Deblocking Filter Chip Design Based on Image Fusion for Surrounding View System

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Abstract

With the nowadays development of technology, there are more and more electronic products based on image processing in people's lives. For example, the automotive screens are developed for surround view related systems. Therefore, this paper describes a deblocking filter chip design which based on image fusion technique to improve the stitched image for surrounding view system applications. It not only applies to panoramic images for each imaging product that relates to electronics, but also realizes this technology on a chip. To reduce visible artifacts on the panoramic stitching and achieve the effect of visually not obvious seams are the target which is created a high-resolution surrounding view system in this proposal. Compared to the H.264 and the H.265 deblocking filters which divide the stitching images into more than 16x16 cells blocks, the proposed filter divides two images of the P block and Q block into four cells blocks for the filter. This method has lower computational complexity than previous studies, and increases the speed of computing for the filter. These advantages make the deblocking filter reduce production costs in the present technology and help to improve the development of the image processing technology.

Keywords: **Deblocking filter, panoramic stitching, image fusion, VLSI, H.265/HEVC, H.264/AVC**

Ⅰ. INTRODUCTION

High-Efficiency Video Coding (HEVC) [1] is a scalable hybrid coding design which is based on a block-based in the recent years. Compared to the H.264/AVC [2] deblocking filter, H.265/HEVC deblocking filter [3] divides the stitching images from a sample of 16x16 cell blocks to a sample of cells ones such as 64x64, 32x32, 16x16, etc. In the section on the boundary condition, H.265 has modified the five filter conditions that are defined as BS=0~4 in H.264 to the filter conditions BS=0~2.

Compared with H.264 and H.265 which divide the stitching images into a sample of 16x16 cells blocks or more than 16x16 cells ones, the proposed method divides the stitching images into a sample of four blocks which expands outwards with seams as the center. The idea of dividing the stitching images can reduce the part of the stitching images where the seams are not obvious and ignored. At the same time, the part of the boundary condition is simplified from BS=0~2 to BS=1 and BS=2. The pixels of the stitching images cannot only need to be used to achieve the effect of fusion, but also can be simplified in complex filter conditions in the overall computing architecture.

To sum up the methods of simplifying the overall computing architecture, this proposed simplifies the block range division in the stitching image for the pixels which need to be fixed by the deblocking filter. And the part of the boundary condition has also simplified the architecture in the filtering conditions part. After this proposal simplifies the architecture, it can effectively reduce the computational complexity and improve the operative speed. It can reduce the input and the output pins, and the chip area, while reducing the resources consumed by the hardware. It is conducive to reduce the cost of chip production on the hardware architecture, too. Therefore, this proposal designs a novel VLSI hardware architecture for the new deblocking filter [4].

II. FILTERING DECISIONS

This paper is proposed to divide the stitching images P and Q into each four ranges of cells blocks from the seam center. The block model of reducing division can reduce the consumption of hardware resources and the chip area, but the stitching images may be caused to have more obvious fusion by filtering the entire range of blocks. The proposed method adjusts the boundary conditions to BS=2 and BS=1 in the deblocking filter, and modifies the

luminance and the chromaticity of each block in the stitching images. The block diagram of the proposed deblocking circuit is shown in Fig. 1. After filtering the stitching images, it cannot only achieve visually effective effect of reducing the blurring on the fusion, but also improve accuracy.

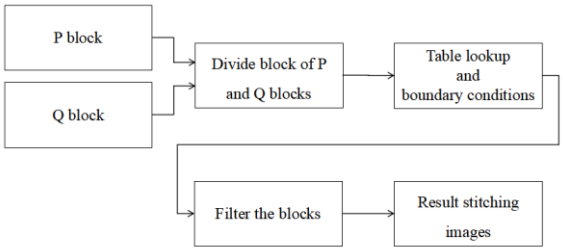


Fig .1. Block diagram of the proposed deblocking filter circuit.

A. Quantization Parameters

It is necessary to know the quantitative parameters of the cells blocks by subtracting the blocks and comparing with the threshold α and β. The proposed method determines the boundary conditions needing to calculate the QP parameters of the pixels of P blocks and Q blocks with equations (1) and (2). After calculating the QP_p, QP_q parameters, the average value QP_avg is calculated by equation (3). To set the offset value Alpha_Offset and Beta_Offset to 12, and finally calculates Index A and the Index B by equation (4) and (5).

$$QP_p = |p1 - p0| \quad (1)$$

$$QP_q = |q1 - q0| \quad (2)$$

$$QP_avg = QP_p + QP_q + 1 \quad (3)$$

$$Index\ A = QP_avg + Alpha_Offset \quad (4)$$

$$Index\ B = QP_avg + Beta_Offset \quad (5)$$

The Alpha, Beta, c0 are built by Index A and Index B as shown in Table Ⅰ. These parameters are used to define the quantization value for calculations.

Table Ⅰ. Alpha, Beta, c0 tables of the proposed method. (a) 0~7 (b) 8~15 (c) 16~23 (d) 24~31 (e) 32~39 (f) 40~42.

Index A	0	1	2	3	4	5	6	7
Index B	0	1	2	3	4	5	6	7
Alpha	0	0	0	0	0	0	0	0
Beta	0	0	0	0	0	0	0	0
c0(BS=1)	0	0	0	0	0	0	0	0
c0(BS=2)	0	0	0	0	0	0	0	0

(a)

Index A	8	9	10	11	12	13	14	15
Index B	8	9	10	11	12	13	14	15
Alpha	0	0	0	0	0	0	0	0
Beta	0	0	0	0	0	0	0	0
c0(BS=1)	0	0	0	0	0	0	0	0
c0(BS=2)	0	0	0	0	0	0	0	0

(b)

Index A	16	17	18	19	20	21	22	23
Index B	16	17	18	19	20	21	22	23
Alpha	3	4	5	6	7	8	9	10
Beta	1	1	2	2	3	3	4	4
c0(BS=1)	0	0	0	0	0	1	1	1
c0(BS=2)	0	1	1	1	1	1	1	1

(c)

Index A	24	25	26	27	28	29	30	31
Index B	24	25	26	27	28	29	30	31
Alpha	12	13	15	17	20	22	25	28
Beta	5	5	6	6	7	7	8	8
c0(BS=1)	1	1	1	1	1	1	1	2
c0(BS=2)	1	1	1	2	2	2	2	3

(d)

Index A	32	33	34	35	36	37	38	39
Index B	32	33	34	35	36	37	38	39
Alpha	32	36	40	45	50	56	63	71
Beta	9	9	10	10	11	11	12	12
c0(BS=1)	2	2	2	2	3	3	4	4
c0(BS=2)	3	3	4	4	4	5	5	6

(e)

Index A	40	41	42					
Index B	40	41	42					
Alpha	80	90	102					
Beta	13	13	14					
c0(BS=1)	5	5	6					
c0(BS=2)	7	8	9					

(f)

B. Boundary Strength

Boundary strength (Bs) [5] is used to calculate boundaries of the stitching images that are classified as a normal mode or a strong mode in the deblocking filter. Boundary conditions can be divided into any of the following possible values. When the conditions are established on BS=1 which is conformed to the equations (6) and (7), and the stitching images of P block is filtered by the normal mode. It is similar to the method above, when the conditions are established on BS=1 and that conformed to the equations (6) and (8), and the stitching image of Q block is filtered by the normal mode. In the normal mode, there is the finally method. It is established on the condition BS=1 which is conformed to the equations (6) ~ (8). In addition to the normal mode, the condition is established on BS=2 and conformed to the equations (6) ~ (10), and the whole stitching image is filtered by the strong mode.

$$| p0 - q0 | < \alpha \quad (6)$$

$$| p1 - p0 | < \beta \quad (7)$$

$$| q1 - q0 | < \beta \quad (8)$$

$$| p2 - p0 | < \beta \quad (9)$$

$$| q2 - q0 | < \beta \quad (10)$$

The conditions defined the boundary strength of this proposed method are shown in Table Ⅱ.

Table Ⅱ. Boundary strength of the proposed method.

Boundary Strength Conditions	BS
At least one of the two blocks next to the boundary is intra and has non-zero residual coefficients	2
At least one block which needs to be filtered is intra and also has a non-residual coefficient.	1

C. Normal Mode Operations

Normal mode operations are divided into two types. One of the mode filters the stitching images of P block by the equations (11) ~ (14). The other mode filters the stitching images of Q block by the equations (15) ~ (18).

$$p0_de = p0+(2*p1+p0+q1+2) >> 1 \quad (11)$$

$$p1_de = p1 \quad (12)$$

$$p2_de = p2 \quad (13)$$

$$p3_de = p3 \quad (14)$$

$$q0_de = q0 + (2*q1+q0+p1+2) >> 1 \quad (15)$$

$$q1_de = q1 \quad (16)$$

$$q2_de = q2 \quad (17)$$

$$q3_de = q3 \quad (18)$$

D. Strong Mode Operations

Compared with the normal mode operations, the stitching images has the most obvious seams which are used the strong mode operations. All the pixels in the P and Q blocks are fixed by the strong mode operations. To filter the blocks of p3, p2, p1, p0, q0, q1, q2, and q3 that beside the seam in the stitching images, and to add the offset values by the equations (19) ~ (26).

$$p0_de = p0+(p2+p1+2*p0+q0+q1+2) << 1 \quad (19)$$

$$p1_de = p1+(p2- p1+p0+q0+2) >>1 \quad (20)$$

$$p2_de = p2+(p3- 2*p2 +p1+p0+q0+2) <<1 \quad (21)$$

$$p3_de = p3 \quad (22)$$

$$q0_de = q0+(q2+q1+2*q0+p0+p1+2) << 1 \quad (23)$$

$$q1_de = q1 +(q2-q1+q0+p0+2) >>1 \quad (24)$$

$$q2_de = q2 + (q3-2*q2 +q1+q0+p0+2) <<1 \quad (25)$$

$$q3_de = q3 \quad (26)$$

III. RESULTS

The resolution of the stitching images filtered by the deblocking filter is successfully reduced the more obvious seams. Compared to the H.264 and the H.265 deblocking filters, the proposed filter cannot only achieve similar effects, but also can effectively simplify the computing architecture.

The two sets of the stitching images are presented by the proposed deblocking filter for the stitching images, as shown in Fig. 2. Both the sets of images are the examples of stitching images which are stitched by descriptor construction algorithm [6] and [7]. Compared with other filters, the original stitching images, Fig. 2(a), has more obvious seam marks. Fig. 2(b), (c) have still some seam marks at the seams in the center of the stitching image because their filters blend the stitching images without much adjustment of the luminance and the chromaticity. Fig 2(d) adjusts the chromaticity and the luminance to achieve the effect of the image fusion. Although the luminance of the stitching images is enhanced to make it brighter than other images, it can effectively fuse the stitching image seams.

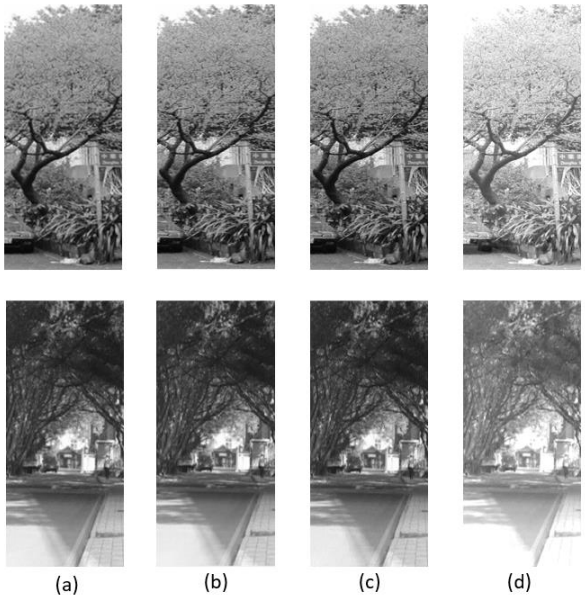


Fig .2. Using the proposed deblocking filter to filter the test images (a) the original image (b) The deblocking filter of H.264 (c) The deblocking filter of H.265 (d) The proposed deblocking filter.

After simulating the deblocking filter of the stitching images by the software and the hardware, Table III lists the three sets of filter's calculation time by those ones. In Table III, the calculation time of the hardware is faster than the calculation time of software. And the deblocking filter that is proposed by the proposed method is the fastest of the three sets of filters.

Table III. Calculation time of the software and the hardware for each filter.

	H.264 [2]	H.265 [1]	NEW
Software	4,446,036 us	4,311,087 us	2,980,910 us
Hardware	0.31 us	0.27 us	0.245 us

The hardware architecture is shown in Fig. 3. and implementing the deblocking filter by a silicon chip. By using the Design Compiler and IC Compiler to generate the digital chip which is shown in Fig. 4. The chip area that is shown in Fig. 5. can be effectively reduced to 623.3 x 621.605 um^2 because the complexity is greatly reduced for the circuit architecture.

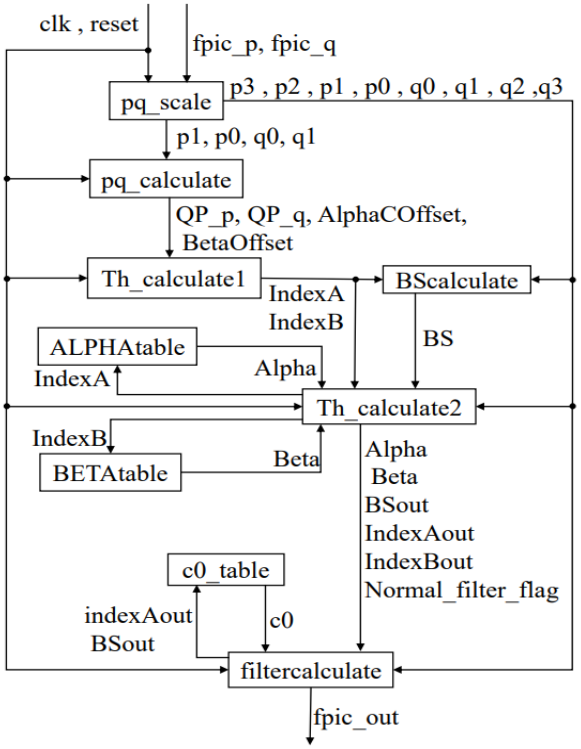


Fig .3. Architecture of hardware

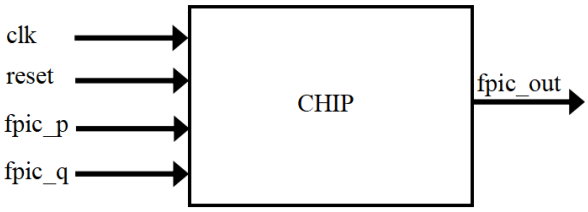


Fig .4. The chip layer circuit generated by the Design Compiler

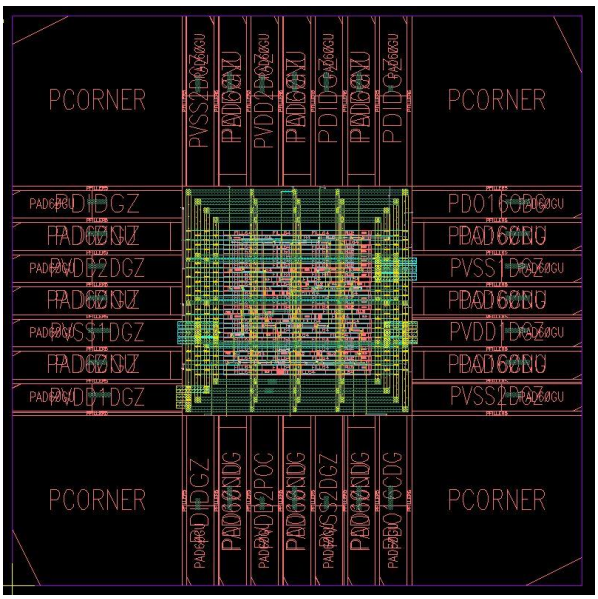


Fig .5. Layout figure of the proposed deblocking filter chip

IV . CONCLUSION

Although the computational complexity of be-blocking filer in H.265 has been much lower than that of H.264, the architecture of deblocking filters in H.265 and H.264 still have complex state. When implementing the hardware chip, the chip area will be larger and the chip speed of operation cannot be effectively reduced. Therefore, this proposed method is proposed to adjust the cells blocks range and boundary strength conditions of the stitching images The P and Q can reduce its computational complexity and maintain its seam fusion effect, which can increase the computing speed and reduce the number of pins and the size of the chip design. At the same time, it also can reduce the consumption of hardware resources on the chip to reduce production costs.

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