



RESEARCH ARTICLE

Advanced VLSI-based digital image contrast enhancement: A novel approach with modified image pixel evaluation logic

C. S. Manikandababu^{1*}, V. Rukkumani²

Abstract

This research uses an extremely memory-intensive and power-efficient very-large-scale-integration (VLSI) architecture to perform nonlinear scaling on pictures. Images can be scaled either up or down so that they can be adapted to the differing resolutions of a variety of devices, such as cameras and printers. Photography with a high resolution calls for significantly more storage space and processing power. The branch of image processing known as "image fusion" has recently had a meteoric rise in prominence. The rapidly growing usage of digital imagery in remote sensing and satellite applications has led to an increase in the need to both store and process massive amounts of picture data. This demand has resulted in an increase in the availability of storage space. Traditional fusion methods produce spatial distortions despite their generally high level of spatial performance. Because of this, the discrete wavelet transformation (DWT), currently the most efficient approach for processing images, focuses on finding a solution to this problem. Within the scope of this investigation, we propose the modified image pixel evaluation logic (MIPEL), a functional method for incorporating the lifting-based strategy utilized in DWT-based picture fusion. In order to avoid excessive delays, high-resolution photo processing typically makes use of hardware processing, which necessitates the utilization of more complex apparatus and more time. In this work, the hardware description language verilog is employed to evaluate the effectiveness of various fundamental approaches to the enhancement of pictures. VHDL is a relatively recent method that has replaced more traditional simulations in the process of producing results for signal processing. It does this by allowing rapid access to physical VLSI representations. Utilizing the proposed MIPEL as a starting point, this study aims to design, model, simulate, and develop several different strategies for enhancing photos using FPGA. Because they take place on the pixel level and in the immediate neighborhood of a pixel, the enhancements that may be made to an image can be thought of as point processing procedures. VLSI architecture is developed for contrast augmentation for low-contrast source photos using pixel-based image fusion, and in the simulation results that followed, we offer findings that clearly illustrate the efficiency of this technology.

Keywords: Contrast improvement, Discrete wavelet transformation, DWT, FPGA, Image filtration, Image contrast, Modified image pixel evaluation logic, MIPEL, VLSI.

Introduction

Research on power and space optimization in battery-powered devices is important for minimizing both cost and

power usage (Shih Lun Chen et al., 2019). Many of today's display-based devices have a fundamental issue that may be remedied by simply increasing the contrast. Hardware implementation difficulty is a standard concern with every image processing application; contrast enhancement is no exception. Low-contrast images are extremely distracting for humans, and for machines, they may be disastrous (Kumar A., et al., 2022). Improved picture quality aids in comprehending the visual data presented to the human eye. In the field of computer vision, this aids in the processing and analysis of images' many features. Medical imaging, displays, astronomy, aerial and oceanography, and other fields can all benefit from automated digital picture contrast enhancement. Many methods for improving images are currently available in hardware. Methods such as bi-histogram equalization, gamma correction, as well as weighting for the probability density of the luminance pixels are introduced in this study as part of the Modified Image Pixel Evaluation Logic (MIPEL) (Annis Fathima Aklak et al., 2021).

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Histograms are a great way to statistically portray a picture. One way to look at it is as the data's probability distribution. An image's histogram may be used to determine the relative frequency of each grayscale value. If the histogram only shows a small range of grays, the resulting image will have little contrast. An image should effectively represent the whole range of tonalities to have high contrast. The image's finer elements are more easily seen (Syed Zaheeruddin and K. Suganthi. 2019).

There are two primary categories into which contrast enhancement techniques fall: 1) Direct techniques and 2) Indirect techniques. To improve anything, the direct technique employs the usage of contrast-specific phrases directly. We use a strategy based on the probability density function in the indirect technique. Figure 1 below describes the step diagram for image clarity enhancement (Kumar S. et al., 2023).

Prior to further processing, images can have their quality and information content improved through a process known as "image enhancement" (G. R. et al., 2016). The subfield of image processing known as "image enhancement" finds extensive use in the field of computer graphics. Picture enhancement is the process of emphasizing or enhancing certain aspects of a picture for the purpose of better viewing and analysis. To enhance a picture means to make it more understandable or more easily seen by humans or to make it a "better" input to other automated methods of image processing (Sungan Yoon and Jeongho Cho. 2023) (Saorabh Kumar Mondal et al., 2021).

Spatial Domain Technique

The term "spatial domain technique" is used to describe methods of image improvement that include working with the picture's pixels directly. Here are some examples of spatial domain methods:

- Range operations: Point operations and Neighborhood operations
- Domain operations

Frequency Domain Technique

It is easy to implement and delivers improvement through the application of mathematical transformations like Fourier transforms (G. R and E. L 2018). Intuitively, it makes sense to soften a picture by decreasing the amplitude of its high-frequency elements and to sharpen it by raising this same component's magnitude. The following Figure 2 illustrates the system flow diagram. Recent research has suggested a low-cost, high-quality picture scaling processor. It is made up of a spatial filter that does some sharpening, a clamp filter, and some bilinear interpolation. The following Figure 3 shows the block diagram for image filtration. The method's major drawback is the significant complexity of the combined filter layout, logic for achieving hardware sharing, and reconfigurable approaches (Nagila A. & Mishra A. K., 2023).

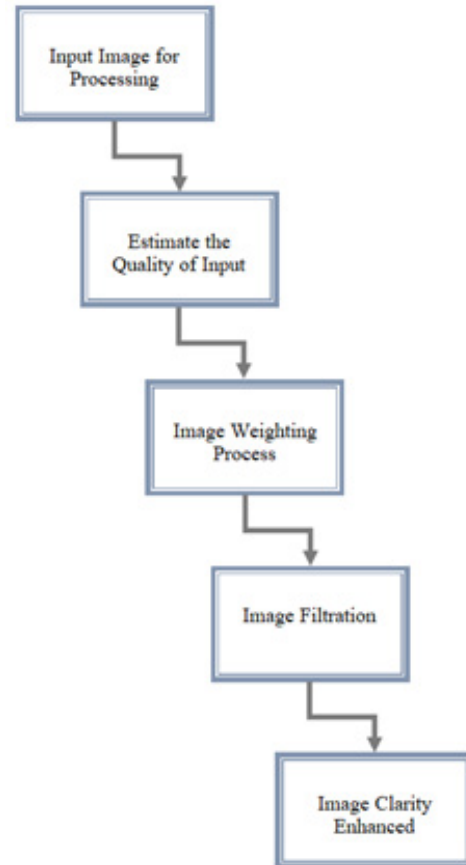


Figure 1: Step Diagram for Image Clarity Enhancement

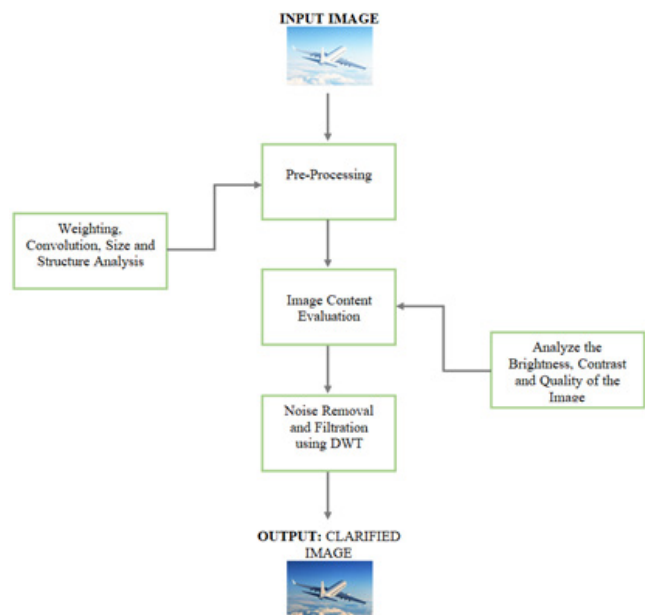


Figure 2: System Flow Diagram

Linear interpolation is used to scale the picture, and high-boost filtering is used for improvement. While this method produces high-quality picture scaling, it requires complicated circuitry for VLSI implementation (Wencheng Wang et al., 2020) (Xin Fan et al., 2022).

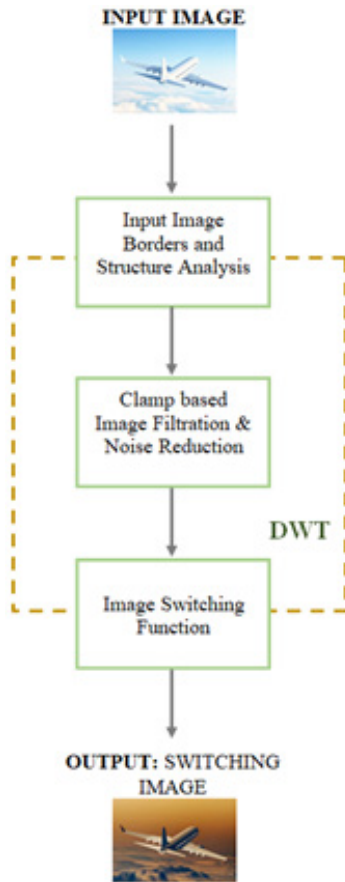


Figure 3: Block Diagram for Image Filtration

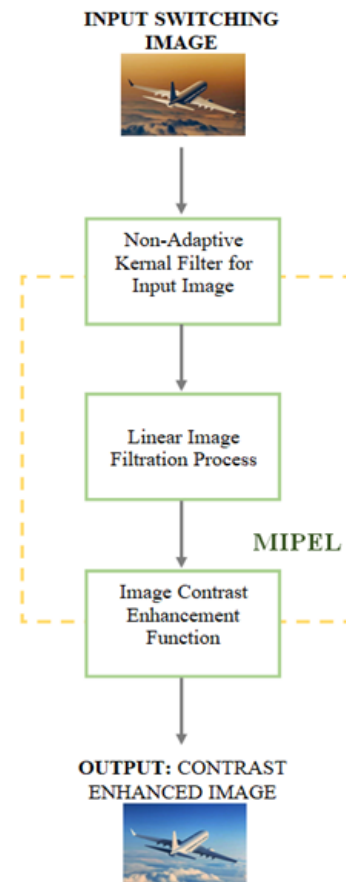


Figure 4: Block Diagram for Image Enhancement

Therefore, the primary goal of this study is to create a low-complexity method for picture scaling (E.L et al. 2018). The following Figure 4 shows the block diagram for image enhancement.

Related Study

Image enhancement using the Retinex model has proved successful, and mastering the decomposition of the Retinex model into its luminance and reflection components is essential for achieving high-quality results (Huateng Chen, et al., 2022). This work offers an image enhancement approach based on the Retinex model, with dual augmentation of the luminance along with reflection components, for more efficient micro-optical picture enhancement. In this research, we first transform an original RGB image to HSV color space and extract the V component to lower the algorithm's computing cost; Then, the luminance component is extracted using the Retinex model, and the V components are processed using a guided filter to ensure there is no edge loss in the final product; The logarithmic decomposition then yields the reflection part. The luminance components are then subjected to global adaptive brightness enhancement as well as local contrast improvement, whereas the reflection component has undergone detail enhancement. The next step is to merge the improved illumination and reflection

components into a single improved picture (Alberto Luque-Chang, et al., 2023). Experimental results on a wide variety of datasets demonstrate that our approach outperforms or performs comparably to the state-of-the-art in terms of picture enhancement quality.

Image Contrast Enhancement (ICE) is an important procedure in many computer vision and image processing applications since it enhances the clarity of the data included in the final product. Most of the offered solutions try to address the issue by shifting the pixel intensities around in a histogram, however, this approach often has unintended consequences, including increased noise, oversaturation, and poor human perception. ABMs, on the other hand, are computer models that can describe the behaviors and relationships of autonomous agents in a cooperative setting. Instead of being guided by mathematical formulas, these agents act according to behavioral principles. This method makes it possible for agents to execute complicated behavioral patterns via their interactions. This study suggests a two-stage procedure in which the image's pixels are modeled after autonomous creatures whose observable behaviors allow for much increased contrast. In our method, the variations in intensity values between pixels, or agents, characterize the interactions between them. In the first stage, modifications are made to pixels and agents that

already exhibit sufficiently large variances in intensity to further amplify such disparities. The second stage involves adjusting pixels or agents with a minute variation so that they all have the same intensity value. Several publicly available datasets that are often cited in the literature have been utilized to evaluate the suggested method. The outcomes are compared to those of other well-known ICE methods as well. Experimental evaluation reveals that the suggested method efficiently brings attention to the image's crucial elements with little computational overhead (Katra tejasri and Dr. Anindya jana. 2021).

In image processing systems, impulsive noise may be recorded with the picture during acquisition. The term "salt-and-pepper" noise is widely used to describe this physical occurrence. For this reason, the nonlinear image processing procedure known as the median filter is employed. The algorithm may be made to run faster by incorporating this digital filter into hardware. A protective approach is required for mission-critical applications where appropriate filter functioning must be guaranteed, however an SRAM-based FPGA implementations for this filter is vulnerable to configurations memory bit flips generated by single event upsets (SEUs). This research introduces and extensively studies a fault-tolerant version of the median filter. The median output is compared to a dynamic range established by the remaining non-median outputs, which is part of our protection method. If a tainted picture pixel is identified, an error signal is sent to the output, and either a partial or full reconfiguration can be carried out to fix the configuration memory problem.

The intricacy of the underwater image environment results in typically low-quality captured underwater pictures, despite the need of high-quality photos and videos for exploitation activities in the underwater environment. Based on differential compensation, we suggested a Differential Attenuation Compensation approach to correct chromatic aberration and increase the sharpness of underwater photos, thus raising the bar for underwater image quality. Underwater images are contrast stretched to enhance contrast and denoised, with the red channel's severe loss of detail being compensated for by the blue and green channels before being restored via the grayscale world for more natural colors. Our approach for post-processing underwater photos improves upon existing metrics for gauging image quality by eliminating artifacts like chromatic aberration and blur and restoring natural colors and sharper focus. This is shown by increasing the underwater imaging benchmark (UIEB), improving underwater visual perception (EUVP), and conducting a quantitative and qualitative comparison with several state-of-the-art approaches utilizing the public underwater picture dataset.

The use of retinal photographs largely diagnoses diabetic retinopathy. Retinal vessels, exudates, as well

as microaneurysms are typically the most prominent features in retinal pictures, yet they have a relatively low contrast. For this reason, the authors of this work offer a novel method for improving contrast, which they refer to as Spatial Collaborative Contrast Enhancement. The geographical extent and spatial distribution of grey levels in the retinal vision are used by SECE to improve contrast. Increased contrasts in the final retinal image is achieved by the use of SCCE, which assigns one rank to each pair of grey levels and guarantees an exact gap between successive grey levels. Multiple tests are conducted on the industry-standard HRF and DRIVE datasets. The suggested SCCE approach outperforms many state-of-the-art methods in improving the contrast of retinal pictures, including CLAHE and Normalized Convolution (NC), as demonstrated by experimental data. The SECE increased its SSIM by 14% relative to CLAHE and by 3% relative to NC on average (Yunfei Zhang et al., 2022).

Optical imaging provides a powerful method for probing and comprehending the inner workings of living tissues (Bharathi Kumari R et al., 2018). Raw images often have poor contrast and an uneven intensity distribution of signals because of the variability of biological tissues. Direct application to picture analysis and data extraction is challenging. In this study, we present a deep learning-based system for rapidly improving picture contrast: the Fast Contrast Enhancement Network. The network was split in two to get geographical data and a wide receptive field. To improve the spatial connection, we also implemented the spatial attention mechanism. We demonstrated that FCE-Net had an average accuracy rate of 97.6% 1.6% and an average recall score of 98.4% 1.4% when applied to the cell count challenge of mouse brain pictures. Images from the vascular extraction dataset were successfully segmented using spatial attention U-Net (SA-UNet) after being pre-processed using FCE-Net, achieving state-of-the-art performance (Zhanxing Zhao and Xia Gao. 2022). We showed that FCE-Net may achieve improved accuracy while preserving the processing speed by comparing it to earlier approaches. On our computer, FCE-Net could process pictures with a resolution of 1024 1024 at a frame rate of 37fps. Further image analysis as well as data extraction using our technique from large-scale and dynamic medical optical images has considerable promise.

The technique of enhancing an image is fundamental and crucial. The primary goal of image enhancement is to modify a picture so that the modified version is superior to the original version in terms of visual quality for a certain application and human viewers. Human-viewable picture quality may be improved by enhancement operations such as de-blurring, denoising, boosting contrast, and bringing out details. Poor contrast and noise detract from the quality of many photos and even real-life photographs; as a result, improving these qualities is crucial.

This fundamental technique is essential and widely used in the fields of remote sensing, monitoring the environment, pattern recognition, and various other areas. The present global contrast improvement detection approach does not have good classification accuracy due to the low-level JPEG compression grade factor; to remedy this, a linear-model based image contrast improvement detection method is proposed in the paper (Fangjin Liu, et al., 2022). Utilize the bi-orthogonal wavelet transformation to break down the source picture. We employ the enhanced fuzzy set improvement approach for the low-frequency sub band coefficient. The simulation results demonstrate that this technique efficiently boosts contrast, brings out picture details, and reduces noise. Advantages include parameter adaptability and high algorithm efficiency, which may significantly enhance the image's visual impression.

Poor-light conditions present a significant challenge for the performance of other tasks related to computer vision because image capture equipment do not access sufficient light sources, leading to poor contrast and brightness of pictures. Improving research on low-light picture augmentation algorithms is crucial for facilitating the smooth performance of other vision tasks. This study aims to suggest a recursive network architecture for improving images via multi-scale feature fusion. The network makes use of a Convolutional Block Attention Module with two independent attention components. CBAM stands for "channel-based attention and mapping," both of which are components of this system. Our Multi-scale inception U-Net Module (MIU) is an inception-based extension of the U-Net model that allows us to extract along with fuse multi-scale features. Each of the T recursive stages in the network's learning process receives the original low-light picture as input and the result of the intermediate estimation performed on the output of the preceding iteration. To direct the network's attention towards the dark area of the picture, the t^{th} recursion use CBAM to first extract channel feature data and then spatial feature information. The MIU component then combines information from three scales to provide intermediately improved images. Finally, the input picture and the intermediately improved image are stitched together and supplied into the $t+1$ th recursive iteration. The intermediate improvement result provides higher-order feature information, whereas lower-order feature information is provided by the original input picture. After numerous iterations, the network as a whole will produce the improved picture. We run experiments on various publicly available datasets and do qualitative and quantitative analyses of the data collected. Although the network topology in this paper is rather straightforward, experimental findings demonstrate that the method presented here improves upon prior approaches in terms of detail recovery, brightness enhancement, and picture degradation reduction.

Salt-and-pepper, Gaussian, as well as random noises may all be removed from a picture with the use of appropriate filters. As a result, filters with a focus on VLSI hardware implementation are critical for real-time applications. Standard hardware-based filters, however, have not been successful in minimizing look-up-table (LUT) sizes, network latency, or power consumption. Therefore, this research aims to develop an HMF implementation based on DC logic. At first, we utilize a data comparator based on multiplexer selection logic to determine which of two integers is greater than the other. The nine-pixel median is then determined by repeatedly applying the data comparator to each of the nine possible permutations of pixels. In comparison to state-of-the-art methods (Shaik Sumayya Sulthana et al., 2023), the suggested HMF-DC has higher performance in terms of decreased noise, hardware metrics such LUTs, latency, and power consumption, as shown by both subjective and objective evaluation.

Methodology

Recently, there has been a lot of focus on the problem of interpolating or scaling digital images. Image scaling, or the enlargement of digital images, is a nontrivial procedure that requires balancing efficiency, smoothness, and clarity. These days, you can find the image scalar in just about any kind of mobile medical device, digital electronic gadget, camera, photo frame, phone, tablet, computer, etc. Recently, the VLSI approach has been a popular choice for designing low-cost, high-quality, and high-performance image scalars used in multimedia devices. The fields of medicine, computer vision, art, remote sensing, and a wide variety of other applications have all found widespread success with picture fusion using multiple image inputs. While human eyes can pick up subtle differences in an image's borders, colors, contrast, etc., some modern gadgets only support a small palette of colors that aren't particularly pleasant to the human eye. Thus, the image fusion approach is used to create a sharp and crisp image by combining two or more photographs to generate an image with more information from the same set of images. The following Figure 5 depicts the architecture of the proposed system for contrast enhancement via Modified Image Pixel Evaluation Logic (MIPEL):

Image enhancement mostly aims to achieve the following:

- Enhancing an image is making it better suited than the original for a certain use, such as in a weather prediction.
- The goal of image enhancement is to make visual information easier to understand and comprehend for human viewers and improve input quality for automated image processing methods.
- Image enhancement methods assist make some parts of an image more visible while making other parts less so by hiding the information they contain.

- It requires a number of steps, including improving the image's quality and searching for objects in it.
- We included the standard Image Enhancement functions of Threshold, Contrast, Brightness, and Invert.

Threshold Operation

Segmentation, the practice of separating an object that is fascinating from its context, benefits greatly from thresholding processes.

Invert Operation

A basic point operation, the inversion an intensity image simply swaps each pixel's positive and negative values and then adds a constant to bring the new image back into acceptable range.

Brightness Operation

Common point operations include brightness increases and decreases, which can make previously dark areas of a picture more visible. A brighter image may be achieved by having an operator add a constant value to each pixel's value, whereas a darker image can be achieved by doing the opposite operation.

Contrast Operation

Utilizing the display to its full potential by increasing contrast by rendering the deepest pixel value as black, the brightest pixel value as white, and the intermediate values as linearly interpolated shade of grey improves visual legibility.

Here are some of the benefits that come along with it:

- With digital photography, there is no need to develop or fix chemicals.
- It is possible to highlight previously obscure details.
- Smoothing images is possible.
- It paves the way for robots to have eyes.
- It enables industries to halt production and discard defective items.

Results and Discussions

Noise is unwanted information that detracts from an image's clarity. Picture noise may originate from a number of different places, including dust in the lenses, electrical noise within the camera, image sensor defects, and data transfer over a communication channel. The ultimate objective of image processing is to restore a digital photo to its original quality while maintaining its composition and features. Primary to the Image Processing Systems is the Image Filter. Impulsive noises might be produced while sending visual data over an unsecured connection. The result is either a consistently dark or black region on the image or tiny, pinpoint-sized specks. Most discussions on noise in digital images centre on impulse noise, which is uniformly distributed over the image. The Impulse noise spectrum also splits into two separate subsets. The first type of noise seen in grayscale images is pepper and salt noise,

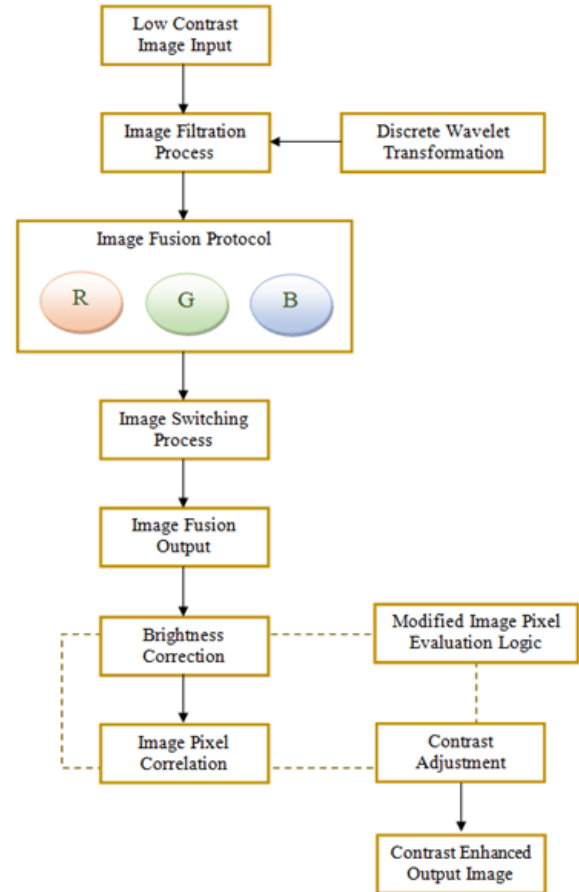


Figure 5: Block Diagram

an impulsive noise with pixels ranging from 0 (the lowest) to 255 (the maximum) in intensity. The images are dotted with random black and white spots. The second category of noise is known as random-valued shot noise, which has noisy pixels with unpredictably fluctuating values. A filter, a form of picture pre-processing stage, is applied to the acquired image to remove distracting noises. The space domain and frequency domain are two separate types of filtering. To implement filter in real-time systems, VHDL code is typically utilized. It is well-known that developing a solution in software takes more time than developing it in hardware. As VLSI technology has progressed, hardware implementation has become the method of choice. It might be costly to add extra cooling equipment to systems in effort to reduce their power consumption. It's difficult to keep functionality constant while reducing power consumption. However, we are not yet at that point in terms of battery and power optimization technologies. Most of these products already include their own central processing units, digital signal processors, or ASICs. Finishing the low force layout of any VLSI circuit is difficult. There has been a range of improvement in VLSI configuration measures for low-force applications. There has been a problem with battery-powered portability. A System-on-a-Chip (SoC)'s power

consumption can be lowered by increasing the amount of power transistor on the chip. Less power consumption from highly integrated SoCs translates to less waste heat. Costs associated with sophisticated packaging as well as cooling systems are avoided. A very-large-scale-integration (VLSI) architecture for noisy reduction in various imaging applications is provided to meet these powers and cost constraints. The primary focus of this research is on low-overhead methods of coding in Verilog by way of an FPGA prototype. Subjective as well as objective image statistics are then computed in the MATLAB environment. The most important findings of this investigation are as follows:

- A data comparator has been implemented using multiplexer selection logic to find extreme values.
- Using a multi-level network to pick the middle pixel in a window of nine.
- De-noising a picture via image switching of data blocks.

Distractions are difficult to get rid of without interfering with the image's nuances, and they are signal-subordinate. Gaussian, drive, dot and Rician perturbations, among others, affect the final product. Picture-denoising metrics heavily rely on information about the type of mistake present in the source picture. The inaccuracy in the picture might be assigned a multiplicative or an additive value.

To operate at or near the threshold

The process of segmentation, which involves isolating an object of interest from the context in which it is located, is helped tremendously by threshold procedures. When you threshold a picture, every pixel in the image is converted to one of two different values. Toggle a value of 256 for pixels that are above a threshold and a value of 0 for pixels that are below the threshold. The following Pseudocode describes the flow of logic that occurs during a thresholding function.

Pseudocode: Thresholding Function

```
If (Inp_Value > def_Threshold)
{
    Memory_In = 256;
    Memory_Out = 256;
    Process = 256;
}
elseif (def_Threshold > Inp_Value)
{
    Memory_In = 0;
    Memory_Out = 0;
    Process = 0;
}
```

Switching Phases

To invert an intensity image, all that is required is a straightforward point operation, which consists of rearranging the values of the pixels (by multiplied them by 1) and then adding a constant value in order to return the output to a range that is considered acceptable. The

RGB values of individual pixels are standardized by taking the mean of their three color channels. The following Pseudocode explanation offers an explanation of the thinking behind an invert function.

Pseudocode: Switching Function

```
def_Val_1 = (Red + Green + Blue)/2;
def_Val_2 = (Red + Green + Blue)/4;
def_Final_Val = (def_Val_1 + def_Val_2)/2;

If (def_Val_1 > 0 && def_Val_2 > 0)
{
    Memory_In = 256 - def_Final_Val;
    Memory_Out = 256 - def_Final_Val;
    Process = 256 - def_Final_Val;
}
else
{
    Memory_In = 256;
    Memory_Out = 256;
    Process = 256;
}
```

Adjusting the Ambient Light Level

One of the most common applications for point operations is to adjust the brightness of a specific region inside an image by either increasing or decreasing the value of the corresponding point. The value of each pixel may be made to appear brighter by having an operator add a constant value to it, while the value of each pixel can be made to appear darker by having the operator perform the reverse action. The following is some Pseudocode that provides a very detailed explanation of the thought process that went into the brightness function.

Pseudocode: Brightness Function

```
def_Val_1 = (Red + Green + Blue)/2;
def_Val_2 = (Red + Green + Blue)/4;
def_Final_Val = (def_Val_1 + def_Val_2)/2;
If (def_Final_Val == 1)
{
    def_Temp = Memory_In + def_Final_Val;
    If (def_Temp > 256)
    {
        Memory_Out = 256;
    }
}
else
{
    def_Temp = Memory_In + Process;
    If (def_Temp > 256)
    {
        Memory_Out = def_Temp;
    }
}
```

In contrast, the method is as follows

By raising the contrast range, which is accomplished by designating the pixel value with the greatest amount of darkness as black, the pixel value with the greatest amount of brightness as white, and the others as linearly interpolated shades of gray, the display may be utilized more effectively. The following piece of Pseudocode provides an explanation of the logic flow that underlies the contrast function.

Pseudocode: Contrast Enhancement Function

```

If (def_Final_Val > def_Threshold)
{
    def_Temp = Memory_In + def_Threshold;
    If (def_Temp > 256)
    {
        Memory_Out = 256;
    }
    else
    {
        Memory_Out = 256 + def_Threshold;
    }
    def_Temp_R = def_Threshold + R_Val;
    def_Temp_G = def_Threshold + G_Val;
    def_Temp_B = def_Threshold + B_Val;
}
    
```

The implemented system is placed into the real-time environment to test the efficiency clearly for a continuous fifty days. And the resulting details are portrayed in graphical manner. Figures 6 (a) and (b) illustrate the proposed input image and the switching operation outcome, in which the switching results are portrayed in grayscale format. And the following Figure 7 illustrates the proposed image contrast enhancement operation outcome clearly.

The following Figure 8 illustrates the proposed algorithm Modified Image Pixel Evaluation Logic (MIPEL) contrast enhancing efficiency, in which the logic is cross-validated with the conventional DWT algorithm to evaluate the efficiency of the proposed logic. The same is illustrated over the following table, Table 1 in descriptive manner.

Table 1: Contrast Enhancing Efficiency

S.No.	Days	DWT (%)	MIPEL (%)
1.	5	90.76	96.62
2.	10	91.53	95.71
3.	15	90.27	95.54
4.	20	90.31	96.39
5.	25	91.54	96.62
6.	30	91.76	95.83
7.	35	90.89	94.46
8.	40	91.71	96.73
9.	45	91.76	96.82
10.	50	91.84	96.94



Figure 6: (a) Input Image and (b) Switching Output



Figure 7: Contrast Enhancement

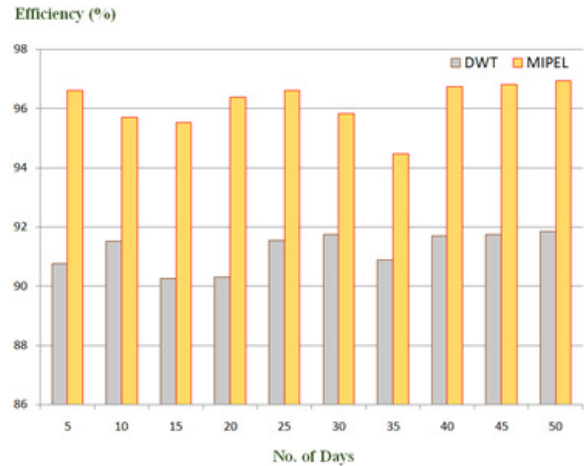


Figure 8: Contrast Enhancing Efficiency

Table 2: Time consumption

S.No.	Images	DWT (s)	MIPEL (s)
1.	56	125	59
2.	34	98	37
3.	82	176	85
4.	54	114	56
5.	36	103	37
6.	71	163	73
7.	63	172	68
8.	39	112	44
9.	73	167	86
10.	81	173	92

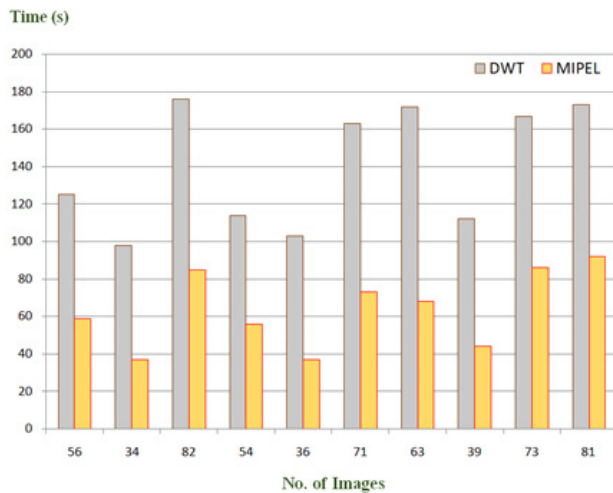


Figure 9: Time consumption

The following Figure 9 illustrates the proposed algorithm modified image pixel evaluation logic performance in terms of time evaluation. This figure shows the evaluation time for processing the images in real-time, in which the logic is cross-validated with the conventional DWT algorithm to evaluate the timing efficiency of the proposed logic. The same is illustrated over the following table, Table 2 in a descriptive manner.

Conclusion

In this paper, a hardware-centric approach is introduced for improving contrast. This new hardware design is truly revolutionary and to test the efficacy of the suggested modified image pixel evaluation logic (MIPEL) approach, it is compared to the standard DWT technique. This technique allows for the average brightness of the picture to be maintained. After doing both qualitative and quantitative analyses, it is clear that the suggested technique outperforms the state-of-the-art algorithms. This technique improves a 256x256 picture so it may be used for analysis. A problem with the method is that it uses more hardware resources than other similar programs. Research into how the algorithm might be altered to use less hardware resources is a promising avenue. This architecture can be made better by the use of parallel processing and a switchable design. An efficient picture scaling technique is given in this study, with a VLSI implementation suggested. An efficient weighted median approach that can interpolate and conduct denoising is the major contribution of this study. The suggested method eliminates blurring and preserves edge features as the degree of scaling rises, in comparison to other methods already in use. The suggested approach improves performance with manageable hardware requirements. In the future, methods will be implemented to reduce the hardware overhead required for efficient MIPEL picture scaling. The suggested approach for resizing images has only been modified to work for zooming and scaling down images.

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