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Image Enhancement in Wavelet Domain Using Histogram Equalization and Median Filters

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ABSTRACT- Image enhancement is one of the challenging but crucial methods that is employed in image processing technology for enhancing the visual appearance of images. This paper presents an effective and efficient image enhancement model in which Non Local mean (NLM) filter is used along with Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE) and Brightness Preserving Dynamic Fuzzy Histogram Equalization (BPDFHE) techniques. The primary objective of the proposed image enhancement model is to enhance the quality of images by reducing the noise effect in them. To do so, we have selected four different images of Barbara, camera, Lena and Hand whose quality is increased and analyzed on three different noise levels of 15, 20 and 25 respectively. Here, we have used NLM filter which is an advanced filtration technique for denoising the images. Also, MMBEBHE and BPDFHE techniques have been implemented for enhancing the quality of images on different noise levels. The efficiency and usefulness of proposed image enhancement model is examined and validated in MATLAB software under Mean Square Error (MSE) and Peak to Signal Ratio (PSNR) values.

KEYWORDS- Image enhancement, Histogram, Median Filters, NLM, MMBEBHE, BPDFHE

I. INTRODUCTION

An image is composed of a grid of pixels, which are all displayed on digital screen devices like computer displays and tv and has a specific size and height [1]. Every pixel on a particular plane is a specific size. A binary image is a two-dimensional representation of an image in binary form, and it has the same two-dimensional geometry as a digital photo, which represents the grey level and is also known as a pixel. A 2D image, or an image with only two coordinates, has the X and Y axes as two-dimensional characteristics. On the contrary side, a three-dimensional image is produced using the three coordinate axes (x, y, and z). Considerable preprocessing is required to convert a 2D image into a 3D view. Digital image processing (DIP) is a set of techniques that an image goes through to give it more distinct visual qualities. Image capture, image processing, and image display are the three main parts of an image processing system [2]. Moreover, the three main processing levels in DIP are low, middle, and high. The low-level procedures include things like image noise reduction, image sharpening, and image enhancement [3-4]. Typical middle-level procedures include image segmentation, picture recognition, image rendering, and others. Pictures are typically used as inputs for this level, and its outputs are the attributes extracted from those pictures. The final and most sophisticated step in image processing is picture analysis. In this paper, our main focus is on image enhancement techniques [5]. Image enhancement is one of the crucial steps in image processing technology in which quality of images is enhanced without loosing any important information. Image enhancement methods are typically used to reveal details that are hidden or to draw attention to specific characteristics in an image. One or more image properties may be changed throughout the image enhancement process. Numerous branches of research and engineering can benefit from image improvement [6]. The clarity of images is also impacted by outside noises and environmental disturbances such changes in temperature and atmospheric pressure, therefore, necessitating Image enhancement. Image enhancement technique can be divided into two broad categories, one is spatial based domain image enhancement and second is Frequency based domain image enhancement [7]. Spatial based domain image enhancement works directly on pixels. The fundamental benefit of spatial based domain approaches is that they are easy to comprehend and have a low level of difficulty, which favors real-time implementations. Again, spatial domain techniques can be divided into two primary groups of Point Processing operation and Spatial filter operation. Point processing operation is the simplest spatial domain operations occur when the neighborhood is simply the pixel itself. Used primarily for contrast enhancement. In Spatial filter operations**, a**n image can be enhanced or modified with filters. Filtering or spatial domain action in which the analyzed amount for the current pixel depends on both that pixel and its surroundings. As a result, filtering is a neighborhood operation where the value of each output pixel is decided by using a particular algorithm to the values of the pixels that surround the input pixel. On the other hand, the phrase "frequency-based domain image enhancement" refers to the examination of mathematical formulas that deal directly with the transform coefficients of an image and are frequency-based, such as the Fourier transform and the discrete cosine transform (DCT) [8-9]. This method's fundamental goal is to improve the image by modifying the transform coefficients. Again, frequency domain techniques can be divided into three groups of Image Smoothing, Image Sharpening and Periodic Noise reduction by frequency domain filtering. Over the years, a number of image enhancement techniques have been presented in scientific journal, and each techniques has one or few other application fields. On the basis of field application, types of images (gray scale or colored), the best appropriate technique for image enhancement is selected. In this paper, we are going to propose an effective and productive image enhancement technique in which work has been done on two phases. the major contributions of this research are;

- In the proposed work, we have tried to enhance the image quality of four images i.e. Barbara, Camera, Lena and Hand on different noise levels.
- Also, an advanced filtration technique is implemented in the proposed work for denoising these images.
- Moreover, we have implemented two histogram equalization techniques in the proposed work for improving overall quality of image.
- The analysis of proposed image enhancement model is done in terms of MSE and PSNR values in MATLAB software.

The remaining sections of the paper are categorized as: Section 2 represents the literature Survey followed by problem statement. Section 3 discusses the proposed work and its working methodology. Section 4 contains results that are obtained for proposed image enhancement model ad finally, in Section 5 conclusion of the paper is given.

II. LITERATURE SURVEY

In order to enhance the quality of images for computer Vision and image processing applications, different researchers have proposed different techniques. Some of them are reviewed here; D. Sharma, et al. [7], proposed fractional order partial differential equations (FPDE) based image enhancement model for denoising the images and improving its contrast. C. Qing-li, et al. [10], proposed a hybrid integer order differential and fractional picture enhancement technique for increasing the differential order beyond 2 and gets around the restriction that the fractional differential order can only be 0–1 in picture enhancement. F. Russo and G. Ramponi, [11], utilized FIRE operator in their work and proposed a Fuzzy logic based image enhancement model for increasing the overall quality of images. The relative simplicity of the suggested approach and a specific fuzzy inference method makes the models really simple with excellent results are essential factors. F. Farbiz, et al. [12], proposed a new fuzzy-logic-control based filter having the ability to effectively preserve edges and picture information while reducing impulsive noise and smoothing out Gaussian noise. Simulation results revealed that proposed filter performs very quickly compared to other filters. M. Fang, et al. [13], integrated spatial and temporal neighboring information and established a new reference pixel set by taking two adjoining frames both before and after the current frame to improve the effectiveness of images, especially in night image and boost the reference information content of low-illumination video images. Results revealed that the proposed algorithm was appropriate for texturing low-light or uneven-light video pictures. M. Zarie, et al., [14], proposed triple clipped dynamic histogram equalization based on standard deviation (TCDHE-SD) approach for robust contrast enhancement in this research. Results revealed that proposed method had a great benefit over the earlier ones in terms of entropy and visual clarity. Dhar S, et al. [15], proposed a method named as novel image thresholding method which was established on interval type-2 fuzzy set (IT2FS). Also, to improve the computation efficacy of proposed thresholding approach, a developmental algorithm known as Bat algorithm was utilized. Draa A, et al. [16], proposed new Artificial Bee Colony (ABC) algorithm for enhancing the image contrast. Furthermore, the proposed method had been developed to handle color image enhancement, and the outcomes were so encouraging. In the paper, additional qualitative and statistical comparisons between the suggested ABC and the Cuckoo Search (CS) algorithm were also provided. T. K. Agarwal, et al. [17], proposed a novel technique for medical picture contrast enhancement named as “Modified Histogram Based Contrast Enhancement using Homomorphic Filtering (MH-FIL) in which image’s contrast was modified by using histogram technique and homomorphic filtering was used for sharpening the image.

From the above literatures, it is observed that a number of methods have been proposed for enhancing the quality of images. No doubt that these models were showing good results, however, we found out that there is a scope of improvement. The image processing techniques used in exiting image enhancement models undergo through shift sensitivity, poor directionality and lack of phase information, which makes the process quite complex and challenging. Moreover, the poor processing speed of current models also enhanced their complexity. In addition to this, we have also analyzed that traditional models used standard filters for removing nose from images, however, a number of new filters are available nowadays that generate high results. Keeping these things in mind, a new and efficient image enhancement method must be proposed that can overcome the limitations of existing image enhancement models.

III. PROPOSED WORK

In order to overcome the limitations of existing models, an effective and efficient image enhancement model is proposed in this paper in which modifications have been done on two phases of Denoising and Image enhancement. The primary goal of the proposed work is to improve the overall quality of image by removing noise from it. In order to achieve this goal, four different images which included, Barbara, camera, Lena and Hand were considered, whose quality has been analyzed on three different noise levels of 15, 20 and 25 respectively. To determine the effectiveness and stability of the suggested image enhancement model, an image is first chosen from the four accessible pictures, and afterwards noise is added to it. The images are then denoised using an advanced filtration technique called the Non-Local Mean (NLM) filter, that improves the image quality and smoothness it. The NLM filter preserves the sharpness of the picture's strong edges whilst removing the noise from the input images. The smooth image created following NLM filtration is subjected to two histogram equalization algorithms namely Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE) and Brightness Preserving Dynamic Fuzzy Histogram Equalization (BPDFHE) in the next stage of the proposed work. One of the main motives for using two histogram equalization techniques is to improve the overall quality of image. Despite the fact that MMBEBHE, that is effectively an extended version of BBHE, is used to maintain the maximum brightness in images, BPDFHE is used to enhance brightness preservation and contrast improvement while lowering the computational burden. Moreover, MMBEBHE technique also divides mage's histogram into its mean value before evaluating each histogram separately. Hence, the quality of the images can be greatly improved with less complexity and processing time by using hybrid image enhancement techniques, namely MMBEBHE and BPDFHE, in combination with modern NLM filtration techniques. The detailed working of the proposed image enhancement model is explained in the next section of this paper.

IV. METHODOLOGY

The proposed image enhancement model undergoes through a series of steps for attaining the desired objective. It must be noted here that we have enhanced the quality of four images i.e. Barbara, Camera, Lena and Hand on three noise levels of 15, 20 and 25 to check the effectiveness of proposed model. The brief explanation of each step is given in this section of paper.

Step 1: At the very beginning, the proposed image enhancement approach reads the image upon which further most edge cutting techniques needs to be applied. Here, as mentioned earlier, we have used images of four categories i.e. Barbara, Camera, Lena and Hand under different noise levels of 15, 20 and 25. The sample images of four images is given in Figure 1.

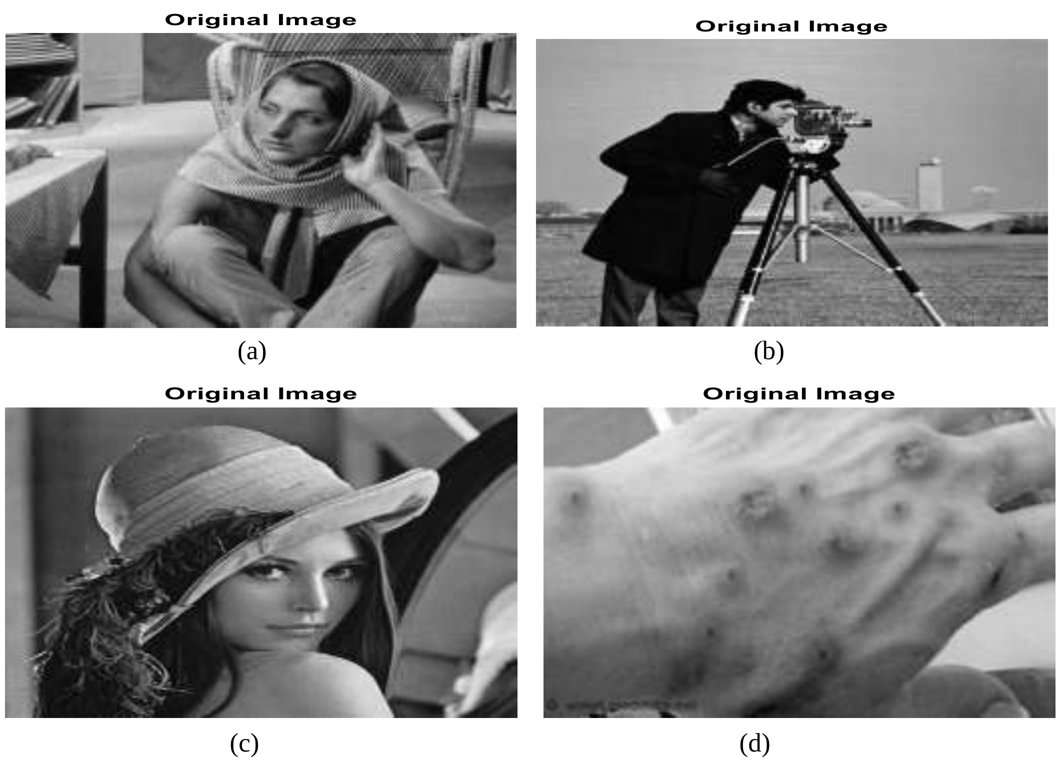


Figure 1: Sample images of Barbara in (a), Camera in (b), Lena in (c) and Hand in (d)

Step 2: In the next step of proposed model, noise is added up in the four images, in order to validate the robustness and efficiency of proposed model. Here, we have added noise to images of three levels i.e. 15, 20 and 25 respectively. The original images after adding noise to them are shown in Figure 2

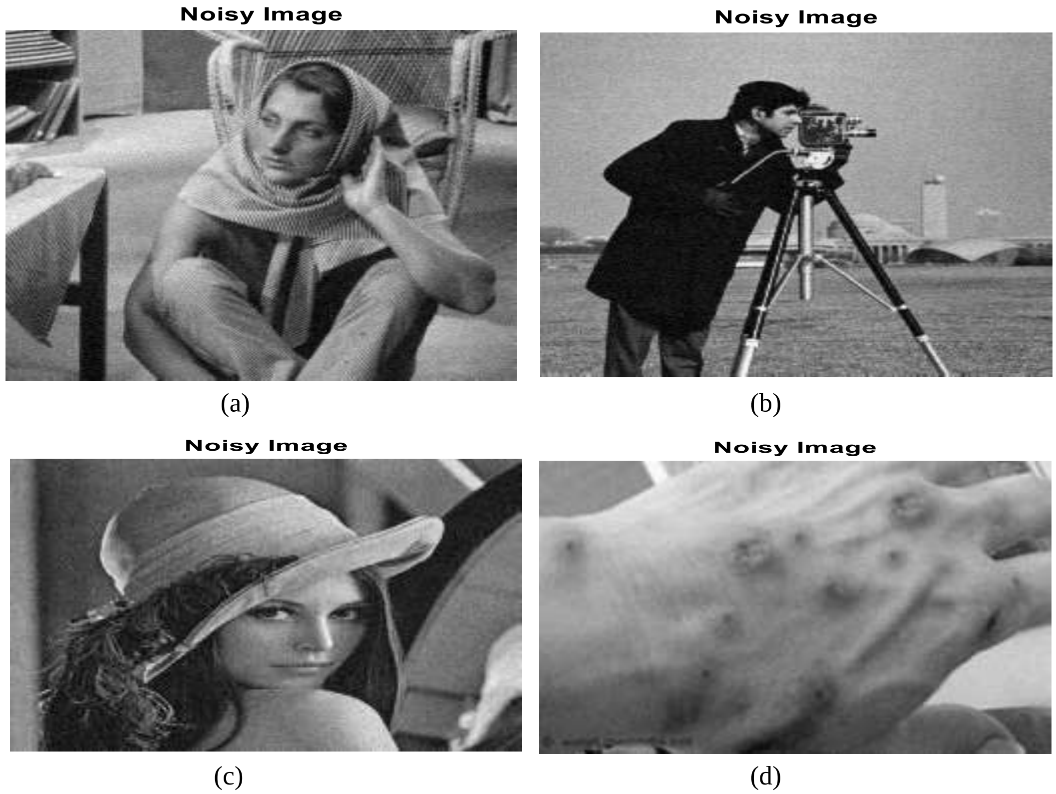


Figure 2: Noisy images for Barbara, camera, Lena and Hand in a, b c and d respectively

Step 3: IN the next stage of proposed work, Non-Local Mean (NLM) filter is applied to the nosy images, for performing the denoising operation. NLM filter efficiently removes noise from images and maintains important information about strong edges of image. The filtered image is shown in Figure 3.

Step 4: In the following stage of the suggested method, the filtered image is subjected to MMBEBHE histogram equalization in order to further improve its quality. It is in charge of preserving the maximum brightness in the picture, which improves picture clarity and consequently picture quality. The MMBEBHE enhanced images are displayed for four categories in Figure 4.

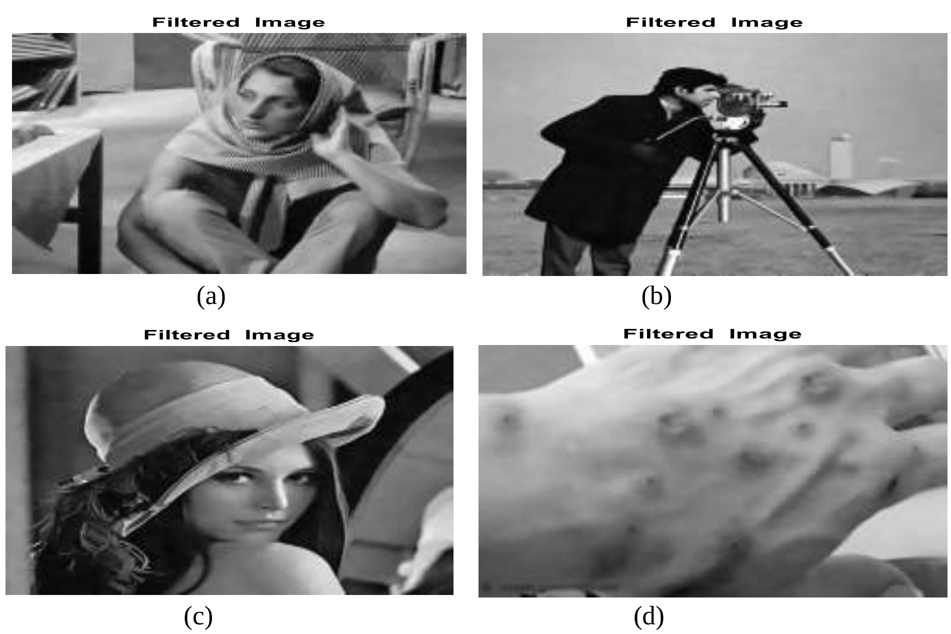
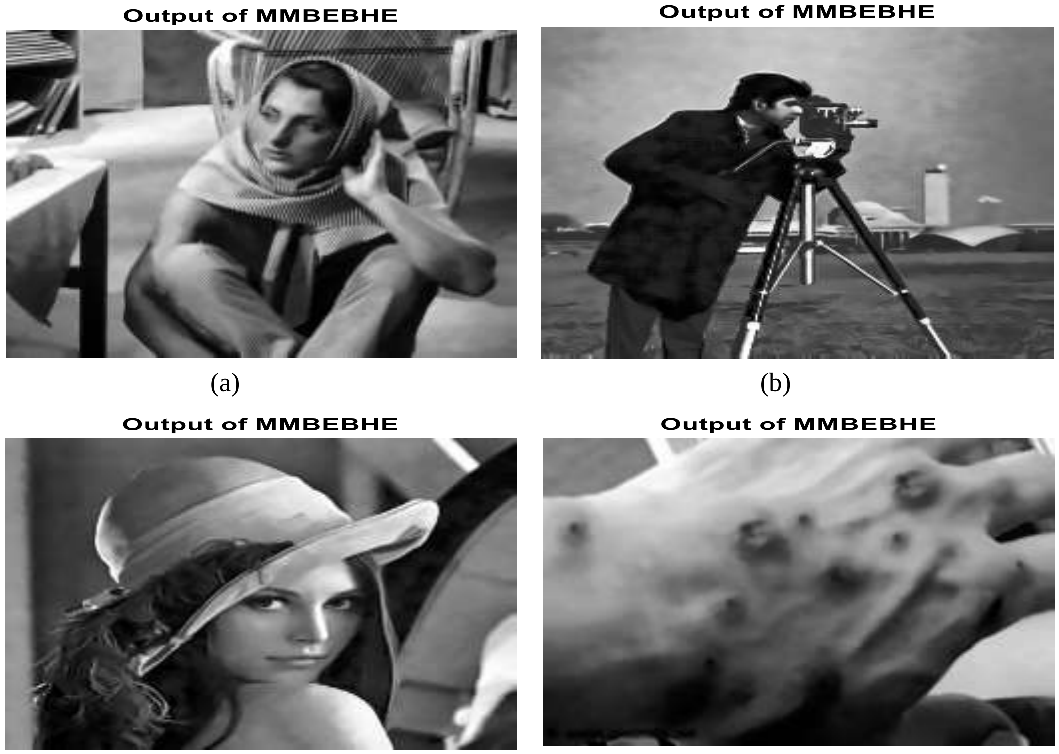


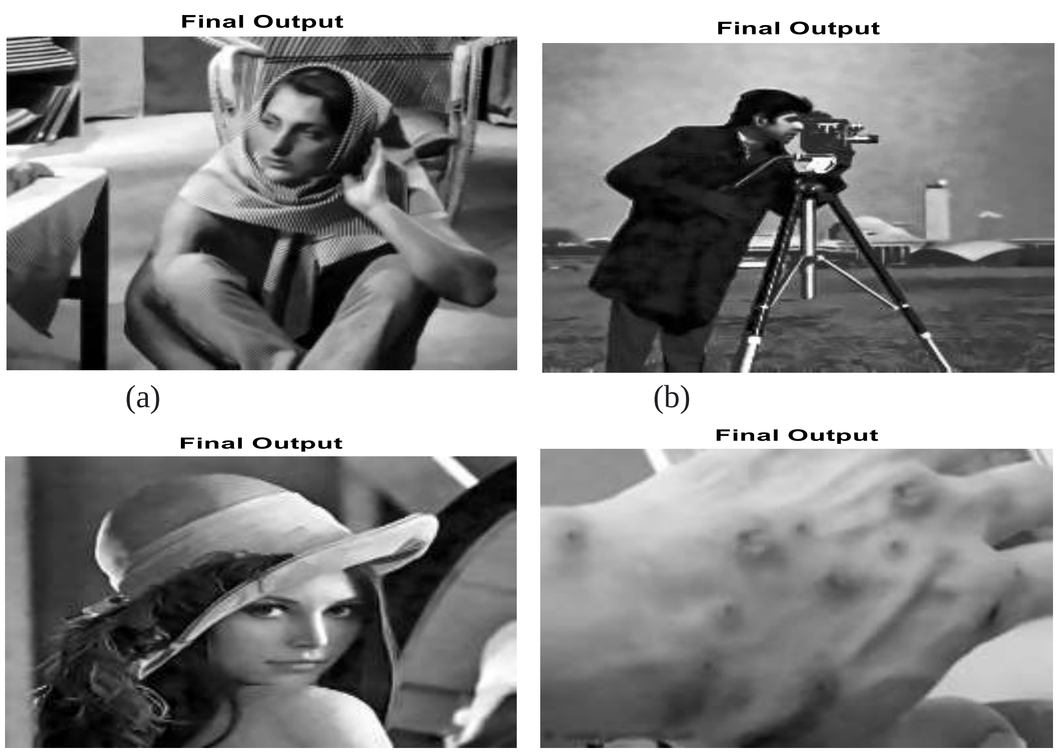
Figure 3: Filtered images for Barbara, Camera, Lena and Hand in (a, b, c and d)



(a) (b) (c) (d)

Figure 4: Output of MMBEBHE for Barbara, Camera, Lena and Hand images in (a, b, c and d)

Step 5: Furthermore, we have also employed BPDFHE technique on the four images to enhance their quality further. This, not only improves the brightness and contrast in images but also reduces their computational complexity. Figure 5 shows the images for four categories after BPDFHE technique is applies to them.



(a) (b) (c) (d)

Figure 5: Final images obtained in proposed model

Step 6: The effectiveness of the suggested model is then evaluated in terms of two crucial metrics, namely MSE and PSNR, in the last step. To demonstrate the effectiveness of the suggested technique, the PSNR values of the proposed model are also contrasted with those of the conventional DWT model. The next section of this manuscript discusses a full summary of the outcomes obtained.

V. RESULTS OBTAINED

The efficiency and usefulness of the proposed image enhancement model is tested in MATLAB software. The experimental outcomes were identified in terms of MSE and PSNR values on three different noise levels of 15, 20 and 25 respectively. Thorough discussion of these results obtained are given in this section of paper.

VI. PERFORMANCE EVALUATION

The efficiency of the proposed image enhancement model is firstly analyzed and validated by comparing its performance with traditional DWT model for Barbara image on three different noise levels in terms of their PSNR values. The comparison graph obtained for the same is shown in Figure 6. After a thorough examination of the provided graph, it was discovered that the PSNR value for the Barbara image was 22.169 in the conventional DWT model and 23.542 in the proposed method at noise level 15. The PSNR value was also calculated at noise levels 20 and 25, yielding values of 22.039 and 21.852 for the classic DWT model and 23.638 and 23.782 for the suggested model, correspondingly.

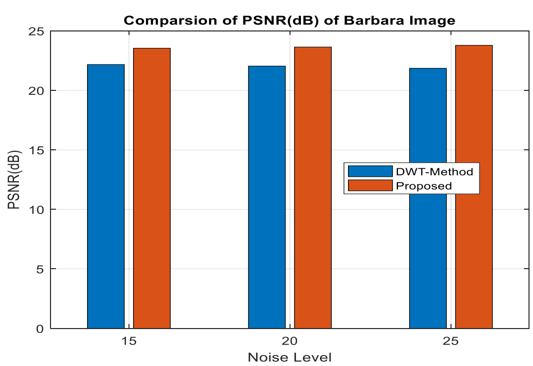


Figure 6: Comparison graph for PSNR on Barbara Image

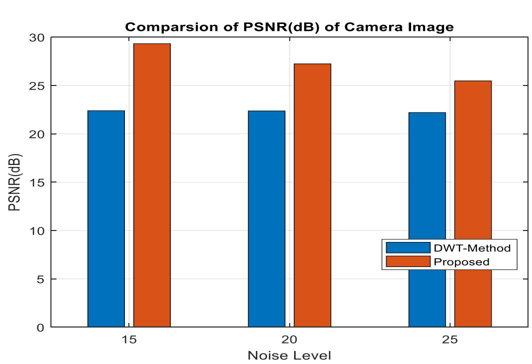


Figure 7: Comparison graph for PSNR for Camera Image

Moreover, the effectiveness of the proposed Image enhancement model is also analyzed and compared with traditional DWT model in terms of their PSNR Values for Camera Image on three noise levels. Figure 7 depicts the comparison graph for the same. From the given graph, it is observed that the value of PSNR in standard DWT model is 22.393, 22.367 and 22.203 at noise level 15, 20 and 25 respectively. While as, the value of PSNR for camera image in proposed model was 29.328, 27.24 and 25.476 for noise level 15, 20 and 25 respectively.

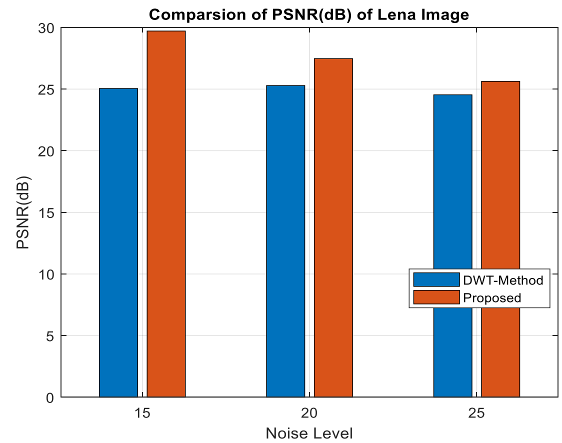


Figure 8: Comparison graph for PSNR for Lena Image

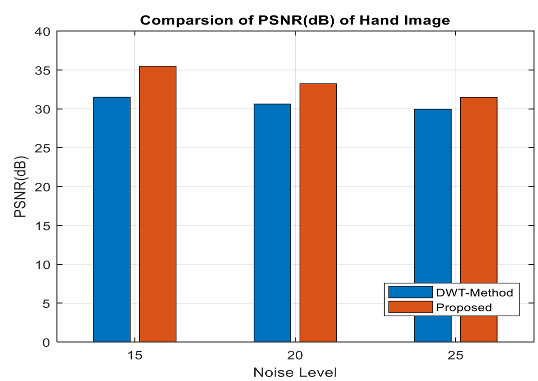


Figure 9: Comparison graph for PSNR on Hand image

Likewise, the performance of proposed image enhancement model was also analyzed and compared with traditional DWT model in terms of their PSNR values at three noise levels in Lena and Hand images. The comparison graph for PSNR for Lena image and Hand image is shown in Figure 8 and 9 respectively. After analyzing the graph closely, it is observed that value of PSNR was 25.047dB, 25.287dB and 24.539dB in traditional DWT model, whereas, it was 29.712dB, 27.474dB and 25.626dB in proposed model on noise level 15, 20 and 25 respectively for Lena Image. On the other hand, the value of PSNR in Hand image was 31.506, 30.622, 29.961 in traditional DWT model and 35.457dB, 33.241dB and 31.489dB in proposed model on noise level 15, 20 and 25 respectively.

In addition to this, we have also analyzed the performance of proposed Image enhancement model for four images of

Barbara, Camera, Lena and Hand on three noise levels of 15, 20 and 25 in terms of their MSE values. The values obtained for each image at three noise levels is given in table 1.

Table 1: Specific values of MSE in images at different noise levels in proposed model

Noise Level	MSE in Barbara	MSE in Camera	MSE in Lena	MSE in Hand
15	287.69	75.914	69.485	18.507
20	281.38	122.78	116.33	30.829
25	272.2	184.3	178.02	46.15

These values show the efficacy and efficiency of proposed image enhancement model in terms of MSE as well. From the above graphs it is observed that proposed image enhancement model is outperforming traditional DWT model in terms of PSNR values to prove the supremacy of proposed approach.

VII. CONCLUSION

In this paper, an effective and efficient image enhancement model is proposed wherein, NLM filter and MMBEBHE and BPDFHE techniques have been used for denoising the image and improving image quality. The efficacy and effectiveness of proposed model is examined in MATLAB software in terms of MSE and PSNR values. The value of PSNR came out to be 22.169, 22.039 and 21.82 in traditional DWT model, whereas, it was 23.542dB, 23.638dB and 23.782 in proposed model at noise level 15, 20 and 25 respectively for Barbara Image. Similar results were obtained for camera images, with PSNR values of 29.328, 27.24, and 25.476 for noise levels of 15, 20, and 25 in the proposed model compared to 22.393, 22.367, and 22.203 in the conventional DWT model. Additionally, the PSNR value in the proposed approach for the Lena image was the highest, coming in at 29.712, 27.474, and 25.626 on noise levels 15, 20, and 25, respectively. On the other hand, the value of PSNR came out to be 35.457, 33.241 and 31.489 for hand image on noise level 15, 20 and 25 in proposed image enhancement model. IN addition to this, proposed model was able to achieve effective MSE values for given four images at three different noise levels to prove its supremacy.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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