[0006]

Therefore, embodiments of the present invention disclose a deblocking filtering process to apply filtering appropriately.

SOLUTIONS TO PROBLEMS

[0007]

According to a first aspect, there is provided an image processing device including: a filtering unit configured to apply a deblocking filter including a first deblocking filter and a second deblocking filter having a stronger filter strength than the first deblocking filter to pixels neighboring a block boundary within a locally decoded image; a controller configured to control, as a condition that the second deblocking filter is applied by the filtering unit, the second deblocking filter so as to apply a clipping process to a difference value change by the second deblocking filter using a second clipping value larger than a first clipping value which is used in case that a clipping process is applied to a difference value changed by the first deblocking filter; and an encoding unit configured to encode an image using a filtered image filtered by the deblocking filter.

[0008]

The controller may apply the clipping process to values of parts that change when the deblocking filter is applied.

[0009]

The controller applies the clipping process according to the following expressions:

[Mathematical formula 37]

$$p0_i = p0_i + Clip_{(-pv)-(pv)}((p2_i + 2*p1_i - 6*p0_i + 2*q0_i + q1_i + 4) >> 3);$$

$$q0_i = q0_i + Clip_{(-pv)-(pv)}((p1_i + 2*p0_i - 6*q0_i + 2*q1_i + q2_i + 4) >> 3);$$

$$p1_i = p1_i + Clip_{(-pv)-(pv)}((p2_i - 3*p1_i + p0_i + q0_i + 2) >> 2);$$

$$q1_i = q1_i + Clip_{(-pv)-(pv)}((p0_i + q0_i - 3*q1_i + q2_i + 2) >> 2);$$

$$p2_i = p2_i + Clip_{(-pv)-(pv)}((2*p2_i - 5*p2_i + p1_i + p0_i + q0_i + 4) >> 3);$$

$$q2_i = q2_i + Clip_{(-pv)-(pv)}((p0_i + q0_i + p1_i - 5*q2_i + 2*q3_i + 4) >> 3);$$

where i = 0, 7 and pv is a clipping value.

[0010]

The controller may set a value that is integer multiples of parameters of the deblocking filter as the clipping value used when the clipping process is performed.

[0011]

The controller may set a value that is twice the parameters of the deblocking filter as the clipping value used when the clipping process is performed.

[0012]

The image processing device further includes: a filter strength determining unit that determines the strength of the deblocking filter applied to the block boundary, and the filtering unit may apply the deblocking filter to the block boundary according to the strength determined by the filter strength determining unit, and the controller may control the filtering unit so that, when the filter strength determining unit determines that strong filtering is to be applied, a clipping process is applied to the deblocking filter with

respect to the luminance components of the image generated by the decoding unit.

[0013]

The filter strength determining unit may determine the strength of the deblocking filter using a plurality of lines as processing units.

[0014]

The filter strength determining unit may determine the strength of the deblocking filter using four lines as the processing units.

[0015]

The image processing device further includes: a filtering necessity determining unit that determines whether the deblocking filter is to be applied to the block boundary using a plurality of lines as processing units, and the filter strength determining unit may determine the strength of the deblocking filter when the filtering necessity determining unit determines that the deblocking filter is to be applied.

[0016]

According to a second aspect, there is provided an image processing method including: applying a deblocking filter including a first deblocking filter and a second deblocking filter having a stronger filter strength than the first deblocking filter to pixels neighboring a block boundary within a locally decoded image; controlling, as a condition that the second deblocking filter is applied, the second deblocking filter so as to apply a clipping process to a

difference value change by the second deblocking filter using a second clipping value larger than a first clipping value which is used in case that a clipping process is applied to a difference value changed by the first deblocking filter; and encoding an image using a filtered image filtered by the deblocking filter.

[0017]

Disclosed herein is an image processing device including: a filtering unit that applies a deblocking filter to a block boundary according to a strength of the deblocking filter applied to the block boundary which is a boundary between a block of an image locally decoded when an image is encoded and an adjacent block adjacent to the block; a controller that controls the filtering unit so that, when strong filtering is applied as the strength of the deblocking filter, a clipping process is applied to the deblocking filter with respect to luminance components of the locally decoded image; and an encoding unit that encodes the image in units each having a layer structure using an image to which the deblocking filter is applied.

[0018]

The controller may apply the clipping process to values of parts that change when the deblocking filter is applied.

[0019]

The controller applies the clipping process according to the following expressions:

[Mathematical formula 38]

$$p0_i = p0_i + Clip_{(-pv)-(pv)}((p2_i + 2*p1_i - 6*p0_i + 2*q0_i + q1_i + 4) >> 3);$$

$$q0_i = q0_i + Clip_{(-pv)-(pv)}((p1_i + 2*p0_i - 6*q0_i + 2*q1_i + q2_i + 4) >> 3);$$

$$p1_i = p1_i + Clip_{(-pv)-(pv)}((p2_i - 3*p1_i + p0_i + q0_i + 2) >> 2);$$

$$q1_i = q1_i + Clip_{(-pv)-(pv)}((p0_i + q0_i - 3*q1_i + q2_i + 2) >> 2);$$

$$p2_i = p2_i + Clip_{(-pv)-(pv)}((2*p2_i - 5*p2_i + p1_i + p0_i + q0_i + 4) >> 3);$$

$$q2_i = q2_i + Clip_{(-pv)-(pv)}((p0_i + q0_i + p1_i - 5*q2_i + 2*q3_i + 4) >> 3);$$

where i = 0, 7 and pv is a clipping value.

[0020]

The controller may set a value that is integer multiples of parameters of the deblocking filter as the clipping value used when the clipping process is performed.

[0021]

The controller may set a value that is twice the parameters of the deblocking filter as the clipping value used when the clipping process is performed.

[0022]

The above image processing device further includes: a filter strength determining unit that determines the strength of the deblocking filter applied to the block boundary, and the filtering unit may apply the deblocking filter to the block boundary according to the strength determined by the filter strength determining unit, and the controller may control the filtering unit so that, when the filter strength determining unit determines that strong filtering is to be

applied, a clipping process is applied to the deblocking filter with respect to the luminance components of the image generated by the decoding unit.

[0023]

The filter strength determining unit may determine the strength of the deblocking filter using a plurality of lines as processing units.

[0024]

The filter strength determining unit may determine the strength of the deblocking filter using four lines as the processing units.

[0025]

The image processing device further includes: a filtering necessity determining unit that determines whether the deblocking filter is to be applied to the block boundary using a plurality of lines as processing units, and the filter strength determining unit may determine the strength of the deblocking filter when the filtering necessity determining unit determines that the deblocking filter is to be applied.

[0026]

Disclosed herein is an image processing method that allows an image processing device to execute the steps of: applying a deblocking filter to a block boundary according to a strength of the deblocking filter applied to the block boundary which is a boundary between a block of an image locally decoded when an image is encoded and an adjacent block adjacent to the block; controlling so that, when strong filtering is applied as the strength of the deblocking filter, a clipping process is applied to the deblocking filter with

respect to luminance components of the locally decoded image; and encoding the image in units each having a layer structure using an image to which the deblocking filter is applied.

[0027]

In an embodiment, an encoded stream encoded in units each having a layer structure is decoded to generate an image; and a deblocking filter is applied to a block boundary according to a strength of the deblocking filter applied to the block boundary which is a boundary between a block of the generated image and an adjacent block adjacent to the block. Moreover, control is performed so that, when strong filtering is applied as the strength of the deblocking filter, a clipping process is applied to the deblocking filter with respect to luminance components of the generated image.

[0028]

In an embodiment, a deblocking filter is applied to a block boundary according to a strength of the deblocking filter applied to the block boundary which is a boundary between a block of an image locally decoded when an image is encoded and an adjacent block adjacent to the block. Moreover, control is performed so that, when strong filtering is applied as the strength of the deblocking filter, a clipping process is applied to the deblocking filter with respect to luminance components of the locally decoded image; and the image is encoded in units each having a layer structure using an image to which the deblocking filter is applied.

EFFECTS OF THE INVENTION

[0029]

According to embodiments of the present invention, it is possible to allow a deblocking filtering process to apply filtering appropriately.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

Figs. 1(A) and 1(B) are diagrams for describing a conventional deblocking filtering process.

Fig. 2 is a diagram illustrating a configuration when applied to an image encoding device.

Fig. 3 is a flowchart illustrating an image encoding operation.

Fig. 4 is a flowchart illustrating an intra-prediction process.

Fig. 5 is a flowchart illustrating an inter-prediction process.

Fig. 6 is a diagram illustrating a configuration when applied to an image decoding device.

Fig. 7 is a flowchart illustrating an image decoding operation.

Fig. 8 is a diagram for describing a basic operation of a deblocking filtering unit.

Fig. 9 is a diagram illustrating the configuration of a first embodiment of the deblocking filtering unit.

Fig. 10 is a flowchart illustrating the operation of the first embodiment of the deblocking filtering unit.

Fig. 11 is a diagram illustrating the configuration of a filter operation unit.

Claims

1. An image processing device comprising:

a filtering unit configured to apply a deblocking filter including a first deblocking filter and a second deblocking filter having a stronger filter strength than the first deblocking filter to pixels neighboring a block boundary within a locally decoded image;

a controller configured to control, as a condition that the second deblocking filter is applied by the filtering unit, the second deblocking filter so as to apply a clipping process to a difference value change by the second deblocking filter using a second clipping value larger than a first clipping value which is used in case that a clipping process is applied to a difference value changed by the first deblocking filter; and

an encoding unit configured to encode an image using a filtered image filtered by the deblocking filter.

2. The image processing device according to claim 1, wherein

the controller is configured to apply, as the condition that the second deblocking filter is applied, apply the clipping process to the difference value change by the second deblocking filter using the second clipping value according to the following expressions:

$$p0' = p0 + Clip_{(-pv)-(pv)}((p2+2*p1-6*p0+2*q0+q1+4)>>3);$$
$$= Clip_{(p0-pv)-(p0+pv)}((p2+2*p1+2*p0+2*q0+q1+4)>>3)$$
$$= Clip3(p0-pv, p0+pv, (p2+2*p1+2*p0+2*q0+q1+4)>>3);$$

$$p1' = p1 + Clip_{(-pv)-(pv)}((p2-3*p1+p0+q0+2)>>2);$$
$$= Clip_{(p1-pv)-(p1+pv)}((p2+p1+p0+q0+2)>>2);$$
$$= Clip3(p1-pv, p1+pv, (p2+p1+p0+q0+2)>>2);$$

$$p2' = p2 + Clip_{(-pv)-(pv)}((2*p3-5*p2+p1+p0+q0+4)>>3);$$
$$= Clip_{(p2-pv)-(p2+pv)}((2*p3+3*p2+p1+p0+q0+4)>>3);$$
$$= Clip3(p2-pv, p2+pv, (2*p3+3*p2+p1+p0+q0+4)>>3);$$

$$q0' = q0 + Clip_{(-pv)-(pv)}((p1+2*p0-6*q0+2*q1+q2+4)>>3);$$
$$= Clip_{(q0-pv)-(q0+pv)}((p1+2*p0+2*q0+2*q1+q2+4)>>3);$$
$$= Clip3(q0-pv, q0+pv, (p1+2*p0+2*q0+2*q1+q2+4)>>3);$$

$$q1' = q1 + Clip_{(-pv)-(pv)}((p0+q0-3*q1+q2+2)>>2);$$
$$= Clip_{(q1-pv)-(q1+pv)}((p0+q0+q1+q2+2)>>2);$$
$$= Clip3(q1-pv, q1+pv, (p0+q0+q1+q2+2)>>2);$$

$q2'=q2+Clip_{(-pv)-(pv)}((p0+q0+q1-5*q2+2*q3+4)>>3);$

$=Clip_{(q2-pv)-(q2+pv)}((p0+q0+q1+3*q2+2*q3+4)>>3);$

$=Clip3(q2-pv, q2+pv, (p0+q0+q1+3*q2+2*q3+4)>>3);$

wherein the pv is the second clipping value,
p0', p1', p2', q0', q1', q2' are the pixel values after applying the second deblocking filter, and p0, p1, p2, q0, q1, q2 are the pixel values before applying the second deblocking filter.

3. The image processing device according to claim 1, wherein
the controller is configured to apply the clipping process to the difference value change by the second deblocking filter using, as the second clipping value, a value that is integer multiples of a parameter used in case that a strength of the deblocking filter is selected.

4. The image processing device according to claim 3, wherein
the controller is configured to apply the clipping process to the difference value change by the second deblocking filter using a value that is twice the parameter as the second clipping value.

5. The image processing device according to claim 4, wherein
the controller is configured to apply, as the condition that the second deblocking filter is applied, apply the clipping process to the difference value change by the second deblocking filter using the second clipping value according to the following expressions:

$p0'=p0+Clip_{(-2*tc)-(2*tc)}((p2+2*p1-6*p0+2*q0+q1+4)>>3);$

$=Clip_{(p0-2*tc)-(p0+2*tc)}((p2+2*p1+2*p0+2*q0+q1+4)>>3);$

$=Clip3(p0-2*tc, p0+2*tc, (p2+2*p1+2*p0+2*q0+q1+4)>>3);$

$p1'=p1+Clip_{(-2*tc)-(2*tc)}((p2-3*p1+p0+q0+2)>>2);$

$=Clip_{(p1-2*tc)-(p1+2*tc)}((p2+p1+p0+q0+2)>>2);$

$=Clip3(p1-2*tc, p1+2*tc, (p2+p1+p0+q0+2)>>2)$

$p2'=p2+Clip_{(-2*tc)-(2*tc)}((2*p3-5*p2+p1+p0+q0+4)>>3);$

$=Clip_{(p2-2*tc)-(p2+2*tc)}((2*p3+3*p2+p1+p0+q0+4)>>3);$

$=Clip3(p2-2*tc, p2+2*tc, (2*p3+3*p2+p1+p0+q0+4)>>3);$

$q0'=q0+Clip_{(-2*tc)-(2*tc)}((p1+2*p0-6*q0+2*q1+q2+4)>>3);$

$=Clip_{(q0-2*tc)-(q0+2*tc)}((p1+2*p0+2*q0+2*q1+q2+4)>>3);$

$=Clip3(q0-2*tc, q0+2*tc, (p1+2*p0+2*q0+2*q1+q2+4)>>3);$

$q1'=q1+Clip_{(-2*tc)-(2*tc)}((p0+q0-3*q1+q2+2)>>2);$

$=Clip_{(q1-2*tc)-(q1+2*tc)}((p0+q0+q1+q2+2)>>2);$

$=Clip3(q1-2*tc, q1+2*tc, (p0+q0+q1+q2+2)>>2);$

$q2'=q2+Clip_{(-2*tc)-(2*tc)}((p0+q0+q1-5*q2+2*q3+4)>>3);$

$=Clip_{(q2-2*tc)-(q2+2*tc)}((p0+q0+q1+3*q2+2*q3+4)>>3);$

$=Clip3(q2-2*tc, q2+2*tc, (p0+q0+q1+3*q2+2*q3+4)>>3);$

wherein tc is the parameter used in case that the strength of the deblocking filter is selected, p0', p1', p2', q0', q1', q2' are the pixel values after applying the second deblocking filter, and p0, p1, p2, q0, q1, q2 are the pixel values before applying the second deblocking filter.

6. The image processing device according to claim 5, wherein

the filtering unit is configured to apply the second deblocking filter to the luminance components of the pixels neighboring the block boundary within the locally decoded image.

7. The image processing device according to claim 6, wherein

the first deblocking filter is a weak filter applied to four pixels neighboring the block boundary; and

the second deblocking filter is a strong filter applied to six pixels neighboring the block boundary.

8. The image processing device according to claim 6, wherein

wherein the block boundary is a boundary of a transform unit as a unit of orthogonal transformation or a boundary of a prediction unit as a unit of prediction process.

9. The image processing device according to claim 8, wherein

the encoding unit comprises:

an orthogonal transformer configured to perform orthogonal transformation on the image to generate transform coefficient data;

a quantizer configured to perform quantization on the transform coefficient data to generate quantized data; and

an arithmetic encoder configured to encode the quantized data.

10. The image processing device according to claim 9, wherein

the encoding unit is configured to encode the image on a coding unit basis, wherein the coding unit is formed by recursively splitting a largest coding unit into smaller coding units as block partitioning.

11. The image processing device according to claim 10, wherein

the coding unit is recursively split according to quad-tree block structure.

12. The image processing device according to claim 11, wherein

the largest coding unit is the coding unit in a root layer according to quad-tree block structure.

13. The image processing device according to claim 12, wherein

the largest coding unit is a block of fixed block size at sequence level, and

the coding unit is a block of variable block size.

14. An image processing method comprising:

applying a deblocking filter including a first deblocking filter and a second deblocking filter having a stronger filter strength than the first deblocking filter to pixels neighboring a block boundary within a locally decoded image;

controlling, as a condition that the second deblocking filter is applied, the second deblocking filter so as to apply a clipping process to a difference value change by the second deblocking filter using a second clipping value larger than a first clipping value which is used in case that a clipping process is applied to a difference value changed by the first deblocking filter; and

encoding an image using a filtered image filtered by the deblocking filter

15. The image processing method according to claim 14, wherein

applying, as the condition that the second deblocking filter is applied, the clipping process to the difference value change by the second deblocking filter using the second clipping value according to the following expressions:

$$p0' = p0 + Clip_{(-pv)-(pv)}((p2+2*p1-6*p0+2*q0+q1+4)>>3);$$
$$= Clip_{(p0-pv)-(p0+pv)}((p2+2*p1+2*p0+2*q0+q1+4)>>3)$$
$$= Clip3(p0-pv, p0+pv, (p2+2*p1+2*p0+2*q0+q1+4)>>3);$$

$p1' = p1 + Clip_{(-pv)-(pv)}((p2-3*p1+p0+q0+2)>>2);$
$= Clip_{(p1-pv)-(p1+pv)}((p2+p1+p0+q0+2)>>2);$
$= Clip3(p1-pv, p1+pv, (p2+p1+p0+q0+2)>>2);$

$p2' = p2 + Clip_{(-pv)-(pv)}((2*p3-5*p2+p1+p0+q0+4)>>3);$
$= Clip_{(p2-pv)-(p2+pv)}((2*p3+3*p2+p1+p0+q0+4)>>3);$
$= Clip3(p2-pv, p2+pv, (2*p3+3*p2+p1+p0+q0+4)>>3);$

$q0' = q0 + Clip_{(-pv)-(pv)}((p1+2*p0-6*q0+2*q1+q2+4)>>3);$
$= Clip_{(q0-pv)-(q0+pv)}((p1+2*p0+2*q0+2*q1+q2+4)>>3);$
$= Clip3(q0-pv, q0+pv, (p1+2*p0+2*q0+2*q1+q2+4)>>3);$

$q1' = q1 + Clip_{(-pv)-(pv)}((p0+q0-3*q1+q2+2)>>2);$
$= Clip_{(q1-pv)-(q1+pv)}((p0+q0+q1+q2+2)>>2);$
$= Clip3(q1-pv, q1+pv, (p0+q0+q1+q2+2)>>2);$

$q2' = q2 + Clip_{(-pv)-(pv)}((p0+q0+q1-5*q2+2*q3+4)>>3);$
$= Clip_{(q2-pv)-(q2+pv)}((p0+q0+q1+3*q2+2*q3+4)>>3);$
$= Clip3(q2-pv, q2+pv, (p0+q0+q1+3*q2+2*q3+4)>>3);$

wherein the pv is the second clipping value,
p0', p1', p2', q0', q1', q2' are the pixel values after applying the second deblocking filter, and p0, p1, p2, q0, q1, q2 are the pixel values before applying the second deblocking filter.

16. The image processing method according to claim 14, wherein
applying the clipping process to the difference value change by the second deblocking filter using, as the second clipping value, a value that is integer multiples of a parameter used in case that a strength of the deblocking filter is selected.

17. The image processing method according to claim 16, wherein
applying the clipping process to the difference value change by the second deblocking filter using a value that is plus or minus twice the parameter as the second clipping value.

18. The image processing method according to claim 17, wherein
applying, as the condition that the second deblocking filter is applied, apply the clipping process to the difference value change by the second deblocking filter using the

second clipping value according to the following expressions:

$p0' = p0 + Clip_{(-2*tc)-(2*tc)}((p2+2*p1-6*p0+2*q0+q1+4)>>3);$
$= Clip_{(p0-2*tc)-(p0+2*tc)}((p2+2*p1+2*p0+2*q0+q1+4)>>3);$
$= Clip3(p0-2*tc, p0+2*tc, (p2+2*p1+2*p0+2*q0+q1+4)>>3);$

$p1' = p1 + Clip_{(-2*tc)-(2*tc)}((p2-3*p1+p0+q0+2)>>2);$
$= Clip_{(p1-2*tc)-(p1+2*tc)}((p2+p1+p0+q0+2)>>2);$
$= Clip3(p1-2*tc, p1+2*tc, (p2+p1+p0+q0+2)>>2)$

$p2' = p2 + Clip_{(-2*tc)-(2*tc)}((2*p3-5*p2+p1+p0+q0+4)>>3);$
$= Clip_{(p2-2*tc)-(p2+2*tc)}((2*p3+3*p2+p1+p0+q0+4)>>3);$
$= Clip3(p2-2*tc, p2+2*tc, (2*p3+3*p2+p1+p0+q0+4)>>3);$

$q0' = q0 + Clip_{(-2*tc)-(2*tc)}((p1+2*p0-6*q0+2*q1+q2+4)>>3);$
$= Clip_{(q0-2*tc)-(q0+2*tc)}((p1+2*p0+2*q0+2*q1+q2+4)>>3);$
$= Clip3(q0-2*tc, q0+2*tc, (p1+2*p0+2*q0+2*q1+q2+4)>>3);$

$q1' = q1 + Clip_{(-2*tc)-(2*tc)}((p0+q0-3*q1+q2+2)>>2);$
$= Clip_{(q1-2*tc)-(q1+2*tc)}((p0+q0+q1+q2+2)>>2);$
$= Clip3(q1-2*tc, q1+2*tc, (p0+q0+q1+q2+2)>>2);$

$q2' = q2 + Clip_{(-2*tc)-(2*tc)}((p0+q0+q1-5*q2+2*q3+4)>>3);$
$= Clip_{(q2-2*tc)-(q2+2*tc)}((p0+q0+q1+3*q2+2*q3+4)>>3);$
$= Clip3(q2-2*tc, q2+2*tc, (p0+q0+q1+3*q2+2*q3+4)>>3);$

wherein tc is the parameter used in case that the strength of the deblocking filter is selected, p0', p1', p2', q0', q1', q2' are the pixel values after applying the second deblocking filter, and p0, p1, p2, q0, q1, q2 are the pixel values before applying the second deblocking filter.

19. The image processing method according to claim 18, wherein

applying the second deblocking filter to the luminance components of the pixels neighboring the block boundary within the locally decoded image.

20. The image processing method according to claim 19, wherein

the first deblocking filter is a weak filter applied to four pixels neighboring the block boundary; and

the second deblocking filter is a strong filter applied to six pixels neighboring the block boundary.

21. The image processing method according to claim 19, wherein

wherein the block boundary is a boundary of a transform unit as a unit of orthogonal transformation or a boundary of a prediction unit as a unit of prediction process.

22. The image processing method according to claim 21, the encoding is including:

performing orthogonal transformation on the image to generate transform coefficient data;

performing quantization on the transform coefficient data to generate quantized data; and

encoding the quantized data.

23. The image processing method according to claim 22, wherein

encoding the image on a coding unit basis, wherein the coding unit is formed by recursively splitting a largest coding unit into smaller coding units as block partitioning.

24. The image processing method according to claim 23, wherein

the coding unit is recursively split according to quad-tree block structure.

25. The image processing method according to claim 24, wherein

the largest coding unit is the coding unit in a root layer according to quad-tree block structure.

26. The image processing method according to claim 25, wherein

the largest coding unit is a block of fixed block size at sequence level, and

the coding unit is a block of variable block size.