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Multi-focus Image Reconstruction and Comparative Analysis

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Abstract

Multi-focus image reconstruction is the process of combining the clear parts of two or more images, which are taken from one scene with the same camera .so as to get a single image with multi-objects well focus. The objective of image reconstruction is to combine information from multiple images of the same scene. When an image is acquired from a camera, only objects at focus plane would appear sharp. A way to get an image with all objects in focus is nothing but a image reconstruction. The result of image reconstruction is a new image which is more suitable for human and machine perception or further image-processing tasks such as segmentation, .feature extraction and object recognition. In the image reconstruction scheme presented in this paper, the wavelet transforms of the input images are effectively combined and the new image is obtained by taking the inverse wavelet transform of fused wavelet coefficients.

Keywords

Image Reconstruction, Wavelet Basis; Fusion Operator,

1. Introduction

Nowadays with the availability of multi sensor data in many fields, such as remote sensing, medical imaging or machine vision, sensor fusion has emerged as a new and promising research area. Image reconstruction is useful technique for merging multi-focus images. The objects in front of are focused and behind the focus would be blurred. A effective method to solve this problem is image reconstruction, in which we can acquire a series of images with different focus and then reconstruct them to develop a single well focus image. Generally, image reconstruction is carried out on gray color images [3][9], in this paper image reconstruction is done on color images. The wavelet transform based reconstruction method is one of the most important methods in common usage[7][10]. Pixel based image fusion is recently used [19][11].There are two important questions in image fusion field selection of wavelet name and decomposition level when wavelet transform is applied to multi-focus image reconstruction. And in the other hand, fusion rule is the kernel of image reconstruction and it directly influences the speed and quality of reconstructed image. So, this paper not only study on the former two questions but also involves the important part of image reconstruction of colored images. The merit of this color image reconstruction method is keeping the living original data as much as possible, which provides the details that other gray level reconstruction methods cannot supply.

2. Literature Review

The proposed system reconstructs the multi focus images& gives comparative analysis. Image reconstruction is a process of combining multiple images to form a single image by utilizing certain features from each image.

W.Wright developed a fast image fusion with a markov random field[16].Currently, most of the image fusion has been performed using pixel based methods [11].The simplest way of pixel level image fusion is to take the average of the two images pixel by pixel.However,this method usually leads to undesirable side effect such as reduced contrast. O.Rockinger presents image fusion technique based on pixel level. Advantage of the pixel level image fusion is that images contain original information. Furthermore is easy to implement [11].L.J.Chipman presented a wavelet based image fusion [8].Dryden proposed image fusion method based on.In this paper they proposed shape variability of fused image[4].Yang and Jiao developed image fusion strategy for panchromatic high resolution image and multi spectral image in Nonsub sampled contourlet (NSCT) domain. Yang Lui developed a new theory about multi-focus image fusion algorithm based on contourlet decomposition and region statistics [20].

In recent year many algorithms are developed for multi resolution image fusion.R.S.Blum, proposed image fusion based on multi-sensor image fusion, i.e. images are taken from different camera are fused[13].Different method a are available methods are available related to image fusion. C Thomas developed a new approach of image fusion for multi spectral images using remote sensing physics [3].

Manjusha D gives quality assessment of result of different techniques used for fusion of multi-sensor images .This paper gives experimental results analysis for total 20 different techniques. In this merging of different images are done where images are taken from different sensor [9].

Image fusion methods based on wavelet transform have been widely used in recent years.S.D.Backer gives a simple image fusion algorithm based on wavelet transform [14]. Bingie gives wavelet analysis based image fusion. In this paper they proposed a algorithm for image fusion using wavelet transform [2].L Wang proposed multi-focus image fusion scheme based on wavelet contrast is given [7].

Q.Huynh gives quality assessment of fused images ,in this paper peak to peak signal to noise ratio is calculated for quality assessment [12].In our paper proposed method is based upon different wavelet and fusion rule, this gives best quality image reconstruction of colored images.

3. Image Reconstruction Scheme

The process of image reconstruction which is based on wavelet transform has a very first step is acquisition of images. In this paper images used are of one mechanical component which is having some finite depth and some finite groove.

3.1. Acquisition of image

The first step involved is acquisition of image. For capturing images we used Rapid–I Vision measurement system. The specifications of this measurement system are as follow.

1. It has in built digital camera of up to 1600x1200 video.
2. Ability to take snapshots in multiple formats.
3. Camera setting is programmable through software.

By using this measurement system we had taken images.

Number of images: 196 (800 x 600 pixel)

Format of images: JPEG (joint photographic expert group)

Images taken of microfludic groove are from bottom to top approach. In first image focus is at bottom then by varying focal length we had taken other images. So we got total 196 images. Our proposed algorithm has to develop single image which is well focus retained original information. The process of image reconstruction which is based on wavelet transform is shown in figure 1.

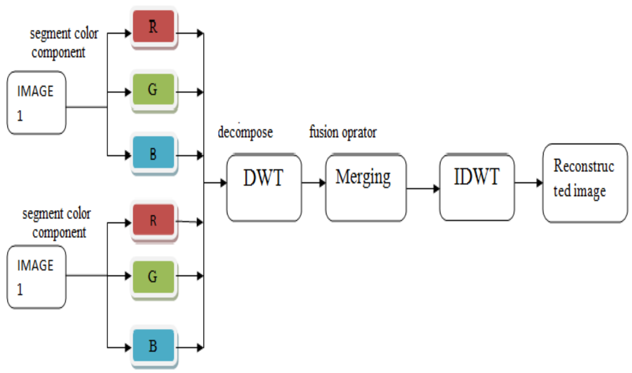

Figure 1: Schematic diagram of image Reconstruction

4. Proposed Reconstruction Scheme

The different steps involved in image reconstruction based on wavelet transform are as follows.

Step1. Segment colored component of images. Image contains three colored components which are red, green and blue.

Step2. Carry out Discrete Wavelet Transform on each image. Output of dwt gives coefficients called decomposition coefficient.

Step3. Merge each coefficient individually by using different fusion operator and finally we get a coefficients contain more information of all images after the merge processing.

Step4. Carry out inverse discrete wavelet transforms to form a single image which means to reconstruct the image.

The details about all the process in given below.

4.1. Wavelet Transform

The transform of a signal is just another form of representing the signal. It does not change the information content present in the signal. The Wavelet Transform provides a time-frequency representation of the signal. Wavelet Transform uses multi-resolution technique by which different frequencies are analyzed with different resolutions. The DWT is computed by successive low pass and high pass filtering of the discrete time-domain signal as shown in figure 2.

In the figure2, the image I, The low pass filter is denoted by *H(x)* while the high pass filter is denoted by *G(x)*. At each level, the high pass filter produces detail information, while the low pass filter associated with scaling function produces coarse approximations. After decomposition of image through low pass and high pass filter four components are generated. These four components are combination of the low and high band such as

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low-low band, low-high band, high-low band and high-high band. These bands are called as coefficient of wavelet. It contains different information of the image like approximate, horizontal, vertical and diagonal. In this project at first we used 50 kinds of wavelet basis functions which are tested and compared. The basic representation of DWT is shown
in figure 2.

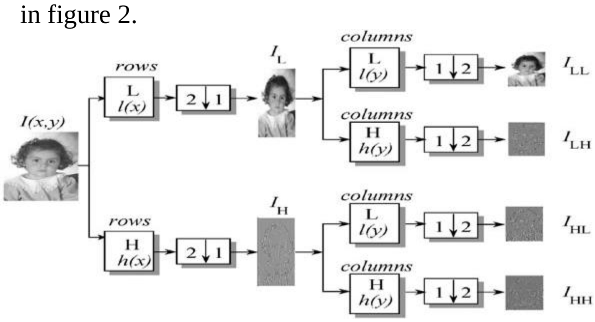


Figure 2: Schematic representation of DWT

In this paper comparison of different wavelet is done. Comparison is based on basis of quality of reconstructed image .For quality assessment performance measurements are used. Table 2 shows different wavelet basis function used in this paper.

Table 1: Kinds of wavelet basis function

50 kinds of wavelet basis functions
Haar db1 db2 db3 db4 db5 db6 db7 db8 db9
db10 sym2 sym3 sym4 sym5 sym6 sym7 sym8
Coif1 Coif2 Coif3 Coif4 Coif5 bior1.1 bior1.3
bior1.5 bior2.2 bior2.4 bior2.6 bior2.8 bior3.1
bior3.3 bior3.5 bior3.7 bior3.9 bior4.4 bior5.5
bior6.8 rbio1.1 rbio1.3 rbio1.5 rbio2.2 rbio2.4
rbio2.6 rbio2.8 rbio3.1 rbio3.3 rbio3.5 rbio3.7

4.2 Fusion Operator

The key process in image reconstruction is based on wavelets is that of coefficient combination, namely, the process of merge the coefficients in an appropriate way in order to obtain the best quality in the reconstructed image. Image information is contained in all frequency components, so merging of coefficient is very important process in image reconstruction. To merge coefficient of images different fusion operators are used .Basically three fusion operators are considered as a primary operator as Max, Mean, Min and by taking combination of these basic operator we used total 9 fusion operator. Some wavelet-based application does not require all coefficients, only the most relevant. So an additional procedure can be carried out to eliminate non-significant coefficients by thresholding, since these have a magnitude close to zero. After thresholding, only the desired coefficients remain. In proposed technique we used all coefficient of discrete wavelet transform to retain important information from images. Primary fusion operators are explained below.

Mean: Mean is average value of coefficient calculated using following formula

$$M(i.j) = \frac{\sum a1(i,j) + a2(i,j)}{N}$$

Where N= total number of coefficient.
Mean of coefficient gives average value from all coefficients to be merged. so the information of image is retained.

Max: This operator uses comparison to find out maximum value from coefficient .Equation of max operator.
*mat= abs(a1)>=abs(a2) ; a=a1.*mat+a2.*(~mat)*

Min: This operator uses comparison to find out minimum value from coefficient.
Equation of max operator.
*mat= abs(a1)<=abs(a2) ; a=a1.*mat+a2.*(~mat)*

Result of discrete wavelet transform gives four frequency coefficient named as approximate, horizontal, vertical and diagonal. According to table shown below we applied fusion operator on coefficient of dwt.
The fusion operators taken from combination of primary fusion operators are shown in Table 2.

Table 2: Fusion Operator

Fusion Operator	Operation on approx image [a]	Operation on detailed images [h v d]
Maxmax	Max	max
Maxmean	Max	mean
Maxmin	Max	min
Meanmax	Mean	max
Meanmean	Mean	mean
Meanmin	Mean	min
Minmax	Min	max
Minmean	Min	mean
Minmin	Min	min

4.3 Inverse Wavelet Transform

Once the fusion operator applied on coefficient of DWT we got a resultant coefficients which contain information of all images. Resultant image can be obtained by applying inverse dwt.Inverse discrete wavelet transform reconstruct all four coefficient images. In this paper we used 50 types of wavelet basis used for Inverse discrete wavelet. The best wavelet basis can be obtained from quality assessment of reconstructed image.Resultant image obtained from inverse dwt contains well clear part of all images. This image is called as reconstructed image, in which original information is retained.

5. Performance Measurement

Assessment of performance of reconstructed image is also one of the important part in image reconstruction. Since reconstructed images are used to enhance visual information for human users, performance assessment of image reconstruction should be first judged by the users based on the mission of specific applications. In these situations ,it is hard to take decision about the quality of reconstructed image Performance measures should only serve as a useful tool to assist human users to make difficult judgments whenever necessary.
We gives two performance measures which is helpful in quality assessment of reconstructed image. Different performance measures used are similitude measure, difference index. The details about performance measure are as following.

5.1 Similitude Measure (SM)

Similitude Measure measures the correlation of the reconstructed image and the ideal image.

$$SM = 2 \times \frac{\sum_{i=1}^{M}\sum_{j=1}^{N} F(i,j) \times R(i,j)}{\sum_{i=1}^{M}\sum_{j=1}^{N}[F(i,j)^2 + R(i,j)^2]}$$

Where, M, N indicate the size of the image , F (i, j), R (i, j) indicate the gray value of the pixel which is in the row i and in the column j of the image. The more close value of SM is to 1, the better the reconstruction effect is. Using SM we can easily calculate which wavelet is efficient and which fusion operator is good.

5.2 Difference Index (D)

Difference Index shows the match between the reconstructed image and the original images in spectral domain

$$D = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{|F(i,j) - R(i,j)|}{R(i,j)}$$

Where, M, N indicate the size of the image is M×N, F (i, j), R (i, j) indicate the gray value of the pixel which is in the row i and in the column j of the image. If the difference index is small, it means the reconstructed image not only raises the spatial resolution, but also retains the spectral information of the image.

Algorithm:

Step 1: Input multi focus images are *In* where *n= 1 2…N*

Step 2: Segment color image into basic color component
red=In(:,:,1) green=In(:,:,3) blue=In(:,:,2)

Step 3: Transfer color component of all images into frequency component using dwt [section 2.1].

Step 3: Apply different wavelet basis given in table no.1 on all input images. Decomposition gives four frequency component .Denote component as *a1,h1,v1,d1*
[a1 h1 v1 d1]=dwt2 (I, wname {i},'mode' per');

Step 4: Merge transform frequency component using fusion operator given in table no 2.Denote merged component as *fa, fh, fv,fd*.

Step 5: Apply inverse dwt to get final image, which is called as reconstructed image.
rec=idwt2(fa,fh,fv,fd,wname{i},'mode',' per');
Where rec is reconstructed image.

Step 6: Calculate similitude measure .High value of similitude measure represents best quality of reconstruction. Value of SM should be less than 1

Step 7: Calculate difference index .Small value of difference Index shows best recovery of spectral information.

Step 8: By comparative analysis of SM & DF for all wavelet basis we can get best wavelet basis and best fusion operator.

6.Result

Here we chosed different test images for testing purpose.The test images are book,leena.Reconstructi--on is totally depend upon wavelet so we used fifty kinds of wavelet,Haar,db1,db2,db3,db4 etc so that we can achieve best quality image .Merging process is heart of image reconstruction, so to achieve best results we used total 9 fusion operator .The quality of image is depend upon which component of DWT is merged. In this paper we used nine combination of mean ,max.min as fusion rule.From SM we got the meanmax as a efficient fusion rule . Also we got Haar as a good wavelet basis function.By applying algorithm on test images we conclude that Haar wavelet and meanmax fusion rule gives the best results.We used 196 colored images taken from Rapid I Vision measuring system.By applying reconstruction algorithm to colored image we got best quality singal colored image which is more closer to orignal image containing all important information of all images.For quality assesment of resultant images we used different performance analysis.Two different performance measures are used ,Similitude measure, Difference index.The value of SM should be 1 ,we got value of SM is a close 1.For test images and for colored images we got different different value of all performance measure .All experimental value gives best wavelet name and good fusion operator .Depend upon value of performance measure quality of image is evaluated ,figure 3 shows graph of value of SM to the wavelet name.

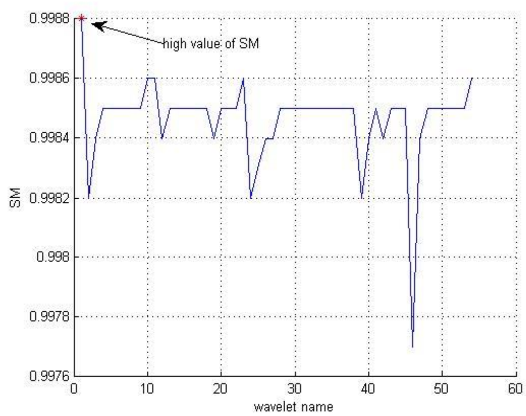


Figure 3:Comparison of wavelet

Value of similitude measure gives best wavelet basis function.If value of SM is high then that wavelet for which we got high value is best basis.Value of SM should be upto 1.For comparision of wavelet we plot graph of SM to wavelet basis,where x axis represents wavelet name and y axis represents value of SM.We are assign number from 1-50 for wavelet basis function like Haar -1,db2-2,db3-3etc. Arrow indicates high value of SM which is ploted with red color and using specific symbol.From this graph we can concluded that Haar is bset wavelte basis.

Table.3:Experimental Analysis

Sr.No.	Images	Wavelet Basis	Fusion Operator	DI	SM
1	Book	Haar	meanmax	0.0062	0.99957
2	leena	Haar	meanmax	0.0085	0.99995
3	Microfludic groove1	Haar	meanmax	0.0042	0.99991
4	Microfludic groove2	Haar	meanmax	0.0042	0.9995

Table 3 shows experimental analyasis which are carried out on different images .Experimental analysis gives comparative study of performance measures similitude measure (SM) and difference index (DI).In this reconstruction scheme 50 types of wavelet basis are used for discrete wavelet transform (DWT) and inverse DWT .The result of all wavelet basis are compared .For comparision performance measures are used ,which are also used for quality assesment.

Tableno 4:Comparative analysis of wavelet basis

Sr.No.	Name of Wavelet Basis	Fusion Operator	SM	DI
1	Haar	meanmax	0.99957	0.0002
2	db1	meanmax	0.99995	0.0085
3	db2	meanmax	0.99992	0.0068
4	db3	meanmax	0.99991	0.0068
5	db4	meanmax	0.99992	0.0068
6	db8	meanmax	0.99968	0.0032

Table shown some comaprative analysis used in this scheme carried out on microfludic groove. Comparative analysis gives overview of results obtained using different wavelet basis for DWT and IDWT.

7. Conclusion

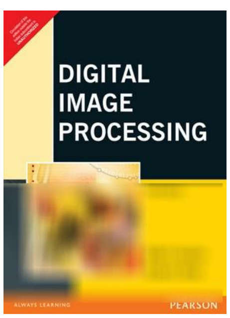
Image reconstruction is used to integrate complementary information from multiple images of the same scene into an image, so that the resultant image is more suitable for the purpose of human visual perception and computer processing tasks. The paper gives an effective technique for reconstruction of multi-focus images. For the multi-focus image reconstruction, the algorithm used in this paper has got very good integration results. In this paper, 50 kinds of wavelet-based reconstruction methods are compared, and 9 fusion operators are used . The use of Similarity Measure (SM) as an image fusion evaluation criteria, more intuitively reflects the image reconstruction results. Finally we summarized the best wavelet, the best fusion operator. The reconstructed images we got were nearly identical to the ideal images since the similarity measures of them were all more than 0.999, which is much more precise than other results Because this paper analyses and compares 50 wavelet bases, 9 kinds of fusion operator there fore result is more detailed and comprehensive.

(a)

(b)

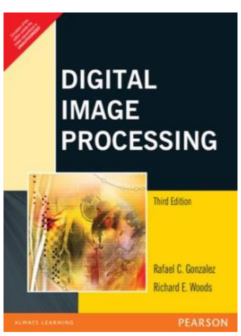
(c)

Figure 4 : Image reconstruction of image leena.(a) image with focus on left side . (b) image with focus on right side. (c) reconstructed image which contain all focus part of image (a)and(b) .



(d)

(e)



(f)

Figure 4 : Image reconstruction of image book (d) image with focus on upper side . (e) image with focus on lower side. (f) reconstructed image which contain all focus part of image (d)and(e)

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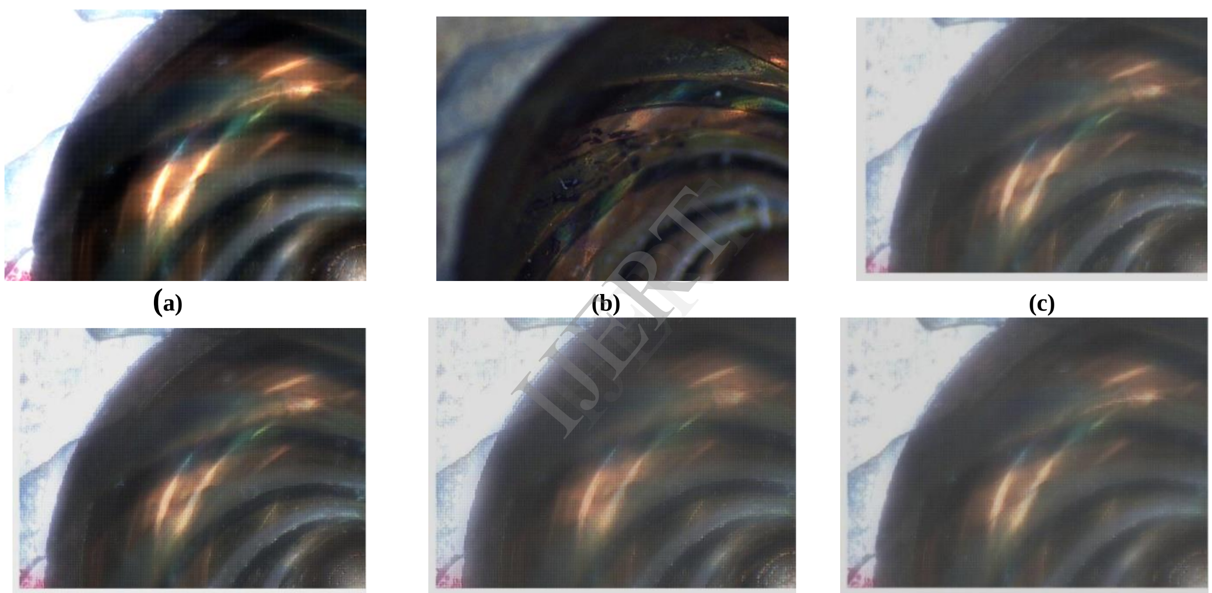
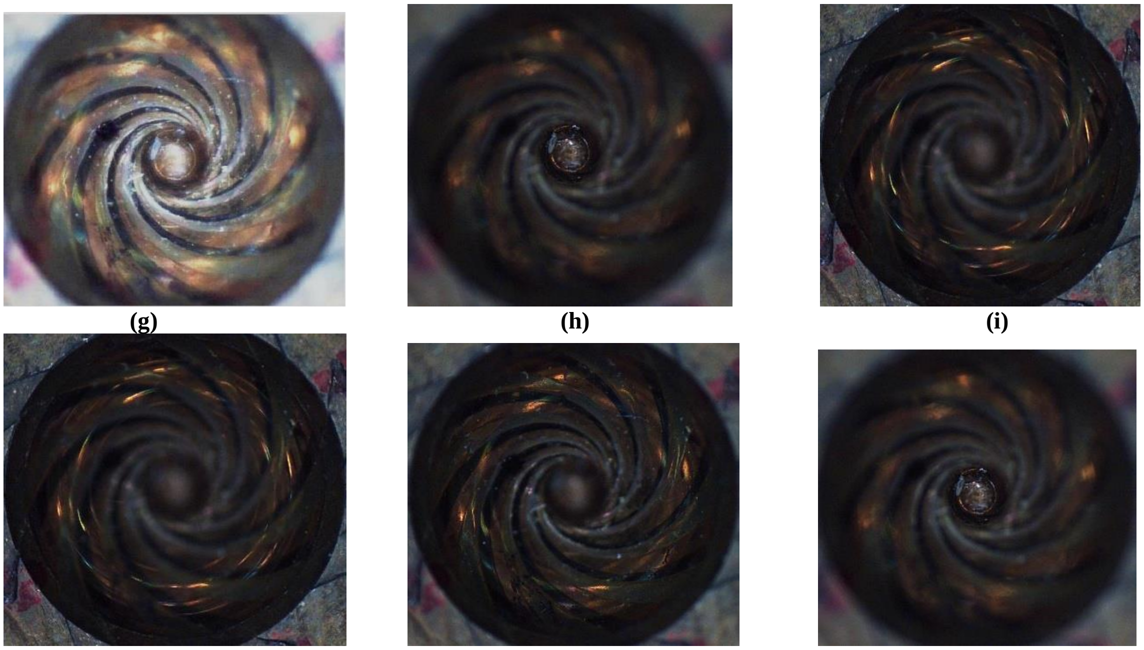


(a) (b) (c)

(d) (e) (f)

Figure 6. Results obtained by different wavelet basis .(a) Reconstructed image of one fourth part of micro-fluidic groove by using Haar wavelet.(b) By using db1 (c) By using db2 (d) By using db3 (e) By using db4 (f) By using db8.



(g) (h) (i)

(j) (k) (l)

Figure 7. Results obtained by different wavelet basis .(g) Reconstructed image of one fourth part of micro-fluidic groove by using Haar wavelet.(h) By using db1 (i) By using db2 (j) By using db3 (k) By using db4 (l) By using db8.