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Enhancement of Image Quality by Noise Reduction using Modified Clustering Algorithm

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Abstract

Nowadays, noise reduction in image processing is a major research to enhance image quality. Clustering algorithm is widely used for segmenting the image in image processing. The goal of clustering algorithm is used to make the intrinsic group in a set of unlabeled data. Image acquisition is the first step in image processing. The occurrence of noise during image acquisition can affect the image acquiring result. De-noise based clustering algorithm is classified as de-noise based K-means, Fuzzy C-means and Moving K-means. To improve the image quality, salt and pepper noise is reduced by de-noise based clustering algorithm. During the segmentation process, the effect of salt and pepper noise can be minimized for reducing loss in the images. The experimental result analyses the mean square error and peak signal to noise ratio which gives less mean square error and high peak signal to noise ratio. It shows the image quality without degrading the image quality at the same time unique performance of noise reduction.

Keywords: *Clustering, Image Processing, Image Segmentation, Noise Reduction, Salt and Pepper Noise.*

1. Introduction

Segmentation is the process in image processing is used to partition the digital image into multiple segments. Based on characteristics like texture or gray level, segmentation process can be used to separate an image into different regions. Image segmentation is typically used to locate objects and boundaries in images like lines, curves, etc. Image segmentation is the process of assigning a label to every pixel in an image. The pixels are having same label share certain visual characteristics.

Clustering is the process which is the task for assigning a set of objects into groups is called clusters. In each cluster, the objects have similar characteristics. The most prevalent attitudes of clusters consists groups with low distances among the cluster members, dense areas of the data space, intervals or particular statistical distributions.

The appropriate clustering algorithm and parameter settings depend on the individual data set and intended use of the results. Cluster analysis is not an automatic task; it is an iterative process of knowledge discovery that involves try and failure. Clustering process require to modify preprocessing and parameters until the result achieves the desired properties.

2. Related Works

There are several techniques for salt and pepper noise minimization is available in the existing work [1]. There are many clustering algorithms are available for segmenting the

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gray scale images. Segmentation is an important process which is used in several applications such as geographical imaging, medical imaging and object recognition etc [2].

Based on segmentation techniques, algorithm for segmentation process is classified as various categories [3]. The segmentation algorithm is used to extract the image features like texture, shape, edges etc. The thresholding technique is widely used for segmentation process which extracts the features more efficient. But this technique is more sensitive to noise [4]. If input image has larger in size, the template matching is one of the time consuming task. Due to over segmentation otherwise time consuming task, region based technique can be suffered [5].

An image in larger size can be divided and grouped which has same characteristics. It is one of the unsupervised classification algorithms [6]. The clustering algorithm can be used to compute the characteristics of each group. It was done by according to the distance between nearest cluster [7]. The clustering algorithms can be provided better segmentation results. In this process, over segmentation is one of the major problems [8].

Chonglun Fang et al proposed a new k-means clustering algorithm for clustering analysis. It consists three different metrics are considered while the exact number of clusters in a data set is not pre-known. In this case, numbers of k-seed points are set to learn the clusters in the large data set. The proposed algorithm has analyzed for synthetic and real world data set to detect the number of actual clusters in a data set [9]. The experimental result shows the high accuracy rate than the conventional clustering algorithm [10].

Weipeng Jing et al proposed open source big data to improve the distributed storage and query for remote sensing data. Distributed storage data base was used to design the storage model of remote sensing data. Traditional methods for process the remote sensing data produced low efficiency and lack of scalability. In this work, grid index and hibert curve was used to establish the index for the image data. Map reduce parallel processing method was used to write and query remote sensing images [11].

3. Conventional Clustering Algorithms

The main objectives of clustering methods are by reducing detached task and its application to segment an image.

K-means (KM) Clustering

With respect to nearest Centre, the conventional algorithm has been used to group the data.

N is considered for total number of data in n_c regions or clusters. v_t represents intensity value at t^{th} data and t represents 1, 2,3,4… N and k^{th} centre is represented by c_k then analytically, the conventional K-Means can be used to partition the dataset $\{v_t\}_{N\ t=1}$ into c_k.It is represented as,

$$J = \sum_{k=1}^{nc} \sum_{t=1}^{N} \|Vt\text{-}ck\|^2 \quad (1)$$

Based on the Euclidean distance, the nearest Centre has data set. Then each centre has new positioned. It is calculated as,

$$C_k = \frac{1}{n_{c_k}} \sum_{t \in ck} v_t \quad (2)$$

This task is processed until, all centers has no longer change which has smaller distance.

Fuzzy C-means (FCM) Clustering

The conventional Fuzzy C-Means segment an image into objective function like c_k clusters. It is given by,

$$J = \sum_{k=1}^{nc} \sum_{t=1}^{N} (M_{kt}^m) \|v_t\text{-}c_k\|^2 \quad (3)$$

Fuzziness exponent is represented by m, it is an integer value which is greater than 1. The new place for each centre is considered by following equation,

$$c_k = \frac{\sum_{t=1}^{N} M_{kt}^m}{\sum_{t=1}^{N} M_{kt}^m} v_t \quad (4)$$

M_{kt} satisfying for each fuzzy membership function 'm' gives,

$$M_{kt}^m = \frac{1}{\sum_{l=1}^{nc} \frac{dkt}{dlt}^{2/(m-1)}};\ if\ d_{lt}>0, \forall l,t \quad (5)$$

$$M_{lt}^m = 1 \qquad if\ d_{lt}=0; \quad (6)$$

$$M_{kt}^m = 0;\ for\ t \neq l \qquad if\ d_{lt}=0; \quad (7)$$

Where, $d_{kt}=\|v_t\text{-}c_k\|^2$

K-Means and Fuzzy means processes are repeated until cluster centers have consecutive repetition. It is varying by more than certain optional value like closure criterion and it has either '0' or '1'.

Moving K-Means (MKM) Clustering

The modified version of K-Means is used to obtain the new position for each cluster. The algorithm works to maintain some significant number of members in each cluster.

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Before obtaining the new position of the cluster, the fitness value for each cluster is obtained by,

$$f(c_k)=\sum_{t\in ck}(\|v_t-c_k\|)^2 \quad (8)$$

The following condition must satisfy the centers in all clusters is given as,

$$f(c_s)\geq \alpha_a f(c_l) \quad (9)$$

α_0 is the small constant integer, it has the range lies between $0<\alpha_o<1/3$. Cs and C_l represent smallest and largest fitness values of the centers. Then, the positions of Cs and C_l are recalculated according to the formula,

$$\left.\begin{aligned} cs &= \frac{1}{ncs}\sum_{t\in cs} vt \\ cs &= \frac{1}{ncl}\sum_{t\in cl} vt \end{aligned}\right\} \quad (10)$$

According to the equation, the value of α_o is updated.

$$\alpha_a=\alpha_a-\alpha_a/n_c \quad (11)$$

4. Denoise Based Cluster Algorithm

During the segmentation process, noise can be minimized by this proposed clustering algorithm. The clustering algorithm is working for minimizing the noise effect which is processed by two ways. Initially, analyze the intensity value then the location of the salt and pepper noise can be identified. Next, based on the characteristics, the clustering algorithm groups the pixels. From this, noise free pixels can be identified by the proposed clustering algorithm.

5. Noise Reduction

High intensity and low intensity values are considered for salt and pepper noise. High intensity value represents positive which has 255 and low intensity value represents 0 which means negative. High intensity the value 255 represents salt noise and low intensity the value 0 gives pepper noise. Salt noise appears as white colour and at the same time pepper noise has in black colour. The high and low intensity value can be used to identify the noise pixels in the image.

The following formula can be used to identify the noise pixels by binary noise mask N(i,j).

$$N(i,j)=\begin{cases} 0, X(i,j)=L_{salt}\ or L_{pepper} \\ 1, \quad otherwise \end{cases} \quad (12)$$

The pixel intensity value at location (i,j) has represented as X(i,j). If N (i,j) value is equal to '1' gives noise-free pixels and if N(i,j) value is equal to '0' gives noise pixels in an image.

6. Clustering Process

The binary noise mask *N(i,j)* is created and altered noise piel value has obtained using the following formula,

$$X'(i,j)= X(i,j)\ .[1-F(i,j)] + M(i,j)\ F(i,j) \quad (13)$$

Where, *X'(i,j)* represents altered noise pixels and median value of the taken pixel is represented by *M(i,j)*. The considered pixel *X(i,j)* and its corresponding median pixel *M(i,j) linear relationship is obtained by* fuzzy membership *F(i,j*. The window size 3x3 has been used to extract the median of the 'noise' pixels. It is given by,

$$M(i,j)=\text{median}\{X(i+k,j+l)\}\ as\ k,l\in(-1,0,1) \quad (14)$$

Then, the absolute luminance difference d (i, j) is calculated by using the below equation.

$$d(i+k,j+l)=|X(i+k,j+l)-X(i,j)| \quad (15)$$

The absolute luminance difference is obtained by,

$$D(i,j)=max\{d(i+k,j+l)\} \quad (16)$$

The local information D(i,j)is extacted by fuzzy concept. The fuzzy membership function F(i,j) is demarcated as,

$$F(i,j)=\begin{cases} 0 & ;D(i,j)<T_1 \\ D(i,j)-\frac{T_1}{T_2} & ;T1\leq D(i,j)<T_2 \\ 1 & ;D(i,j)\geq T_2 \end{cases} \quad (17)$$

T1 and T2 represents are threshold value which is used to calculate the corrected value of noise pixel. While assigning data to its nearest centre, the original pixels values are replaced by its corrected values. This is used to increase the robustness of KM clustering towards noise.

By using the concept of conventional K-Means clustering algorithm, this proposed algorithm has been developed based on de-noising. It is called as de-noising based K-Means. Fuzzy C-Means and moving K-Means algorithm can be used for similar concept. These algorithms can be modified which is called as de-noising based Fuzzy C-means and de-noising based Moving K-means algorithms.

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7. Calculation

The Mean Square error (MSE) is used to represent the differences between original image and recovered image. It is calculated as,

$$MSE = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - k(i,j)]^2 \qquad (18)$$

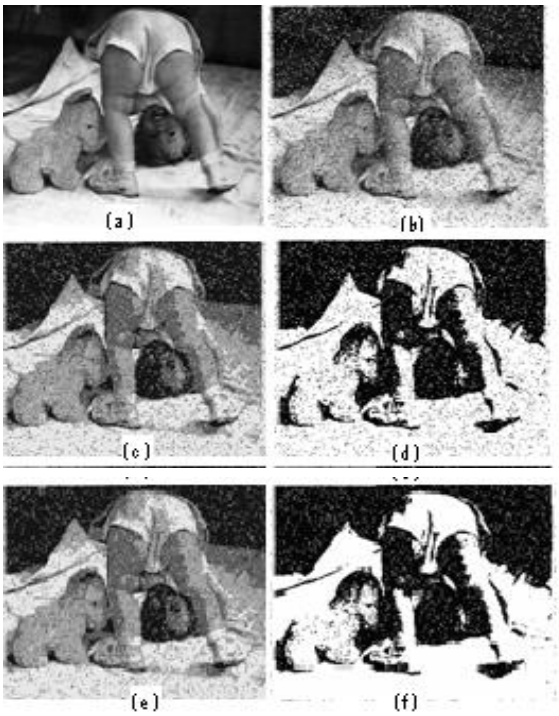
The PSNR is used to measure the quality of reconstruction of lossy compression codecs. The PSNR is calculated by using Mean Square Error value.

$$\text{PSNR} = 10\log_{10}\left(\frac{Max_I^2}{MSE}\right) \qquad (19)$$

MAX_I represents the maximum possible pixel value of the image. If pixels are represented as 8 bits per sample, maximum gray scale value as 255.

8. Experimental Results

The experimental results on several standard real images are shown below. The conventional clustering algorithms are K-Means, Fuzzy C-Means and Moving K-Means and its extension is used for experimental analysis. The simulation results of the proposed algorithms are tabulated.



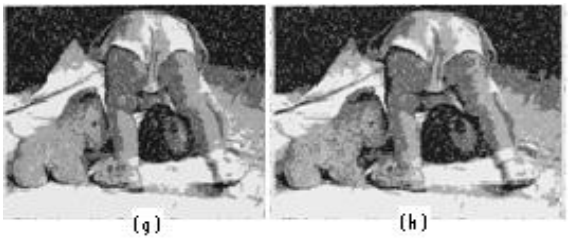


Figure 1: Segmentation results on baby of salt-and pepper noise

The Fig 'a' represents original image and Fig 'b' represents noisy image which consists of salt and pepper noise. Fig 'c' gives segmentation result of conventional KM and Fig'd' gives segmentation result of conventional FCM. Fig 'e' shows the result of conventional MKM and Fig 'f', 'g' and 'h' shows the result of DB-KM, DBFCM and DB-MKM respectively.

The experimental analysis shows that the proposed algorithms high PSNR and low mean square error value. It demonstrates their quality of the image which is used to overcome the issue of noise sensitiveness.

Table 1: Experimental Analysis

Algorithm	MSE	PSNR
KM	0.030309	63.315
DKM	0.017372	65.7323
FCM	0.094118	58.3941
DFCM	0.081375	59.0259
MKM	0.030294	63.3173
DMKM	0.017855	65.6131

9. Conclusion

The proposed work used clustering algorithm for segmenting the noise corrupted images. The clustering algorithm has been used for reducing the effect of noise during segmentation process. The salt and pepper noise can be eliminated by using these clustering algorithms. The proposed method conserves the significant feature of the digital images. The experimental results show that less mean square error value and high PSNR value. It shows the segmented image has high quality and respectable noise reduction.

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