Image Enhancement using Various Discrete Wavelet Transformation Filtration Methods

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Abstract:- Image enhancement is related as an important field in digital image processing. Normally, it is world-wide used in daily image improvement, remote sensing and medical image processing and microscopic images various areas. Several research papers are studied and found some issues such as noise images, lack of quality etc. In earlier researches, the authors have developed various image enhancement techniques. But the main problem is that some of the pixels are lost from the image. There are a number of existing methodologies for image super-resolution, but it is difficult to determine the best one. Some techniques may not work accurately with high spectral images. The main aim of this research work is to propose a comparative analysis of some of the most commonly used techniques for image super-resolution that work in the wavelet domain. The research completely describes and implements some of the techniques and a comparison is made by calculating the PSNR values of the respective techniques. Search a best suitable method according to the user's requirement. It has provided an image that is free noise and blurriness. Various DWT methods used to improve the image quality factor such an image in minimum response time and error rate and high PSNR rate.

Keywords: Digital Image, Image Resolution, Image Zooming, Improvement and DWT (Discrete Wavelet Transformation.

1. Introduction

In 3D image is simply a numeric definition of a picture in terms of the number of image pixels in horizontal and vertical planes of an image. Images help to focus the ideas of an individual. Images are easier to understand and interpret in contrast to textual information. Thus, due to a large number of applications of digital images, it is needed that the details contained in the image are clearly described and do not contain any kind of distortions or artefacts. Image resolution is the most important feature of an image that depicts the details held by an image and in this context; image resolution improvement is a significant approach that is widely used for enhancing the image resolution and visual entrance of an image [1].

Zooming has a world wide range of applications such as digital video, World Wide Web, Digital Video Disks, images of science. While zooming, pixels are embedded into the image keeping in mind the end goal to grow the extent of the image [2] in Fig. 1.1(a).

Fig 1.1 (a) Real Image (b) Zoomed Image

Image Super-resolution is an image zooming technique that feeds upon a low resolution image and produces an image as output with high resolution that contains more details. The essential aim of digital image enhancement is to extract the independent knowledge from individual image of lower resolution (LR) and consolidate the gathered learning into a solitary image of higher resolution [3].

In existing methods are described three dimensional image resolution improvements methodologies can be categories into two broad categories:

(i) **Frequency domain strategies**: It works upon the Fourier change of the picture. Fourier change is figured for the first picture, all the handling tasks are done on this change and afterward after every one of the activities, and the opposite of change is connected to get a high-goals picture [4].
(ii) **Spatial domain strategies:** It digital images legitimately work upon the pixels of the info pictures. The tasks are legitimately carried on the pixel estimations of the info picture lastly; a higher goals picture is accomplished. Be that as it may, these systems are not powerful when contrasted with the recurrence area [5].

In earlier researches, the authors have developed various image enhancement techniques. But the main problem is that some of the pixels are lost from the image. There are a number of existing methodologies for image super-resolution, but it is difficult to determine the best one. Some techniques may not work accurately with high spectral images.

The main aim of this research is to propose a comparative analysis of some of the most commonly used techniques for image super-resolution that work in the wavelet domain. The research completely describes and implements some of the techniques and a comparison is made by calculating the PSNR values of the respective techniques.

Section I defines about the introduction of the digital image improvement, image resolution and types, image zooming, existing methods, problem found and research objectives. Section II describes the related research work with various image improvement and enhancing methods and issue finding. Section III and IV discusses the research work with flow chart and detail description. Result analysis with performance metrics such as MSE, PSNR etc and comparison analysis. Section V. describes the conclusion and future work in research work.

2. Related Work

In the section, different research papers have been included by virtue of concentrates of all the papers that have been considered for reference. ***O. Harikrishna et al.***[6]have proposed a novel method for image super-resolution that can be used for various applications such as medical imaging, remote imaging, hype-spectral imaging and microscopic imaging. The authors have analysed and focused on different image contrast enhancement techniques and have postulated a novel method made from the mixture of local and global contrast enhancement techniques that improvises the image quality in terms of visual clarity and brightness. ***A. Raju et al.*** [7] have reviewed and compared different methodologies to enhance the image quality based on histogram equalization. The authors have analysed various types of bi-histogram equalization, multi-histogram equalization and clipped histogram equalization methods, implemented these and compared the results on the basis of AMBE and PSNR values by application of these methodologies on some well-known images. ***P. Karunakar et al.*** [8] in this paper, the authors have proposed a satellite picture determination upgrade strategy in view of the addition of the high-recurrence sub groups got by discrete wavelet change (DWT) and the information picture. The proposed determination improvement strategy utilizes DWT to break down the info picture into various sub groups. At that point, the high-recurrence sub band pictures and the info low-determination picture have been interjected, taken after by joining every one of these pictures to produce another resolution enhanced picture by utilizing converse DWT. Keeping in mind the end goal to accomplish a more honed picture, a middle of the road organize for assessing the high-recurrence sub groups has been proposed. The proposed procedure has been tried on satellite benchmark pictures. The quantitative (crest motion to-commotion proportion and root mean square mistake) and visual outcomes demonstrate the predominance of the proposed method over the regular and state of craftsmanship picture determination upgrade methods. ***K.S Singh et al.*** [9] have thought about and broke down different non-versatile interjection techniques utilized for the up degree of a picture in particular: Bilinear addition, Bi-cubic insertion and Nearest Neighbour Interpolation. The non-versatile introduction philosophies are more helpful than those with variance as far as yield picture's quality. The creators have connected these techniques on some eminent benchmark pictures. On correlation, the outcomes delineate that the bi-cubic addition outflanks the other customary insertion procedures. ***P. Suganya et al.*** [10] have assessed different picture determination improvement procedures in the wavelet space as wavelet changes were observed to be more capable than different changes. The methods talked about are: Wavelet Zero Padding, Wavelet Zero Padding and Cycle Spinning, Stationary Wavelet Transform, Discrete Wavelet Transform, Dual Tree Complex Wavelet Transform and Stationary Wavelet Transform-Discrete Wavelet Transform. Fundamentally, every one of these techniques feed upon a picture of lower determination, apply a wavelet change to part the first flag into a few sub-parts, and after that apply the backwards of the relating wavelet to blend these sub-parts lastly create a higher determination picture. These procedures are regularly utilized as a part of medicinal imaging; confront acknowledgment, picture up-degree in ultrasound and infrared imaging, unique mark identification and numerous different fields where satellite pictures are utilized. The correlation examination of various wavelet changes demonstrates that Discrete Wavelet Transform is the best methodology among the various changes.

3. Research Proposal

In this section, elaborates the research proposed techniques and performance metrics. Enhancement techniques like Wavelet Zero Padding, Wavelet Zero Padding and Cycle Spinning, Stationery Wavelet Transform, Discrete Wavelet Transform, Dual Tree-Complex Wavelet Transform and Stationery Wavelet Transform-Discrete Wavelet Transform. All these techniques take a low resolution image as an input and produce a high resolution images by dividing the image into distinct sub-bands and working upon them. These techniques work in the wavelet domain by making use of different wavelet transforms. Wavelet transforms are preferred over other transforms as it has been found that strategies that work in wavelet domain are less vulnerable to blurriness and other types of artefacts [12][13]. These transforms give the best response and among all these, the Discrete Wavelet Transform is the most proficient one. Interpolation techniques are used for constructing new data points within the range of a discrete set of known points. The interpolation strategies are broadly used in combination with the wavelet transforms so as to upgrade the given image without losing any details and to improve the quality of the image yielded [14]. Among all the discussed interpolation strategies, higher order splines yield the best response in terms of the quality of the image produced [15]. Used MATLAB toolbox 2016a is a tool for numerical computation and visualization. MATLAB was developed by Math Works. Initially it was a matrix programming language having simple linear algebra programming. It functions as both interactive sessions and batch job. Refined image: It is the most important part of the proposed strategy that depicts the result values and shows the actual output level achieved by all the strategies used. A refined image is obtained by applying the inverse of the wavelet transformation techniques like Inverse *WZP*, Inverse *SWT*, Inverse *DWT*, and Inverse *DT-CWT* [16]. It is the final highly resolved image that is presented as the output. Interpolated image: An interpolated image is obtained to determine the unknown pixels in the image with an objective to remove blurriness from an image on zooming. It is an intermediary result that is produced as a result of the application of some interpolation strategy [9]. It is an important part that is to be considered for further evaluation to obtain a refined output image. Performance parameters will be used to measure the performance of the proposed technique. Various performance metrics used for this purpose are: noise variance, mean square error, signal-to-noise ratio, peak signal-noise-ratio. All these parameters help us to compare and contrast the actual performances of all the strategies used in the proposed technique. On the basis of these parameters, a comparison analysis can be carried out to determine which of all the used strategies is the most proficient and reliable in terms of quality, response time and error. These parameters can be worked upon in MATLAB to measure the performance.

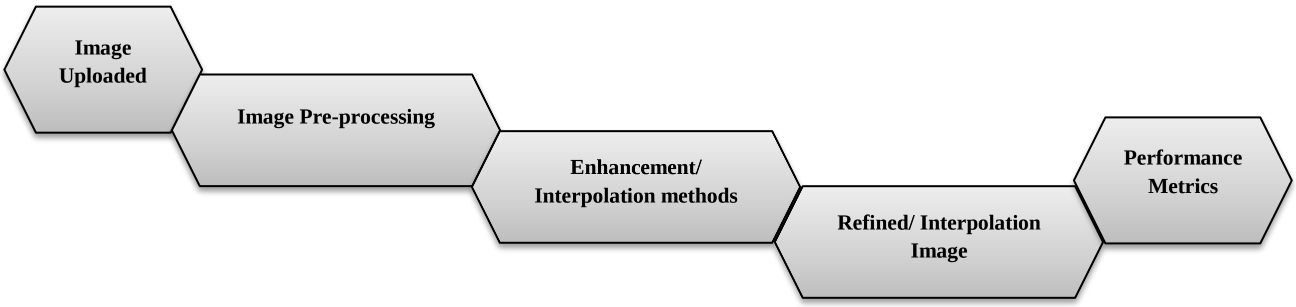

Fig 1.2. Research Proposal Methodology Flow Chart

4. Experimental Results

Discrete Wavelet Transform is the most suitable and thus, the research completely focuses on combining Discrete Wavelet Transform with a number of interpolation techniques for producing a high resolution image. These are implemented and compared based on the mathematical *PSNR* measures of the output images of different techniques. The proposed methodology is tested upon several renowned benchmark images and their PSNR values have been recorded. For this purpose, nine different images have been considered which are as shown in Fig. 1.3

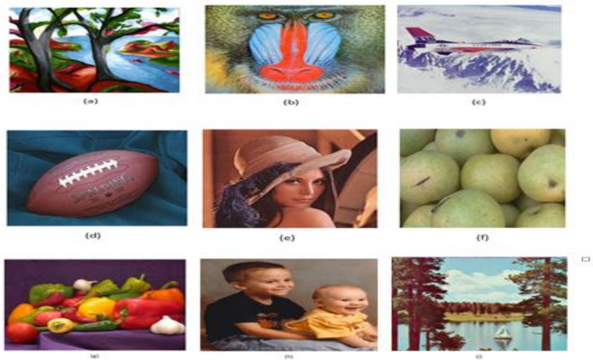

Fig 1.3 Output images (a) Trees (b) Baboon (c) Airplane (d) Football (e) Lena (f) Pears (g) Peppers (h) Kids (i) Sailboat

The input images shown in Fig. 5.1 are first of all decomposed by the application of *DWT*, and then various interpolation techniques are tried upon these sub images. Comparing the quality of outcomes produced a performance metric named *PSNR* (Peak signal-to-noise ratio) is used. The *PSNR* measures indicate the ratio of the noise present in the input and the output images. Greater the *PSNR* value, more fine is the image quality.

Table 1. Calculated PSNR measures for DWT in combination with different interpolation techniques.

Images/Filters	**Techniques in combination with *DWT***			
	Linear	**Bilinear**	**Nearest**	**Cubic**
Trees	72.3439	70.0172	70.265	69.9119
Baboon	69.999	68.9269	68.6571	68.7394
Airplane	74.8232	72.9779	72.8927	72.8927
Football	76.8462	71.6977	74.8436	75.5388
Lena	75.9232	74.4171	74.2504	74.2795
Pears	80.7309	78.7720	78.4745	78.6362

Table 1 shows the *PSNR* measures for various benchmark images that have been enhanced using the proposed methodology. The above tabular analysis represents the obtained *PSNR* measures of various renowned images on which *DWT* has been applied in combination with various interpolation strategies. When *DWT* is combined with linear interpolation, the minimum value is 69.999 and maximum value is 80.7309; in case of bilinear interpolation, the minimum and maximum values are 68.9269 and 78.7720 respectively; for nearest neighbour interpolation 68.6571 is the minimum value and 78.4745 is the maximum value; for cubic interpolation, minimum value is 68.7394 and maximum value is 78.6362; for bi-cubic interpolation, 67.3078 and 76.9808 are the minimum and maximum values respectively and lastly, for spline interpolation, the minimum and maximum values are 70.5864 and 82.1168 respectively.

Table 2 Comparison-MSE of various filters

Image/Filters	Bi-Cubic	Cubic	Linear	Bi-linear
Lena	0.0082	0.0082	0.0080	0.0080
Baboon	0.0257	0.0257	0.0247	0.0247
Peppers	0.0018	0.0018	0.0018	0.0018
Butterfly	0.3753	0.3753	0.3734	0.3734
F16	0.0103	0.0103	0.0100	0.0100
Average	**0.08426**	**0.08426**	**0.08358**	**0.08358**

The table 2 shows variation between values obtained by using various parameters .The MSE (Mean Square Error) value shows method to check the error rate in the enhanced image obtained. Clearly upon the execution, the performance of bi-linear and linear filter shows less MSE value and hence leading to the enhanced results for the execution upon passing through these filters.

Table 3 Comparison-PSNR of various filters

Image/Filters	Bi-Cubic	Cubic	Linear	Bi-linear
Lena	68.9808	68.9835	69.1054	69.1054
Baboon	64.0261	64.0261	64.2107	64.2107
Peppers	75.6324	75.6324	75.6138	75.6138
Butterfly	52.3874	52.3874	52.4092	52.4092
F16	67.9865	67.9865	68.1267	68.1267
Average	**65.80264**	**65.80318**	**65.89316**	**65.89316**

The tabular chart 3 is representing the values of PSNR (Peak signal to noise ratio) utilized as a performance parameter to calculate the quality of an image. Here the parameter is being used to check the enhanced image quality after passing it through various Filters. The processing of Bi-cubic and cubic is superior as they show high PSNR value in the execution. The quality of an image is far better in comparison to other filters as to when processed with cubic and bi-cubic filters.

Table 4 Comparison-Response Time of various filters

Image/Filters	Bi-Cubic	cubic	Linear	Bi-linear
Lena	1.8107	1.9620	1.9444	2.0959
Baboon	2.2447	1.9301	1.8979	1.9272
Peppers	1.9516	2.0084	1.8461	1.8628
Butterfly	3.4937	3.4086	3.5357	3.2346
F16	2.2559	1.9170	2.0737	1.9021
Average	**2.35132**	**2.24522**	**2.25956**	**2.20452**

In this table 4 outcome of Response time has being calculated using different filters which represent the total processing time of an algorithm, which is used to implement a series of steps in order to achieve an image and with an amplified output. Here in the given figure various Filters are used to process the image and compare the execution in terms of time it takes to respond to the commands. It is clear from the table that the calculated response time of bi-cubic is less than others, hence it becomes evident that bi-cubic has high speed processing in image enhancement when executed.

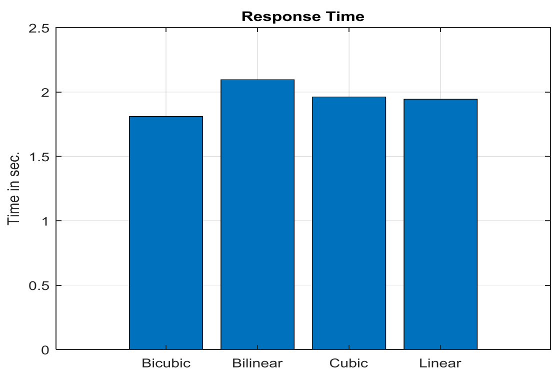

Fig. 1.4 Compares- Response Time

Response time is the total processing time of an algorithm, which used to process and image and provide enhanced output. Here in the given figure various Filters are used to process the image and compared in terms of response time. The calculated response time of bi-cubic is less than others, so it shows a high speed processing in image enhancement for the execution.

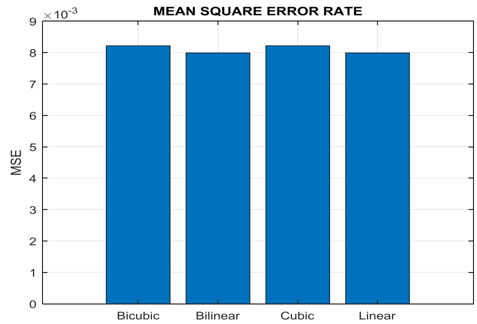

Fig. 1.5 Compares- MSE

Mean square error function is to check the rate of error in enhanced image. This parameter should be less as calculated from the enhanced image. Less MSE shows high performance of the protocol and provide better quality image. Here in the execution the performance of bi-linear and linear shows less MSE value and enhanced results for the execution.

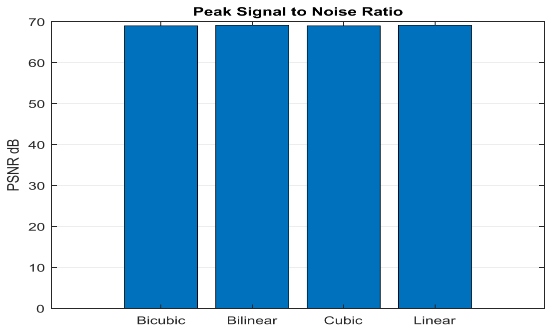

Fig. 1.6 Compares - PSNR

Peak signal to noise ratio parameter is for calculating the quality of an image. It is used to check the enhanced image quality with various Filters. The processing of Bi-cubic and cubic is better as shows high PSNR value in the execution. The quality of an image is better as compared with other filters as processed with cubic and bi-cubic filters.

Table 5 Comparison-PSNR with existing technique

Test Case/ Filters	EBSE(Base Paper)	Bi-Cubic	cubic	Linear	Bi-linear
Lena	30.2516	68.9808	68.9835	69.1054	69.1054
Butterfly	29.3826	52.3874	52.3874	52.4092	52.4092
F16	27.5627	67.9865	67.9865	68.1267	68.1267
Average	**29.065**	**63.1183**	**62.8264**	**63.2137**	**63.2137**

The table 5. Shows difference between various protocols including base paper. The PSNR value shows the quality of image [Fig. 5.2] which is calculated after the enhancement process. Here the performance of Linear and Bi-linear Filters is better as average of all the compared execution in terms of image quality.

5. Conclusion and Future Scope

The main motive of this research work is to develop a strategy to enhance an image without affecting the image quality. This research first of all studied the various processes that can be applied on the images namely: Compression, Watermarking, Contrast Equalization, De-hazing and Enhancement. Image Enhancement is taken up for consideration which uses different wavelet transforms including WZP, WZP-CS, DT-CWT, SWT, DWT and SWT-DWT. Among all these, the studies show that the DWT is the most proficient one that disintegrates the given image into four sub images: low-low (LL), low-high (LH), high-low (HL) and high-high (HH). The second step in the research moved on to the various interpolation strategies used for image enhancement that covered the analysis of Linear, Bilinear, Bi-cubic and Nearest

Neighbour interpolations. The results of all these techniques were up to the mark, but some higher order interpolations such as spline interpolation using Haar wavelet was found to be the most prominent among all these in combination with DWT. The study extended to a different feature of an image: Image Contrast. Image contrast was found to be a very basic feature that needed to be enhanced. This required the study of contrast equalization strategies: Adaptive Histogram Equalization and Contrast Limited Adaptive Histogram Equalization. With the help of these studies, a novel enhancement strategy has been proposed and tested upon some widely known benchmark images. The output images are analysed and their PSNR values have been calculated. The detailed comparison shows the overall average contrast improvement of 13.2% on the output images of the proposed method. Compared techniques clearly depicts that the existing strategies lag much behind the proposed methodology.

In future work, proposed steps can be elaborated to overcome issues of haze and blurriness in case of aerial effects caused in satellite images. The proposed methodology can also be further modified for underwater image enhancement.

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