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About this book

This book contains revised and extended research articles written by prominent researchers, selected from presentations at the International MultiConference of Engineers and Computer Scientists (IMECS 2018) held in Hong Kong, 14-16 March, 2018. Topics covered include engineering physics, communications systems, control theory, automation, engineering mathematics, scientific computing, electrical engineering, and industrial applications. The book gives a snapshot of selected advances in engineering technologies and their applications, and will serve as a useful reference for researchers and graduate students in these fields.

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About the authors

Table of contents (28 chapters)

Table of contents (28 chapters)

Table of contents (28 chapters)

Chapter 14

A COMPARATIVE ANALYSIS OF IMAGE SEGMENTATION METHODS WITH MULTIVARIOUS BACKGROUND AND INTENSITY

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Abstract: Segmentation is the process of separating the object into parts that generally separates the foreground and background. The techniques proposed segmentation using different approaches and based on the problems in the background pattern and intensity of the image. There are 10 (ten) techniques used are Adaptive Threshold, Region Growing, Watershed, YCbCr-HSV, K-Means, Fuzzy C-Means, Mean Shift, Grab Cut, Skin Color HSV, and Otsu Gaussian. Spoken image using American Sign Language fingerspelling of ASL University, fingerspelling primary image and the retinal image of STARE. ASL fingerspelling is fingerspelling which is standard in sign language so that the application of these ten segmentation techniques can help maximize the application of pattern recognition. While the retinal image is used to separate the blood vessels. Measuring the quality of segmentation using the Root Mean Square Error (RMSE) and Peak Signal to Noise Ratio (PSNR), the experimental results show that all tested techniques that produce an average PSNR above 40dB, meaning segmentation techniques work well in both datasets. In ASL fingerspelling dataset, a technique that generates the highest PSNR Skin Color whereas techniques for segmentation of vessels on the Retinal dataset namely Adaptive thresholding technique.

Keywords: Adaptive Threshold, Biometric Image, Fuzzy C-Means, K-Means, Mean Shift, Otsu Gaussian, Region Growing, Segmentation, Skin Color Watershed, YCbCr-HSV

1. INTRODUCTION

In the system of recognition and identification of digital image data acquisition are often susceptible to interference (noise), which in this case research is the brightness (brightness), the complexity of the background. In this research, the luminance noise is divided into two, which is too dark or too bright. Background complexity occurs because of differences in color, shape (pattern) that affect the introduction of foreground-background. So as a challenge to overcome this problem by distinguishing foreground and background so that objects can be recognized.

Image segmentation is a process of dividing the image into regions or characteristics[1], Each pixel in the image are allocated to categories. Segmentation is said to be good if it meets one of the criteria, namely, pixels in the same category have a similar scale value and form an interconnected region or neighboring pixels that are in different categories have different values.

According to [2,3,4], there are three categories in which Intensity-Based segmentation (thresholding), Region-Based (Region Growing, Split and Merge) and Other Methods (Texture, Edge, Motion or Color). A thresholding segmentation makes pixels grouped into groups divided by the threshold value. In the region-based segmentation algorithm iteratively operates by classifying pixels which neighbors and have similar values and separate groups of pixels whose value is not the same. Meanwhile, edge-based segmentation, edge filter applied to the image, pixel pixels classified as edge or non-edge hanging out, and pixels are not separated by the edges, is allocated in the same category.

2. Datasets

Testing techniques using datasets fingerspelling of ASL American Sign Language University (ASLU), fingerspelling primary and STARE retinal image. We used the dataset for fingerspelling which is starting from 1 to 10 of American Sign Language and the retina is based on the type of disease. There are 8 intensity and pattern of a different background for ASL fingerspelling and 1 intensity and background patterns on the Retinal. The size of the image dataset has dimensions of 200x200 pixels.

3. INTENSITY BASED: ADAPTIVE THRESHOLD

The value of T (x, y) is the thresholding that complies:

$$h(a,b) = \begin{cases} 0, & if \;\; c(a,b) \leq T(a,b) \\ 1, & otherwise \end{cases}$$

f(x, y) is the intensity of the input image as the pixel at (x, y) and. If the value of T (x, y) is given equally to all of the input images, then this process is called global thresholding, but when the value of T (x, y) is given differently depending on the value of the parameter statistical around (x, y), this process called Adaptive thresholding (local thresholding). $f(x,y) \in [0,1]$. Adaptive thresholding algorithm is as follows:

Algorithm 1: Adaptive Threshold

```
BEGIN
1.  Input RGB image
2.  new_image ← image
3.  Initialize size of neighborhood area
4.  Covert RGB image to grayscale image
5.  FOR x in image_width DO
6.    FOR y in image_height DO
7.       Threshold ← mean(neighborhood
                         image_pixel_x,y)
8.       IF image_Pixel_x,y < Threshold
9.       THEN
10.        new_image_pixel_x,y = 0
11.      ELSE
12.        new_image_pixel_x,y = 255
13.      END IF
14.    END FOR
```

```
15. END FOR
END
```

4. BASED REGION: GROWING REGION

Region Growing is the method of approach to image segmentation by starting from a few pixels (seeds), which represent a different image area and grow to form a wider region in the image. To use this method required rules that explain the mechanism of growth and homogeneity rules each region having grown[5,6]:

Algorithm 2: Growing Region:

```
BEGIN
1. Input the image
2. Initialize number of neighbors
3. Initialize threshold value
4. FOR x in image_width
5.    FOR y in image_height DO
6.      Initialize region S_i
7.      FOR EACH neighbor_pixel_x,y DO
8.        d ← distance(pixel_x,y, neighbor_pixel_x,y)
9.        IF d <= threshold
10.       THEN
11.         Add neighbor_pixel_x,y
12.       END IF
13.     END FOR
14.   END FOR
15. END FOR
END
```

5. Watershed

Watershed transformation is based on morphological transformation functions for image segmentation. Use of the watershed is recognized as a powerful method because it has the advantage of speed and simplicity[7]. This method is the basis of development of edge detection[8,9]. Watershed Algorithm in[10] represents a watershed transformation is applied to image segmentation.

Algorithm 3: Watershed Transformation:

```
BEGIN
1. Input the image
2. Convert image into gray level.
3. Using the gradient magnitude as a function of segmentation.
4. Marking the foreground object.
5. Calculate background markers.
6. Calculating the watershed transformation of the function of the
   segmentation.
END
```

6. BASED COLOR: YCbCr-HSV

YCbCr-HSV techniques in this study had an algorithm as follows:

Algorithm 4: YCbCr-HSV Segmentation

```
BEGIN
  1. Input RGB image
  2. Convert RGB to HSV image
  3. Convert HSV to YCbCr image
  4. FOR x ← 0 to image_{width} DO
  5.    FOR y ← 0 to image_{height} DO
  6.       Calculate Hue_{x,y} and Saturation_{x,y} from
           YCbCr_{x,y} value
  7.       IF Hue_{x,y} <= Hue_{th} AND
  8.          Saturation_{x,y} <= Saturation_{th} THEN
  9.        Pixel_{x,y} is skin color
  10.          ELSE
  11.             PIxel_{x,y} NOT Skin color
  12.          ENDIF
  13.        END FOR
  14.      END FOR
  END
```

7. CLUSTERING BASED: K-MEANS

K-Means technique is that unsupervised clustering techniques with the aim of minimizing the number of squared distances between all the points and the center of the cluster. This procedure follows a simple and easy way to classify a given set of data through a number of previously defined clusters. K-Means algorithm is as follows:

Algorithm 5: K-Means Clustering

```
BEGIN
  1. Input the image
  2. Initialize number of cluster K
  3. Initialize error tolerance
  4. Convergence ← False
  5. Initialize K cluster centers by random
  6. WHILE NOT Convergence:
  7.    FOR EACH pixel in image DO
  8.       calculate distance between pixel and cluster
           centers
  9.       find the smallest distance and assign pixel
           to that cluster
  10.            calculate cluster error
  11.            IF cluster error < error tolerance
  12.            THEN
  13.              Convergence ← True
  14.            ELSE:
```

```
15.               Update cluster centers
16.             END IF
17.           END FOR
18.       END WHILE
END
```

8. CLUSTERING BASED: Fuzzy C-MEANS

This is the development of low-level segmentation techniques where this approach uses the concept of region growing and pyramid data structure in the analysis of aerial imagery hierarchy. FCM algorithm approach has a higher level of an image obtained by averaging the four lower-level image and block the effects observed in the process of segmentation that this technique including good initial approach and are often developed in any research[11]. The fuzzy C-Means algorithm is as follows:

Algorithm 6: `Fuzzy C-Means`

BEGIN

1. Initialization U ← [u_{ij}] matrix, U $^{(0)}$
2. In step k: calculate the vector center of C $^{(k)}$ ← [c_j] with U $^{(k)}$

$$c_j = \frac{\sum_{i=1}^{N} u_{ij}^{m} \cdot x_i}{\sum_{i=1}^{N} u_{ij}^{m}}$$

3. Update U$^{(k)}$, U$^{(k+1)}$

$$u_{ij} = \frac{1}{\sum_{k=1}^{C} \left(\frac{\| x_i - c_j \|}{\| x_i - c_k \|} \right)^{\frac{2}{m-1}}}$$

4. **IF** $\|U^{(k+1)} - U^{(k)}\| < \varepsilon$
5. **THEN**
6.   STOP
7. **ELSE**
       GOTO step 2
8. **END IF**

END

9. clustering based: MEAN SHIFT

Mean Shift is one of the methods that categorized as an unsupervised clustering segmentation method. In addition, the termination process of segmentation is based on several strategies incorporation of the territory that is applied to the images that are being filtered, and the number of regions in the image is segmented primarily determined by the minimum number of pixels in a region, which is denoted as M (ie, the region containing less than M pixels will be eliminated and merged into neighboring regions).

Algorithm 7: `Mean Shift`

```
BEGIN
   1. Initialize number of data point neighbor N(p), where p ∈ Pixels.
   2. Initialize kernel K(d), where d is distance formula
   3. REPEAT
   4.    FOR EACH data point p in image DO
   5.       Find the neighbor point of p, N(p)
   6.    FOR EACH data point p DO
   7.       Calculate Mean Shift m(p), where
```

$$m(p) \longleftarrow \frac{\sum p_i \in N_{(p)} K(p_i - x) p_i}{\sum p_i \in N_{(p)} K(p_i - x) p_i}$$

```
   8.    FOR EACH data point p DO
   9.     p ← m(x)
   10.      UNTIL convergence
  END
```

10. GRAB CUT

Grab Cut works based on pixel color distribution (intensity) and so this technique has the ability to delete interior pixels that are not part of the object. The Grab Cut algorithm can be described as follows:

Algorithm 7: `Grab Cut`

1. `Initialize foreground pixel`
2. `Initialize background pixel`
3. `Initialize unknown pixel`
4. `Foreground and Background are modeled as Gaussian Mixture Model using Orchard-Bouman clustering algorithm.`
5. *`Each pixel is assigned a Gaussian component most likely in the foreground GMMs and the rest is background GMMs.`*
6. *`GMMs newly learned from a collection of pixels that have been created in step 5.`*
7. *`Graph Cut is created and it is used to search for a new classification of the pixels of the foreground and background.`*
8. *`Repeat steps 4-6 until classification is completed`*

11. SKIN COLOR: HSV

The HSV value which is set for the ASL fingerspelling and retinal datasets in this study are as follows:

Lower RGB to Gray = R: 80 G: 255 B: 20 to H: 105° S: 92.2% V: 100%

Upper RGB to Gray = R: 255 G: 255 B: 0 to H: 60° S: 92.2% V: 100%

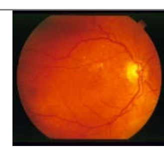
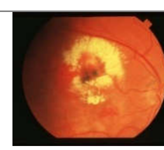
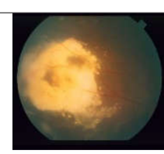
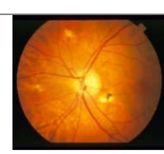
12. Otsu gaussian

This method is using Gaussian blur to disguise noise in the image and then the Otsu method is implemented as a segmentation technique. At the kernel we set 3x3 to define standard Gaussian so that we got the same result[12].

13. RESULT AND ANALYSIS

Testing methods using 10 images of American Sign Language University (ASLU) with one type of background and intensity, 71 images from the primary dataset with 7 kinds of background and different intensities. For the retinal, there are 84 diseased images from 6 types of blood vessel pattern and intensity within the same range. This is done with the aim to test the 10 methods of segmentation that is Adaptresh, Region Growing, Watershed, YCbCr-HSV, Fuzzy C-Means, K-Means, Mean Shift, Grab Cut, Skin Color, and Otsu Gaussian.

Table 1. Illustration of ASL fingerspelling and Retinal Image with 8 Background and Different Patterns

Type of Backgrounds	Fingerspelling ASL	Disease Names	Retinal STARE
Background 1		Background Diabetic Retinopathy	
Background 2		Branch Retinal Vein Occlusion	
Background 3		Choroidal neovascularization	
Background 4		Coats	
Background 5		Histoplasmosis	

Background 6		**Myelinated Nerve Fibers**	
Background 7			
Background 8			

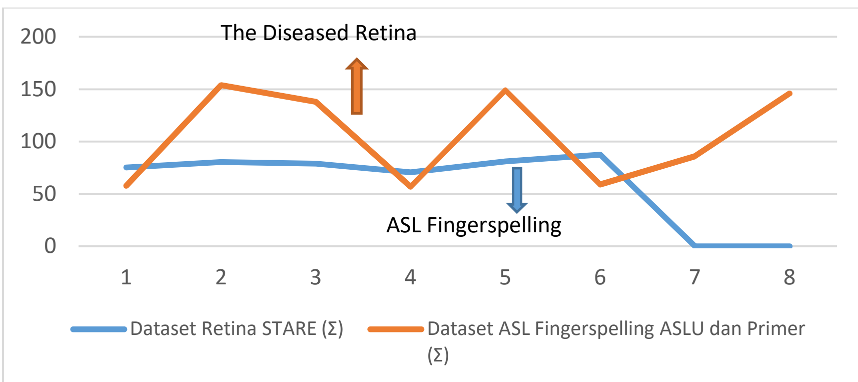


Figure 1. Average Graph of Intensity Level of 8 background types ASL Fingerspelling and 6 Types of Disease Retinal Patterns

From the graph in Figure 1, it can be hypothesized that the intensity can affect the results (image segmented). In testing dataset ASLU (American Sign Language University) and primary dataset (doc. Private), the intensity in the range of 57-86 grades is sufficient conditions dark image while the intensity in the range of 138-154 is quite a bright image with the condition. While the retinal image has an average range of 50-60 where the comparison of which 50 were quite dark and 60 are quite bright.

In addition to the intensity of the condition of an effect, there are other factors that also affect, i.e. the pattern of the background. If it is quite complicated as the text or other images and if we just do the background-foreground separation (segmentation), the pattern of the background and the shadow belong to the foreground as a joined identified.

Table 2a. The Result of ASL Fingerspelling Image using 5 Methods in Segmentation

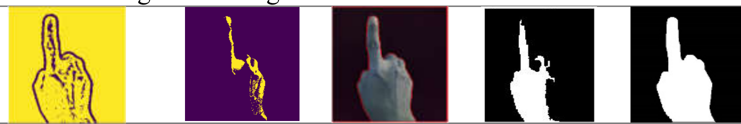
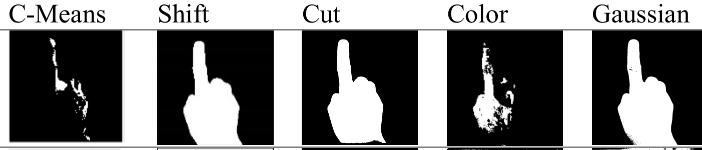
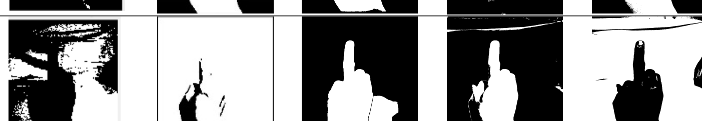
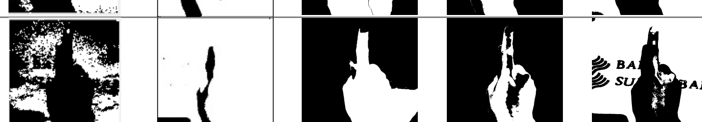
Type of Background	Adaptive Thresholding	Region Growing	Water shed	YCbCr-HSV	K-Means
Back-ground 1					
Back-ground 2					
Back-ground 3					
Back-ground 4					
Back-ground 5					
Back-ground 6					
Back-ground 7					
Back-ground 8					

Table 2b. The result of ASL fingerspelling image using other 5 Methods in Segmentation

Type of background	Fuzzy C-Means	Mean Shift	Grab Cut	Skin Color	Otsu Gaussian
Back-ground 1					
Back-ground 2					
Back-ground 3					
Back-ground 4					

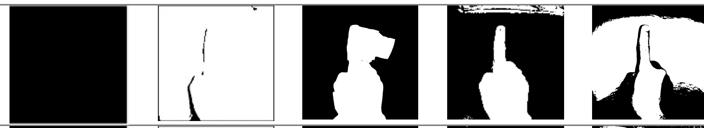
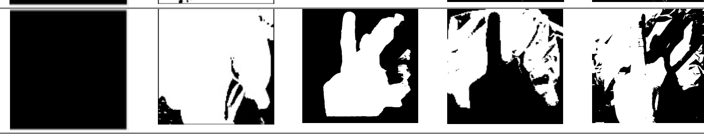
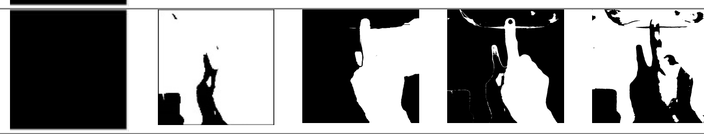
Back-ground 5					
Back-ground 6					
Back-ground 7					
Back-ground 8					

Table 3a. The Results of Retinal Image using 5 Methods in Segmentation

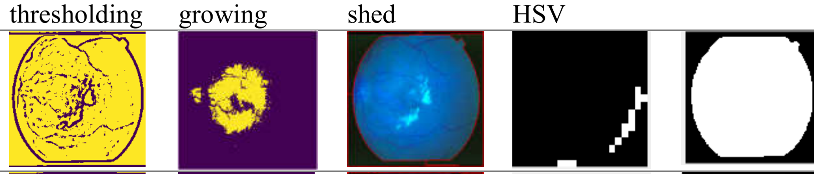
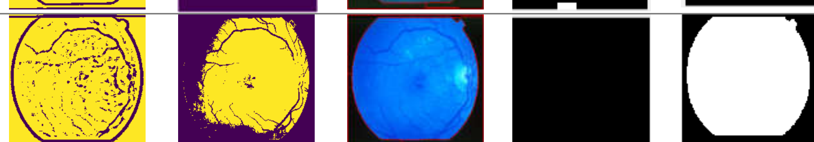
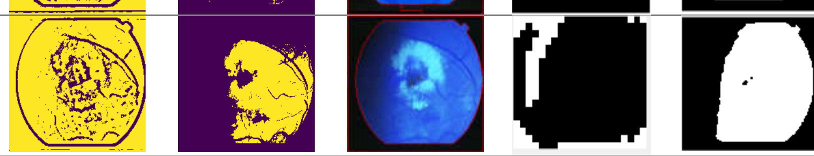
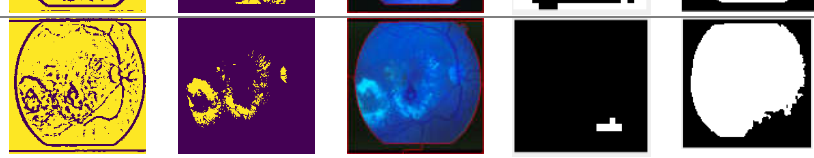
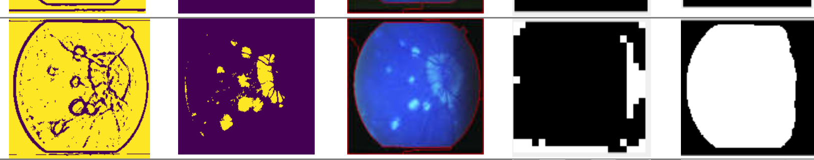
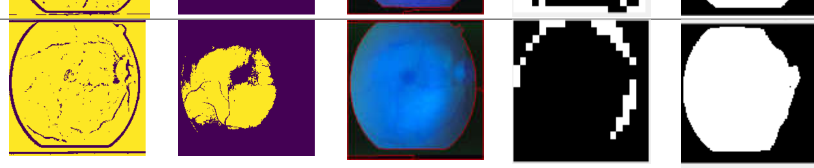
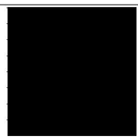
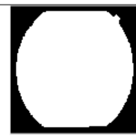
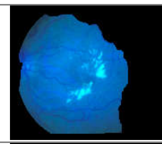
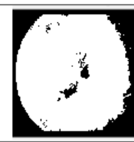
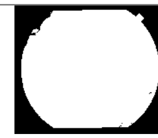
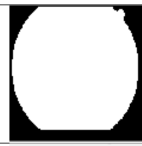
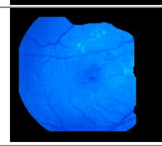
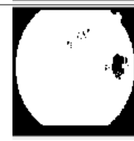
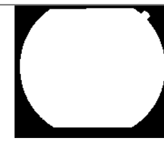
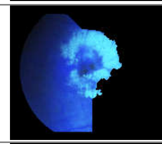
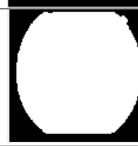
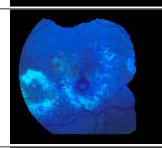
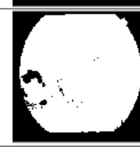
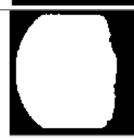
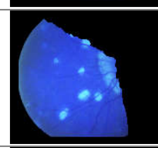
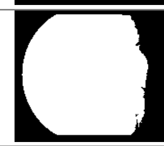
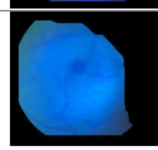
Type of Disease	Adaptive thresholding	Region growing	Water shed	YCbCr-HSV	K-Means
Background Diabetic Retinopathy					
Branch Retinal Vein Occlusion					
choroidal Neovas cularization					
Coats					
Histoplas Mosis					
Myelinated Nerve Fibers					

Table 3b. The Results of Retinal Image using other 5 Methods in Segmentation

Type of Disease	Fuzzy C-Means	Mean Shift	Grab Cut	Skin Color	Otsu Gaussian
Background Diabetic Retinopathy					
Branch Retinal Vein Occlusion					
choroidal Neovas cularization					
Coats					
Histoplas Mosis					
Myelinated Nerve Fibers					

Data representation from RMSE is a parameter to find out the difference between the original image and the segmented image, where the closer to 0, the bigger the image is identified.

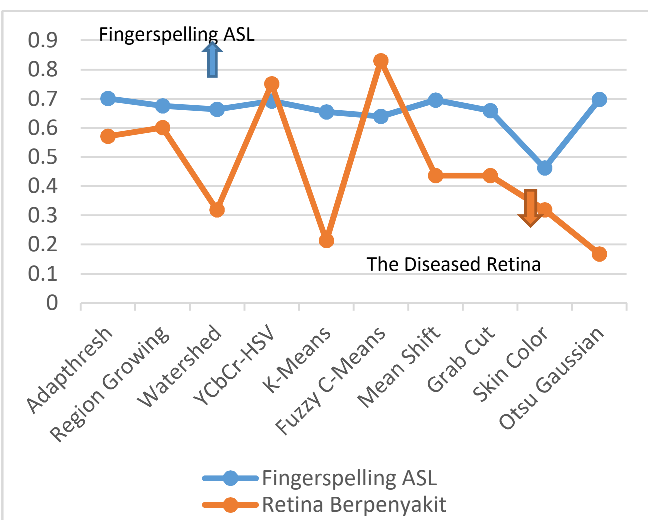


Figure 2. The Comparison of RMSE Average in ASL Fingerspelling Dataset ASLU and Primary and Retinal STARE

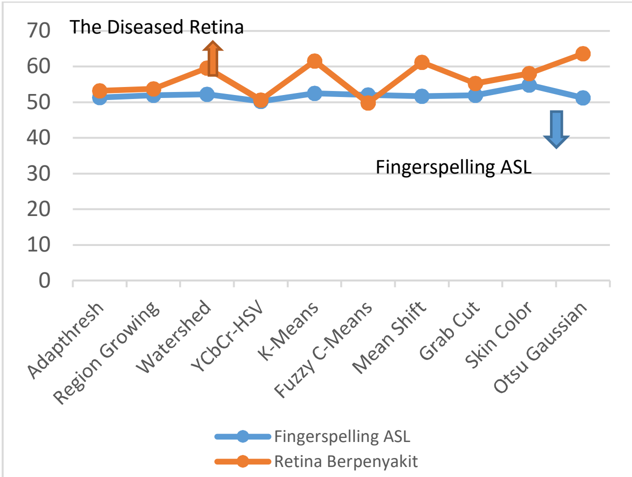


Figure 3. The Comparison of PSNR Average in ASL Fingerspelling Dataset ASLU and Primary and Retinal STARE

In the background one with specification range of intensities of 75.2 and black background, the best technique is the technique of Mean Shift, background 2 with specification range of intensities of 154 and a plain white background, the best technique is a technique YCbCr. Mechanical Skin Color produces the best segmentation for background 3, 5 and 8. Background 3 with a yellow background and patterned specification text with a range of intensities of 138, background 5 with plain white specs that its intensity range at 149 and background 8 with a range of intensities of 146 and white background, slightly yellow. While on the retinal image, adaptive thresholding techniques produce well at recognizing the blood vessels by 53.19 dB PSNR.

14. Conclusion

From the data of test results and data representation of the above, it can be concluded that the method of segmentation based on background with a background in mono-color intensity is quite light, a technique well segmented is Skin Color and K-Means successfully segmenting 4 types of background are: Background 1, 2, 4, 5 and 2, 3, 5, 8. for Gaussian Otsu techniques and YCbCr-HSV successfully segmenting the 3 types of background: Background 1, 2, 8 and 1, 2, 5. While the technique of Adaptive Thresholding produces the best segmentation in identifying blood vessels compared to other techniques.

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