Forward image compression using segment level-plurality (FSLP)

Dr. Tariq Mohammed Salman
Lecturer, College of Engineering,
Electrical Engineering Department, Al-Mustansirya University

Abstract

To solve the problems of digital image processing for mapping, surveillance, recognition, video transmission and other areas used the image compression techniques. One way of image compression is image segmentation, there are number of segmentation methods based on the division and merging areas, which are widespread due the relative ease of implementation. The disadvantage of these methods is the appearance of segmentation faults structurally complex areas of pixels and lack of adaptation to the constraints of computational-enforcement resources, computation time and the vulnerability against changing brightness and contrast and weakness via the noise effect. The proposed method (FSLP) is more robust against the change in brightness and contrast and less affected by noise compared with the two-segmentation method used in the increment of (20-25%).

Keywords:

Classic Quad-tree Segmentation CQTS, Modification Quad-tree Segmentation MQTS, forward image segmentation based on the reverse lay-polarization (FSLP)

تقنية ضغط الصور الرقمية بالاعتماد على مستوى تعددية القطع

م.د. طارق محمد سلمان
الجامعة المستنصرية/ كلية الهندسة
قسم الهندسة الكهربائية

الخلاصة:

لغرض حل مشاكل معالجة الصور الرقمية في تطبيقات مثل رسم الخرائط الرقمية، والمراقبة الفديوية، وانظمة استحصال المعلومات، وانظمة نقل الفيديو وتقنيات ضغط الصور الرقمية وغيرها من الاستخدامات، فأن احدى الطرق المستخدمة لضغط الصورة هي تجزئة الصورة، وهناك العديد من الطرق المستخدمة للتجزئة على أساس تقسيم ودمج المناطق، وهي مستخدمةعلى نطاق واسع بسبب السهولة النسبية في التنفيذ. وعيوب هذه الطرق هو ظهور اخطاء في ال تجزئة أخطاء هيكلية ذات عند تعقيد مجالات مساحات البكسل وعدم التكيف مع قيود الموارد الحسابية وزمن التنفيذ وشدة التأثر عند تغيير السطوع والتباين اللوني. في هذا البحث تم اقتراح طريقة (FSLP) هي أكثر قوة ضد التغيير في السطوع والتباين اللوني وأقل تتأثر الضجيج مقارنة مع أسلوبين مستخدمين للمقارنة في التجزئة بنسبة (20-25٪).

1. Introduction

In this paper, forward image segmentation based on the reverse level plurality [FSLP] is proposed. The aim of this paper is to develop a method for image segmentation that eliminates errors of highlighting areas of any structure and provides an image processing with limited computing resources and computing time, in the same time it must be more robust against the change in brightness and contrast. addition A method forward image segmentation [1-3], The essence of the method is tree clustering of uniform brightness regions and forming a plurality of pixels cluster of multiresolution images and quantity source-reflection (direct clustering); assigning number of clustered homogeneous areas at all levels of the multiresolution representation of the original image (reverse clustering); by adjacent homogeneous brightness clustered areas-bathrooms on each level of the multiresolution representation of the original image (Update segment numbers).

As a result, the line formed by clustering hierarchical approximation of the set of matrices (determined by the average brightness of the cluster) and clustering (defined uniformity of the cluster members) [4]. Matrix of each hierarchy level co-responsible to some cluster of multiresolution representation of the original image. This allow to implement the next phase of progressive segmentation, and secreting homogeneous area [5] first for large-scale representation of the image, and then gradually refines the boundaries of homogeneous regions in the lower hierarchy of small-scale representation of the image. By scaling them vertically and horizontally (selected based on the size of the cluster).

During reformation of hierarchical clustering segmentation for a set of matrices whose elements have given numbers with the corresponding segments as a result of the formation of new existing merged of uniform brightness areas. In addition, the identified neighboring homogeneous regions having identical average brightness [6], but has different numbers of segments, for their subsequent operations. Contacted clusters begin with the large-scale representation of the image and extends to a number of levels of the multiresolution representation of the image defined by limited processing time[7],[8].

As a result, more accurate numbers of segments are formed a resultant segmentation matrix, the size of which coincides with the size of the original image, or a multiple of it. Each element of the resulting segmentation matrix is not that same value of the image pixel or its multiresolution representation, and has some value of the number of the segment [9]. The method allows to eliminate a segmentation fault structurally complex areas by identifying neighboring homogeneous regions having the same mean value, but different numbers of segments.

The method adapts to limit the computing resources and computing time due to image segmentation at each level of its multiresolution representation.

2. Forward phase of clusterization operation

Algorithm of forward clustering method is consists of the following steps:

1) By generating plurality $\{A(l)\}_{(l=\overline{0,L})}$ matrix $A(l)=\left\|a^{(l)}(y,x)\right\|_{\left(y=\overline{0,Y/2^{l}-1},x=\overline{0,X/2^{l}-1}\right)}$ approximation and initialization of elements $A(0)$ with the 0th level in accordance with the expression $a^{(0)}(y,x)\Leftarrow p(y,x)$ where $y=\overline{0,Y-1}$, $x=\overline{0,X-1}$, $\Leftarrow$ is an assignment; $p(y,x)$ is pixel of segmented image $P=\left\|p(y,x)\right\|_{\left(y=\overline{0,Y-1},x=\overline{0,X-1}\right)}$; $Y=2^{f_Y}$, $X=2^{f_X}$ – the size of segmented image P; $f_Y>0$, $f_X>0$ – over all; $l=\overline{0,L}$ – number of iterations (level of segmentation); $L=\min(f_Y,f_X)$ – the number of iterations that determines the minimum of the values f_Y and f_X. As a result, we conclude an approximated image $A(0)$ by the using of the segmented image P.

2) By generating plurality $\{C(l)\}_{(l=\overline{0,L})}$ matrix $C(l)=\left\|c^{(l)}(y,x)\right\|_{\left(y=\overline{0,Y/2^{l}-1},x=\overline{0,X/2^{l}-1}\right)}$ clusterization and approximation of matrix elements $C(0)$, the 0th level of cluster in accordance with the expression $c^{(0)}(y,x)\Leftarrow 0$ at $y=\overline{0,Y-1}$, $x=\overline{0,X-1}$. In the resulted matrix, $C(0)$ clusterization of the 0th level which known as the zero level.

3) Initializing the counter of l cycles according with the expression of; $l\Leftarrow 1$.

4) By beginning a cycle of clustering, a matrix of clusters $C(l)$ will be formed with l-th level, element values are calculated using the following expression,

$$\forall\left(j=\overline{0,1}\right)\forall\left(i=\overline{0,1}\right)\left(a^{(l-1)}(2y+j,2x+i)=a^{(l)}(y,x)\right)\wedge\left(c^{(l-1)}(2y+j,2x+i)=0\right)\rightarrow\left(c^{(l)}(y,x)\Leftarrow 0\right),\quad(1)$$

$$\exists\left(j=\overline{0,1}\right)\exists\left(i=\overline{0,1}\right)\left(a^{(l-1)}(2y+j,2x+i)\neq a^{(l)}(y,x)\right)\vee\left(c^{(l-1)}(2y+j,2x+i)=1\right)\rightarrow\left(c^{(l)}(y,x)\Leftarrow 1\right)\quad(2)$$

at $y=\overline{0,Y/2^{l}-1}$, $x=\overline{0,X/2^{l}-1}$,

where $a^{(l)}(y,x)=\frac{1}{4}\sum_{j=0}^{1}\sum_{i=0}^{1}a^{(l-1)}(2y+j,2x+i)$ – the arithmetic mean of cluster elements with coordinates $(2y,2x)$ inside matrix $A(l-1)$ approximation of $(l-1)$-th level.

As a result, the zero clusters $\left\{c^{(l-1)}(2y+j,2x+i)\right\}_{(j=\overline{0,1},i=\overline{0,1})}$ matrix $C(l-1)$ of $(l-1)$-th level and the corresponding values for homogeneous clusters $\left\{a^{(l-1)}(2y+j,2x+i)\right\}_{(j=\overline{0,1},i=\overline{0,1})}$ matrix $A(l-1)$ approximation of $(l-1)$-th level are associated with zero elements $c^{(l)}(y,x)$ matrix $C(l)$. The 0th level cluster $\left\{c^{(l-1)}(2y+j,2x+i)\right\}_{(j=\overline{0,1},i=\overline{0,1})}$ matrix $C(l-1)$, also the zero level cluster $\left\{c^{(l-1)}(2y+j,2x+i)\right\}_{(j=\overline{0,1},i=\overline{0,1})}$ matrix $C(l-1)$, having a non-uniform values of the corresponding clusters $\left\{a^{(l-1)}(2y+j,2x+i)\right\}_{(j=\overline{0,1},i=\overline{0,1})}$ matrix $A(l-1)$ approximation, are assigned to the unit cells $c^{(l)}(y,x)$ matrix $C(l)$. By forming in this way for L cycles, L- level of zero tree, will describe the location of the cluster of homogeneous regions in a variety of $\{A(l)\}_{(l=\overline{0,L})}$.

5) Incrementing the cycle counter according to the expression $l \Leftarrow l+1$.

6) Closing the clustering loop, by verifying the conditions of $l \le L$. If it is done, then go to step number 4, otherwise, skip out of the loop and get out of the algorithm.

3. The reverse phase of clusterization operation

Algorithm of reverse clusterization consists of the following steps.

1) By generating plurality $\{S(l)\}_{(l=\overline{0,L})}$ matrix $S(l)=\left\|s^{(l)}(y,x)\right\|_{\left(y=\overline{0,Y/2^l-1},\,x=\overline{0,X/2^l-1}\right)}$ elements of segmentation and initialization matrix $S(l)$ segmentation level $\overline{0,L}$ in accordance with the expression $s^{(l)}(y,x) \Leftarrow 0$ at $l=\overline{0,L}$, $y=\overline{0,Y/2^l-1}$, $x=\overline{0,X/2^l-1}$. Because of this step, the matrix $S(l)$ segmentation level $\overline{0,L}$ is determined by zero level.

2) Setting counter initialization of N_A homogeneous region according to the expression $N_A \Leftarrow 1$.

3) Initialization of segmentation matrix $S(L)=\left\|s^{(L)}(y,x)\right\|_{(y=0,x=0)}$ of the L-th level, in which the value of a single element of which (the tree top segmentation) is calculated by using the expression

$$\left(c^{(L)}(y,x)=0\right) \to \left(s^{(L)}(y,x) \Leftarrow N_A, N_A \Leftarrow N_A+1\right) \qquad (3)$$

At $y=\overline{0,Y/2^L-1}, x=\overline{0,X/2^L-1}$.

From the equation (3), it is showing that for a uniform image $s^{(L)}(y,x)=0$, and for a non-uniform $s^{(L)}(y,x)=1$.

4) Initializing the counter with l number of cycle that satisfies the expression $l=L$.

5) Starting a cycle of progressive segmentation, forming values of the elements of the matrix $S(l-1)$ of $(l-1)$-th level by using the expression (scaling areas)

$$\left(c^{(l)}(y,x)=0\right) \wedge \left(c^{(l-1)}(2y+j,2x+i)=0\right) \to \left(s^{(l-1)}(2y+j,2x+i) \Leftarrow s^{(l)}(y,x)\right) \qquad (4)$$

At $y=\overline{0,Y/2^l-1}, x=\overline{0,X/2^l-1}$, $j=\overline{0,1}, i=\overline{0,1}$.

As a result $(l-1)$-th level matrix will be formed, for clustering the zero tree.

In general, there are four possible combinations of the respective values of the matrix clustering l–m, and $(l-1)$–m levels. For each processing, at the next will assumed that $(l-1)$–m level: (0,0) – the scaling region (the cluster of $(l-1)$–th level, will be inherit the segment number of the corresponding element l–th level); (1,0) – forming a new segment (element of $(l-1)$–th level, will results a new number of segment) or join an existing adjacent segments (element $(l-1)$–th level, results the number of the joined element of $(l-1)$–th level); (1,1) – not processed; (0,1) – an impossible combination.

6) Forming new areas (division of regions) according to the expression:

$$\begin{gathered}\left(c^{(l)}(y,x)=1\right)\wedge\left(c^{(l-1)}(2y+j,2x+i)=0\right)\wedge\\ \wedge\neg\exists(k\in[-1,1])\neg\exists(l\in[-1,1])\begin{pmatrix}a^{(l-1)}(2y+j,2x+i)=a^{(l-1)}(2y+j+k,2x+i+m)\wedge\\ \wedge\, s^{(l-1)}(2y+j+k,2x+i+m)\neq 0\end{pmatrix}\rightarrow\\ \rightarrow\left(s^{(l-1)}(2y+j,2x+i)\Leftarrow N_A,\, N_A\Leftarrow N_A+1\right)\end{gathered}\tag{5}$$

At $y=\overline{0,Y/2^l-1}, x=\overline{0,X/2^l-1},\ j=\overline{0,1}, i=\overline{0,1}, k=\overline{-1,1}, m=\overline{-1,1},\ k+m\neq 0$.

7) Initializing the matrix $N_B=\left\|n_B(p,q)\right\|_{(p=\overline{0,N_A-1},q=\overline{0,M_A-1})}$, which represents number of quantity $V_B=\left\|v_B(p)\right\|_{(p=\overline{0,N_A-1})}$ of adjacent areas for the same expressions $n_B(p,q)\Leftarrow 0$, $v_B(p)\Leftarrow 0$ at $p=\overline{0,N_A-1}, q=\overline{0,M_A-1}$, where M_A – the maximum number of adjacent identical areas.

8) Building up areas using their accession to existing homogeneous areas according to the expression

$$\begin{gathered}\left(c^{(l)}(y,x)=1\right)\wedge\left(c^{(l-1)}(2y+j,2x+i)=0\right)\wedge\left(s^{(l-1)}(2y+j,2x+i)=0\right)\wedge\\ \wedge\exists(k\in[-1,1])\exists(l\in[-1,1])\begin{pmatrix}a^{(l-1)}(2y+j,2x+i)=a^{(l-1)}(2y+j+k,2x+i+m)\wedge\\ \wedge\, s^{(l-1)}(2y+j+k,2x+i+m)\neq 0\end{pmatrix}\rightarrow\\ \rightarrow\left(s^{(l-1)}(2y+j,2x+i)\Leftarrow s^{(l-1)}(2y+j+k,2x+i+m)\right)\end{gathered}\tag{6}$$

At $y=\overline{0,Y/2^l-1}, x=\overline{0,X/2^l-1},\ j=\overline{0,1}, i=\overline{0,1}, k=\overline{-1,1}, m=\overline{-1,1},\ k+m\neq 0$.

9) The merging phase of homogeneous areas will be done according to the expression

$$\begin{gathered}\left(c^{(l)}(y,x)=1\right)\wedge\left(c^{(l-1)}(2y+j,2x+i)=0\right)\wedge\left(s^{(l-1)}(2y+j,2x+i)\neq 0\right)\wedge\\ \wedge\exists(k\in[-1,1])\exists(l\in[-1,1])\begin{pmatrix}a^{(l-1)}(2y+j,2x+i)=a^{(l-1)}(2y+j+k,2x+i+m)\wedge\\ \wedge\, s^{(l-1)}(2y+j+k,2x+i+m)\neq 0\wedge\\ \wedge\, s^{(l-1)}(2y+j+k,2x+i+m)\neq s^{(l-1)}(2y+j,2x+i)\wedge\\ \wedge\neg\exists(q\in[0,M_A])n_B\left(s^{(l-1)}(2y+j,2x+i),q\right)=\\ =s^{(l-1)}(2y+j+k,2x+i+m)\end{pmatrix}\rightarrow\\ \rightarrow\begin{pmatrix}n_B\left(s^{(l-1)}(2y+j,2x+i),v_B\left(s^{(l-1)}(2y+j,2x+i)\right)\right)\Leftarrow s^{(l-1)}(2y+j+k,2x+i+m),\\ v_B\left(s^{(l-1)}(2y+j,2x+i)\right)\Leftarrow v_B\left(s^{(l-1)}(2y+j,2x+i)\right)+1,\\ n_B\left(s^{(l-1)}(2y+j+k,2x+i+m),v_B\left(s^{(l-1)}(2y+j+k,2x+i+m)\right)\right)\Leftarrow s^{(l-1)}(2y+j,2x+i),\\ v_B\left(s^{(l-1)}(2y+j+k,2x+i+m)\right)\Leftarrow v_B\left(s^{(l-1)}(2y+j+k,2x+i+m)\right)+1\end{pmatrix}\end{gathered}\tag{7}$$

At $y = \overline{0, Y/2^l - 1}$, $x = \overline{0, X/2^l - 1}$, $j = \overline{0,1}$, $i = \overline{0,1}$, $k = \overline{-1,1}$, $m = \overline{-1,1}$, $k + m \neq 0$.

10) Reducing the loop counter according to the expression $l \Leftarrow l - 1$.

11) Ending the cycle of progressive segmentation. By check the condition $l > 0$. If it is done - go to step 5, otherwise - to exit the loop and completing the algorithm.

4. Clarification of segment numbers

The algorithm refinement segment numbers is consists of the following steps.

1) By forming the matrix of numbers $N_X = \left\| n_X(p,q) \right\|_{\left(p=\overline{0,N_A-1}, q=\overline{0,M_A-1}\right)}$, $N_C = \left\| n_C(p) \right\|_{\left(p=\overline{0,N_A-1}\right)}$ will replace of numbers $V_X = \left\| v_X(p) \right\|_{\left(p=\overline{0,N_A-1}\right)}$ of merged regions.

2) Initializing the segments counter $N_S \Leftarrow 0$.

3) Forming numbers of isolated homogeneous regions according to an expression

$$\exists\left(p \in [0, N_A]\right)\left(v_B(p) = 0\right) \rightarrow \left(\left(n_X(N_S, 0) \Leftarrow p\right), \left(n_C(p) \Leftarrow N_S\right), \left(N_S \Leftarrow N_S + 1\right)\right) \quad (8)$$

At $p = \overline{0, N_A - 1}$.

4) Initialize loop counter for the merged regions $p \Leftarrow 0$.

5) Beginning of a loop for the merged regions. Checking level value $\left(v_B(p) = 0\right)$. If the condition is satisfied, then go to step 12.

6) Identification of numbers for the first group, including the area according to an expression

$$\left(v_B(p) > 0\right) \rightarrow \left(\left(n_X(N_S, 0) \Leftarrow p\right), \left(v_X(N_S) \Leftarrow 1\right)\right). \quad (9)$$

7) Initializing the stack pointer that associate with region numbers $s \Leftarrow 0$.

8) Processing the stack according to expressions

$$\neg\exists\left(t \in [0, v_X(N_S) - 1]\right)\left(n_X(N_S, t) = n_B\left(n_X(N_S, s), q\right)\right) \rightarrow$$
$$\rightarrow \left(n_X\left(N_S, v_X(N_S) + q\right) \Leftarrow n_B\left(n_X(N_S, s), q\right), \left(v_X(N_S) \Leftarrow v_X(N_S) + 1\right)\right) \quad (10)$$

At $q = \overline{0, v_B\left(n_X(N_S, s)\right) - 1}$,

$$v_B\left(n_X(N_S, s)\right) \Leftarrow 0, \quad (11)$$

$$n_C\left(n_X(N_S, s)\right) \Leftarrow N_S. \quad (12)$$

9) Incrementing the stack pointer associated to region numbers $s \Leftarrow s + 1$.

10) Checking the level of the end of stack processing operation $s < v_X(N_S)$. If the condition met then go to step number 8, otherwise - go to the next step.

11) Incrementing segment number by one $N_S \Leftarrow N_S + 1$.

12) Incrementing cycle counter for the merged region $p \Leftarrow p + 1$.

13) Checking ending conditions of combining areas $p < N_A$. If the condition is met - go to step 5, otherwise - go to the next step.

14) Formation the resulting segmentation matrix $S_R = \|s_R(y,x)\|_{(y=\overline{0,Y-1},\, x=\overline{0,X-1})}$ resulting re-definition rooms homogeneous regions according to the expression

$$s_R(y,x) \Leftarrow n_C\left(s^{(0)}(y,x)\right) \quad (13)$$

At $y = \overline{0, Y-1}$, $x = \overline{0, X-1}$. Figure 1. Shows the steps of the proposed algorithm.

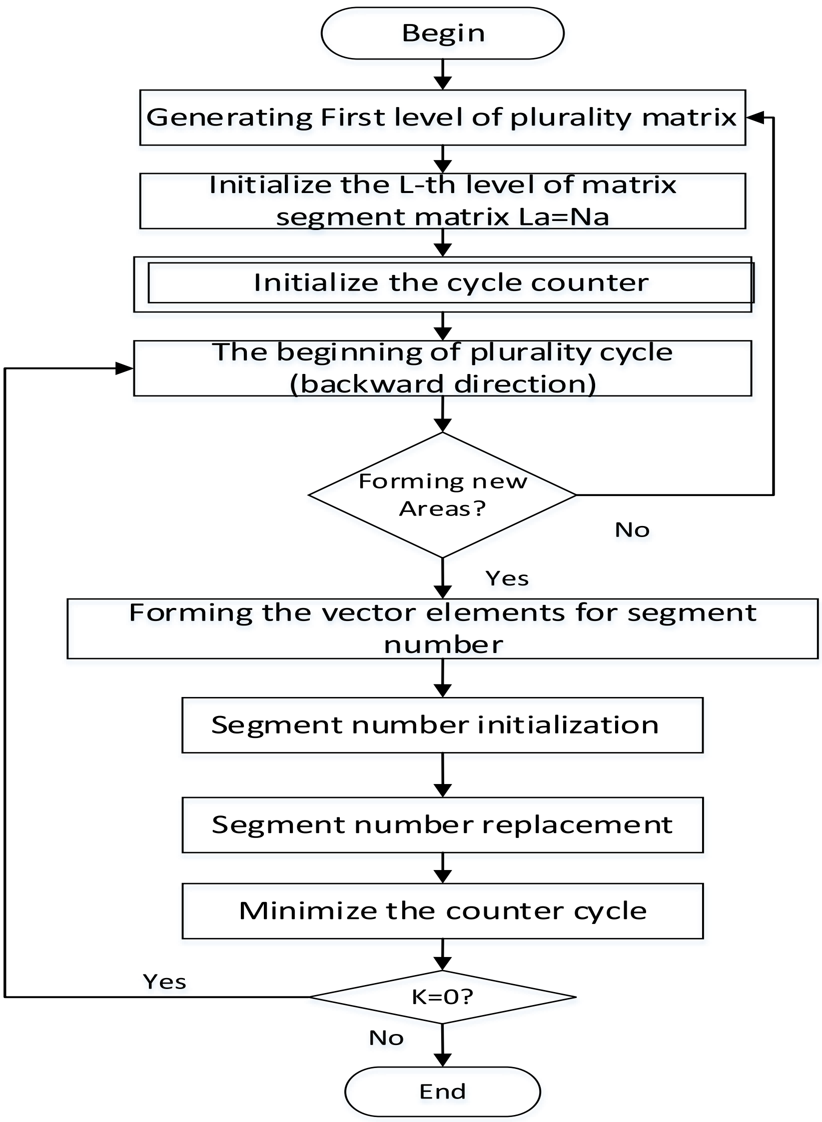
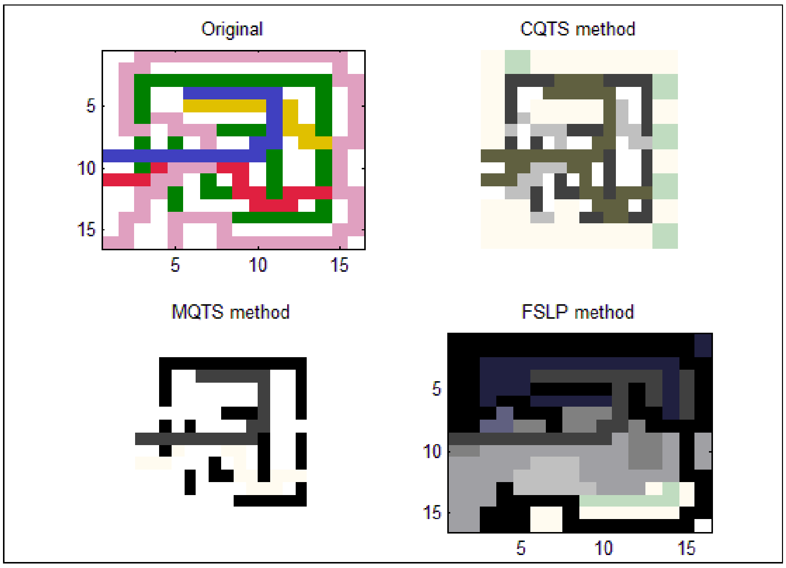


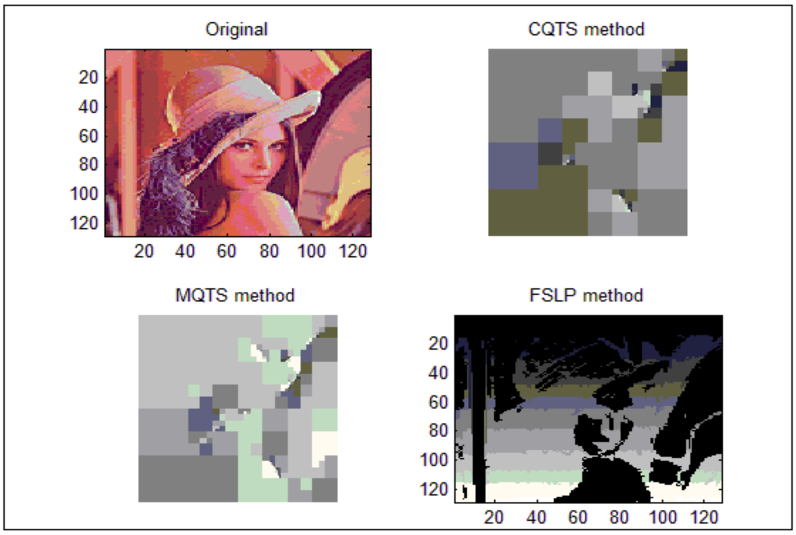
Figure 1. Flowchart of FSLP Method

5. Evaluation of Simulation results.

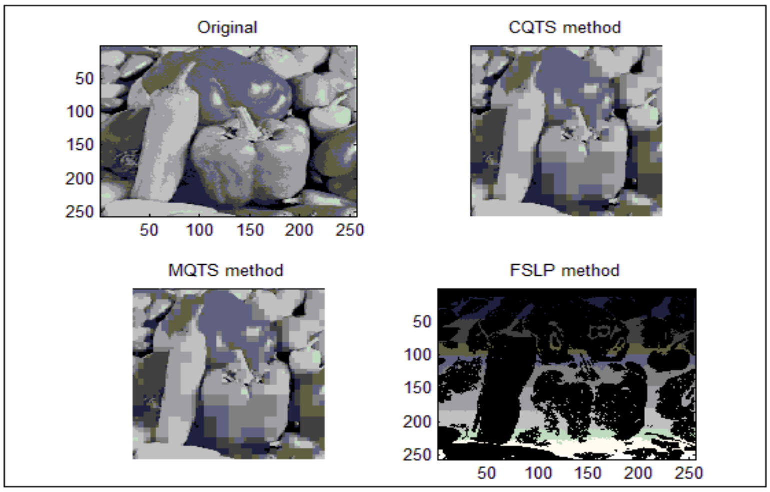
The proposed method **forward image segmentation based on the reverse lay-polarization (FSLP)** are compared with method CQTS split and merge regions based on quadtree [1, 2] and its modification MQTS [4]. As an example, Figure 2. presents the results of the segmentation of complex images obtained by the methods of **(FSLP)**, CQTS and MQTS in MatLab environment (used software-based methods and CQTS MQTS, a part of library MatLab). As follows from Figure 3 (a,b and c), results of the segmentation obtained by using the proposed method **(FSLP)**, will contains less errors, in case of firmness of brightness and contrast, when comparing the with results obtained using CQTS [2] and MQTS [4].



(a)



(b)



(c)

Figure 2.(a, b and c): The resulting segmented images after applying the algorithms CQTS, MQTS and FSLP respectively

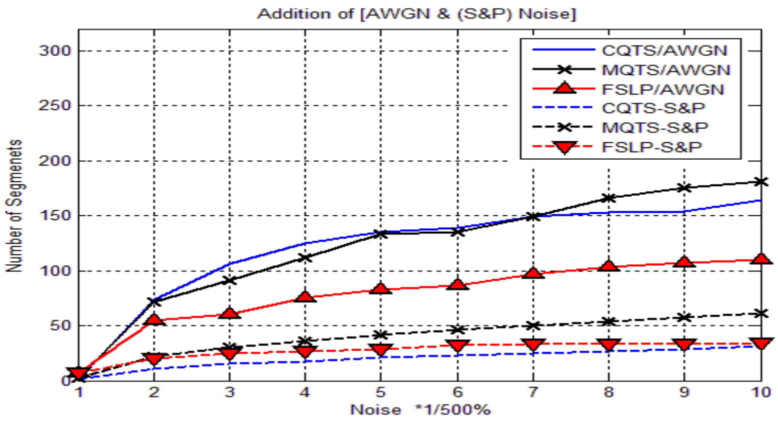
(a) Segmentation results of a 16x16 pixel dimension image

(b) Segmentation results of a 128x128 pixel dimension image

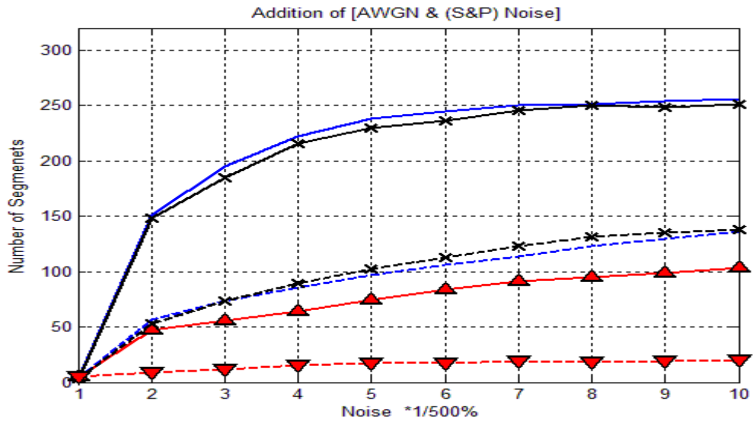
(c) Segmentation result of a 256x256 pixel dimension image

The evaluation of the new method **(FSLP) is obtained using two approaches**. The first, by examining the changes of resulted segments, via- the ratio for the change that is happening in the contrast of the image, as well as when changing the amount of bright-ness. Images of different sizes (16 x 16), (64 x 64), (256 x 256) are chosed for studying the effect of changing the intensity of brightness and contrast by the three algorithms. Algorithms used for comparison with the proposed method are (CQTS) and algorithm (MQTS). (Figure 2- a, b and c) shows the image of the dimensions (16 x 16, 64x64 and 256x256) pixels respectively-(three-dimensional color), it can be seen the large difference due to the effect of changing the number of segments by using the new algorithm. It has clear that it maintains nearly the same number of segments when increasing the lighting, or reducing it, as well as when changing the contrast ratio in both sides. This test gives a good indication at different conditions experienced by the noised images taken, in different circumstances and it is possible to conclude the segmented images wanted.

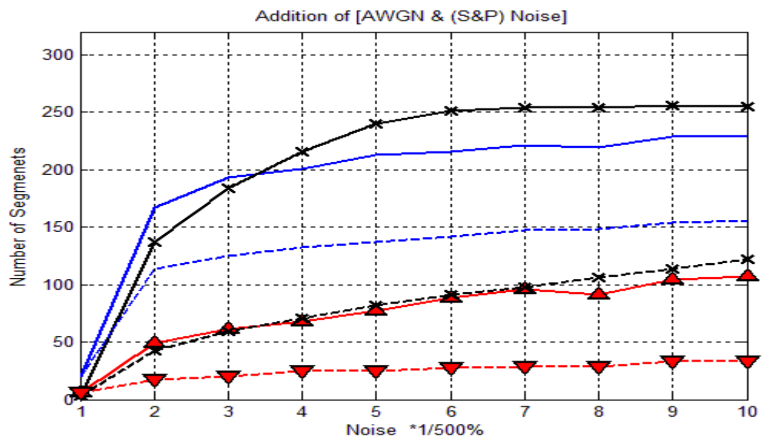
In the first evaluation test, three types of noise have applied to simulate their effect on the resulting images using each algorithm of previous methods. Figure (3- a, b and c) describes the effect of noise test (salt and pepper) and (Gaussian noise) respectively. Observing the impact of these types of noise, we can conclude easily, that the immunity of the new algorithm is higher by up to 20% as compared with the other algorithms. The noise that may affect the quality of digital images in various stages of data transceivers and when capturing images in difficult weather conditions, such as raindrops, dust and snowfall.



(a).



(b)



(c)

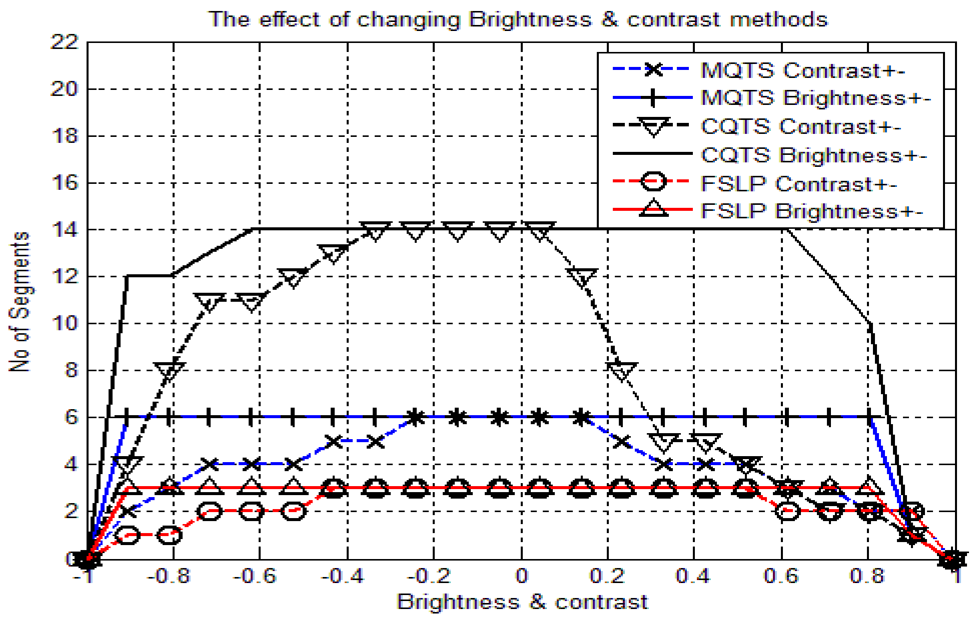
Figure (3- a, b and c) The effect of additive noise test (salt and pepper) and (Gaussian noise), when applied to segmented resultant images of CQTS,MQTS and FSLP methods respectively.

(a) The effect of noise addition at image of dimensions (16 x 16) pixels.

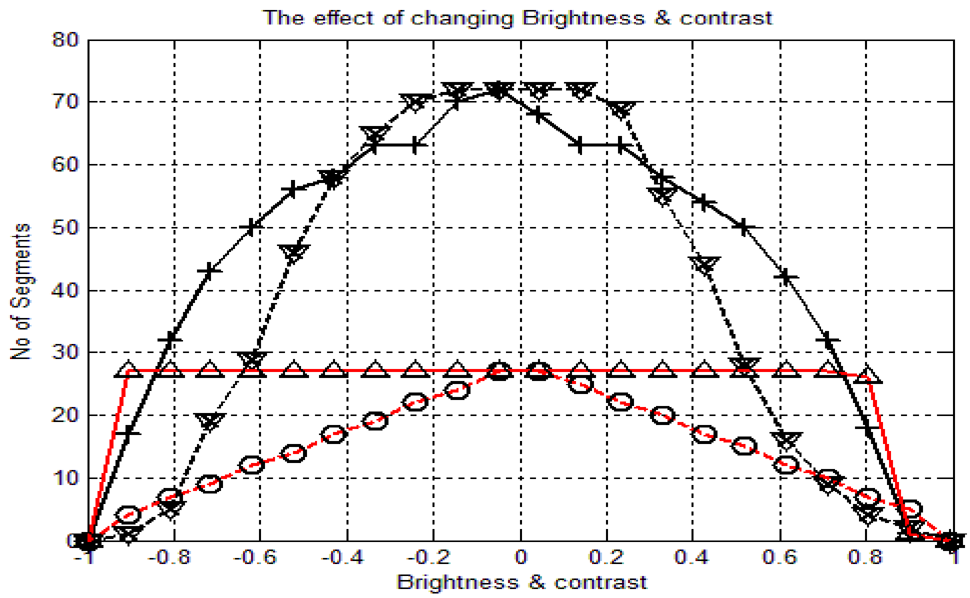
(b) The effect of noise addition at image of dimensions (64x64) pixels.

(c) The effect of noise addition at image of dimensions (256x256) pixels.

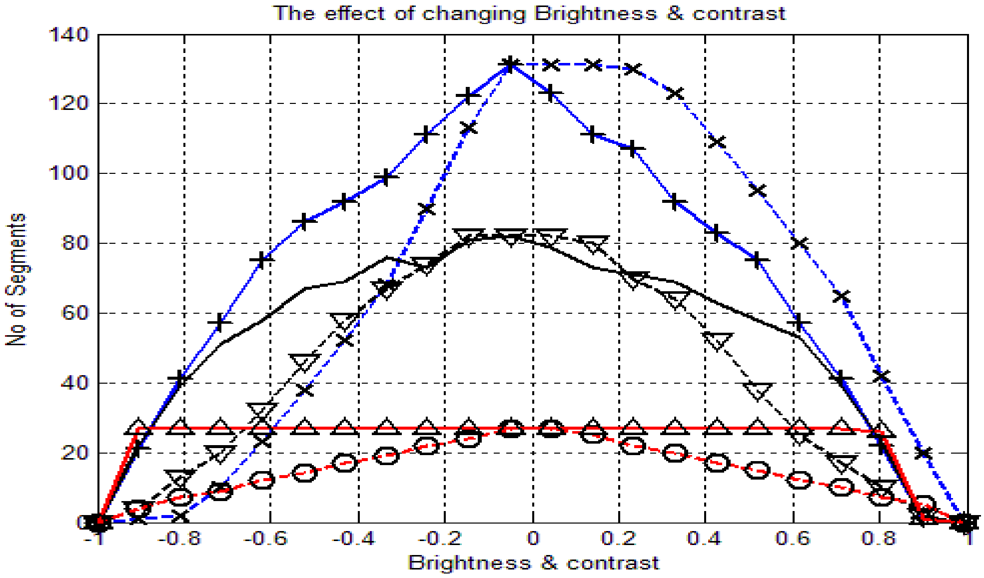
In Figure (4- a, b and c), it can be noticed that the number of segments in the normal level of brightness and the contrast, which is expressed as the zero level, will be a fixed number at the beginning of the test, CQTS= 6, 27 and 28 respectively. Depending on the type of segmentation used and with fixed threshold value (0.5) as a default threshold. When we increase or decrease the brightness and contrast levels, it observed that the method (FSLP) is more robust against the changes in luminance (brightness and contrast) values of 20% as compared with the other two methods.



(a)



(b)



(c)

Figure (4- a, b and c) describes the effect of additive noise test (salt and pepper) and (Gaussian noise), when applied to segmented resultant images of (CQTS, MQTS and FSLP) respectably

(a) The effect of noise addition at image of dimensions (16 x 16) pixels.

(b) The effect of noise addition at image of dimensions (64x64) pixels.

(c) The effect of noise addition at image of dimensions (256x256) pixels.

Conclusion

A proposed method named Forward image segmentation based on the reverse Level-Plurality (FSLP) has been presented in this paper. The method has designed for the purpose of adaptation to limited computational resources and computation time due to image segmentation at each level of its multiresolution representation. It has shown that the method allows eliminating a segmentation fault of structurally complex areas by identifying neighboring homogeneous regions in which the same average brightness but different numbers of segments. As well the paper studying the effect of noise addition (AWGN) and (Salt and pepper) and the impact of the change in the color contrast on amount of changing the number of segments in each of the proposed method (FSLP) and the methods that were used for the purpose of comparison;(CQTS) and (MQTS). The proposed method (FSLP) has more immunity against the change in brightness and contrast and has lower affection by noise compared with the two-segmentation method by (20-25%).

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