Title: ADVANCED DEBLOCKING FILTER IN VIDEO CODING

Parameters for BS= 1, for vertical edges
Parameters for BS= 2, for vertical edges
Parameters for BS= 1, for horizontal edges
Parameters for BS= 2, for horizontal edges

Fig. 5

Abstract: Advanced de-blocking filtering methods are proposed. In the proposed methods, the parameters used in de-blocking filtering such as the thresholds and clipping boundaries can be different for different pictures, slices, coding tree units (CTU) or CUs. And they can be signaled from the encoder to the decoder.
— with international search report (Art. 21(3))
ADVANCED DEBLOCKING FILTER IN VIDEO CODING

TECHNICAL FIELD

[0001] The invention relates generally to video coding. In particular, the presented invention relates to de-blocking filter.

BACKGROUND

[0002] In video coding standard H.265/HEVC, de-blocking filter is applied after the picture is reconstructed. The boundaries between coding unit (CU)/prediction unit (PU)/transform unit (TU) are filtered to alleviate the blocking artefacts caused by the block-based coding. The boundary can be vertical or horizontal boundary as depicted in Fig. 1.

[0003] In HEVC, luma pixels and chroma pixels are processed in different ways in de-blocking.

[0004] A boundary strength (BS) is calculated for each boundary according to the coding modes of the two adjacent blocks P and Q as follows.

\[
BS = \begin{cases} 
2 & \text{P or Q is intra-coded} \\
1 & \text{P and Q are not predicted by neighboring blocks} \\
0 & \text{P and Q are predicted by neighboring blocks}
\end{cases}
\]

[0005]

[0006] For luma pixels, de-blocking is conducted by each 4 lines when BS is larger than 0. For each 4 lines, several variants are calculated as follows.

[0007] \[dp_O = |2*p_{01}-p_{02}-p_{00}|\]

[0008] \[dq_O = |2*q_{01}-q_{02}-q_{00}|\]

[0009] \[dp_3 = |2*p_{31}-p_{32}-p_{30}|\]

[0010] \[dq_3 = |2*q_{31}-q_{32}-q_{30}|\]

[0011] \[dp = dp_0+dp_3\]

[0012] \[dq = dq_0+dq_3\]

[0013] \[dO = dp+dp\]

[0014] When filtering a single line for the luma component in the 4 lines as depicted in Fig. 2, the filtering flow-chart is demonstrated in Fig. 3.

[0015] In strong filtering,

[0016] \[p_{0}' = \left( p_2 + 2*p_{1} + 2*p_{0} + 2*q_0 + q_{i} + 4 \right) \rightarrow 3\]

[0017] \[p_{i}' = \left( p_2 + p_{i} + p_{0} + q_{0} + 2 \right) \rightarrow 2\]

[0018] \[p_2' = \left( 2*p_{3} + 3*p_{2} + p_{i} + p_{0} + q_{0} + 4 \right) \rightarrow 3\]
\[ q_0' = (p_i + 2*p_o + 2*q_0 + 2*q_i + q_2 + 4) \]
\[ q_i' = (p_o + q_o + q_i + q_2 + 2) \]
\[ q_2' = (p_o + q_o + q_i + q_2 + 3*q_2 + 2*q_3 + 4) \]

In weak filtering,

\[ \Delta = (9*(q_o - p_o) - 3*(q_i - p_i) + 8) \]
\[ p_o' = p_o + \Delta, \]
\[ q_o' = q_o - \Delta \]
\[ \Delta p = ((p_2 + p_o + 1) \cdot 1 - p_i + \Delta) \]
\[ p_i' = p_i + \Delta p \]

When filtering a single line for the chroma component in the 4 lines as depicted in Fig. 2, the filtering flow-chart is demonstrated in Fig. 4.

In chroma filtering,

\[ \Delta = (((q_o - p_o) + 2) + p_i - q_i + 4) \]
\[ p_o' = Clip_{c}(p_o + \Delta) \]
\[ q_o' = Clip_{c}(q_o - \Delta) \]

The thresholds and clipping boundaries are set as follows.

1. \[ QP = (QP_P + QP_Q)/2 \]
2. \[ B = B_{Table}[QP], T = T_{Table}[QP][BS] \]
3. \[ BetaO = B, BetaL = 10*TB, Beta2 = 3*B/16 \]
4. \[ T_{c}\beta = 4*B, T_{c\beta} = T, T_{el} = T/2, T_{c\beta} = T \]

B_{Table} and T_{Table} are two fixed tables predefined in the standard.

The current de-blocking filtering method cannot always achieve the best subjective and objective performance for different kinds of sequences.

**SUMMARY**

In light of the previously described problems, some advanced de-blocking filtering methods are proposed. In the proposed methods, the thresholds and clipping boundaries can be set adaptively for different pictures and signaled from the encoder to the decoder. Besides, the filtering method can depend on the intra prediction mode of the adjacent blocks.

Other aspects and features of the invention will become apparent to those with ordinary skill in the art upon review of the following descriptions of specific embodiments.
BRIEF DESCRIPTION OF DRAWINGS

The invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

[0040] Fig. 1 is a diagram illustrating vertical boundary (above) and horizontal boundary (below);

[0041] Fig. 2 is a diagram illustrating pixels in filtering a single line;

[0042] Fig. 3 is a diagram illustrating flowchart of filtering a single line for the luma component;

[0043] Fig. 4 is a diagram illustrating flowchart of filtering a single line for the chroma component;

[0044] Fig. 5 is a diagram illustrating an example of signaling the intra prediction mode in the proposed method;

[0045] Fig. 6 is a diagram illustrating flowchart of filtering a single line for the luma component removing one judge condition;

[0046] Fig. 7 is a diagram illustrating flowchart of filtering a single line for the luma component removing some judge conditions;

[0047] Fig. 8 is a diagram illustrating an example of finding optimal T;

[0048] Fig. 9 is a diagram illustrating an example of finding optimal Tc.

DETAILED DESCRIPTION

[0049] The following description is of the best-contemplated mode of carrying out the invention. This description is made for the purpose of illustrating the general principles of the invention and should not be taken in a limiting sense. The scope of the invention is best determined by reference to the appended claims.

[0050] In the following description, Y component is identical to luma component, U component is identical to Cb component and V component is identical to Cr component. A chroma component can be U component or V component.

[0051] Advanced de-blocking filtering methods are proposed.

[0052] In one embodiment, the parameters used in de-blocking filtering such as the values of threshold and clipping boundaries, such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be different for each picture, slice, coding tree unit (CTU) or CU.
In one embodiment, the parameters used in de-blocking filtering such as the values of threshold and clipping boundaries, such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC are signaled from the encoder to the decoder.

In one embodiment, the parameters of threshold and clipping boundaries, such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC are different for vertical and horizontal de-blocking filtering.

In one embodiment, the parameters of threshold and clipping boundaries, such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC are different for different boundary strengths.

In one embodiment, the parameters of threshold and clipping boundaries, such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC are different for different QPs.

In one embodiment, the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be signaled in video parameter set (VPS), sequence parameter set (SPS), picture parameter set (PPS), slice header (SH), and coding tree unit (CTU) or CU.

In one embodiment, a flag is signalled to indicate whether the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC are signaled or not. If the parameters are not signaled, predefined parameters such as the parameters defined by HEVC is applied.

In another embodiment, a flag is signalled to indicate whether the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC for a particular BS are signaled or not. If the parameters are not signaled, predefined parameters such as the parameters defined by HEVC is applied for this BS.

In another embodiment, a flag is signalled to indicate whether the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC for a particular boundary direction such as vertical boundary or horizontal boundary are signaled or not. If the parameters are not signaled, predefined parameters such as the parameters defined by HEVC is applied in de-blocking filtering for this particular boundary direction.

In another embodiment, a flag is signalled to indicate whether the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel for a particular component such as luma component are signaled or not. If the parameters are not
signaled, predefined parameters such as the parameters defined by HEVC is applied in de-blocking filtering for this particular component.

[0063] In another embodiment, a flag is signalled to indicate whether the parameters of threshold and clipping boundaries such as TcC for one particular component such as U or V component, or some components such as both U and V components are signaled or not. If the parameters are not signaled, predefined parameters such as the parameters defined by HEVC is applied in de-blocking filtering for this particular component or components.

[0064] In one embodiment, the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be signaled by any coding method, such as fixed length coding or UVLC coding defined in HEVC.

[0065] In one embodiment, the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be signaled in a predictive way.

[0066] In one embodiment, the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC for horizontal de-blocking filtering can be predicted by the parameters such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC for vertical de-blocking filtering.

[0067] In one embodiment, the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC for vertical de-blocking filtering can be predicted by the parameters such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC for horizontal de-blocking filtering.

[0068] In one embodiment, the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC for BS=X can be predicted by the parameters such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC for BS=Y. X can be larger or smaller than Y.

[0069] In one embodiment, the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be predicted by some predefined values. For example, they can be predicted by the predefined values used in HEVC.

[0070] In one embodiment, the parameters of threshold and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be predicted one by one. For example, Beta2 can be predicted by Betal, and Betal can be predicted by BetaO. In another example, TcS is predicted by TcO, and TcO is predicted by Tel. In another example, TcC is predicted by TcC.

[0071] In one embodiment, the parameters of threshold and clipping boundaries such as TcC can be different for component U and V, denoted as TcCU and TcCV respectively.

[0072] In one embodiment, TcCV can be predicted by TcCU when signaled from the
encoder to the decoder. In another embodiment, TcCU can be predicted by TcCV when signaled from the encoder to the decoder.

[0073] In one embodiment, the judge condition of \( d1 < \beta_1 \) can be removed. And the flowchart of de-blocking filtering for this embodiment is demonstrated in Fig. 6.

[0074] In one embodiment, the judge conditions of \( d1 < \beta_1 \), \( dp < \beta_2 \) and \( dq < \beta_2 \) can be removed. And the flowchart of de-blocking filtering for this embodiment is demonstrated in Fig. 7.

[0075] In one embodiment, the parameters used in de-blocking filtering can be obtained by a training process at encoder.

[0076] In the training process, a table based algorithm is applied to get trained parameters. The algorithm can also be regarded as histogram based.

[0077] The problem to find an optimal threshold is described as below.

- For each judgment condition, a \( d \) (such as \( d0 \) in HEVC) is calculated
- If \( d < T \), the line is filtered. Otherwise it is not filtered
- Find the optimal \( T \) that can minimize the total distortion after de-blocking filtering.

[0078] The algorithm to solve the above problem is described below.

1. Build a table \( S \) with all entries initialized as 0.
2. For each judgment, \( d \) is calculated
3. Get distortions \( D0 \) and \( Dl \) for this boundary in the not filtering and filtering case respectively.
4. \( S[k] += D0 \) for all \( k \leq d \). \( S[k] += Dl \) for all \( k > d \)
5. After processing de-blocking filtering for all boundaries in training, find the minimal \( S[p] \). And \( p \) is the optimal \( T \).

[0079] Fig. 8 demonstrates an example of finding the optimal \( T \). In this very simplified example, there are totally 3 boundaries to be filtered. After the training process, 7 is chosen as the optimal \( T \).

[0080] The problem to find an optimal clipping boundary is described as below.

- For a sample with value \( X \) (Original sample value is \( X0 \)), the sample value after de-blocking filtering without clipping is calculated as \( X' \).
- The output filtered value is \( \text{Clip3}(X-Tc, X+Tc, X') \)
- Find the optimal \( Tc \) that can minimize the total distortion after de-blocking filtering.

[0081] The algorithm to solve the above problem is described below.
1. Build a table \( S \) with all entries initialized as 0.
2. For each sample, calculate \( d = |X - X'| \)
3. \( S[k] += (X - X'O) \) for all \( k \geq d \)
4. \( S[k] += (X - k - X'O) \) for all \( k < d \) if \( X > X' \)
5. After processing all samples, find the minimal \( S[p] \), \( p \) is the optimal \( T_c \)

Fig. 9 demonstrates an example of finding the optimal \( T_c \). In this very simplified example, there are totally 3 samples to be filtered. After the training process, 1 is chosen as the optimal \( T_c \).

There are several parameters affecting each other in the de-blocking process. So an iterative strategy can be applied in the training process as below.

1. Initialization: Get the trained parameters with the original parameters (such as the parameters predefined in HEVC) in the filtering process at first.
2. Training cycle: Get the new trained parameters with the old parameters (which are the trained parameters in the last training cycle) in the filtering process.
3. Termination: Repeat step 2 until the picture Rate-Distortion (RD) cost or total distortion cannot be decreased

In one embodiment, the parameters used in de-blocking filtering can be obtained by a training process on the current coded picture.

In one embodiment, the parameters used in de-blocking filtering can be obtained by a training process on a previous coded picture. For example, the parameters in de-blocking filtering signaled by Frame K can be obtained by a training process on Frame K-1.

In one embodiment, the parameters used in de-blocking filtering can be obtained by a training process at decoder. In this way, the parameters are not signaled from the encoder to the decoder, but they are derived in the same way at encoder and decoder.

The methods described above can be used in a video encoder as well as in a video decoder. Embodiments of disparity vector derivation methods according to the present invention as described above may be implemented in various hardware, software codes, or a combination of both. For example, an embodiment of the present invention can be a circuit integrated into a video compression chip or program codes integrated into video compression software to perform the processing described herein. An embodiment of the present invention may also be program codes to be executed on a Digital Signal Processor (DSP) to perform the processing described herein. The invention may also involve a number of functions to be performed by a computer processor, a digital signal processor, a microprocessor, or field programmable gate array (FPGA). These processors can be configured to perform particular
tasks according to the invention, by executing machine-readable software code or firmware code that defines the particular methods embodied by the invention. The software code or firmware codes may be developed in different programming languages and different format or style. The software code may also be compiled for different target platform. However, different code formats, styles and languages of software codes and other means of configuring code to perform the tasks in accordance with the invention will not depart from the spirit and scope of the invention.

[0088] The invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described examples are to be considered in all respects only as illustrative and not restrictive. To the contrary, it is intended to cover various modifications and similar arrangements (as would be apparent to those skilled in the art). Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.
CLAIMS

1. An de-blocking filtering method, comprising:
   - the parameters used in de-blocking filtering such as the thresholds and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be different for different pictures, slices, coding tree units (CTU) or CUs;
   - the parameters used in de-blocking filtering such as the thresholds and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be different for different boundary strengths;
   - the parameters used in de-blocking filtering such as the thresholds and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be different for vertical and horizontal de-blocking filtering;
   - the parameters used in de-blocking filtering such as the thresholds and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC are signaled from the encoder to the decoder;
   - some judging conditions can be removed;
   - the parameters used in de-blocking filtering such as the thresholds and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC are derived in the same way at encoder and decoder.

2. The method as claimed in claim 1, wherein in one embodiment, the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be signaled in video parameter set (VPS), sequence parameter set (SPS), picture parameter set (PPS), slice header (SH), and coding tree unit (CTU) or CU.

3. The method as claimed in claim 1, wherein a flag is signalled to indicate whether the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC are signaled or not. If the parameters are not signaled, predefined parameters such as the parameters defined by HEVC is applied.

4. The method as claimed in claim 3, wherein a flag is signalled to indicate whether the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC for a particular BS are signaled or not. If the parameters are not signaled, predefined parameters such as the parameters defined by HEVC is applied for this BS.

5. The method as claimed in claim 3, wherein a flag is signalled to indicate whether the
parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal, and Beta2, and TcS, TcO, Tel, and TcC for a particular boundary direction such as vertical boundary or horizontal boundary are signaled or not. If the parameters are not signaled, predefined parameters such as the parameters defined by HEVC is applied in de-blocking filtering for this particular boundary direction.

6. The method as claimed in claim 3, wherein a flag is signalled to indicate whether the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal, and Beta2, and TcS, TcO, Tel for a particular component such as luma component are signaled or not. If the parameters are not signaled, predefined parameters such as the parameters defined by HEVC is applied in de-blocking filtering for this particular component.

7. The method as claimed in claim 3, wherein a flag is signalled to indicate whether the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as TcC for one particular component such as U or V component, or some components such as both U and V components are signaled or not. If the parameters are not signaled, predefined parameters such as the parameters defined by HEVC is applied in de-blocking filtering for this particular component or components.

8. The method as claimed in claim 1, wherein the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal, and Beta2, and TcS, TcO, Tel, and TcC can be signaled by any coding method, such as fixed length coding or UVLC coding defined in HEVC.

9. The method as claimed in claim 1, wherein the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal, and Beta2, and TcS, TcO, Tel, and TcC can be signaled in a predictive way.

10. The method as claimed in claim 9, wherein the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal, and Beta2, and TcS, TcO, Tel, and TcC for horizontal de-blocking filtering can be predicted by the parameters such as BetaO, Betal, and Beta2, and TcS, TcO, Tel, and TcC for vertical de-blocking filtering.

11. The method as claimed in claim 9, wherein the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal, and Beta2, and TcS, TcO, Tel, and TcC for vertical de-blocking filtering can be predicted by the parameters such as BetaO, Betal, and Beta2, and TcS, TcO, Tel, and TcC for horizontal de-blocking filtering.

12. The method as claimed in claim 9, wherein the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal, and Beta2, and TcS, TcO, Tel, and TcC for BS=X can be predicted by the parameters such as BetaO, Betal, and Beta2,
and TcS, TcO, Tel, and TcC for BS=Y. X can be larger or smaller than Y.

13. The method as claimed in claim 9, wherein the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be predicted by some predefined values. For example, they can be predicted by the predefined values used in HEVC.

14. The method as claimed in claim 11, wherein the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as BetaO, Betal and Beta2, and TcS, TcO, Tel, and TcC can be predicted one by one. For example, Beta2 can be predicted by Betal, and Betal can be predicted by BetaO. In another example, TcS is predicted by TcO, and TcO is predicted by Tel. In another example, TcC is predicted by TcC.

15. The method as claimed in claim 1, wherein the parameters used in de-blocking filtering such as thresholds and clipping boundaries such as TcC can be different for component U and V, denoted as TcCU and TcCV respectively.

16. The method as claimed in claim 15, wherein TcCV can be predicted by TcCU when signaled from the encoder to the decoder. In another embodiment, TcCU can be predicted by TcCV when signaled from the encoder to the decoder.

17. The method as claimed in claim 1, wherein the judge condition of d1 < betal can be removed.

18. The method as claimed in claim 1, wherein the judge conditions of d1 < betal, dp < beta2 and dq < beta2 can be removed.

19. The method as claimed in claim 1, wherein the parameters used in de-blocking filtering can be obtained by a training process at encoder.

20. The method as claimed in claim 19, wherein a table based algorithm is applied to get the trained parameters. The algorithm can also be regarded as histogram based.

21. The method as claimed in claim 19, wherein the parameters used in de-blocking filtering can be obtained by a training process on the current coded picture.

22. The method as claimed in claim 19, wherein the parameters used in de-blocking filtering can be obtained by a training process on a previous coded picture. For example, the parameters in de-blocking filtering signaled by Frame K can be obtained by a training process on Frame K-l.
Fig. 1
**Fig. 2**

- If BS > 0?
  - Yes: Y
  - No: N
- If d0 < beta0?
  - Yes: Y
  - No: N

**Luma filtering**

- If Strong filtering?
  - Yes: Y
  - No: N

**Decision Points**

- If d1 < beta1
  - No: N
  - Yes: Y

**Filtering Actions**

- Weak filter on P0/Q0
  - X = Clip3( X-Tc0, X+Tc0, X')
- Weak filter on P1
  - X = Clip3( X-Tc1, X+Tc1, X')
- Weak filter on Q1
  - X = Clip3( X-Tc1, X+Tc1, X')

- Strong filter on
  - P0/P1/P2/Q0/Q1Q2
  - X = Clip3( X-TcS, X+TcS, X')

**Fig. 3**
Chroma filtering

Is BS>1?

Chroma filter on P0/Q0
\[ X = \text{Clip3}(X-TcC, X+TcC, X') \]

Fig. 4

Parameters for BS= 1, for vertical edges

Fig. 5

Parameters for BS= 2, for vertical edges

Encoder

\[ \text{Path} \]

Decoder

Parameters for BS= 1, for horizontal edges

Parameters for BS= 2, for horizontal edges
Luma filtering

Is BS > 0?

Is d0 < beta0?

Not filter 4 lines

Is Strong filtering?

Weak filter on P0/Q0
X = Clip3(X - Tc0, X + Tc0, X')

Weak filter on P1
X = Clip3(X - Tc1, X + Tc1, X')

Weak filter on Q1
X = Clip3(X - Tc1, X + Tc1, X')

Strong filter on P0/P1/P2/Q0/Q1Q2
X = Clip3(X - TcS, X + TcS, X')

Fig. 7
**Boundary 0:** \( d=5, \) \( D0 = 120, \) \( D1 = 100 \)

\[
\begin{array}{cccccccccc}
S & 120 & 120 & 120 & 120 & 120 & 100 & 100 & 100 & 100 & \ldots
\end{array}
\]

**Boundary 1:** \( d=7, \) \( D0 = 50, \) \( D1 = 60 \)

\[
\begin{array}{cccccccccc}
S & 170 & 170 & 170 & 170 & 170 & 150 & 150 & 150 & 160 & \ldots
\end{array}
\]

**Boundary 2:** \( d=6, \) \( D0 = 30, \) \( D1 = 20 \)

\[
\begin{array}{cccccccccc}
S & 200 & 200 & 200 & 200 & 200 & 180 & 180 & 170 & 180 & \ldots
\end{array}
\]

Optimal \( T=7 \)

Fig. 8
Sample 0: $X_0 = 100, X = 95, X' = 97, d = 2$

Sample 1: $X_0 = 100, X = 106, X' = 109, d = 3$

Sample 2: $X_0 = 100, X = 103, X' = 102, d = 1$

Optimal $T_c = 1$

Fig. 9
INTERNATIONAL SEARCH REPORT

International application No. PCT/CN2015/089523

A. CLASSIFICATION OF SUBJECT MATTER

H04N 19/82(2014.01)j

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT,CNKI,WPI,EPODOC:loop, deblock, filter, parameter, signal, predict, decrease, reduce, judge, condition

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>TW 201334543 A1 (QUALCOMM INCORPORATED) 16 August 2013 (2013-08-16) the whole document</td>
<td>1-22</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C. See patent family annex.

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Date of the actual completion of the international search 17 May 2016

Date of mailing of the international search report 12 June 2016

Name and mailing address of the ISA/CN

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