

Retraction

Retracted: An Ensembled Spatial Enhancement Method for Image Enhancement in Healthcare

Journal of Healthcare Engineering

Received 23 May 2023; Accepted 23 May 2023; Published 24 May 2023

Copyright © 2023 Journal of Healthcare Engineering. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process. Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] M. H. Siddiqi and A. Alsirhani, "An Ensembled Spatial Enhancement Method for Image Enhancement in Healthcare," *Journal of Healthcare Engineering*, vol. 2022, Article ID 9660820, 12 pages, 2022.

Research Article

An Ensembled Spatial Enhancement Method for Image Enhancement in Healthcare

Muhammad Hameed Siddiqi  and Amjad Alsirhani

College of Computer and Information Sciences, Jouf University, Sakaka, Aljouf, 2014, Saudi Arabia

Correspondence should be addressed to Muhammad Hameed Siddiqi; mhsiddiqi@ju.edu.sa

Received 15 November 2021; Revised 13 December 2021; Accepted 20 December 2021; Published 4 January 2022

Academic Editor: Liaqat Ali

Copyright © 2022 Muhammad Hameed Siddiqi and Amjad Alsirhani. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Most medical images are low in contrast because adequate details that may prove vital decisions are not visible to the naked eye. Also, due to the low-contrast nature of the image, it is not easily segmented because there is no significant change between the pixel values, which makes the gradient very small. Hence, the contour cannot converge on the edges of the object. In this work, we have proposed an ensembled spatial method for image enhancement. In this ensembled approach, we first employed the Laplacian filter, which highlights the areas of fast intensity variation. This filter can determine the sufficient details of an image. The Laplacian filter will also improve those features having shrill disjointedness. Then, the gradient of the image has been determined, which utilizes the surrounding pixels for the weighted convolution operation for noise diminishing. However, in the gradient filter, there is one negative integer in the weighting. The intensity value of the middle pixel might be deducted from the surrounding pixels, to enlarge the difference between the head-to-head pixels for calculating the gradients. This is one of the reasons due to which the gradient filter is not entirely optimistic, which may be calculated in eight directions. Therefore, the averaging filter has been utilized, which is an effective filter for image enhancement. This approach does not rely on the values that are completely diverse from distinctive values in the surrounding due to which it recollects the details of the image. The proposed approach significantly showed the best performance on various images collected in dynamic environments.

1. Introduction

Nowadays, in the real-world society of artificial intelligence (AI), the images might be sensed anytime and anyplace, which are commonly based on the human visualization that intuitively direct the people to easily realize the information that the images carry to us [1]. In healthcare domains, the images comprise various noises, due to which the physicians may face a problem detecting the corresponding diseases. We might utilize the image enhancement technology to diminish the various noises and visual effects to improve the quality of the image [2].

Image enhancement is one of the significant parameters in healthcare domains. Image enhancement is commonly divided into single-point procedures and spatial procedures. The point procedures contain contrast increase, noise reduction, histogram modulation, and similar colors. Point operations are generally simple nonlinear operations. In

contrast, today, linear spatial processes are often used in image processing. The reason is that local linear operations are simple and easy to implement. Though linear image enhancement techniques are frequently suitable in numerous applications, important advantages in image enhancement might be achieved if nonlinear methods are utilized. The nonlinear methods efficiently reserve the individual characteristics of the image, while the operators using the linear mode distort the image. In addition, nonlinear techniques are less sensitive to noise canceling devices. The noise is always presented because of random physical imagination [3].

There are various types of image processing and machine learning approaches proposed for the enhancement of images. One approach is to propose and realize the possibility of artificial intelligence and pattern recognition applications which categorize the images through their corresponding pictorial resources such as radiology images. These days, the

main resource which is employed for such images is the electromagnetic energy spectrum such as acoustic, super-sonic, and electrical microscopy. Radiology images such as X-ray, computed tomography (CT), and magnetic resonance imaging (MRI) have fascinating roles in the wellness domain that help the medical specialists to easily identify various illnesses from such radiology images.

A state-of-the-art method for image enhancement was proposed by Ma et al. [4], where they ensembled the local filters along with the global optimization approach. This method was based on global sparseness disintegration and a variable factor. Initially, the global sparse disintegration has been utilized in order to preeliminate a portion of the surface to improve the performance of smoothing. Similarly, Fang and Han [5] proposed a nonlinear incline field-guided image enhancement technique where they proved optimal value as a model factor. Moreover, the fractional order calculus is utilized to gradient ancestry along with the impetus technique in order to train the neural network. Moreover, a new type of method was designed by Deng et al. [6] for the purpose of smoothing or enhancement based on a fine-tuning parameter. This filter was based on a Laplacian-based formulation (that amalgamates the operations of smoothing and enhancement), an interpolation method (similar to that employed in the trained filter that delivers edge-consciousness ability), and the comprehensive Gamma spreading (that is utilized as the preceding for parameter approximation). However, the performances of these systems were decreased in dynamic and naturalistic domains.

Accordingly, in this work, we have proposed an ensembled spatial method for the purpose of image enhancement. In this ensembled approach, first, we utilized the Laplacian filter that highlights the regions of the fast intensity variation. This is a capable filter that determines the acceptable descriptions of an image. Moreover, those features having piercing disjointedness will be enhanced by the Laplacian filter, which has been fed to another filter that finds the gradient of the corresponding image. This filter is same as an averaging filter that utilized neighboring pixels for the weighted convolution operation for noise diminishing. However, in the gradient filter, there is one negative integer in the weighting, due to which the intensity value of the middle pixel might be deducted from the surrounding pixels, to enlarge the difference between the head-to-head pixels for calculating the gradients. This is one of the reasons due to which the gradient filter is not completely optimistic, which may be calculated in eight directions. Therefore, the averaging filter will be utilized which is an effective filter for image enhancement. This approach does not rely on the values that are completely diverse from distinctive values in the surrounding due to which it recollects the details of the image. The proposed approach significantly showed best performance on various images collected in dynamic environments. Moreover, this method also showed best performance against existing state-of-the-art works.

The rest of the paper is organized as follows: Section 2 presents some related work regarding the image enhancement method with their shortcomings. Section 3 presents the detailed description of the proposed ensembled spatial

enhancement method. The performance of the proposed ensembled methods along with some discussions are presented in Section 4. Lastly, Section 5 summarizes the proposed approach along with some future directions.

2. Related Work

Image enhancement has a significant role in healthcare domains that facilitates the physicians to easily diagnose various kinds of diseases from clear images. Huge amount of works have been carried out for the purpose of image enhancement; however, most of them suffer from their own limitations.

A novel point-level method was developed by Hao et al. [7] for diminishing the illumination effects and decomposition of reflectance that was based on nonlocal Haar wavelet transform. In this method, they utilized low-level frequency coefficients for diminishing the illumination effects, while high-level frequency coefficients were utilized for the reconstruction of the image. However, Haar transform might not be utilized for image enhancement because it has a poor energy concentration for the image [8]. Similarly, a latest approach was proposed by Kirsten et al. [9] where the authors evaluated numerous state-of-the-art deep neural networks for document enhancement. They assessed their performance qualitatively and quantitatively against the matrix of image quality assessment and then compared it with existing methods. However, deep neural networks cannot be utilized in real healthcare domains because this model has huge number of operations that requires a lot of time for training and testing.

On the other hand, a novel method was developed by Wan et al. [10] in order to diminish the noise and improve the lighting effects in real domains. This method was based on the entanglement network, which completely employed the corresponding features of the noise removal and environmental effects. However, the entanglement network only reduced the noise and does not consider the illumination in real-world domains. Furthermore, a new and modified ambient light-fused equation was designed by Wang et al. [11] for image enhancement that is based on the analysis-synthesis network. This method explained the association between the ambient light of color channels, and many dependances are entrenched. They performed extensive evaluation against the underwater synthetic dataset. However, the analysis-synthesis network considered resident block consequences that required lots of calculations. Also, in this approach, the overbright effects might not be diminished. Furthermore, this method has some other shortcomings such as damage of detail and color misrepresentation [12]. Likewise, a normalized flow model was proposed by Wang et al. [13] that was based on one-to-many associations which took low-illuminated features in order to map the delivery of the normal visible images with well-enhanced images. They claimed significant performance under the realistic domains. However, normalizing flow is implied in the formalism of constant normalization which necessitates the creation of equivariant feature space—constraining their modest application to

conservative advanced dimensional multiplicative demonstrating areas such as real images [14].

An underwater image enhancement method was designed recently by Yadav et al. [15] that was based on histogram equalization. Before the histogram equalization process, the image was converted from color to gray scale in order to speed up the process. Then, the histogram equalization was employed to sustain the intensities of the images in order to improve the contrast. Furthermore, the image colors were maintained by utilizing a convolutional neural network model. However, histogram equalization only emphasizes the local contrast instead of considering the entire contrast of the image. Also, histogram equalization produces artifacts during enhancement which is a common limitation. Similarly, the authors in [16–18] presented an approach which finds the optimum arrangement and strength of different image enhancement techniques through a neural network along with a new kind of layer which acquires the limitations of optimum image enhancement. However, the neural network has no specific scheme for finding the structure of neurons due to which the suitable and targeted results may not be achieved [19]. Moreover, in [20], the authors proposed an image enhancement method which was based on illumination tuning and the field variations of depth. This is attained and clustered by utilizing the principle of dark channel and spectral clustering techniques, respectively. Once the image had been divided in subimages, then, respectively, it was enhanced and fused. However, the performance of this approach degraded in real domains.

An integrated method was proposed by Moran et al. [21] that is the combination of multiple local parametric filters such as elliptical, graduated, and polynomial filters. This approach enhanced the images by the automatic estimation of the parametric filters. These filters are fast and easy to implement; however, these filters have common limitations that the entire display range might not be employed and possibly more critical, which is one of the reasons through which we may lose the performance [22]. Similarly, an alternative approach was designed by Muller [23] in order to interrupt the ration of the amount of FLOP (floating point operation per second) to the amount of parameter, which conserves the image scale. This method was expecting convolutional filters from the input image through a hypernetwork [23]. However, the convolutional filters are difficult to train when it got extensive along with dense hypernetworks [24].

Furthermore, an architecture of deep neural network has been proposed by Liang et al. [25] in order to pick up the RAW and color mapping based on a generalized nature. In this architecture, the authors utilized global subnetwork and local subnetwork. The local subnetwork emphasized on finding the mapping of illumination and color, while the global subnetwork was utilized in order to recover the image details. However, this approach cannot be utilized in naturalistic domains.

Therefore, this work proposes an ensembled spatial method for the purpose of image enhancement. In this ensembled approach, we first employed the Laplacian filter,

which highlights the areas of fast intensity variation. This filter has the ability to determine the acceptable details of an image. Then, the gradient of the image has been determined, which utilizes the surrounding pixels for the weighted convolution operation for noise diminishing. After this stage, the averaging filter was utilized which is an effective filter for image enhancement. This approach does not rely on the values that are completely diverse from distinctive values in the surrounding due to which it recollects the details of the image.

3. Proposed Ensembled Spatial Method

The overall procedure of the proposed approach is presented in Figure 1. Moreover, the step-by-step procedure is described in the following sections.

3.1. Laplacian. The second-order derivative is called as the Laplacian and is an isotropic, whose response is independent of the direction of the discontinuities in the image. For an image, function $f(x, y)$ can be written as

$$\nabla^2 z \approx \frac{\partial^2 z}{\partial^2 x^2} + \frac{\partial^2 z}{\partial^2 y^2}. \quad (1)$$

The derivative has linear operations, so the Laplacian is a linear operator. Considering only the horizontal and vertical neighbor of a pixel, we can find the Laplacian in the x and y direction.

$$\frac{\partial^2 z}{\partial^2 x^2} \approx z(x+1, y) + z(x-1, y) - 2z(x, y), \quad (2)$$

$$\frac{\partial^2 z}{\partial^2 y^2} \approx z(x, y+1) + z(x, y-1) - 2z(x, y).$$

The 2D Laplacian can be found by summing the abovementioned two equations.

$$\nabla^2 z \approx [z(x+1, y) + z(x-1, y) + z(x, y+1) + z(x, y-1) - 4z(x, y)]. \quad (3)$$

The original image data and the Laplacian filter data are, respectively, shown in Figure 2. Numerically, the data of the original image are presented in Figure 2(a). The enhanced pixels are the zero-crossings represented in Figure 2(b).

Equation (3) calculates the template coefficients of the Laplacian operator, which has a normalization function that guarantees the addition of the template coefficients is one so that the noise is not reduced in the uniform regions. This is because, in contrast, the sum of the template coefficients is zero against the previous Laplacian operator. Meanwhile, the template which is created by the aforementioned function might be used inside the template intricacy. Here, the Laplacian operator overpowers the effect of pixels far away from the middle of the template, finding the variation on those pixels closer to the middle pixel; then, the standard deviation is selected in order to make sure this act. Some of the well-known properties of the Laplacian filter are described as follows:

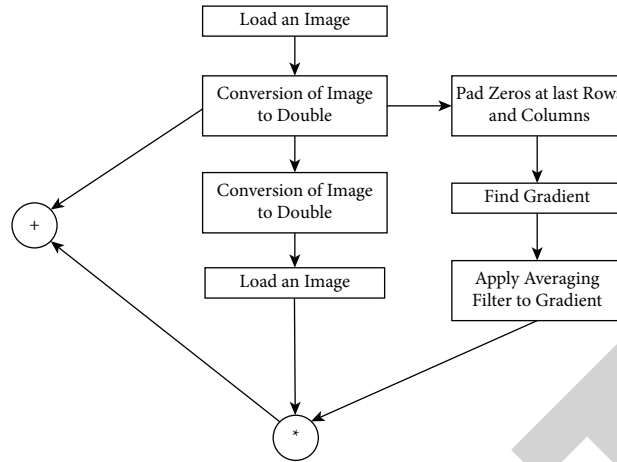


FIGURE 1: The overall flow of the proposed ensemble approach.

$$a = \begin{bmatrix} 1 & 2 & 3 & 4 & 1 & 1 & 2 & 1 \\ 2 & 2 & 3 & 0 & 1 & 2 & 2 & 1 \\ 3 & 0 & 38 & 39 & 37 & 26 & 3 & 0 \\ 4 & 1 & 40 & 44 & 41 & 42 & 2 & 1 \\ 1 & 2 & 43 & 44 & 40 & 39 & 1 & 3 \\ 2 & 0 & 39 & 41 & 42 & 40 & 2 & 0 \\ 1 & 2 & 0 & 2 & 2 & 3 & 1 & 1 \\ 0 & 2 & 1 & 3 & 1 & 0 & 4 & 2 \end{bmatrix} \quad M = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & -31 & -47 & -36 & -32 & 0 & 0 \\ 0 & -44 & 70 & 37 & 31 & 60 & -28 & 0 \\ 0 & -42 & 34 & 12 & 1 & 50 & -39 & 0 \\ 0 & -37 & 47 & 8 & -6 & 33 & -42 & 0 \\ 0 & -45 & 72 & 37 & 45 & 74 & -34 & 0 \\ 0 & 5 & -44 & -38 & -40 & -31 & -6 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

(a) (b)

FIGURE 2: (a) The original image data; (b) the data after Laplacian.

- (i) It is used to highlight the fine detail of an image
- (ii) Moreover, it is also used to enhance the blur image, but the Laplacian amplifies the noise in the image
- (iii) Also, the Laplacian of the image in a flat area (having the same intensity level) is zero
- (iv) The Laplacian of a ramp or a step at the onset is nonzero
- (v) Similarly, the Laplacian of a ramp is zero with a constant slop
- (vi) The Laplacian has a stronger response to highlight the fine details
- (vii) The Laplacian has a double response at the step change in a gray level
- (viii) The Laplacian has a stronger response to a line than to a step and to a point than to a line

However, the Laplacian has some common limitations during implementation.

- (xi) If we place the mask at the first and last row and column of the image, some elements of the mask are outside of the image, so to remove this difficulty:
 - (i) Extra rows and columns are padded at the start and end of the image

- (ii) The pixel intensity of the first and last rows and columns is replicated
- (iii) The first and last row and columns are not considered, as shown in Figure 3

- (x) During Laplacian calculation, the range of the pixel intensities is [0–255]
- (xi) First, the minimum in the image is found
- (xii) The sign is changed to minimum and added to each value of the image
- (xiii) Then, the maximum in the image is found and multiplied (255/max) with each element and converted into the whole number

Therefore, in order to tackle the abovementioned limitations, we consider to utilize the gradient filter.

3.2. Gradient of the Image. The gradient of an image is simply the first-order derivative of an image. The gradient is used to enhance the edges, line, and point in an image. The edge is a group of associated points which lies on the border among various areas (as shown in Figure 4).

There are two elements associated with the gradient: the first one is the magnitude of the gradient, while the second one is the direction of the gradient and the edges as indicated in Figure 5.

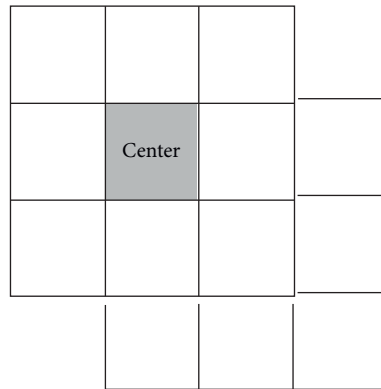


FIGURE 3: The implementation mask of the Laplacian.

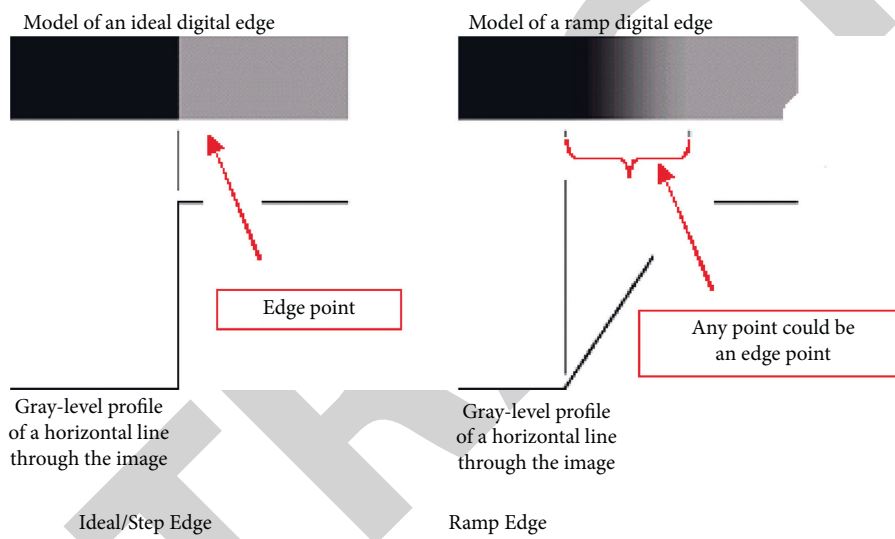


FIGURE 4: A model to show the group of associated points which lie on the border among two areas.

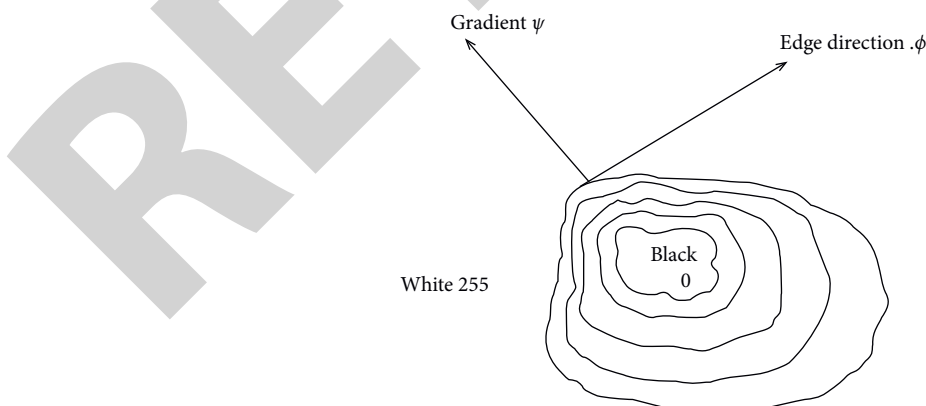


FIGURE 5: The direction of the gradient and edges inside an image.

The gradient of an image at the location at (x, y) is

$$\nabla z \approx \left[\frac{\partial z}{\partial x} \quad \frac{\partial z}{\partial y} \right],$$

$$\text{mag}(\nabla z) \approx \sqrt{\left[\frac{\partial z}{\partial x} \right]^2 + \left[\frac{\partial z}{\partial y} \right]^2} \approx \left| \frac{\partial z}{\partial x} \right| \left| \frac{\partial z}{\partial y} \right|, \quad (4)$$

$$\cdot \arctan \left(\frac{(\partial z / \partial y)}{(\partial z / \partial x)} \right).$$

Some common shortcomings of the gradient during implementation are as follows:

- (i) Using the formula $G_x = z(x+1, y) - z(x, y)$ and $G_y = z(x, y+1) - z(x, y)$, there is a problem when we are at the last row or at the last column. So, to solve it, we
 - (i) Either pad extra rows and columns at the end of the image
 - (ii) Replicate the pixel intensity of the last rows and columns
 - (iii) Do not consider the last rows and columns

So, the smoothing filter has been considered in order to tackle the abovementioned shortcomings of the gradient.

3.3. Averaging Filter. For every pixel in the processed image, $z(i, j)$ is attained from the average in a neighborhood pixel value of (i, j) in the involvement image. For instance, for a 3×3 neighborhoods window, we utilized the following mask for the surrounding pixels.

The value of the corresponding pixel is increased by $1/9$ and added, and the outcome is positioned in the corresponding resultant image. The abovementioned window is continuously moved on the entire image till each pixel has been enclosed. This means, the corresponding image is convoluted along with this enhancement mask that is also represented as a spatial filter.

3.3.1. Weighted Mask. A weighted average spatial filter is one of the robust filters for the smoothing averaging filter. The term weighted averaging filter indicates that different pixels are multiplied by various factors, which gives the most significance (weight) to some points at the additional area as represented in Figure 6.

The weighted averaging filter of size $m \times n$ (m and n odd) is given by the expression

$$g(x, y) = \frac{\sum_{s=-a}^a \sum_{t=-b}^b w(s, t) f(x+s, y+t)}{\sum_{s=-a}^a \sum_{t=-b}^b w(s, t)}. \quad (5)$$

1	2	1
2	4	2
1	2	1

FIGURE 6: Weighted filter mask.

The strong point about the weighted filter is that it is used to diminish the noise from the corresponding image. Also, the average filter adds blur to the image. Moreover, it is a linear filter.

3.3.2. Box Mask. A form of spatial averaging filter also known as box filter is given in Figure 7.

$$R = \frac{1}{9} \sum_{i=1}^9 z_i. \quad (6)$$

It is the average of the gray levels of the pixel in a 3×3 neighborhood defined by the mask.

4. Performance Evaluation

The proposed ensembled spatial algorithm has been assessed against various experiments. The experimental results are prescribed in the following sections.

4.1. Setup. The proposed approach has been validated as follows:

- (i) The proposed algorithm has been tested and thoroughly assessed on various images in order to show the effectiveness of the proposed ensembled spatial algorithm
- (ii) A subjective comparison has been provided against various recent works, which means that their corresponding average accuracies were taken based on the enhancement rate against various images

5. Results

The Laplacian of an image can be found by using the mask if we consider only the x and y coefficient the Laplacian mask is under (as shown Figures 8 in 9, respectively).

The sum of the coefficient of the Laplacian mask is zero because when we apply the Laplacian mask to a flat area that has same grayscale value, there will be no change. The image is enhanced by applying the following rules:

$$g(x, y) = \begin{cases} f(x, y) - \nabla^2 f(x, y) & \text{if the mask center coeff is negative} \\ f(x, y) + \nabla^2 f(x, y) & \text{if the mask center coeff is positive} \end{cases} \quad (7)$$

$$\frac{1}{9} \times$$

1	1	1
1	1	1
1	1	1

FIGURE 7: Box filter mask.

0	1	0	0	-1	0
1	-4	1	-1	4	-1
0	1	0	0	-1	0

Center is Negative Center is Positive

FIGURE 8: Laplacian 4×4 mask for implementation.

1	1	1	-1	-1	-1
1	-8	1	-1	8	-1
1	1	1	-1	-1	-1

Center is Negative Center is Positive

FIGURE 9: Laplacian mask for implementation when we considered diagonal.

The corresponding results of the Laplacian are presented in Figure 10.

Similarly, we use different masks for enhancing the edges of an image. First, we enhance the vertical edges and then the horizontal edges, and to enhance the overall edges of an image, we add the result of the vertical and horizontal edges (as shown in Figures 11 and 12, respectively).

As can be described from Figure 10 that the Laplacian did not clearly enhance, we did not get the best results. Therefore, we applied the gradient along with averaging. The sample results are presented in Figure 13.

As illustrated in Figure 13, we still did not achieve the best enhancement results, due to which we are unable to enhance the desired features of the images. Therefore, we utilized the proposed ensembled spatial enhancement algorithm in order to get the best results that may be further utilized in the healthcare domain. The sample results of the proposed approach are presented in Figures 14(a) and 14(b), respectively.

It is significant from Figures 14(a) and 14(b) that the proposed ensembled spatial enhancement algorithm achieved significant results. The significance is because the proposed approach has the ability to enhance various kinds of images in different dynamic environments.

Lastly, we presented the subjective comparison of the proposed approach with some state-of-the-art methods. The subjective performances along with the proposed approach are presented in Table 1.

A subjective comparison has been provided against various recent works, which means that their corresponding average accuracies were taken based on the enhancement rate against various images. As presented, the proposed

approach not only achieves significant performance on various images but also showed the best enhancement accuracy subjectively (shown in Table 1). This is because the proposed approach highlights the areas of fast intensity variation, through which it determines the acceptable details of an image. Moreover, the proposed method also determines the surrounding pixels for the weighted convolution operation for noise diminishing. After this stage, the averaging filter was utilized which is an effective filter for image enhancement. This approach does not rely on the values that are completely diverse from distinctive values in the surrounding due to which it recollects the details of the image.

6. Discussion

We have proposed an ensembled spatial method for the purpose of image enhancement. In the proposed approach, first, an adoptive Laplacian filter was utilized, which includes various image information due to which the effects might be a bit diverse. The middle increment of every structure might be negative, and the rest of the neighbors (that will be either four or eight) might be positive, without damaging the image information. Essentially, this is significant to guarantee that the summation of template parameters must be zero, which further signifies the edges should not be detected in the uniform brightness regions. The Laplacian operator has equal possessions in every direction; however, at present, it comprises no smoothing and will rejoin the noise again, more so than a first-order operator since it is differentiation of a higher order. But still, computation wise, the Laplacian filter is less expensive. After the Laplacian, we employed the averaging filter, where the average result is used to diminish

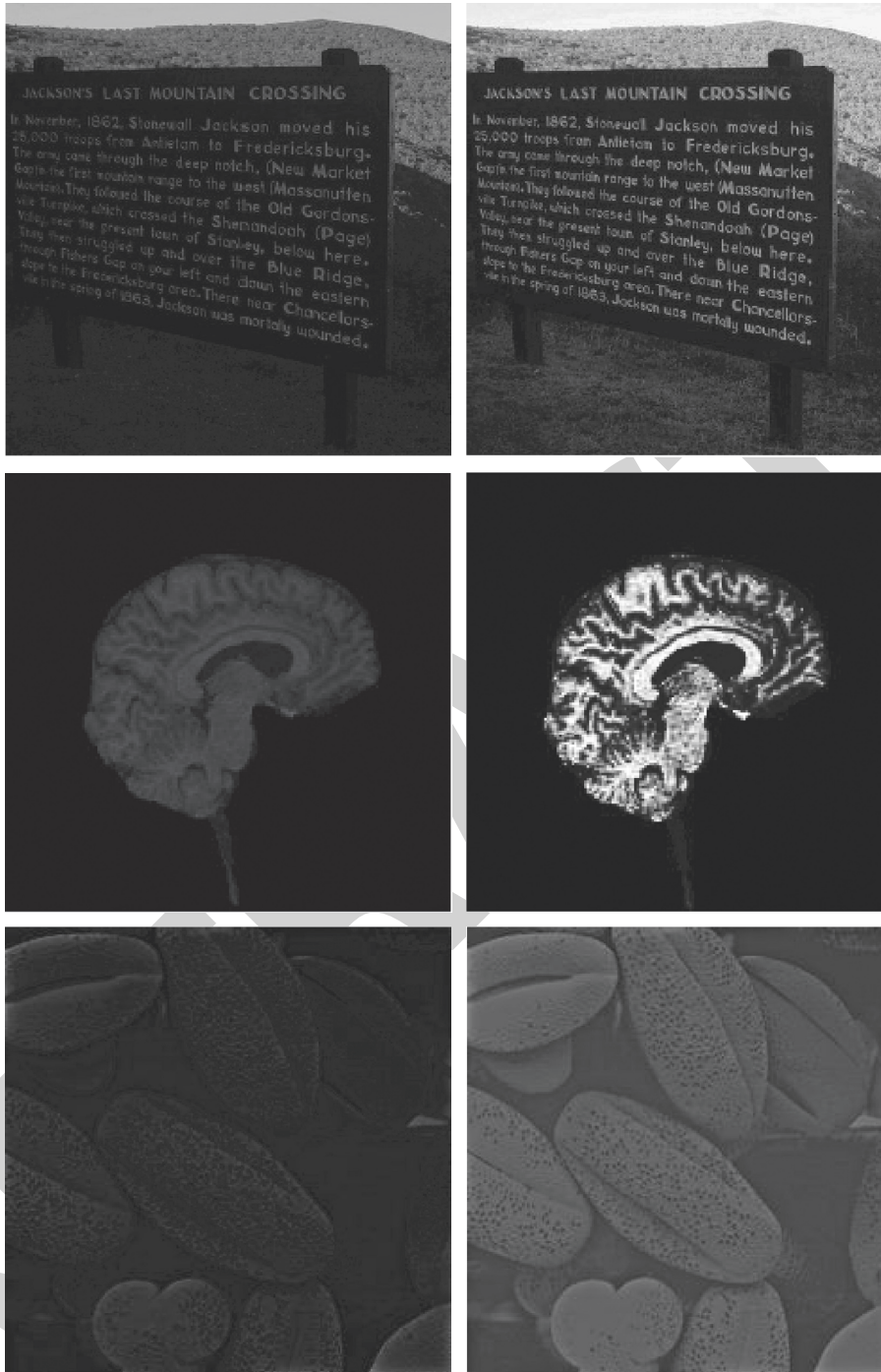


FIGURE 10: Sample enhancement results of the Laplacian mask (left column represents the original images, while the right column is the enhanced images).

-1	-1	-1
0	0	0
1	1	1

Prewitt

-1	-2	-1
0	0	0
1	2	1

Sobel

FIGURE 11: Horizontal edge detector $G_x = df/dx$.

-1	0	1
-1	0	1
-1	0	1

Prewitt

-1	0	1
-2	0	2
-1	0	1

Sobel

FIGURE 12: Vertical edge detector $G_y = df/dy$.

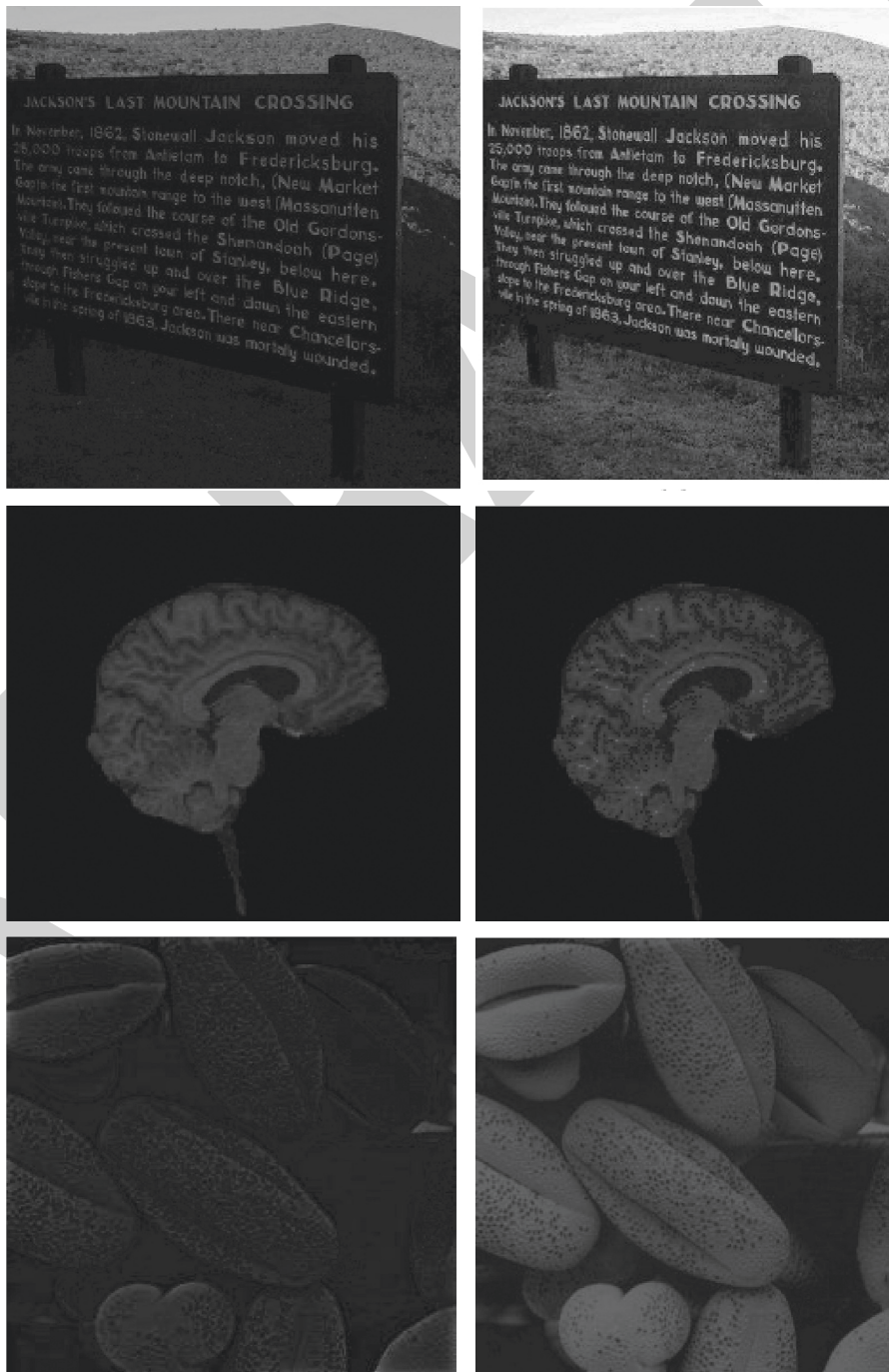


FIGURE 13: Sample results of the gradient along with the averaging filter.

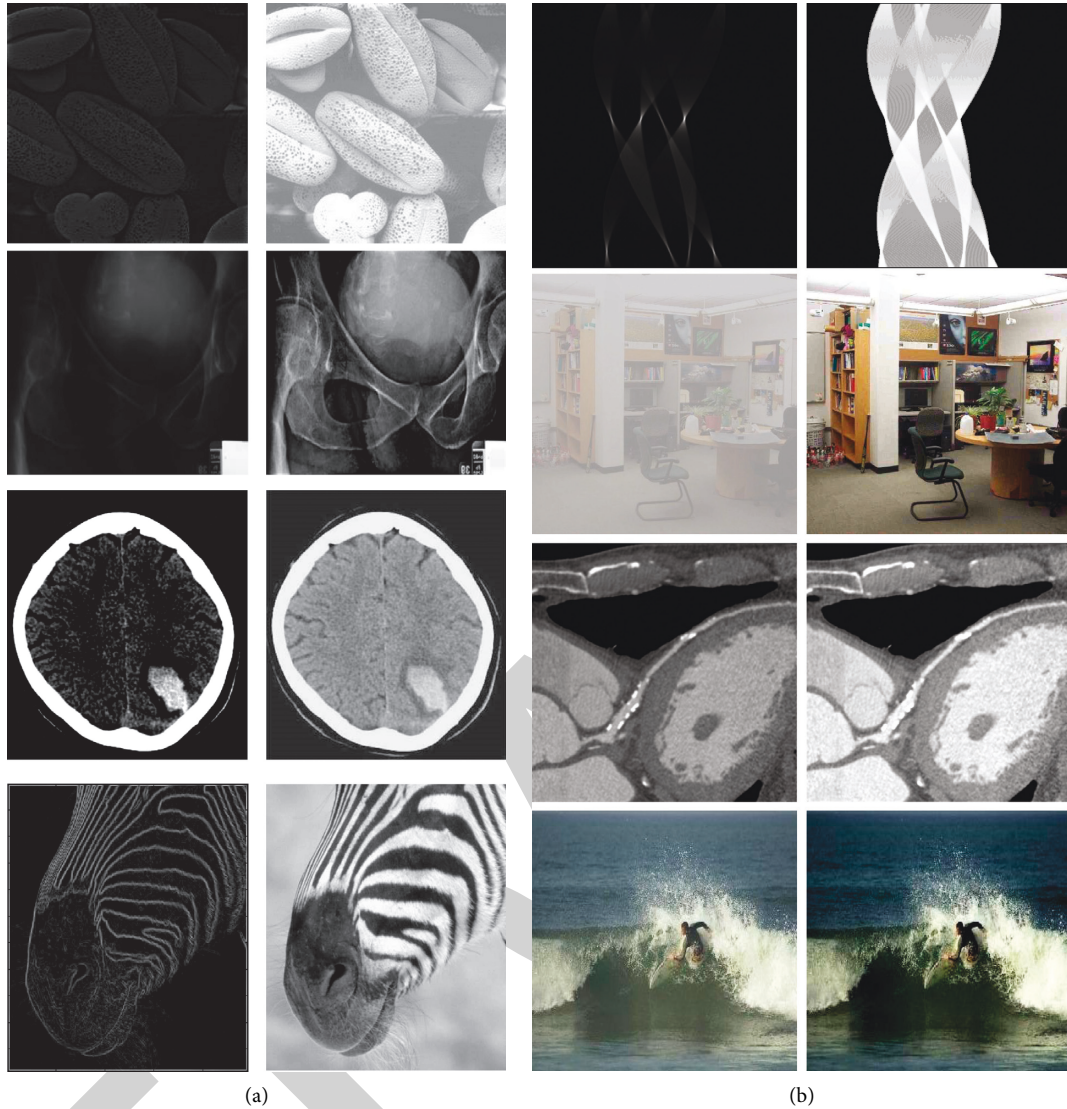


FIGURE 14: (a), (b) The sample results of the proposed approach.

TABLE 1: Subjective comparison between the state-of-the-art and the proposed approach.

Existing approaches	Performance (%)
[26]	89
[27]	91
[28]	88
[29]	93
[30]	90
[31]	94
[32]	91
Proposed approach	98

the noise. This is a low-pass filter whose result is used to permit the frequencies of the low spatial to be reserved, and the high-frequency components will be overpowered. In order to diminish the noise, a 5×5 window is used, but it reduced the detailed level. Therefore, the averaging operator size is equal to the mutual of a low-pass filter. As described before, the smoothing was attained by the

gradient of images, which actually gives another approach to execute the template convolution. In the gradient of images and the Laplacian operator, multiplication is the twin procedure for convolution, which means that it might be applied by reproducing the template along with the gradient of images and the Laplacian operator of the image to whom the template is employed. In order to return the domain of the image, the result must be inverse transform, for which the size of the transformed template and the size of the image must be similar. Hence, initially, the picture comprising the template is zero-expanded. The procedure begins by the estimation of the transmute of the zero-expanded template. Then, the convolution multiplies the template transform by the image transform pixel by pixel. Once the scheme is raised, it is completed along with an image transform, and the resultant transform is ordered again before the converse alteration, to make sure that the picture is represented accurately.

7. Conclusions

Over a couple of years, healthcare image processing has arisen as a significant research domain. Medical images are very subtle to the illumination and naturalistic factors. The principal goal of image enhancement is to improve the quality of the image by recovering the features of corresponding image. However, image enhancement is challenging due to some factors such as dynamic changes of ecological factors, illumination, lighting effects, and noise (made by humans or machine). Thus, in the medical domain, the correct image enhancement is necessary, before the disease diagnosis. In the literature, there are various types of image processing approaches proposed for the enhancement of images. One approach is to propose and realize the possibility of artificial intelligence and pattern recognition applications which categorize the images through their corresponding pictorial resources such as radiology images. However, most of the previous techniques produced over-enhancement, and sometimes, they produced checker board on images. Because of that, the physicians might lose the significant evidences in the X-ray, CT, and MR image. Therefore, in this work, we have proposed an ensembled spatial method for the purpose of image enhancement. In this ensembled approach, we first employed the Laplacian filter, which highlights the areas of fast intensity variation. This filter has the ability to determine the acceptable details of an image. Then, the output has been fed to another filter which utilized neighboring pixels for the weighted convolution operation for noise diminishing. Then, the averaging filter has been employed which is an effective filter for image enhancement. This approach does not rely on the values that are completely diverse from distinctive values in the surrounding due to which it recollects the details of the image. The proposed approach significantly showed the best performance on various images collected in dynamic environments.

In the future, we will try to improve the proposed model and will employ it in the healthcare, especially for the enhancement of the radiology images for the recommendation of physicians.

Data Availability

Data used for this study and simulation will be provided on demand.

Conflicts of Interest

The authors declare no conflicts of interest regarding the present study.

Acknowledgments

This work was funded by the Deanship of Scientific Research at Jouf University under grant no. DSR-2021-02-0344.

References

- [1] P. Li, H. Wang, M. Yu, and Y. Li, "Overview of image smoothing algorithms," *Journal of Physics: Conference Series*, vol. 1883, no. 1, Article ID 012024, 2021.
- [2] A. Vacavant, "Smoothed shock filtering: algorithm and applications," *Journal of Imaging*, vol. 7, no. 3, p. 56, 2021.
- [3] G. R. Arce, J. Bacca, and J. L. Paredes, "Nonlinear filtering for image analysis and enhancement," in *The Essential Guide to Image Processing*, pp. 263–291, Academic Press, Cambridge, MA, USA, 2009.
- [4] X. Ma, X. Li, Y. Zhou, and C. Zhang, "Image smoothing based on global sparsity decomposition and a variable parameter," *Computational Visual Media*, vol. 7, no. 4, pp. 483–497, 2021.
- [5] Q. Fang and X. U. E. Han, "A nonlinear gradient domain-guided filter optimized by fractional-order gradient descent with momentum RBF neural network for ship image dehazing," *Journal of Sensors*, vol. 2021, Article ID 8864906, 15 pages, 2021.
- [6] G. Deng, F. Galetto, M. Alnasrawi, and W. Waheed, "A guided edge-aware smoothing-sharpening filter based on patch interpolation model and generalized Gamma distribution," *IEEE Open Journal of Signal Processing*, vol. 2, pp. 119–135, 2021.
- [7] H. Hao, H. Yingkun, S. Yuxuan, W. Benzhen, and X. Jun, "NLHD: a pixel-level non-local retinex model for low-light image enhancement," 2021, <https://arxiv.org/abs/2106.06971>.
- [8] P. Porwik and A. Lisowska, "The Haar-wavelet transform in digital image processing: its status and achievements," *Machine Graphics and Vision*, vol. 13, no. 1/2, pp. 79–98, 2004.
- [9] L. N. Kirsten, R. Piccoli, and R. Ribani, "Evaluating deep neural networks for image document enhancement," in *Proceedings of the 21st ACM Symposium on Document Engineering*, Limerick, Ireland, 2021, August.
- [10] Y. Wan, Y. Cheng, and M. Shao, "Rain Removal and Illumination Enhancement Done in One Go," 2021, <https://arxiv.org/abs/2108.03873?context=cs>.
- [11] Z. Wang, L. Shen, M. Yu, Y. Lin, and Q. Zhu, "Single Underwater Image Enhancement Using an Analysis-Synthesis Network," 2021, <https://arxiv.org/abs/2108.09023>.
- [12] W. Wang, X. Wu, X. Yuan, and Z. Gao, "An experiment-based review of low-light image enhancement methods," *IEEE Access*, vol. 8, Article ID 87884, 2020.
- [13] Y. Wang, R. Wan, W. Yang, H. Li, L. P. Chau, and A. C. Kot, "Low-Light Image Enhancement with Normalizing Flow," 2021, <https://arxiv.org/abs/2109.05923>.
- [14] A. J. Bose and I. Kobzyev, "Equivariant Discrete Normalizing Flows," 2021, <https://arxiv.org/abs/2110.08649>.
- [15] A. Yadav, M. Upadhyay, and G. Singh, "Underwater Image Enhancement Using Convolutional Neural Network," 2021, <https://arxiv.org/abs/2109.08916>.
- [16] N. Mitschke, Y. Ji, and M. Heizmann, "Task specific image enhancement for improving the accuracy of CNNs," in *Proceedings of the 10th International Conference on Pattern Recognition Applications and Methods*, pp. 174–181, Vienna, Austria, January 2021.
- [17] Y. Zhao, L. Gao, L. Xiang, Q. Zhang, and Z. Zhao, "Research on image enhancement algorithm base on convolutional neural network in scotopic vision environment," in *Proceedings of the 2020 International Conference on Pattern Recognition and Intelligent Systems*, pp. 1–5, Athens, Greece, July 2020.
- [18] Y. Lu, Y. Guo, and M. Liang, "CNN-enabled visibility enhancement framework for vessel detection under haze environment," *Journal of Advanced Transportation*, vol. 2021, Article ID 5598390, 14 pages, 2021.
- [19] <https://www.asquero.com/article/advantages-and-disadvantages-of-artificial-neural-networks/>.

- [20] D. Li, J. Bao, S. Yuan, H. Wang, L. Wang, and W. Liu, "Image Enhancement Algorithm Based on Depth Difference and Illumination Adjustment," *Scientific Programming*, vol. 2021, Article ID 6612471, 10 pages, 2021.
- [21] S. Moran, P. Marza, S. McDonagh, S. Parisot, and G. Slabaugh, "Deepplpf: deep local parametric filters for image enhancement," in *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, Article ID 12826, Washington, DC, USA, June, 2020.
- [22] A. Koschan and M. Abidi, *Digital Color Image Processing*, John Wiley & Sons, Hoboken, NJ, USA, 2008.
- [23] L. K. Muller, "Overparametrization of HyperNetworks at fixed FLOP-count enables fast neural image enhancement," in *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, pp. 284–293, Nashville, TN, USA, June, 2021.
- [24] Y. K. Ooi and H. Ibrahim, "Deep learning algorithms for single image super-resolution: a systematic review," *Electronics*, vol. 10, no. 7, p. 867, 2021.
- [25] L. Liang, I. Zharkov, F. Amjadi, H. R. V. Joze, and V. Pradeep, "Guidance network with staged learning for image enhancement," in *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, pp. 836–845, Nashville, TN, USA, June 2021.
- [26] Y. Pourasad and F. Cavallaro, "A novel image processing approach to enhancement and compression of X-ray images," *International Journal of Environmental Research and Public Health*, vol. 18, no. 13, p. 6724, 2021.
- [27] G. Sandoub, R. Atta, H. A. Ali, and R. F. Abdel-Kader, "A low-light image enhancement method based on bright channel prior and maximum colour channel," *IET Image Processing*, vol. 15, no. 8, pp. 1759–1772, 2021.
- [28] T. Rahman, A. Khandakar, Y. Qiblawey et al., "Exploring the effect of image enhancement techniques on COVID-19 detection using chest X-ray images," *Computers in Biology and Medicine*, vol. 132, Article ID 104319, 2021.
- [29] Q. Mu, X. Wang, Y. Wei, and Z. Li, "Low and non-uniform illumination color image enhancement using weighted guided image filtering," *Computational Visual Media*, vol. 7, no. 4, pp. 529–546, 2021.
- [30] M. A. Elaziz, K. M. Hosny, A. Salah, M. M. Darwish, S. Lu, and A. T. Sahlol, "New machine learning method for image-based diagnosis of COVID-19," *PLoS One*, vol. 15, no. 6, Article ID e0235187, 2020.
- [31] U. K. Acharya and S. Kumar, "Genetic algorithm based adaptive histogram equalization (GAAHE) technique for medical image enhancement," *Optik*, vol. 230, Article ID 166273, 2021.
- [32] J. Jose, N. Gautam, M. Tiwari et al., "An image quality enhancement scheme employing adolescent identity search algorithm in the NSST domain for multimodal medical image fusion," *Biomedical Signal Processing and Control*, vol. 66, Article ID 102480, 2021.