Performance Evaluation of Haar Wavelet for Image Inpainting

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Abstract— *Image inpainting or restoration is one of the techniques which are being used from medieval times. Wavelets have shown significant performance in the process of image inpainting. But there are many wavelets available which can be used. In this paper we will evaluate the performance of Haar wavelet in image inpainting. Its performance will also be compared with some other wavelets using different cracked images.*

Keywords— Haar, Image inpainting, Multiresolution, Texture, Wavelet.

I. INTRODUCTION

The aim of image inpainting is to restore an image such that a viewer cannot detect the restored parts. One application of image inpainting is to retouch damaged parts of a digital picture. Before the inpainting process is started, the user defines a binary mask for the image, which marks the region that should be restored. Medieval artwork started to be restored as early as the renaissance. The motive was simple, to bring medieval pictures, 'up to date' as to fill any gaps. This practice is called 'retouching' or 'Inpainting'. Also image Inpainting has been widely investigated in the applications of digital effect (i.e. object removal, image editing, image resizing), image restoration (e.g. Scratch or text removal in photograph), image coding and transmission (e.g. recovery of missing blocks) etc. The conventional schemes that are proposed for image inpainting can be divided into two categories:

a) Texture oriented b)Structure oriented.

Both these techniques were used to inpaint different cracked images. But the results were not satisfactory. Though the techniques of texture synthesis are effective, they have difficulty in filling holes in photographs of real world scenes consisting of composite textures. On the other hand structure based technique had the drawback that they introduce some blur, which becomes noticeable when filling larger regions. Thus Marcelo Bertalimo[4,5] introduced implementation of wavelet transform for the image inpainting process. Wavelet transform has been used for various image analysis problems due to its nice multi-resolution properties and decoupling characteristics. For the wavelet transform, the coefficients at the course level represent a larger time interval but a narrower band of frequencies. This feature of the wavelet transform is very important for image coding. In the active areas, the image data is more localized in the spatial domain, while in the smooth areas, the image data is more localized in the frequency domain. If the target region information is local and concentrated then decision method is based on the characteristic and direction of the neighbouring pixels. The image information can also be global and dispersed. If a great amount of data is lost then it becomes very difficult to repair the image using the neighbouring pixels information. Then we use the human vision's characteristic as the basis for image repair. When the reference image data is not sufficiently available then we can zoom the image to get the image shape for repairing. Wavelet transform has been used as a good image representation and analysis tool mainly due to its multi resolution analysis, data reparability, compaction and sparsity features in addition to statistical properties. A wavelet function (t) is a small wave, which must be oscillatory in some way to discriminate between different frequencies. The wavelet contains both the analyzing shape and the window. Hence widely used for image inpainting.

1.1 Haar WAVELET

In mathematics, the Haar wavelet is a sequence of rescaled "square-shaped" functions which together form a wavelet family or basis. The Haar wavelet is also the simplest possible wavelet. The technical disadvantage of the Haar wavelet is that it is not continuous, and therefore not differentiable. This property can, however, be an advantage for the analysis of signals with sudden transitions, such as monitoring of tool failure in machines. The Haar wavelet's mother wavelet function ψ(t) can be described as:

$$\psi(t) = \begin{cases} 1 & 0 \le t < 1/2, \\ -1 & 1/2 \le t < 1, \\ 0 & \text{otherwise.} \end{cases}$$

Its scaling function ϕ(t) can be described as:

$$\phi(t) = \begin{cases} 1 & 0 \le t < 1, \\ 0 & \text{otherwise.} \end{cases}$$

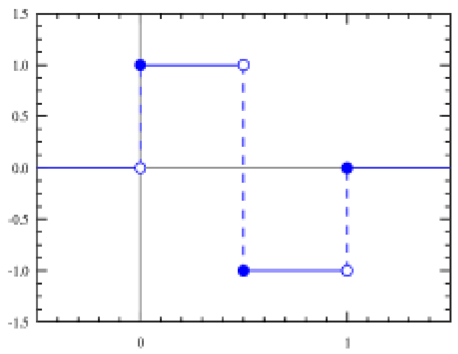


Figure 1 Haar Wavelet

1.1.1 Haar WAVELET PROPERTIES

The Haar wavelet has several notable properties:

1. Any continuous real function with compact support can be approximated uniformly by linear combinations of ϕ(t), ϕ(2t), ϕ(4t),………, $\phi(2^n t)$,…… and their shifted functions. This extends to those function spaces where any function therein can be approximated by continuous functions.

2. Any continuous real function on [0, 1] can be approximated uniformly on [0, 1] by linear combinations of the constant function **1**,ψ(t), ψ(2t), ψ(4t),……., $\psi(2^n t)$ and their shifted functions.

3. Orthogonality in the form

$$\int_{-\infty}^{\infty} 2^{(n+n_1)/2}\psi(2^n t - k)\psi(2^{n_1} t - k_1)\, dt = \delta_{n,n_1}\delta_{k,k_1}$$

Here δi,j represents the Kronecker delta. The dual function of ψ(*t*) is ψ(*t*) itself.

1.2 Haar TRANSFORM

The Haar transform is the simplest of the wavelet transforms. This transform cross-multiplies a function against the Haar wavelet with various shifts and stretches, like the Fourier transform cross-multiplies a function against a sine wave with two phases and many stretches.

The Haar transform is one of the oldest transform functions, proposed in 1910 by a Hungarian mathematician Alfred Haar. It is found effective in applications such as signal and image compression in electrical and computer engineering as it provides a simple and computationally efficient approach for analysing the local aspects of a signal.

1.2.1 Haar TRANSFORMS PROPERTIES

The Haar transform has the following properties:

1. No need for multiplications. It requires only additions and there are many elements with zero value in the Haar matrix, so the computation time is short. It is faster than Walsh transform, whose matrix is composed of +1 and -1.
2. Input and output length are the same. However, the length should be a power of 2, i.e. $N = 2^k$.
3. It can be used to analyse the localized feature of signals. Due to the orthogonal property of the Haar function, the frequency components of input signal can be analyzed.

Modern cameras are capable of producing images with resolutions in the range of tens of megapixels. These images need to be compressed before storage and transfer. The Haar transform can be used for image compression and image inpainting. The basic idea is to transfer the image into a matrix in which each element of the matrix represents a pixel in the image. For example, a 256×256 matrix is saved for a 256×256 image.

II. IMPLEMENTATION

From the distorted image first we extract the three basic colour components red, blue & green. Then the wavelet decomposition is applied to the distorted image with red, blue & green components separated. We have different wavelets available for this process. Some them used here are Haar, Coiflet, Db4, Db2, Bior2 and Bior4. The decomposition made by these wavelets provide us the detailed horizontal, vertical and diagonal component. It also provide us the complete coefficient of the image. Hence we get the 4 major information of the distorted or test image. The three colour components red, blue & green with horizontal, vertical, diagonal & complete coefficient give us 12 different subplots. Each subplot provide us with the detailed information of the test image. More the information we get about the image better will be the inpainting result. From these components that we have extracted we will mainly use the detailed horizontal component and the complete coefficient of the image. Then the process of normalization is done using the maxima and minima of the image. Thus we marked the boundary region of the effected area of the image which is to be inpainted. Then the region marked is horizontally shifted and the effected region is filled by the information of the neighbouring pixels. Now we get the new value of detailed horizontal component and complete coefficient. Again the region is horizontally shifted and the area is filled with the neighbouring pixels. This process is again and again repeated and a number of horizontal shifts are done. After these various iterations we will get the final detailed horizontal component and the new complete coefficient of the image. Then we have to apply IDWT to obtain the new RGB values for image reconstruction. So finally we get the new inpainted image.

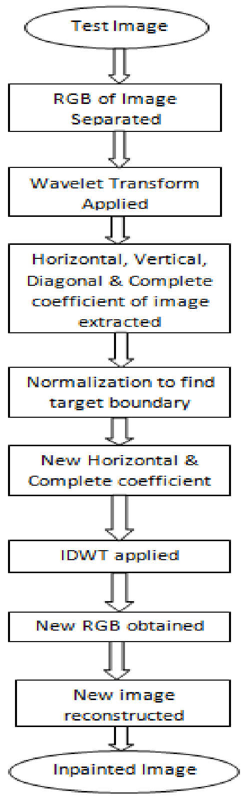
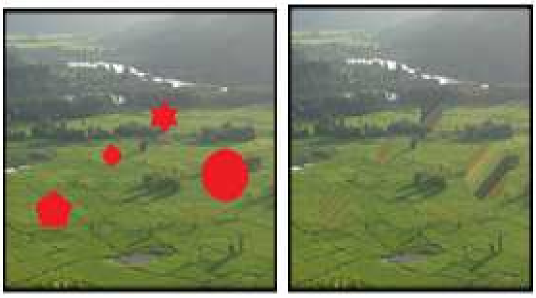


Figure 2 Flowchart of the proposed inpainting Algorithm

III. SIMULATION RESULT

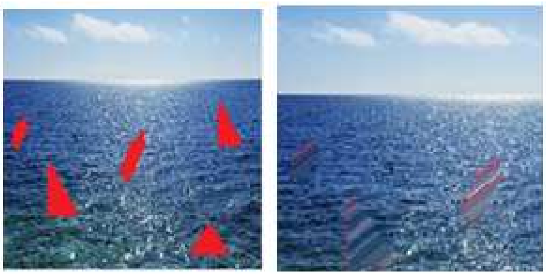
In simulation result we have performed image inpainting on various images. We have used different wavelets for the image decomposition. Some of the wavelets used are Haar, Coiflet, Bior4, Bior2, Db4, Db2 etc. Different wavelets have shown variation in the parameters of image inpainting. The parameters used here are PSNR(Peak Signal to Noise Ratio), MSE(Mean Square Error), MSSIM(Mean Structural Similarity Index) and WPSNR(Weighted Signal to Noise Ratio).



(a)

(b)

(c)



(d)

Figure4. Distorted Images on the left side along with Inpainted Images on the right side

TABLE I. RESULT FOR IMAGE (a)

Wavelet Used	PSNR	MSE	SSIM	WPSNR
Haar	36.2642	15.3694	0.96474	37.7129
Db2	36.1407	15.813	0.96425	37.6042
Coiflet	35.3441	18.9966	0.96446	36.8526
Bior2	32.649	35.3329	0.9624	34.276
Db4	35.3319	19.0498	0.96371	36.8542
Bior4	34.1079	25.2514	0.96557	35.6921

TABLE II .RESULTS FOR IMAGE (b)

Wavelet Used	PSNR	MSE	SSIM	WPSNR
Haar	38.3516	9.5043	0.98574	39.993
Db2	37.7031	11.0349	0.98513	39.205
Coiflet	37.4092	11.8077	0.98529	39.0911
Bior2	33.9947	25.9186	0.98369	35.6871
Db4	36.9498	13.1252	0.98374	38.6742
Bior4	36.2797	15.3148	0.98564	37.8676

TABLE III RESULT FOR IMAGE (c)

Wavelet Used	PSNR	MSE	SSIM	WPSNR
Haar	44.4434	2.3374	0.99681	45.7676
Db2	44.1342	2.5099	0.99627	45.1177
Coiflet	43.8964	2.6512	0.99633	44.6249
Bior2	43.5747	2.855	0.99578	43.8518
Db4	43.9027	2.6474	0.99582	44.7188
Bior4	42.5677	3.6	0.99493	42.9802

TABLE IV RESULT FOR IMAGE (d)

Wavelet Used	PSNR	MSE	SSIM	WPSNR
Haar	37.4808	11.6144	0.96095	39.5811
Db2	37.1705	12.4746	0.96071	39.0929
Coiflet	37.9202	10.497	0.9627	39.6983
Bior2	38.117	10.0318	0.9657	39.4671
Db4	37.5581	11.4097	0.9605	39.5886
Bior4	38.0332	10.2273	0.96537	39.3812

IV. CONCLUSION

In this paper we have analyzed Haar wavelet for image inpainting. Different distorted images were taken and each image was inpainted using 6 different wavelets. The performance of Haar wavelet was compared with different wavelets on the basis of 4 performance parameters; PSNR, SSIM, MSE & WPSNR. The main parameter of comparison is SSIM & PSNR. From the results shown we can conclude that **Haar** wavelet has given the maximum similarity index (SSIM) **99.68%.** PSNR is also maximum **44.44** for Haar wavelet. **MSE** is also minimum **2.33** for Haar wavelet. Thus we can conclude that Haar wavelet has performed better, for image inpainting, then other wavelets.

REFERENCES

[1] R. H. Chan, S. Setzer, and G. Steid, “Inpainting by Flexible Haar- Wavelet Shrinkage”, SIAM J. IMAGING SCIENCES 2008 Society for Industrial and Applied Mathematics Vol. 1, No. 3, pp. 273–293.

[2] Vaibhav V Nalawade & Sachin D Ruikar, “Image Inpainting using Wavelet Transform”, International Journal of Advanced Engineering Technology E-ISSN 0976-3945.

[3] Komal s Mahajan & Prof. M. B. Vaidya, “Image in Painting Techniques: A survey”, IOSR Journal of Computer Engineering (IOSRJCE) ISSN: 2278-0661, ISBN: 2278-8727 Volume 5, Issue 4 (Sep-Oct. 2012), PP 45-49.

[4] Marcelo Bertalmio, Guillermo Sapiro,Vicent Caselles and Coloma Ballester, “Image Inpainting”, in Proceedings of SIGGRAPH, 2000, pp. 417–424.

[5] Marcelo Bertalmıo, Vicent Caselles, Simon Masnou & Guillermo Sapiro, ”Inpainting”.

[6] Chaitali P. Sathe & Dr. Shubhalaxmi P. Hingway, “Image Restoration using Inpainting”, Volume 2, Issue 1, January 2014 International Journal of Advance Research in Computer Science and Management Studies.

[7] V. Janarthanan and G. Jananii,” A Detailed Survey on Various Image Inpainting Techniques”, International Journal of Advances in Image Processing, Vol. 2, No. 3, September 2012.

[8] George Papandreou, Petros Maragos & Anil Kokaram,” Image Inpainting with a wavelet domain hidden markov tree model”.

[9] Huaming Liu, Weilan Wang and Xuehui Bi,” Study Of Image Inpainting Based On Learning”.

[10] Nirali Pandya and Bhailal Limbasiya, “A Survey on Image Inpainting Techniques” International Journal of Current Engineering and Technology ISSN 2277 – 4106