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Quantitative Analysis based on Supervised Classification of Medical Image Fusion Techniques

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Abstract

Fusion can be described as the process of integrating information resulting from the collection of two or more images from different sources to form a single integrated image. This image will be more productive, informative, descriptive and qualitative as compared to original input images or individual images. Fusion technology in medical images is useful for the purpose of diagnosing disease and robot surgery for physicians. This paper describes different techniques for the fusion of medical images and their quality studies based on quantitative statistical analysis by studying the statistical characteristics of the image targets in the region of the edges and studying the differences between the classes in the image and the calculation of the statistical scale (mode) between the classes in the region of the edges before and after fusion. The results proved highly efficient in the integration of medical information and increase the sharping of contrast, force the separation and show the fine details between the classes.

Keywords: Medical Image Fusion, Supervised Classification, Quantitive Analysis.

التحليل الكمي المعتمد على التصنيف الموجهه لتقنيات دمج الصور الطبية

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الخلاصـــة

الاندماج يوصف كعملية دمج اثنين او اكثر من المدخلات المختلفة لتكوين مدخل جديد، صورة الدمج هي عملية دمج صور7 متعددة من مصادر مختلفة للحصول على صورة دمج منفردة وهذه الصورة تتميز باكثر نوعية ووصفية وغنية بالمعلومات المفيدة مقارنة بصور الادخال الاصلية او المنفردة . تقنية دمج الصور الطبية مفيدة لغرض تشخيص الامراض والجراحة الالية للاطباء . في هذا البحث تم دراسة تقنيات مختلفة لدمج الصور الطبية ودراسة الخصائص الاحصائية لاهداف الصورة قبل وبعد عملية الدمج في منطقة الحافات ، وتقييم النتائج باستخدام طرق التحليل الكمي المتمثل بالتصنيف الغير موجهه للصور الطبية قبل وبعد الدمج ودراسة الخصائص الاحصائية (التباين) بين الاصناف ، وحساب معيار النمط لمنطقة الحافات بين الاصناف . كانت النتائج ذات كفاءة عالية في دمج المعلومات ، زيادة حدة التباين ، زيادة قوة الفصل بين الاصناف.

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1. Introduction

Fusion image is merging two or more photos into a single image, and there are important features for all process and contains a description of the scene more accurate than any of the individual source images, with advances in technology, we can get information from images from different sources to produce a new high quality image which also contain anatomical and functional information. Thus, it can be described as a fusion image of a process that will improve the quality of information from a range of images. The aim of this technique is to integrate complementary information from images so that new multimedia images are more appropriate for the purpose of human visual perception and processing. Therefore, the fusion image is important to make many of the outstanding features of the new image, such as border and regions [1].

Medical imaging systems play a vital role in human health care and provide complete information about the human body for better treatment. The fused image became a term commonly used in medical diagnosis and treatment. The term is used when multiple images are recorded for the patient and their interface or integrated to provide additional information. The goal of the medical image fusion is to maximize information and improve the quality of the image through the most powerful features offered by the different methods of collection [2].

There are many previous studies in field image merge and some of them were selected due to their proximity to the field of research work where the study was conducted from Vishal P. Tank et al. Focuses in 2013 on by an image fusion algorithm based on wavelet transform and second generation curvelet transform the image fusion is done. Then Deron Rodrigues et al. Presented in 2014 image fusion methods based on wavelet transform fusion of (CT) scanned images and (MRI) images using a multi resolution wavelet transform with necessary preprocessing of it is proposed. While Pradeep Patil, et al. Used in 2015 a multimodal image fusion algorithm based on Dual tree discrete wavelet transform and particle swarm optimization (PSO) is proposed. On the other hand, Kiran D. Dhore et al. Used in 2016 an image fusion technique for the fusion of multimodal medical images is proposed based on non-sub sampled contour let transform (NSCT). In this study, adopted edge detection to study the statistical characteristics of the different targets of the image in the edge region. And used technique unsupervised classification by minimum distance and studied contrast and mode between classes and feature extraction [3-6].

2. Medical Images Fusion

This technique is used when many images of the patient are added or merged to provide additional recording information, with increased demand requiring clinic, researchers pay more attention to medical image integration. Medical diagnosis often benefits from complementary information in the images obtained by various medical imaging devices. Create images combined from multiple images of the same imaging method, or by merging information from multiple methods, such as magnetic resonance imaging (MRI), computed tomography (CT) and others in radiology and radiography, these images serve different purposes. Where, the CT image of the best information on the availability of more dense tissue with less distortion, while MRI provides better information on the image of soft tissue with further distortion. Integration the two images with different methods can provide more accurate and sound information to the patient. Use of the (CT) in many cases to ensure that differences in tissue density while MRI is usually used to diagnose brain tumors [7- 9].

3. Medical Images Fusion Techniques

In this study the medical image fusion process was done using four techniques that can be directly applied mathematical Technique (Brovey Transformation and Multiplactive Transformation Technique), frequency technique (High-Pass Filter Additive Technique) and statistical technique (Local Mean Matching Technique). Were the mathematical techniques (BT and MLT) and can be applied by using the addition, division, ratios, subtraction and multiplication between the band of first and second images before the fusion process according to the equations below where eq. (1) Gives the mathematical formula for the (BT) and eq. (2) Gives the mathematical formula for the MLT [10]:

$$F_{(i,j)} = \frac{b_{1(i,j)} \times b_{2(i,j)}}{\sum b_{1(i,j)}} \quad (1)$$

$$F_{(i,j)} = \sqrt{b_{1(i,j)} \times b_{2(i,j)}} \quad (2)$$

Where

$F_{(i,j)}$: The fused image of mathematical technique $F_{(i,j)}$ for eq. (1) to BT, $F_{(i,j)}$ for eq. (2) to MLT and i, j are pixel coordinates, $b_{1(i,j)}$ and $b_{2(i,j)}$ is the band first medical image and band second medical image in (i, j) pixel coordinates.

While frequency technique (HPFA) is a spatial filtering technology. This technique uses standard square box HP filters 3×3 pixel kernel given by, which is used in this study (3) [11]:

$$P_{HPF} = \frac{1}{9}\begin{pmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{pmatrix} \quad (3)$$

Where:

P_{HPF} : A filter is used to extract the frequencies.

In its simplest form, The HP filter matrix is occupied by "-1" at all but at the center location. The center value is derived from c = (n × n) − 1, where c is the center value and (n × n) is the size of the filter box. This technique is filtered that compute a local mean around each pixel in the second medical image [12].

The extracted high frequency components of P_{HPF} imposed on the first medical image by simple addition and the result divided by two to offset the increase in brightness values. This is given by (4) [13]:

$$F = \frac{(b1 + P_{HPF})}{2} \quad (4)$$

Where

F: is the fused image by HPFA technique, b_1 is the band first medical image, P_{HPF} A filter is used to extract the frequencies.

Finally, the fourth technique the local mean matching (LMM) is a statistical technique used to fuse the two medical images second into first interface to the same size as the second medical image, and The LMM algorithm given by (5) as follows [14]:

$$F_{(i,j)} = b_{2(i,j)} \times \frac{\overline{b_{1(i,j)(w,h)}}}{\overline{b_{2(i,j)(w,h)}}} \quad (5)$$

Where

$F_{(i,j)}$ Is the fused image by LMM technique, $b_{2(i,j)}$Is the second medical image respectively at pixel coordinates (i, j): $\overline{b_{1(i,j)\,(w,h)}}$ and $\overline{b_{2(i,j)(w,h)}}$ are the local means of the first and second medical images calculated inside the window size (w, h), which used in this study an 11×11 pixel window.

4. Medical Images Classification

Medical image classification plays an important role in diagnosing and teaching in medicine. For these purposes different imaging modalities are used. There are many classifications created for medical images using both grayscale. Classification is a process that correctly assigns unknown patterns to a specific style class. The pattern indicates a set of points in the image that have common attributes and attributes and represent a specific object in the image. While Pattern class is a set of patterns that share some common characteristics. There are two basic theories in class classification unsupervised classification and supervised classification. The supervised classification method begins by defining some possible categories of image areas. The classification algorithm is assigned to each point of the class image being the attributes closest to the point of the image In this study the supervised classification method by the minimum distance is used [15, 16].

4.1 The Minimum Distance (MD): is base decision suitable for the degree of similarity between the two statements give on base distance minimum (MD) states. The image element due to the vector spectral closest to him knew vector spectral multidimensional, if the vector data dimension L and base the minimum distance is given by eq. (6a), eq. (6b) and eq. (7). Starts the definition of some of the possible varieties of areas the image. The classification algorithm allocates each point in the image category features are closest to the image dot [17].

$$d\,(X,\ m_i) = \sqrt{\left(X_1 - m_{i_1}\right)^2 + \cdots \left(X_L - m_{i_L}\right)^2} \quad (6a)$$

$$d\,(X, m_i) = |X_1 - m_{i_1}| + \cdots\ |X_L - m_{i_L}| \quad (6b)$$

As the requirement of achieving the minimum distance is:

$$d(X, m_i) < d(X, m_i) \text{ For all } i \neq j \quad (7)$$

It said:
X: Vector data entering and dimension her in space length L.
m_i: The vector data generated known dimension her length L also.
In this class vector X is a class number (i) according to equation (7).

5. Algorithms Adopted in the study

1. Stage 1

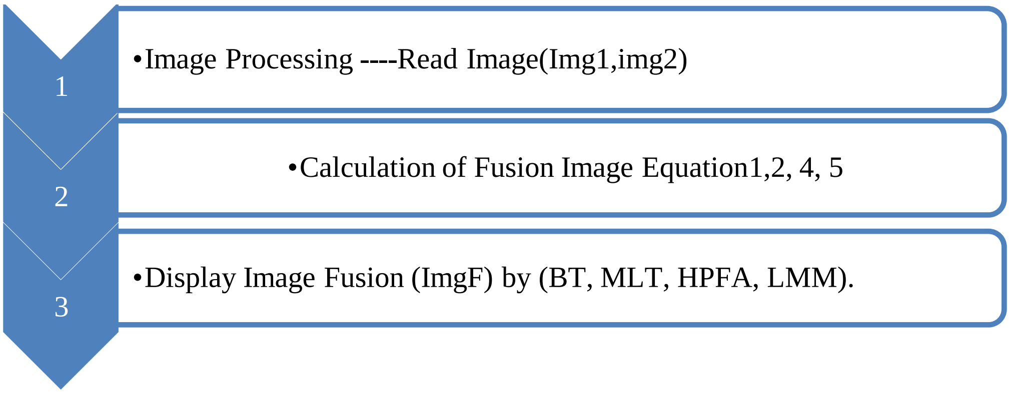


Figure 1- Data flow fusion image techniques.

1. Stage 2

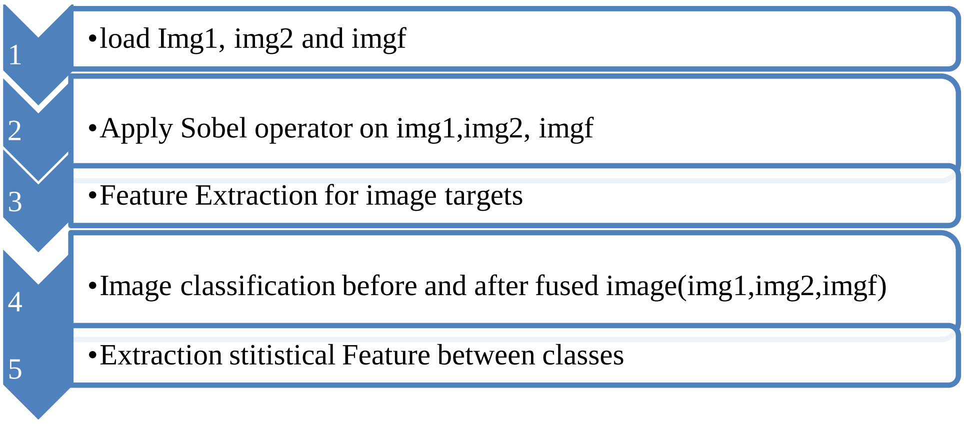
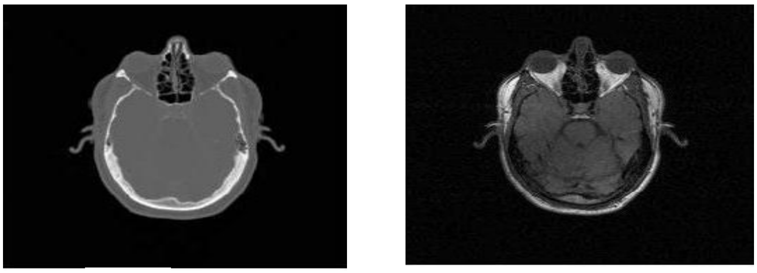


Figure 2- Data flow image unsupervised classification.

2. Medical Image Model Adopted

In this study, the model of medical image adopted in fusion processing is using Computed Tomography (CT) has size (248×249) pixels and bit depth (8bits), shown as in Figure-(4a) and use Magnetic Resonance Imaging (MRI) has a size (248×249) pixels and bit depth (8bits), shown as in Figure- (4b) [18].

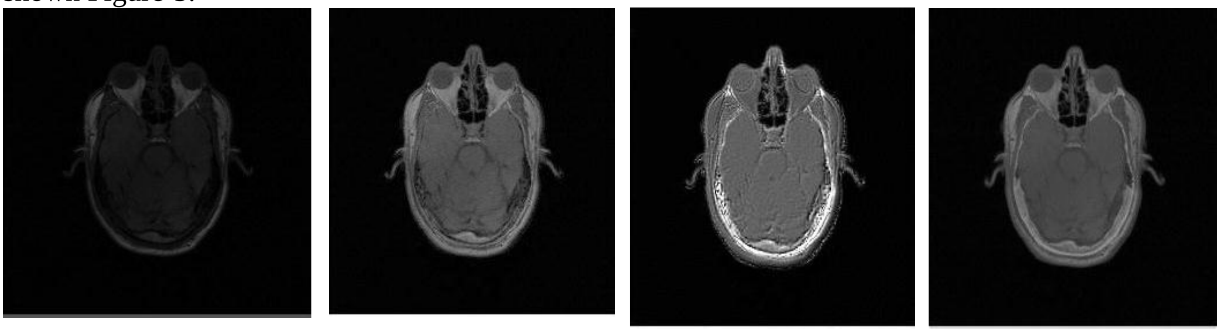


a.CT b. MRI CT

Figure 4- Show the model of medical imaging [18].

3. Fusion Image Results

The fusion pair adopted medical image using several different techniques and they include mathematical, spatial filtering and statistical techniques and as a result of the fusion of the images shown Figure-5.



a.BT b. MLT c. LMM d. HPFA

Figure 5-Show the fusion model of medical imaging.

After the fusion process, in this study, the quantitative analysis of the medical images was calculated before and after the fusion process based on the statistical criteria of (mean (µ), standard deviation (σ), intensity contrast (Ci) and statistical contrast (Cs)) calculating them for the different targets in the image in the edge region as in Figure-6.

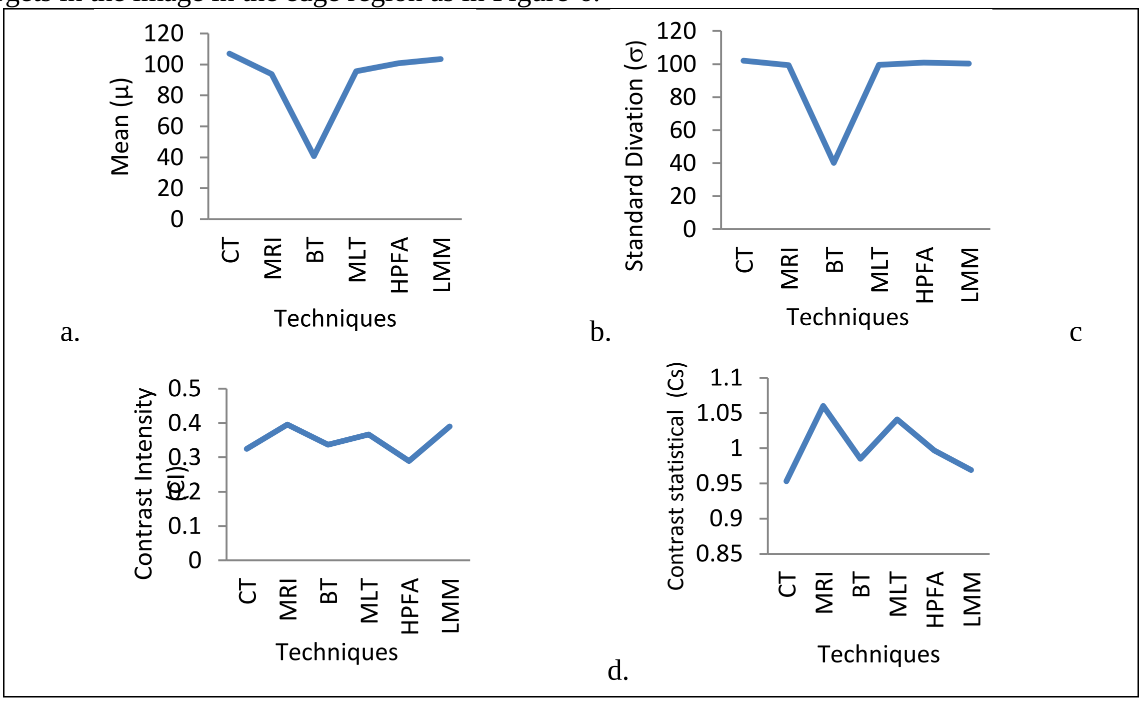


Figure 6- Show feature extraction of image target regional and fused image.

From Figure-6 note that the value of the mean of the images before fusion and images after fusion has approximately near except technique (BT) observed a decrease in the value of the mean because this technique in which the chromatic deformation of the difference in the spectral range of band, but the technique of (MLT, HPFA and LMM) respectively notice an increase in the value of the mean, ie increase both the intensity of the image and the clarity of detail in it. As for the standard deviation, observe a constant value in almost all the techniques used, except (BT) which indicate the stability of the amount of joint information. The value of the intensity and statistical contrast and is almost constant, indicating the stability of the joint details.

4. Supervised Classification of Medical Image Fusion Model

Supervised classification methods have been adopted on using the minimum distances on the medical image model shown in the Figure-4 and It was obtained after extraction different areas of the image before and after the fusion. The process of extraction from each region has on the basis of the image that holds the most classes visible. The results of the classification, as shown in Figure-6. Which contains (6) blocks and the size of each block (4×4) pixels**.** Then counted special mode between class to class and also counted contrast between class to class to original and image fusion according to the Table-1.

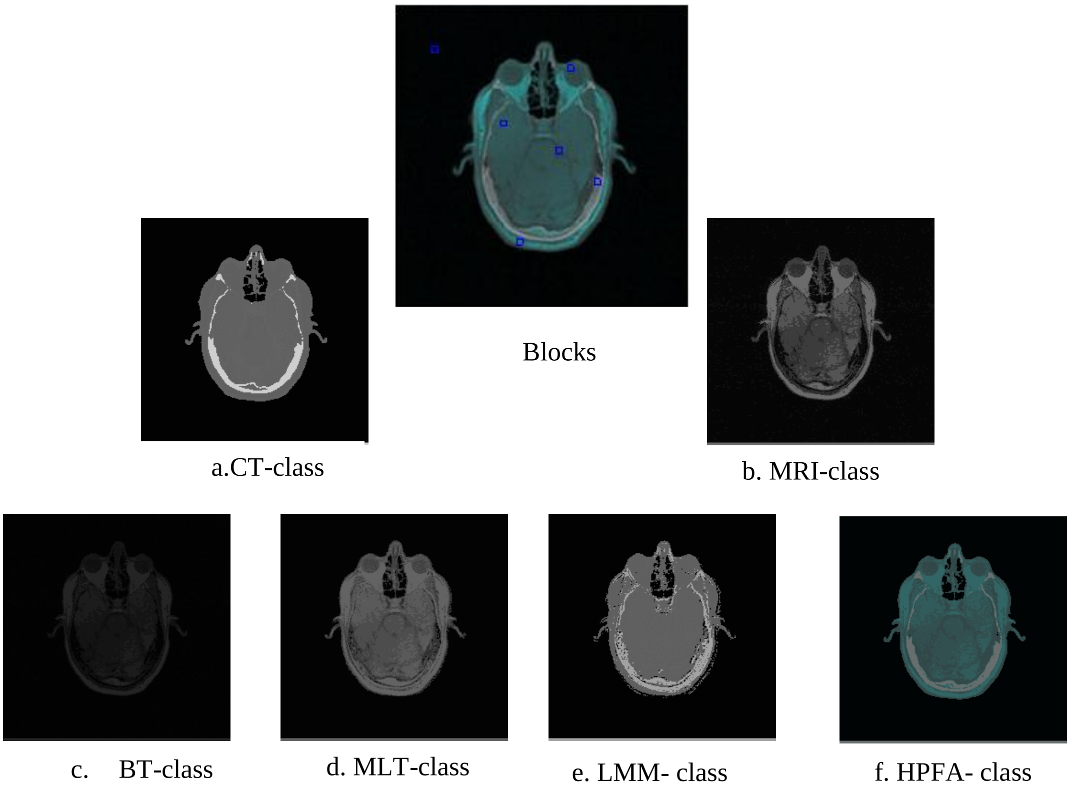


Figure 7- Show the results of the classification of the medical imaging model.

The contrast between the different image classes were studied to determine the severity of details between classes in the image, as well as the study of the mode between the classes to determine the mode between them after make edge detection for image classification, as shown in the Table-1.

Table 1- Shows the statistical criteria between the classes for medical images before and after the fusion process**.**

Image	Contrast							Mode						
CT	Class	1	2	3	4	5	6	Class	1	2	3	4	5	6
	1	0	0.267	0.31	0.172	0.137	0.196	1	0	109	100	99	99	99
	2	0.337	0	0.498	1	1	0.999	2	173	0	255	163	156	157
	3	0.931	0.898	0	0.865	0.805	0.963	3	43	2	0	39	43	8
	4	0.103	0.027	0.065	0	0.046	0.0633	4	97	96	97	0	97	96
	5	0.073	0.026	0.025	0.045	0	0.069	5	98	98	98	98	0	98
	6	0.318	0.257	0.166	0.271	0.305	0	6	95	94	72	95	95	0
MRI	Class	1	2	3	4	5	6	Class	1	2	3	4	5	6
	1	0	0.371	0.382	0.4	0.296	0.618	1	0	60	56	72	53	68
	2	0.58	0	0.693	0.68	0.626	0.954	2	28	0	9	28	28	28
	3	0.538	0.689	0	0.587	0.724	0.997	3	6	7	0	6	8	1
	4	0.354	0.26	0.307	0	0.287	0.455	4	73	73	79	0	76	84
	5	0.594	0.528	0.457	0.599	0	0.696	5	51	32	32	52	0	46
	6	0.528	0.416	0.433	0.47	0.799	0	6	97	97	255	97	97	0
BT	Class	1	2	3	4	5	6	Class	1	2	3	4	5	6
	1	0	0.372	0.391	0.407	0.306	0.621	1	0	18	18	24	18	24
	2	0.44	0	0.699	0.687	0.608	1	2	9	0	3	9	9	9
	3	0.496	0.718	0	0.795	0.941	1	3	2	2	0	2	2	2
	4	0.359	0.304	0.216	0	0.309	0.459	4	25	26	26	0	25	31
	5	0.618	0.54	0.472	0.615	0	0.705	5	17	11	11	17	0	15
	6	0.522	0.396	0.425	0.473	0.819	0	6	33	34	85	33	33	0
MLT	Class	1	2	3	4	5	6	Class	1	2	3	4	5	6
	1	0	0.265	0.323	0.219	0.185	0.341	1	0	72	72	82	74	83
	2	0.719	0	619	0.623	0.496	0.727	2	57	0	30	57	57	57
	3	0.972	0.898	0	0.864	0.851	0.998	3	24	24	0	24	25	9
	4	0.204	0.147	0.211	0	0.194	0.265	4	84	85	85	0	85	92
	5	0.366	0.301	0.285	0.3	0	0.466	5	70	60	61	70	0	70
	6	0.286	0.234	0.241	0.301	0.564	0	6	95	97	255	95	95	0
	Class	1	2	3	4	5	6	Class	1	2	3	4	5	6

HPFA	1	0	0.341	0.125	0.17	0.101	0.202	1	0	55	52	50	50	50
	2	0.279	0	0.254	0.269	0.241	0.644	2	89	0	134	90	87	90
	3	0.926	0.86	0	0.825	0.883	0.998	3	17	1	0	17	5	13
	4	0.183	0.128	0.075	0	0.144	0.188	4	50	59	48	0	51	51
	5	0.411	0.305	0.29	0.233	0	0.395	5	50	50	45	50	0	48
	6	0.257	0.204	0.254	0.211	0.216	0	6	49	58	37	50	51	0
LMM	Class	1	2	3	4	5	6	Class	1	2	3	4	5	6
	1	0	0.332	0.314	0	0.186	0.272	1	0	102	97	0	97	97
	2	0.468	0	0.512	0	0.568	1	2	255	0	253	0	255	138
	3	0.87	0.824	0	0	0.835	1	3	46	1	0	0	41	32
	4	0	0	0	0	0	0	4	0	0	0	0	0	0
	5	0.336	0.297	0.279	0	0	0.434	5	95	95	60	0	0	95
	6	0.173	0.064	0.211	0	0.103	0	6	96	96	96	0	96	0

10. Conclusion

From the results can be concluded:

1. The results indicate that fusion techniques have been highly efficient in the fusion of different information between medical images taken from different medical devices and these techniques differ in the type of information.
2. The statistical criteria for image targets in the edge region was very effective for determining image quality before and after fusion as well as identifying the best techniques for the fusion process.
3. The efficiency of the image processing technology (classification) in the classification of the image into different classes, the extraction of features between them to increase the sharpness of contrast and extract the fine details between classes.
4. Calculate the statistical measure (mode) between classes in the edge region to increase the separation force between the classes and determine the stronger class in edges only.

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