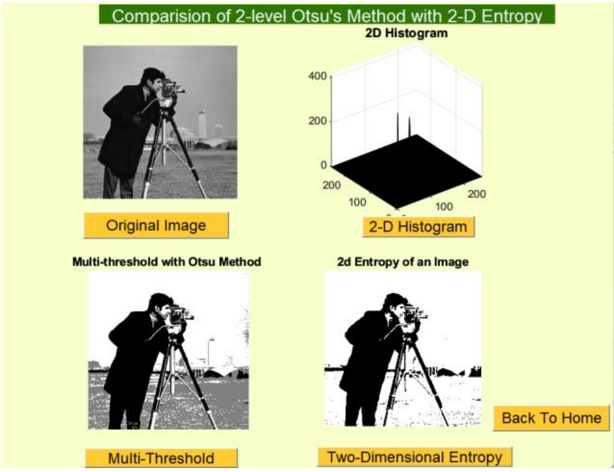


Fig: GUI window for comparison of 2-level Otsu's method with 2-D Entropy

VIII. PAL LOCAL AND JOINT ENTROPY METHODS

Local Entropy, Joint Entropy which was proposed by Pal and Pal which are derived on the cell-probabilities.

Here there is no spatial correlation involved so we can extend 1D histogram to 2-D histogram.2-D histogram always cluster at a place because i,j should be nearer.

Let the threshold, denoted by t -> G, be chosen in such a way that the co-occurrence matrix is divided into the four quadrants A, B, C, and D, as shown below (NG is the maximum grayscale value 255).

To begin, in order to compute the local and global entropies, we need to compute the grey-level co-occurrence matrix as well as the quadrants of the grey-level co-occurrence matrix.

Here we have calculated gray-level co-occurrence matrix and return the scaled image.

Fig: The scaled version of the image after GLCM calculation

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	43394	4308	91	6	0	0
0	0	4308	39696	4054	91	20	0
0	0	91	4054	36722	361	50	0
0	0	6	91	361	602	78	0
0	0	0	20	50	78	180	4
0	0	0	0	0	0	4	0
24752	1129	386	249	192	232	76	20
1129	2450	565	290	236	198	68	18
386	565	986	1195	669	222	87	32
249	290	1195	8600	5464	471	166	45
192	236	669	5464	21030	2604	186	62
232	198	222	471	2604	40402	472	54
76	68	87	166	186	472	468	109
20	18	32	45	62	54	109	366

Fig: The GLCM matrix for cameraman image

The above is the grey-level co-occurrence matrix for the camera man image.

Normalizing the total number of transitions in the co-occurrence matrix, a desired transition probability from grey level i to grey level j is obtained by

```
  Columns 1 through 4
      0.191872994217144     0.0087518022976388    0.00299220167129192    0.00193020263251733
     0.0087518022976388     0.0189919536131223    0.00437977705772003    0.00224802716236958
    0.00299220167129192    0.00437977705772003    0.00764329235205656    0.00926342227252291
    0.00193020263251733    0.00224802716236958    0.00926342227252291     0.0666656330909598
    0.00148834901784468    0.00182942900110076    0.00518596610905257     0.0423559324661633
    0.00179842172989566    0.00153485992465233    0.00172090355188292    0.00365110618440024
   0.000589138152896854   0.000527123610486659   0.000674408148710873    0.00128680175501155
   0.000155036356025488   0.000139532720422939   0.000248058169640781   0.000348831801057348
  Columns 5 through 8
    0.00148834901784468    0.00179842172989566   0.000589138152896854   0.000155036356025488
    0.00182942900110076    0.00153485992465233   0.000527123610486659   0.000139532720422939
    0.00518596610905257    0.00172090355188292   0.000674408148710873   0.000248058169640781
     0.0423559324661633    0.00365110618440024    0.00128680175501155   0.000348831801057348
      0.163020728360801     0.0201857335545185    0.00144183811103704   0.000480612703679013
     0.0201857335545185      0.313188942807088    0.00365885800220152   0.000418598161268818
    0.00144183811103704    0.00365885800220152    0.00362785073099642   0.000844948140338909
   0.000480612703679013   0.000418598161268818   0.000844948140338909    0.00283716531526643
```

Fig: The transition probability fro grey level i to grey level j for the camera an image.

Here in order to calculate quadrants of Co-occurrence matrix we have taken t=4 has 0<=t<=L-1.The probabilities associated with each quadrant is given by

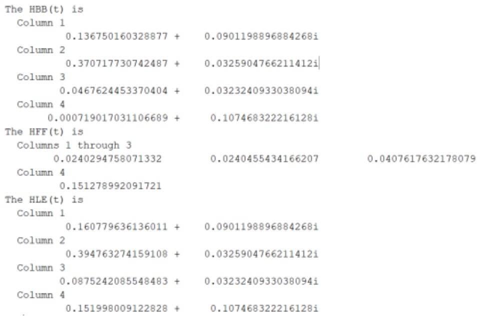
```
>> palquestion5
The problitiy associated with Quadrant A is 0.344305
The problitiy associated with Quadrant B is 0.062642
The problitiy associated with Quadrant C is -12.760840
The problitiy associated with Quadrant D is -8.844311
```

The probabilities of grey-level transition within each particular quadrant. Can be further obtained by so called cell probabilities.

```
The probability of grey-level transition with Quadrant A is
      0.127980801230615      0.409883261445717   -0.00280692803862067   -0.00333594970508811
    -0.0192351630173726     0.0135923800685226   -0.00748215042190913   -0.00395469758711003
   -0.00579373448638129   -0.00773693595327827     0.0140221741914515    -0.0269175821207804
   -0.00365715432586496   -0.00263693495067267    0.00837346424268213     0.0447062822513473
The probability of grey-level transition with Quadrant B is
  Columns 1 through 4
                      0                      0                      0                      0
                      0                      0                      0                      0
                      0                      0                      0                      0
                      0                      0                      0                      0
  Columns 5 through 7
   -0.00262906971541132   -0.00470848071541465    -0.0011447399190774
   -0.00333282094097267   -0.00236736170984164  -0.000762035289288997
    -0.0136596476515735   -0.00373863041398203   -0.00248713498529947
     0.0283377661227008    0.00244942233057262   0.000870909465341853
The probability of grey-level transition with Quadrant C is
                      0                      0                      0                      0
                      0                      0                      0                      0
                      0                      0                      0                      0
                      0                      0                      0                      0
    0.00139162799491224    0.00170929221153152    0.00482314889160722     0.0375030990038903
    0.00168041554536762    0.00143498724285841    0.00161259461035374    0.00350788221678504
   0.000551933794655929   0.000493907945712085   0.000633407524723389    0.00124278372329677
```

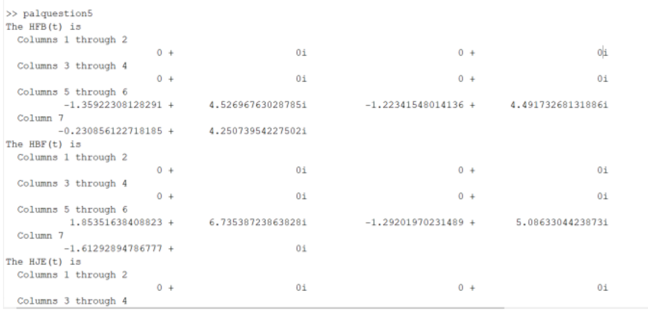
Fig: The different probability of grey-level transitions with different quadrant namely A, B, C, D.

Here we can find any values as 0 has we have NAN values. The resultant values of HLE (t) .The image with local Entropy of an Image are 149.



```
The HBB(t) is
  Column 1
         0.136750160328877 +    0.090119889688426 8i
  Column 2
         0.370717730742487 +    0.032590476621141 2i
  Column 3
        0.0467624453370404 +    0.0323240933038094i
  Column 4
      0.000719017031106689 +     0.107468322216128i
The HFF(t) is
  Columns 1 through 3
       0.0240294758071332        0.024045543416 6207        0.0407617632178079
  Column 4
        0.151278992091721
The HLE(t) is
  Column 1
         0.160779636136011 +    0.0901198896884268i
  Column 2
         0.394763274159108 +    0.0325904766211412i
  Column 3
        0.0875242085548483 +    0.0323240933038094i
  Column 4
         0.151998009122828 +     0.107468322216128i
```

Fig: The resultant values of HBB (t), HFF (t), and HLE (t)



```
>> palquestion5
The HFB(t) is
  Columns 1 through 2
                    0 +                    0i                    0 +                    0i
  Columns 3 through 4
                    0 +                    0i                    0 +                    0i
  Columns 5 through 6
     -1.35922308128291 +      4.52696763028785i     -1.22341548014136 +      4.49173268131886i
  Column 7
    -0.230856122718185 +      4.25073954227502i
The HBF(t) is
  Columns 1 through 2
                    0 +                    0i                    0 +                    0i
  Columns 3 through 4
                    0 +                    0i                    0 +                    0i
  Columns 5 through 6
      1.85351638408823 +      6.73538723863828i     -1.29201970231489 +      5.08633044238731i
  Column 7
     -1.61292894786777 +                    0i
The HJE(t) is
  Columns 1 through 2
                    0 +                    0i                    0 +                    0i
  Columns 3 through 4
```

The HFB (t) and HBF (t) are calculated with the HJE (t).After computing HJE (t) maximize with 255.The Joint Entropy of an Image is 255.

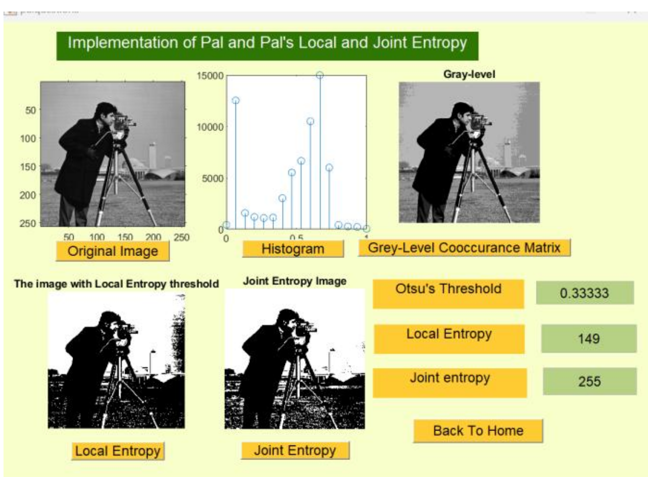


Fig: GUI Implementation of Pal and Pal's local and Joint Entropy Methods with the output threshold values displayed and images displayed.

The threshold value of Local Entropy is 149 whereas Joint Entropy is 255.

IX. Relative Entropy Methods

In order to compute the local entropy of an image, first the histogram of the image must be calculated, then the histogram must be normalized, and last the gray level of the image must be calculated. The low range image is the next one that we look at.

After that, the image with a high dynamic range is computed. The entropy of both of the images will be determined by us. After which you will perform the cross entropy, and select the optimal threshold.

The following is included in the Joint Relative Entropy Methods with the thresholding Image Function. The threshold, which we are going to calculate, is going to be 3, and the joint relative entropy of an image is going to be calculated and multiplied by 3.Calculating an image's histogram involves first determining the differential evolution and then determining the thresholds by utilizing the mean of the values. When differential evolution is applied, the upper limit of the search space for 8-bit images will be set to 255, and the lower limit of the search space will be set to 0.

For the global Entropy the low range entropy and high range entropy are calculated, after which we will choose the best threshold and determine the threshold value and global entropy threshold of an image. The global entropy of an image is calculated by first normalizing the histogram, then performing the cumulative distribution function. This is followed by the calculation of the global entropy threshold.

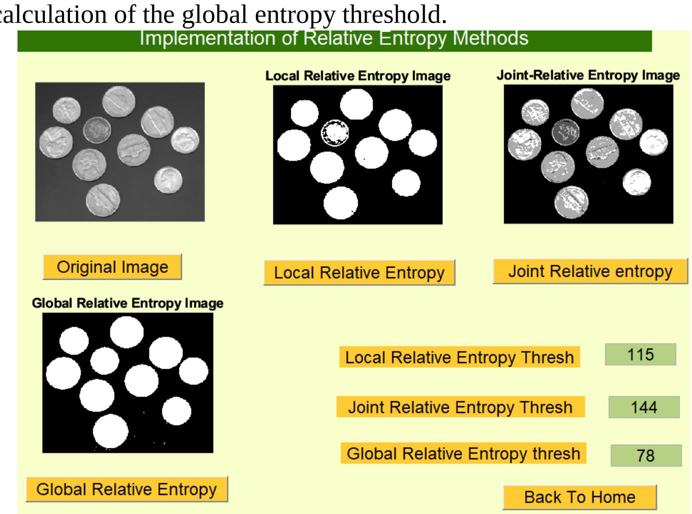


Fig: GUI Implementation of different Relative Entropy Methods with the threshold values displayed.

After uploading coins image we will be calculating the Local Relative Entropy Threshold which is 115, Joint Relative Entropy Threshold is 144 and Global Relative Entropy threshold is 78.

X. Conclusion

Here we have implemented Edge Detection and thresholding with various methods involved. We also performed single and multi level Otsu method threshold and compared the results with 2-D Entropy. We also extended the Single level classification and performed edge detection. For the entropy methods we have calculated the values based on co-occurrence matrix values and calculated different entropy and relative-entropy methods.

References

[1] https://apps.dtic.mil/sti/pdfs/ADA464347.pdf

[2] https://www.sciencedirect.com/science/article/abs/pii/0734189X89900510.