

# The Use of Threshold Technique in image segmentation

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## Abstract

Image segmentation technique refers to the process of partitioning a digital image into multiple segments i.e. set of pixels, pixels in a region are similar according to some homogeneity criteria such as color, intensity or texture, so as to locate and identify objects and boundaries in an image. Several general-purpose algorithms and techniques have been developed for threshold image segmentation. In this paper we introduce two segmentation algorithms the first one is histogram and iterative method. The histogram algorithm uses minimum two peaks in gray image to determine constant threshold(global) ,while the iterative algorithm uses variable threshold(local) to segment image, and finally get binary image. with application in programming environment Matlab. Next are describing some advantage and disadvantages of those algorithms.

## 1. Introduction

The main goal of image segmentation is to divide an image into parts that have a strong correlation with objects or areas of the real world contained in the image. In image processing useful pixels are separated from the rest. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image [1]. Image segmentation is the fundamental step in image analysis, understanding, and interpretation and recognition tasks; Segmentation is the most important step in automated recognition system which has numerous applications in the field of medical imaging satellite imaging, movement detection, Security. Matlab is a popular Mathematical Programming Environment. Matlab can be used for operations with images through special toolbox Image Processing that provides an algorithms and graphical tools for image processing, analysis, visualization, and algorithm development. This describes the possibilities of image segmentation with Matlab. There are many problems that can occur during image segmentation related with ambiguity of image data (complexity of objects, non-uniform color and intensity, shadows, reflections). Threshold is the most common image segmentation techniques [2].

## 2. Image Segmentation

Image segmentation is the process of partitioning an image into multiple segments, so as to change the representation of an image into something that is more meaningful and easier to analyze. [3]. Practical application of image segmentation range from filtering of noisy images, medical applications (Locate tumors and other pathologies, Measure tissue volumes, Computer guided surgery, Diagnosis), and the choice of a segmentation technique over another and the level of segmentation are decided by the particular type of image and characteristics of the problem being considered [4].

### 3- Threshold technique

Threshold is one of the widely methods used for image segmentation. It is useful in discriminating foreground from the background. By selecting an adequate threshold value  $T$ , the gray level image can be converted to binary image. The binary image should contain all the essential information about the position and shape of the objects of interest (foreground). The advantage of obtaining first a binary image is that it reduces the complexity of the data and simplifies the process of recognition and classification. The most common way to convert a gray-level image to a binary image is to select a single threshold value ( $T$ )[5]. Then all the gray level values below this  $T$  will be classified as black (0), and those above  $T$  will be white (1). The segmentation problem becomes one of selecting the proper value for the threshold  $T$ . A frequent method used to select  $T$  is by analyzing the histograms of the type of images that want to be segmented. The ideal case is when the histogram presents only two dominant modes and a clear valley (bimodal). In this case the value of  $T$  is selected as the valley point between the two modes. In real applications histograms are more complex, with many peaks and not clear valleys and it is always easy to select the value of  $T$  [6].

#### 3.1 Global Threshold

Suppose the histogram of an image  $f(x, y)$  is composed of light objects on a dark background. The pixel intensity levels of the object and the background are grouped into two dominant modes. In global threshold, a threshold value  $T$  is selected in such a way that it separates the object and the background. The condition for selecting  $T$  is given as follows:

$$g(x, y) = \begin{cases} 1 & \text{if } f(x, y) > T \\ 0 & \text{if } f(x, y) \leq T \end{cases} \dots\dots\dots (1)$$

Equation (1) has no indication on selecting the threshold value  $T$ . The threshold  $T$  separates the object from the dark background. Any point  $(x, y)$  for which  $f(x, y) \geq T$  is called an object point. After threshold

operation, the image is segmented as follows: Pixels labeled 1 corresponds to object whereas pixels labeled 0 corresponds to the background. In global threshold, the threshold value  $T$  depends only on gray levels of  $f(x, y)$ . Global threshold technique will not produce the desired output when pixels from different segments overlap in terms of intensities [3]. The overlapping of intensities may be caused due to (a) noise (b) variation in illumination across the image. In the first case, minimum-error method can be used to estimate the underlying cluster parameters and the threshold is chosen to minimize the classification error. Variable threshold technique is used for the latter case. Global threshold is popular due to simplicity and easy implementation [6][7].

### 3.2 Local Threshold

Global threshold method is not suitable whenever the background illumination is uneven. In local threshold technique, the threshold value  $T$  depends on gray levels of  $f(x, y)$  and some local image properties of neighboring pixels such as mean or variance [2].

The threshold operation with a locally varying threshold function  $T(x, y)$  is given by

$$g(x, y) = \begin{cases} 1 & \text{if } f(x, y) \geq T(x, y) \\ 0 & \text{if } f(x, y) < T(x, y) \end{cases} \quad \dots\dots\dots (2)$$

where

$$T(x, y) = f_0(x, y) + T_0 \quad \dots\dots\dots (3)$$

$f_0(x, y)$  is the morphological opening of  $f$ , and the constant  $T_0$  is the result of function *graythresh* applied to  $f_0$ . Local threshold is superior to the global threshold method in the case of poorly illuminated images [6].

### 3.3 Adaptive Threshold

Adaptive threshold technique is used when images are captured under unknown lightning condition and it is required to segment a lighter foreground object from its background or whenever the background gray level is not constant and object contrast varies within an image. This technique allows the threshold value  $T$  to change based on the slowly varying function of position in the image or on local neighboring hood statistics. Threshold  $T$  depends on the spatial coordinated  $(x, y)$  themselves[6].

## 4. Threshold Selection

The key parameter in image segmentation using threshold technique is the choice of selecting threshold value  $T$ . In case of manual threshold method, the threshold value  $T$  can be selected by the user with the help of image histogram. This method is generally accomplished by a tool that allows the user to select the threshold value  $T$  based on choice. In case of

automatic threshold selection method, the value of T can be chosen based on histogram, clustering, variance, means etc [8].

#### 4.1 Histogram based Threshold Selection

An image having an object on a contrasting background has a bimodal histogram. The two peaks correspond to the relatively large number of points inside and outside the object. The valley is commonly used to select the threshold gray level. If the image containing the object is noisy and degraded due to illumination artifacts the histogram itself will be noisy and will not be sharp. This can introduce an error in selecting the threshold value T. This effect can be overcome to some extent by smoothing the histogram using either a convolution filter or the curve-fitting procedure [3]. Histogram based thresholding is applied to obtain all possible uniform regions in the image[9].

Let P1 and P2 be the gray value of the peaks of the histogram. The threshold value T is given by

$$T = \frac{P_1 + P_2}{2} \dots\dots\dots (4)$$

Or T may be the gray level at the minimum between the two peaks.

$$T = \min_{u \in [P_1, P_2]} H(u) \dots\dots\dots (5)$$

Where H (u) is the histogram value at gray level u between P1 and P2

#### 4.2 Iterative based Threshold Selection

Iterative methods give better result when the histogram doesn't clearly define valley point. This method doesn't require any specific knowledge about the image. Iterative method has the ability to improve the anti-noise capability.[6]

Gonzalez and Woods [2002] describe the following iterative procedure:

1. Select an initial estimate for the threshold value (T). This can be done by selecting the midpoint between the minimum and maximum intensity values in the image.
2. Segment the image using T. This will produce two sets of pixels G1 and G2. G1 contains all pixels with intensity values  $\geq T$  and G2 Contains pixels values  $< T$ .
3. Compute average intensity values m1 and m2 for each set of pixels.  
m1 = average value of G1  
m2 = average value of G2
4. Compute new threshold value  $T = (m1+m2)/2$
5. Repeat steps 2 through 4 until the difference in T in successive iteration is smaller than a predetermined parameter  $\Delta T$ .

This iterative algorithm is a special one dimensional case of K-means clustering that converges at a local minimum. But the main

disadvantage is, a different initial estimate for T may give a different result [10].

## 5- Proposed System algorithm

In this section, we introduce a novel segmentation algorithm based on histogram analysis and iterative threshold concepts discussed in the earlier sections. The general structure of the segmentation process is presented in the Figure (1). The basic components of the proposed segmentation framework are presented as follows:

-*Input Image*. The cover image may be of any image format using the 8-bit, power of two's representation (Gray image).

-*Histogram*. The histogram of an image is considered as a probability distribution over the pixels values. Further, the thresholds should be chosen based on the distance between the valleys to peaks of the histogram.

- Iterative algorithm. The iterative algorithm compute a threshold T ( mean gray value of image ) by partition the image into G1 , G2 using T

Outputs Image: - Segmented Image (Binary Image).

The Segmentation process is a straight forward process where all necessary parameters are dictated based on the histogram analysis or iterative threshold. Input image is segmented into various uniform and non-uniform regions without any loss or integrity with reference to the input with highest efficiency and low time complexity, binary image is the key feature of the proposed segmentation process as the efficiency of the segmentation process depends on how wide the binary label matrix is defined. Then compute the mean value of G1,G2

### 5-1 Algorithm of proposed system

A- Steps Histogram algorithm ( Peskinness detection)

- 1- find the two highest local maximum peaks P1,P2 in the histogram that are at least at distance
- 2- find the lowest point valley (u ) in the histogram between p1 and p2
- 3- peakness =  $\min ((H(p1))/ H(p2))$
- 4- Take the combination (p1 ,p2) with the highest peakness
- 5- Threshold = take the N greater peakness (  $T = H (u)$  )

B- Steps Iterative algorithm

- 1- select initial estimate for threshold T
- 2- segment image using T
  - produce two pixel groups:
  - G1:all pixel values > T
  - G2: all pixel values < T
- 3- Compute average intensity values:
  - M1 for G1

- M2 for G2

4- Repeat steps 2 through 4 until difference ,  $T < S$

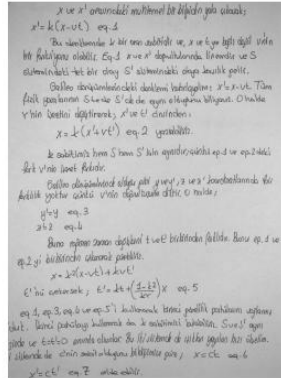
6- Experimental Results

Two segmentation methods are employed on 3 images such as: face, hand-written text and sky. Original gray level images are given below.

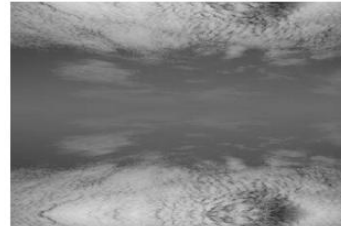
Face:



Text:



Sky:

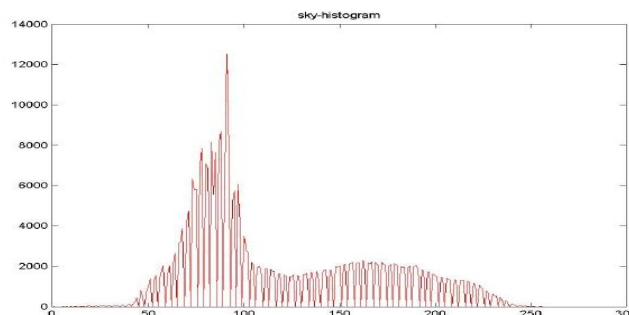
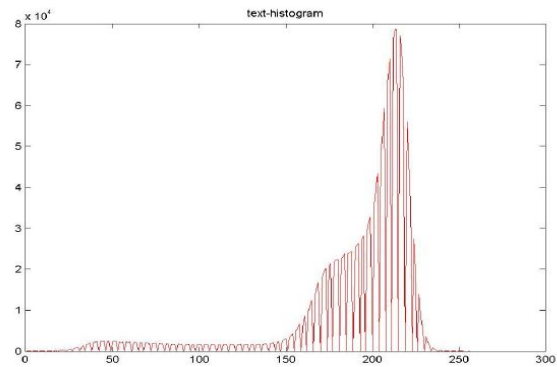
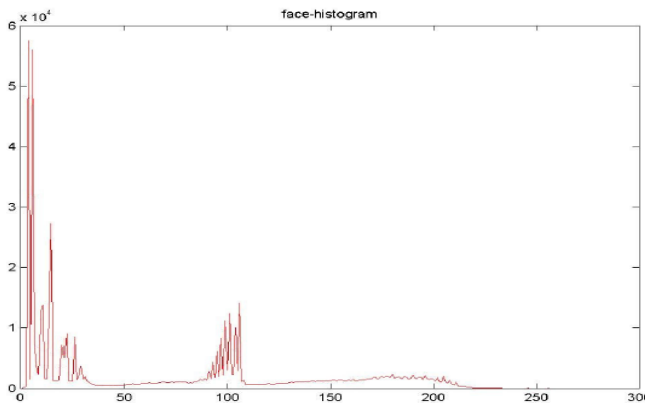


Face

Text

Sky

Histograms of these images are:

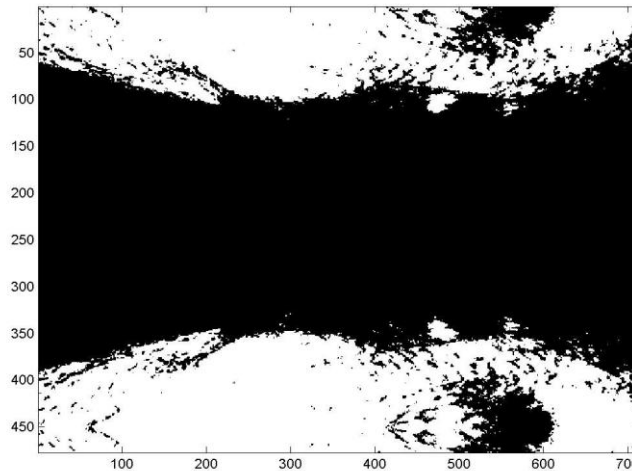
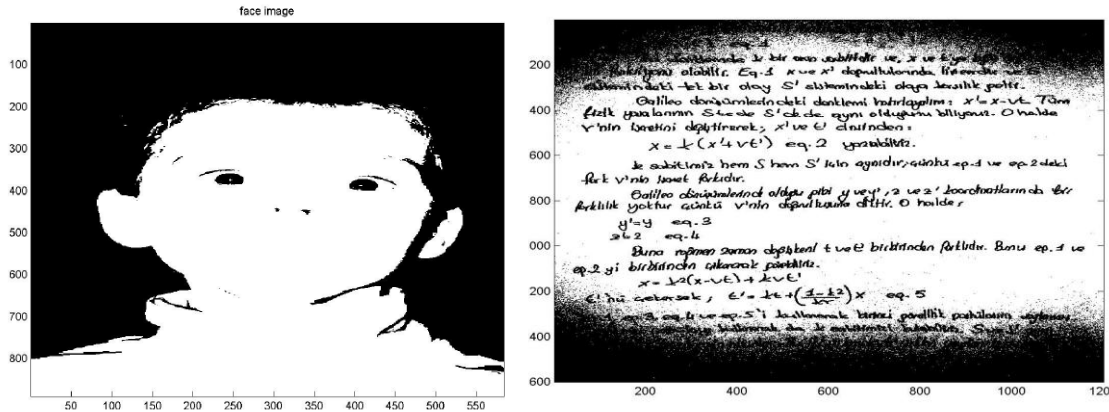


### 6-1 Histogram Algorithm

Take “Method of two Peaks” is employed by finding two local maximum points in the histogram and defining a threshold separating them.

Image	Face Image	Text Image	Sky Image
Threshold Value	55	129	153

Outputs

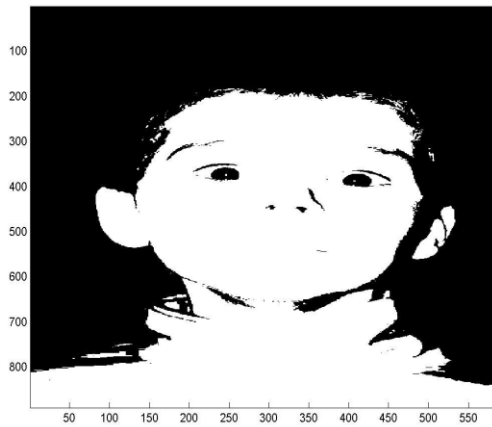


### 6-2 Iterative Threshold Method

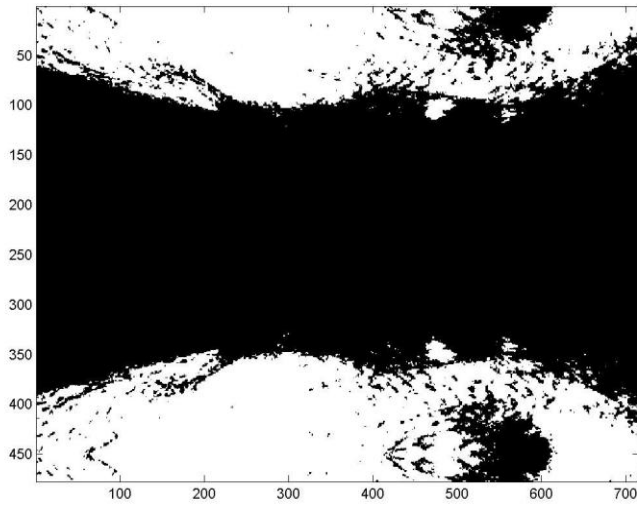
In this method a threshold is iteratively calculated and refined by consecutive passes through the image.

Image	Face Image	Text Image	Sky Image
Threshold Value	76	52	135

**Outputs**



$x$  ve  $x'$  arasında bir mültemel bir ilişkiyi göstermek için;  
 $x' = k(x - v + t)$  eq. 1  
 Bu denklemde  $k$  bir oran sabitidir ve,  $x$  ve  $t$  ye bağlı  $v$  nin bir fonksiyonu olabilir. Eq. 1  $x$  ve  $x'$  hesaplanırken lineer ve  $S$  sistemindeki tek bir olay  $S'$  sistemindeki olaya karşılık gelir.  
 Galileo deneyimlerinden elde edilen denklemleri kullanarak:  $x' = x - vt$ . Tüm fizik problemlerinde  $S$  ve  $S'$  de aynı ölçümleri kullanılır. O halde  $v$  nin yerini değiştirerek;  $x'$  ve  $t'$  arasındaki;  
 $x = k(x' + vt')$  eq. 2 yazılabilir.  
 İki sabitimiz hem  $S$  hem  $S'$  için aynıdır; çünkü eq. 1 ve eq. 2 deki  $k$  ve  $v$  nin aynı olduğu için.  
 Galileo deneyimlerinden elde ettiğimiz  $y = y'$ ,  $z = z'$  koordinatlarının bir ilişkisi yoktur çünkü  $v$  nin değeri sadece  $x$  dir. O halde;  
 $y = y'$  eq. 3  
 $z = z'$  eq. 4  
 Buna karşın zaman değişimi  $t$  ve  $t'$  arasındaki ilişki. Bunu eq. 1 ve eq. 2 yi birbirine eşitlersek elde ederiz.  
 $x = k(x - vt) + kvt'$   
 $t'$  ni çıkararak;  $t = k + t' \left( \frac{1 - k^2 v^2}{c^2} \right)$  eq. 5  
 eq. 1, eq. 3, eq. 4 ve eq. 5'i kullanarak birinci parantez içindeki üyeleri çıkartarak; ikinci parantezi kullanarak da  $k$  nin yerini bulabiliriz.  $S$  ve  $S'$  aynı yerde ve  $t = t' = 0$  anında oluncaya kadar  $S$  ve  $S'$  aynı yerde aynı zamanda  $x = ct$  ve  $x' = ct'$  eşitlikleri geçerlidir.  $x = ct$  eq. 6  
 $x' = ct'$  eq. 7 elde edilir.



**7- Comparative study between Histogram Algorithm and Iterative algorithm**

Threshold method is a suitable for simple image, while Histogram method use for image we can separate objects from background, but when iterative method use give better result when the histogram doesn't clearly define valley point, and the calculate time consuming is complexity with size of the image. Finally Threshold technique is computationally inexpensive and fast

**8- Conclusion**

Image segmentation by thresholing is a simple but powerful approach for segmenting images having light objects from dark background. Threshold technique is based on image-space regions i.e on characteristics of image, threshold operation convert a multilevel image into a binary image, it choose a proper threshold T, to divide image pixel into several regions and separate objects from background. Two types of threshold methods are in



existence, global and local threshold. When T is constant, the approach is called is global threshold otherwise it is called local threshold. Global threshold methods can fail when the background illumination is uneven. In local threshold, multiple thresholds are used to compensate for even illumination. There is no universally accepted method for image segmentation, as the results of image segmentation is affected by lots of factors, such as: homogeneity of images, spatial characteristics of the image continuity, texture, image content. Thus there is no single method which can be considered good for all type of images. Due to all factors, image segmentation remains a challenging problem in image processing and computer vision and is still a pending problem in the word.

### References:

- [1]- Tibor Moravcik, University of Zilina “Image Segmentation Programming Environment MATLAB” XI International PhD Workshop OWD 2009, 17-20 October 2009.
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**MatLab Code of Histogram algorithm**

```

%Two Peaks
%Segmentation
imface = imread('face.jpg');
imtext = imread('text.jpg');
imsky = imread('sky.jpg');
%FACE
histog=hist(double(imface),256);
histogram=sum(histog');
figure(2);plot(histogram,'r');title('face-histogram');
locmax=find(histogram==max(histogram));
T=zeros(1,256);
for hi=1:256
T(hi)=histogram(hi)*(hi-locmax)^2;
end
locmaxx=find(T==max(T));
tresh=(locmax+locmaxx)/2
imface(find(imface<tresh))=0;
imface(find(imface>=tresh))=1;
%Text
histog=hist(double(imtext),256);
histogram=sum(histog');
figure(4);plot(histogram,'r');title('text-histogram');
locmax=find(histogram==max(histogram));
T=zeros(1,256);
for hi=1:256
T(hi)=histogram(hi)*(hi-locmax)^2;
end
locmaxx=find(T==max(T));
tresh=(locmax+locmaxx)/2
imtext(find(imtext<tresh))=0;
imtext(find(imtext>=tresh))=1;
%Sky
histog=hist(double(imsky),256);
histogram=sum(histog');
figure(6);plot(histogram,'r');title('sky-histogram');
locmax=find(histogram==max(histogram));
T=zeros(1,256);
for hi=1:256
T(hi)=histogram(hi)*(hi-locmax)^2;
end
locmaxx=find(T==max(T));
tresh=(locmax+locmaxx)/2
imsky(find(imsky<tresh))=0;
imsky(find(imsky>=tresh))=1;
figure(1);colormap('gray'); imagesc(imface);title('face
image');

```

---

```
figure(3);colormap('gray'); imagesc(imtext);title('text
```

```
In this method a threshold is iteratively calculated and refined by consecutive
image');
```

```
figure(5);colormap('gray'); imagesc(imsky);title('sky
image');
```

### MatLab Code of iterative algorithm

```
%Iterative Selection
```

```
%Segmentation
```

```
clear all; clc;
```

```
imface = imread('face.jpg');
```

```
imtext = imread('text.jpg');
```

```
imsky = imread('sky.jpg');
```

```
tresholds=zeros(1,3);
```

```
%FACE
```

```
%calculate mean grey level
```

```
[rmax cmax]=size(imface);
```

```
T=0;
```

```
T=sum(sum(imface));
```

```
T=T/(rmax*cmax)
```

```
Tnew =-1;
```

```
while round(T)~=round(Tnew) %not equal
```

```
if Tnew~=-1
```

```
T=Tnew;
```

```
end
```

```
Tlow=
```

```
sum(sum(imface(find(imface<T))))/max(size(find(imface<T)))
```

```
Thigh=
```

```
sum(sum(imface(find(imface>=T))))/max(size(find(imface>=T)))
```

```
Tnew=(Tlow+Thigh)/2
```

```
end
```

```
imface(find(imface<T))=0;
```

```
imface(find(imface>=T))=1;
```

```
figure(1);colormap('gray'); imagesc(imface);
```

```
tresholds(1,1)=T;
```

```
%Text
```

```
%calculate mean grey level
```

```
[rmax cmax]=size(imtext);
```

```
T=0;
```

```
T=sum(sum(imtext));
```

```
T=T/(rmax*cmax)
```

```
Tnew =-1;
```

```
while round(T)~=round(Tnew) %not equal
```

```
if Tnew~=-1
```

```
T=Tnew;
```

```
end
```

```
Tlow=
```

```

sum(sum(imtext(find(imtext<T))))/max(size(find(imtext<T)))
Thigh=
sum(sum(imtext(find(imtext>=T))))/max(size(find(imtext>=T)))
Tnew=(Tlow+Thigh)/2
end
imtext(find(imtext<T))=0;
imtext(find(imtext>=T))=1;
figure(2);colormap('gray'); imagesc(imtext);
tresholds(1,2)=T;
%Sky
%calculate mean grey level
[rmax cmax]=size(imsky);
T=0;
T=sum(sum(imsky));
T=T/(rmax*cmax)
Tnew =-1;
while round(T)~=round(Tnew) %not equal
if Tnew~=-1
T=Tnew;
end
Tlow=
sum(sum(imsky(find(imsky<T))))/max(size(find(imsky<T)))
Thigh=
sum(sum(imsky(find(imsky>=T))))/max(size(find(imsky>=T)))
Tnew=(Tlow+Thigh)/2
end
imsky(find(imsky<T))=0;
imsky(find(imsky>=T))=1;
figure(3);colormap('gray'); imagesc(imsky);
tresholds(1,3)=T;
thresholds

```

### المستخلص

ان تقنية تقطيع (تجزئة) الصورة هي عملية تجزئة الصورة الى مناطق مترابطة ومتجانسة وفقا لمعيار محدد كاللون، وشدة الاضاءة لغرض تحديد اجزاء وحواف الصورة. وتوجد عدة خوارزميات وتقنيات لغرض استخدام طريقة العتبة في تقطيع الصورة. وتم في هذا البحث تطوير ومناقشة استخدام خوارزميتين في هذه التقنية. الاولى خوارزمية المدرج التكراري وفي هذه الخوارزمية تم استخدام اصغر قمتين في الصورة الرمادية لتحديد قيمة العتبة (ثابتة). بينما في الخوارزمية الثانية وهي الطريقة التكرارية يتم استخدام قيمة (متغيرة) للعتبة في كل دورة لغرض تقطيع الصورة. واخيرا سوف نحصل على الصورة الثنائية. وفي هذا البحث استخدامنا بيئة برمجة لغة ماثلاب في برمجة الخوارزميات، وكذلك تم وصف مقارنة بين الخوارزميتين من خلال ذكر بعض فوائد ومساوي استخدام هذه الخوارزميات.