Key Engineering Materials
ISSN: 1662-9795, Vol. 620, pp 516-521
doi:10.4028/www.scientific.net/KEM.620.516

Online: 2014-08-11

Adaptive video image enhancement algorithm based on FPGA design

WU Li-ming[1,a], Yang Shi-long[2,b], LI Fu-jian[3,c],Luo Xin[4,d]and Li Bing-jing[5,e]

[1,2,3,4,5]Information Engineering College, Guangdong University of Technology, Guangzhou 510006 , China

[a]jkyjs@gdut.edu.cn;[b]shilonglk@126.com;[c]380594615@qq.com;

[d]404500468@qq.com;[e]libingjing1127@163.com

Keywords: scene change, FPGA, image enhancement, parallel processing, intelligent adaptive

Abstract. Aiming at the problem of image quality degradation due to scenes change rapidly, an image enhancement algorithm based on scene intelligent identification is proposed. The algorithm sharpen the image detail by using Laplace operator. Determines the change image scene according to the gray value, constructs different gray mapping function, and adjusts gray value range of image adaptively to improve the contrast ratio of image enhancement. By using parallel processing, the algorithm has high execution efficiency, so it can meet the real-time processing of HD video. Experimental result shows that the proposed algorithm has satisfying performance in the rapidly change scene.

Introduction

Because of the rapidly change of scene, the contrast ratio of video image is low and the image has dark gray value. And many characteristics in the video image is dim or cover lead to drop the quality of the video image. Image enhancement can convert original images to the other images where information can be easily achieved. It can clarity the fuzzy image or emphasize some characteristics of the fuzzy image, expand the difference of characteristics between different object in the image, improve image quality and abundant the informations of image so that to meet target recognition, feature extraction and image processing requirements.The traditional image enhancement processing methods divide into the airspace image enhancement and the frequency domain image enhancement. The two methods can enhance image in the general condition, but when the scene transform fast such as video image, the performance of the two methods is very poor and its computational efficiency cannot meet the demand of increasingly extensive application.

Aiming at the above problems, an image enhancement algorithm based on scene intelligent identification is proposed in this paper. The new algorithm adaptively adjusts image's gray value range to improve the performance of image enhancement based on dynamic scene estimation. And parallel lines processing technology is used to process the original image, the algorithm has a good timing performance and compact hard ware implementation with minimum use of memory resource.

Scene adaptive image enhancement algorithm

The algorithm sharpen the image detail by using Laplace operator first, then chooses the appropriate gray mapping function according the determine the outcome of image scene, and adjusts image gray value according mapping relationship and a high quality of enhanced image would be obtain. process shown in Fig.1.

image sharpening based on Laplacian . Laplacian is a second-order differential operator with isotropy, and it can sharping the image[1]. Assume n=3,we construct a nxn neighborhood filter window centered on pending pixel. The Laplace algorithm can be expressed as Eq.1.

$$f_{lp}(x,y)=\nabla^2 f(x,y)=8f(x,y)-\begin{bmatrix} f(x+1,y)+f(x-1,y)+ \\ f(x,y-1)+f(x,y+1)+ \\ f(x-1,y-1)+f(x-1,y+1)+ \\ f(x+1,y-1)+f(x+1,y+1) \end{bmatrix} \quad (1)$$

Where the $f_{lp}(x,y)$ is pending pixel and f(x,y) expresses the gray value of image after filtering processing by using Laplacian.So the pixel gray value after sharpening enhancement can be expressed as the Eq.2.

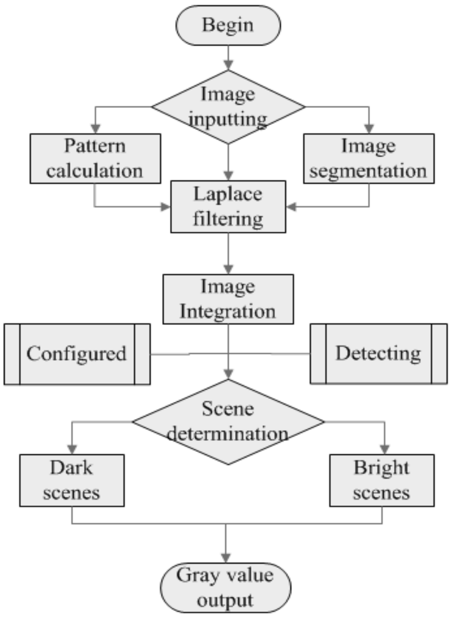

Fig. 1 Algorithm Flowchart

$$g(x,y)=f(x,y)+\frac{f_{lp}(x,y)}{P} \quad (2)$$

Where the g(x,y) is the pixel gray value after sharpening enhancement. f(x,y) is the gray value before processing. If the value of expression is beyond 8-bit gray scale image gray value limit, the gray value is instead of 255 and the gray value is instead 0 if the value of expression is less than 0.In addition, Laplacian can also be expressed as template form, the template of discrete Laplacian is show as the Table 1(a) and its extension template is show as Table 1(b).

Table 1. Laplacian template

(a)discrete Laplacian template			(b)extension template		
0	1	0	-1	-1	-1
1	-4	1	-1	8	-1
0	1	0	-1	-1	-1

determine of change scene. The image after Laplace sharpening need to determine the scene of the image so that to select the appropriate mapping function and adjust the gray value so that to promote the contrast ratio of the image. The average gray value of image can be expressed as:

$$Ave=\frac{\sum_{y=1}^{N}\sum_{x=1}^{M}g(x,y)}{M\times N} \tag{3}$$

$$\text{Ave}<\text{dark}_{\text{std}} \tag{4}$$

$$\text{Ave}>\text{bright}_{\text{std}} \tag{5}$$

Where the g(x,y) is the pixel gray value after sharpening enhancement. M and N represent the number of rows and columns of pixel image. The dark_{std} and $\text{bright}_{\text{std}}$ represent threshold of too dark and too bright. The Eq.4 expresses the average gray value is smaller than the threshold too dark scenes, so we can determine the image is too dark scene. On the contrary, we can determine the image is too bright scene according the formula Eq.5.

mapping function calibration. There are ideal image, too dark image and too bright image according to transform the scene. If the image is too dark image, it need to transform the low amplitude of the image pixel gray value of tension, while compress conversion amplitude of high gray value pixels in image. If the image is too bright to be determined, we need to compress conversion amplitude of the low gray value in image, while stretch the conversion amplitude of the high gray value in image. It don't need to adjust the gray value of image for ideal image. According to the analysis above, the algorithm with logarithmic function brightness mildness role in image enhancement process[2], the algorithm constructs different types transformation function by setting different values to meet different requirement of enhancement image in the scenes.

transformation function of bright image. The transformation function of the bright image can be express as:

$$\hat{g}(x,y)=\frac{\left\{{}_{10}\left[g(\mathrm{x},y)\times\lg(\mathrm{p})\big/255\right]_{-1}\right\}\times 255}{p-1}+\frac{graphics_{std}-graphics_{sharp}}{2} \tag{8}$$

In Eq.8, $\hat{g}(x,y)$ is the (x,y) pixel value of the enhanced image and it made up of two parts.g(x,y) is the (x,y) pixel value of the image after sharpening.p expresses controls parameter. $\text{graphics}_{\text{std}}$ is the standard mean parameters and $\text{grahics}_{\text{sharp}}$ is the gray value images to be processed, they upgrade the overall gray value of the image. The amplitude range of the high gray value region in image can be expanded dynamically and the average gray value of the image can be reduced.

transformation function of dark image. The transformation function of the dark image and the ideal image can be express as:

$$\hat{g}(x,y)=\frac{\lg\left[\frac{\mathrm{g(x,y)}}{255}\times(p-1)+1\right]\times 255}{\lg(p)}+\frac{graphics_{std}-graphics_{sharp}}{2} \tag{9}$$

In Eq.9, $\hat{g}(x,y)$ is the (x,y) pixel value of the enhanced image. g(x,y) is the (x,y) pixel value of the image after sharpening .p expresses controls parameter, it can change the mapping characteristic of the conversion curve.$\text{graphics}_{\text{std}}$ is the standard mean parameters and $\text{grahics}_{\text{sharp}}$ is the gray value images to be processed. For dark image, the transformation function improves the low gray region in dark image and expands the range of gray value in the dark image. It can adjust the range of gray value according different condition. The gray mapping transformation function can be selected intelligently to adust the range of gray value according the image scene. So the contrast ratio of image is upgraded and we can obtain the enhanced image finally.

FPGA design and verification

Algorithm design and verification in the experimental box with Xilinx's Virtex-4 FX-based chips[3].The whole algorithm can be roughly divided into the filter window construction, adaptive algorithm, Architecture using parallel pipeline processing, processing speed, small footprint, to meet the requirements of real-time video.

filter module. Matrix window module schematic in Fig.2, the areas chosen for the 3x3's,The filtering in the FPGA is mainly sliding 3x3 block, using the three FIFO buffer as the data of three lines, three lines of data read out by counting, and data delayed by the shift register, a 3x3 window is formed,Finally, the filtered image data obtained by the data convolution with Qualcomm template. Involving multiplication or division, using the shift or IP core ways, for the division of slow characteristics, the three lines of division IP core implementation, improve processing speed.

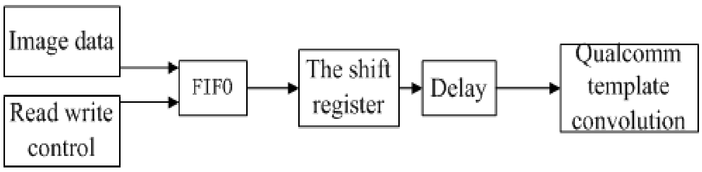

Fig.2 Filter module principle

Adaptive algorithm module. Adaptive algorithms can be divided into two steps and dynamic Laplacian sharpening function reference table plate 1, when the neighbor pixels with the same gray level, the convolution operation result is 0, When the neighborhood of the center pixel intensity is higher than the other pixels in the average gray areas within it, the module convolution result is positive, when the center pixel is less than the gradation in the neighborhood of it in the other areas of the pixel when the average gray level, the convolution operation result is negative,When the result of the convolution with the appropriate attenuation factor applied to the original process and the center pixel, image sharpening can be realized[1]; FPGA to implement dynamic adjustment function, the pre-configured scene, Use FPGA ROM lookup table design, Grayscale initial data as an address，remove the lookup table as the gradation value conversion enhancement algorithm after completion, A lookup table to reduce consumption while increasing processing speed[5].

Results and analysis

The results of new algorithm this paper are compared with histogram equalization algorithm[1]. The experimental platform is experimental box based Xilinx's Virtex-4 FX chip. We assume the Laplacian sharpening parameter of algorithm is p=8,scene intelligent determine parameters are darkstd=70,brightstd=180 for ideal image. For the bright scene, we assume the p=3 and graphicsstd=brightstd=180.For dark scene,p=28,graphicsstd=darkstd=70.

Comparison of image quality. the results of the two algorithms to enhance dark image shown in Fig.3.The figure shows that the new algorithm not only sharpen the image detail of dark scene but also enhance the dynamic contrast ratio of image, the brightness and color of the enhanced image is sofer, so the visual effect is better. the results of the two algorithms to enhance bright image shown in Fig.4.The figure shows that the performance of new algorithm is better than the histogram equalization algorithm. The image enhancement algorithm is proposed this paper has good performance under scene rapidly change and the original semantic of image is better preserved.

(a) The original image (b) Histogram equalization (c) This algorithm

Fig. 3 Enhanced effect of dark scenes

(a) The original image (b)Histogram equalization (c) This algorithm

Fig.4 Enhanced effect of dark scenes

Performance analysis and comparison. The purpose of image enhancement is improve the contrast, rich detail texture, abundant information and keep soft and primitive traits of image. We use modified peak signal to noise ratio to express matching degree between enhanced image and ideal image. The greater of the value is, the higher matching degree it is. Image entropy is expressed the information of the image, the greater of the value is, the greater of the amount of information it is. The dynamic range of gray value is expressed the degree performance of the image, the greater of the value is, the higher the contrast ratio is[4].

Respectively, Fig.3(a) called road and Fig.4(a) called boat for scene processing, it degenerates into too dark, too bright scene effects, using the histogram algorithm and the algorithm are enhanced, show as table1 and table2. The parameters have certain improvement except signal to noise ratio by using algorithm is proposed this paper compared with the histogram equalization algorithm. The matching degree and the amount of information are closer to the ideal image. So the new algorithm can enhance image effectively in rapidly change scene.

Table 1. Enhancement algorithm processing under bright scene

Algorithm	Image	Parameter comparison		
		SNR	Entropy	Dynamic range of gray
Histogram	road	1.1413	1.5072	7.8823
	boat	1.2321	1.7455	7.8832
This algorithm	road	1.1397	2.1025	7.7974
	boat	1.2193	2.1516	7.7970

Table 2. Enhancement algorithm processing under bright scene

Algorithm	Image	Parameter comparison		
		SNR	Entropy	Dynamic range of gray
Histogram	road	1.2210	1.3418	6.7748
	boat	1.2325	1.4101	6.5389
This algorithm	road	1.3541	1.6703	6.4179
	boat	1.2702	1.3801	6.2443

Conclusion

An image enhancement algorithm based on scene intelligent identification is proposed for the target image of video in rapidly change scene. The algorithm sharpen the image detail by using Laplace operator. Determines the change image scene according to the gray value, constructs different gray mapping function, and adjusts image's gray value range adaptively to improve the contrast ratio of image enhancement. we verified the performance of the algorithm on the FPGA platform and make full use of the flexibility and parallel processing of FPGA platform finally. Experimental results show that the performance of the new algorithm is better than other algorithm. The new algorithm is able to adapt to rapidly changing scenes and meet the requirements of real-time video.

Acknowledgments

This work is partially supported by Science and Technology Project of Guangzhou, Guangdong, China (No. 12A342112033). Thanks for the help.

References

[1] R.C. Gonzalez, R.E. Woods: Digital Image Processing (Beijing. Electronic Industry Press, 2007).
[2] S.C. Tai, N.C. Wang, Y.Y. Chang: IEEE Computer Society, Vol. 3 (2008), pp. 256.
[3] W.J. Li, L.M. Wu, Y.H. Deng: TV technology, Vol. 37 (2013), pp. 178.
[4] Q. Sun, S.Y. Yao, J. Li: Application of Electronic Technology, Vol. 39(2013), pp. 50.
[5] J.X. Wang, C.L. Yin: Chinese Journal of Liquid Crystals and Displays, Vol. 28 (2013), pp. 459.