Saturation Adjustment of Image Enhancement Based on FPGA

Zhuoyue Yang[1,a,*]

[1]*School of Intelligent Manufacturing and Smart Transportation, Suzhou City University, Suzhou, China*

a. scyxf@szcu.edu.cn

corresponding author

Abstract: FPGA can allow designers to produce hardware functions quickly in accordance with requirements. Because of its flexibility and parallel processing ability. It has been widely used in image, signal processing and other fields. Image saturation is an important standard to describe image quality, which affects the color brightness and visual perception of the image. At the same time, image enhancement, it is an important part of enhancing image visual effects and improving image quality. Combined with the above two points, the high-speed parallel capability of FPGA can be used to carry out complex image processing to achieve the purpose of efficiency improvement. The aim of this experiment is to adjust image saturation based on FPGA. This experiment is based on the theory of image processing and the algorithm of saturation adjustment. Then plan a new solution based on the known algorithm. It is expected that the production cost can be reduced under the premise of obtaining the desired effect. The final result is successfully simulated in modelsim and its reliability is ensured. This experiment will provide a new idea for image processing. It is helpful to further improve and enrich the existing image processing theory, and provide theoretical reference for other related research.

Keywords: Image enhancement, RGB, HSL, Saturation enhancement.

1. Introduction

Since the development of image enhancement algorithms, there have been several relatively traditional methods such as spatial domain enhancement and frequency domain enhancement. The basic idea of spatial domain enhancement is to adjust the gray value of each pixel and its adjacent pixels in the image based on the space of the image itself, so as to improve the clarity of the image. Common spatial domain enhancement algorithms include histogram correction [1], gray transform [2], image smoothing [3] and image sharpening [4]. Frequency domain enhancement is to convert the image into a signal, and then use the frequency variable as a reference to describe the image features, and then decompose, analyze and process the frequency features of the image signals. The typical classical methods are low-pass and high-pass filtering algorithms. In the process of image processing, Fourier transform [5] can be used to convert the two into each other, and the combination of these two methods can also achieve relatively good results. This experiment is mainly about the design of color model and image segmentation algorithm. These methods and theories have a wide range of applications from photographic art to medical imaging, from satellite images to virtual reality.

Image saturation refers to the intensity or purity of the color in the image, which describes the vividness of the image color and is one of the important attributes that affect the final effect of color. Saturation is also known as picture color purity, that is, the proportion of color components and achromatic components in the color, which determines the saturation and vividness of the color. High saturation means that the color is pure and strong, without gray and white components, giving people a strong visual feeling; On the contrary, it means that the color contains more gray and white components, which will look more dim and weaken the impact on the visual effect. Therefore, as one of the three dimensions that describe color, it is very important for images. Abnormal image saturation is not uncommon, and there are many related factors, such as the performance of the device, lighting conditions, white balance Settings, and image noise problems caused by high ISO shooting are very common. Therefore, in order to make the image more restore the shooting environment and have a better visual effect, the processing of the image in the later stage becomes particularly important.

Regarding the adjustment of image saturation, the field of image saturation enhancement has developed rapidly in recent years, which is mainly divided into three categories: the improvement and development of traditional algorithms, the introduction of deep learning methods and the innovation combined with other technologies. Traditional Retinex algorithm has coloring bias, color distortion and other phenomena, so there are improvements based on traditional Retinex algorithm [6]. For example, an image enhancement algorithm based on YIQ-Retinex model is proposed to improve the brightness and color processing method of Retinex algorithm, and solve the noise problem. In addition, an image enhancement algorithm based on adaptive gain modulation based on local brightness is proposed [7]. In this algorithm, the brightness channel image of the image to be processed is separated, and the local average brightness image is obtained by means of average filtering, and then the smooth brightness gain image is obtained according to the local average brightness image and brightness gain function. Finally, each color component is processed with the brightness gain image to obtain the final enhancement result. This adaptive method can enhance the image according to the local brightness features, and improve the quality of the image. At the same time, there are also related studies on the combination of color space, and some studies combine saturation enhancement with color space conversion to improve the enhancement effect. For example, an image is converted from RGB space to HSV space, the saturation component is enhanced in HSV space, and then converted back to RGB space. This method can better control the degree of saturation enhancement and avoid excessive influence on the tone and brightness of the image. [8]

This paper aims to further study the effective methods of image saturation adjustment, mainly around the following aspects: First, study the pre-processing process of the conversion from RGB to HSL format to ensure the accurate extraction and standardization of color information; The second is to explore the reasonable setting of parameters and the calculation logic of saturation adjustment in the saturation enhancement module to achieve accurate saturation control; The third is to optimize the post-processing flow of HSL back to RGB format to ensure that the image quality is not damaged in the adjustment process. The research objective of this paper is to propose a reliable, efficient and flexible method to adjust image saturation. The method is to meet the needs of users for image enhancement in different application scenarios. The research objective is also to improve the accuracy and stability of this method in processing various kinds of images. This can provide strong support for image saturation adjustment in image editing, photography, medical imaging and other fields.

2. Theory

Here, image enhancement (saturation adjustment) is realized based on FPGA. Because FPGA is not good at complex floating-point operations, and this experiment aims to improve basic image processing. A relatively simple saturation algorithm is chosen. Generally, the saturation adjustment of RGB images is based on the adjustment of the ratio of values in the three color channels to affect

the vividness of the colors. The process of changing the values will inevitably have an impact on hue and brightness. Meanwhile, the HSL color mode is used here due to the influence of the study on the combination with the color space. Hue, saturation and brightness are separated to avoid the impact on the other two quantities when adjusting saturation, and considering that HSL mode is more in line with the human eye's cognition of color. In HSL mode, different color areas can be adjusted, and their saturation can be adjusted separately, without affecting other color attributes. So as to achieve finer color adjustment. It avoids the problem of color distortion caused by brightness changes, and can better retain the original information and hierarchical sense of the image. The greater advantage is that after saturation adjustment in HSL mode. In this mode it can be turned back to RGB mode, which is convenient for use and display on multiple occasions and multiple devices.

The module is divided into parts, and five modules are set up respectively. The input module is responsible for receiving the original image data; Preprocessing module converts RGB image to HSL format [9]

The saturation enhancement module is responsible for receiving the saturation related adjustment values and adjusting the corresponding saturation data. The post-processing module outputs the adjusted HSL data and converts it back to RGB image format. The output module finally outputs the resulting RGB image to the display device or to storage.

In addition, the realization of the sub-module is to receive the relevant parameters of the RGB map on the display screen or camera device in the pre-processing module, and then convert the pre-processing module into HSL to standardize it. First of all, RGB is normalized, and each value is divided by 255 to get R ', G ', B ', and the maximum and minimum weight in the RGB three channels are compared, denoted as max and min. Then it is solved. For saturation, if the maximum value is 0, then S is also 0; Conversely, the value of S is (max-min) /max; The formula for calculating the brightness value L is the corresponding value of 2 (max + min) /255; For the hue H will be discussed by case, when the max value is R ', substitute the formula 60°*{[(G '-B') /(max-min)]+0}, when the max value is G ', substitute the formula 60°*{[(B '-R') /(max-min)]+2}, when the max value is B ', Plug in the formula 60°*{[(R '-G') /(max-min)]+4}, and finally get the value of HSL.

Next the routine will go into the saturation enhancement module. Seting a parameter called present with the value -100 to 100, dividing it by 100 to get a ratio, stored in increment. The subsequent cycle is adopted. The alpha value is used to adjust the values of the red, green, and blue channels.

If increment is greater than or equal to 0, it means that the saturation is increased, and the following two points are discussed: (1) To determine whether the adjusted saturation value is greater than 1, the value of increment+1 is calculated here, and if INCREMENT is greater than or equal to 1, the saturation has exceeded the upper limit. In this case, alpha=s is set, that is, the current saturation remains unchanged. (2) If the saturation does not exceed 1, the value of alpha=1-increment is calculated here to obtain the first adjustment factor, and then alpha=1/alpha-1 is calculated to further adjust the value of the factor.(3) If increment is less than 0, it means reduced saturation, then alpha=increment.

Then, the post-processing module brings in the adjusted data and converts HSL into RGB again: for increment greater than or equal to 0, the judgment and corresponding calculation are completed and brought into the corresponding calculation formula of the color value: blue: t[3 * j + 0] = [b + (B-L * 255) * alpha]; Green: t[3 * j + 1] = [g + (G-L * 255) * alpha]; Red: t[3 * j + 2] = [r + (R-L * 255) * alpha]. To adjust the values of the three channels separately, thereby enhancing image saturation.

In addition, for increment less than 0, it is calculated according to the following formula:
(1)Red:t[3 * j + 2] = [L * 255 + (r - L * 255) * (1 + alpha)];
(2)Green:t[3 * j + 1] = [L * 255 + (g - L * 255) * (1 + alpha)],
(3)Blue:t[3 * j + 0] = [L * 255 + (b - L * 255) * (1 + alpha)].

Therefore, this method can adjust the saturation of the image by directly adjusting the value of precent.

Finally, enter the output module, the obtained image output to the display device or storage device, to get the image enhancement needs.

3. Result and Discussion

3.1. Results

Figure 1 shows the relevant waveform graphs and results obtained from the simulation software
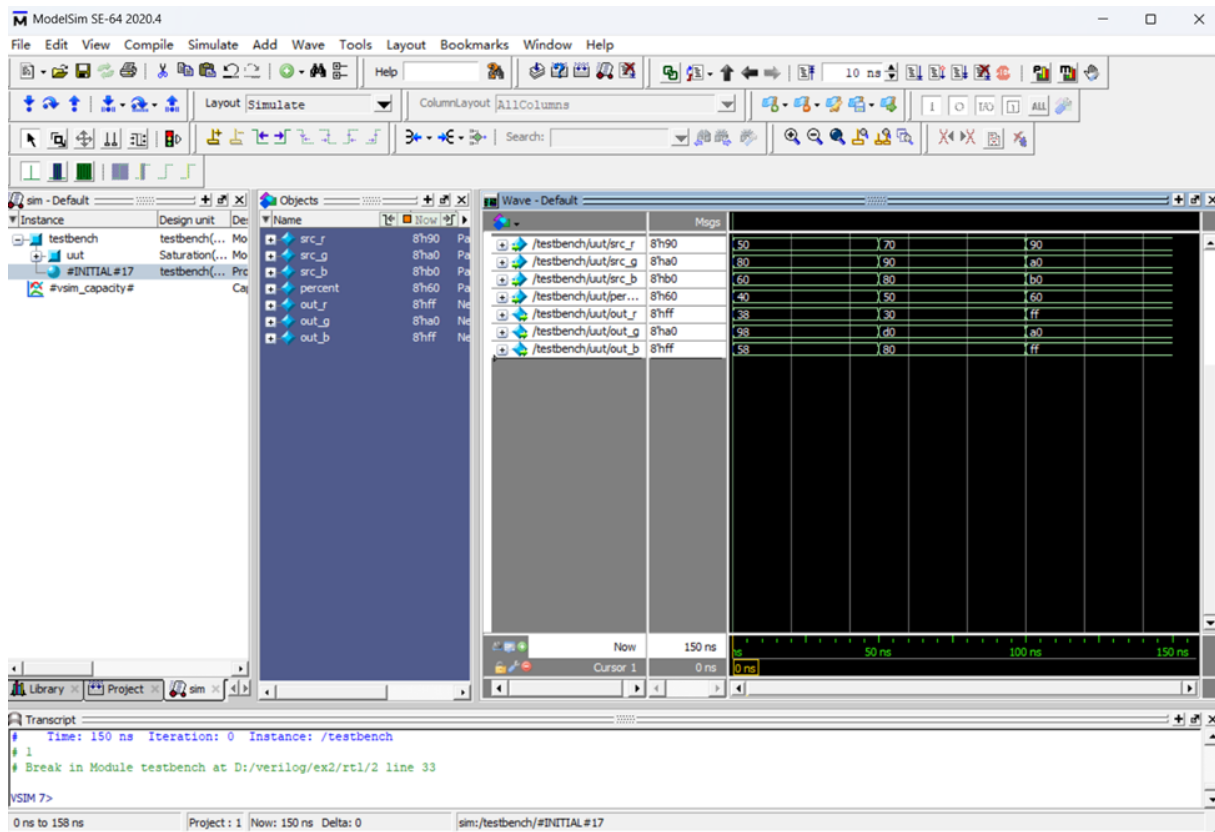

Figure 1: Simulation waveform diagram of the program in modelsim

First, the effectiveness of module division. In this study, image processing is divided into five modules: input, pre-processing, saturation enhancement, post-processing and output. This modular design makes the entire image processing process clearer, easier to understand and maintain. Each module has clear functions and responsibilities, allowing for individual optimizations and improvements. Then through the function test and performance evaluation of each module, the rationality and effectiveness of module division are verified. The input module can accurately receive the original image data, the pre-processing module can successfully convert the RGB image into HSL format, the saturation enhancement module can adjust the saturation according to user needs, and the post-processing module can convert the adjusted HSL data back into RGB image format. The output module can output the processed image to the display device or storage device. Second, the accuracy of the saturation adjustment method. The saturation adjustment method proposed in this study adjusts the values of the red, green and blue channels by setting the present parameter and converting it into increment and alpha values, so as to realize the adjustment of image saturation. By testing different types of images, the results show that the method can accurately adjust the image saturation, and

maintain good image quality when increasing and decreasing the saturation. Moreover, for different image scenes and color distribution, the method can be flexibly adjusted according to user needs to meet the individual needs of different users. At the same time, the accuracy and effectiveness of the method are verified by the subjective evaluation and objective index analysis of the image after saturation adjustment. Third, the improvement of image processing effect. Through the comparative analysis of the images before and after processing. It can be clearly seen. The image saturation after processing by this method has been effectively adjusted. The color of the image is more vivid. The visual effect has been significantly improved.

In some specific application scenarios, such as photography, image editing and video production. This method can provide users with better image quality and visual experience, and can meet the needs of users for image enhancement.

3.2. Discussion

3.2.1. Impact of parameter settings

The value of the present parameter ranges from -100 to 100. Different values have different effects on the saturation adjustment effect. In practical application, the user needs to set the present parameter reasonably according to the specific image scene and demand to obtain the best image processing effect. In addition, the calculation of increment and alpha values is also affected by the present parameter. In future research, the optimization method of parameter setting can be further explored to improve the accuracy and flexibility of parameter setting, so as to better meet the needs of users.

3.2.2. Limitations of the algorithm

Although the saturation adjustment method proposed in this study can achieve good results in most cases, it may have certain limitations when dealing with some special image scenes. For example, for some monochromatic, low-contrast images, there may be over - or under-saturation adjustment. In future research, the algorithm can be further improved to improve its adaptability and robustness to better deal with various complex image scenes. At the same time, it can be combined with other image processing technologies, such as contrast enhancement, sharpening, etc., to further improve the quality of the image and visual effects.

3.2.3. Application prospect

The method of image saturation adjustment proposed in this study has a wide application prospect. In the fields of photography, image editing, video production, etc., users can enhance the visual effect of the image by adjusting the saturation of the image, improving the quality and attractiveness of the image. In addition, the method can also be applied to medical images, remote sensing image and other professional fields to provide better support for image analysis and processing. With the continuous development of image processing technology and the increasing application demand, the application prospect of this method will be more broad [10].

4. Conclusion

By modularizing the image processing flow, the flexible adjustment of image saturation is realized successfully in this study. After the input module receives the original image data, the pre-processing module converts the RGB image into HSL format and accurately calculates the HSL value through normalization processing and specific formulas. The saturation enhancement module uses the parameters present and the calculated increment and alpha values to effectively adjust the saturation of the image according to different saturation adjustment requirements. The post-processing module

converts the adjusted HSL data back to RGB image format, and adjusts the values of the three channels according to different increment cases by using corresponding calculation formulas, thus enhancing the image saturation. Finally, the output module outputs the obtained RGB image to the display device or storage device to meet the needs of image enhancement. This method has the following advantages: First, the modular design makes the image processing flow clear and easy to understand and expand. Secondly, the image saturation can be adjusted by directly adjusting the present value, which is easy to operate. In addition, the adjustment of the saturation takes into account a variety of situations, which can achieve more accurate and reasonable adjustment when increasing and reducing the saturation, and avoid the situation that the saturation exceeds the reasonable range. This research provides an effective method for image saturation adjustment, which has a wide application prospect in image editing, photography, video production and other fields. Although the current image processing process can achieve saturation adjustment, it may be inefficient when processing large-scale image data or high-resolution images. Therefore, it is hoped that the algorithm can be further optimized in the future to improve the running speed of each module and reduce the processing time, so as to meet the application scenarios with higher real-time requirements. It is also hoped the computer can automatically find an ideal value and then adjust the image in future experiments, such as Bayes algorithm. Using this method so as to improve the whole content of image processing and make this program more intelligent.

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