DYNAMIC RANGE MAPPING METHOD AND APPARATUS

[0001] This application claims priority to Chinese Patent Application No. 202010365696.3, filed with the China National Intellectual Property Administration on April 30, 2020 and entitled "DYNAMIC RANGE MAPPING METHOD AND APPARATUS", which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] This application relates to the field of display technologies, and more specifically, to a dynamic range mapping method and apparatus.

BACKGROUND

[0003] A dynamic range (dynamic range, DR) indicates a ratio of a maximum value to a minimum value of a variable in many fields. For a digital image, a dynamic range indicates a ratio of maximum luminance to minimum luminance in a displayable range of the image, that is, a quantity of grayscale levels obtained through division between a "brightest" part and a "darkest" part of the image. A unit of luminance is candela per square meter (cd/m^2) or may be represented as nit (nit). A larger dynamic range of an image indicates more luminance levels for representing the image and more realistic visual effect of the image. A dynamic range of a natural scene in the real world is between 10^{-3} and 10^6. The dynamic range is very large, and therefore is referred to as a high dynamic range (high dynamic range, HDR). Compared with a high dynamic range image, a common image has a standard dynamic range (standard dynamic range, SDR) or a low dynamic range (low dynamic range, ~~SDR~~LDR).

[0004] Currently, a display device whose dynamic range is less than 0.1 nits to 400 nits is generally referred to as an SDR display device. A display device whose dynamic range is greater than 0.01 nits to 540 nits is generally referred to as an HDR display device. Different high dynamic range display devices display different dynamic ranges, for example, an HDR display device of 0.01 nits to 540 nits and an HDR display device of 0.005 nits to 1000 nits. A dynamic range

obtaining unit is specifically configured to:

obtain the metadata of the image data; and

determine the first parameter of the first tone mapping curve based on the metadata and the display parameter.

[00103] According to a third aspect, a computer-readable storage medium is provided. The computer-readable storage medium stores instructions. When the instructions are run on a computer, the computer is enabled to perform the method according to the first aspect.

[00104] According to a fourth aspect, a computer program product including instructions is provided. When the computer program product runs on a computer, the computer is enabled to perform the method according to the first aspect.

[00105] According to a fifth aspect, an electronic device is provided, including the dynamic range mapping ~~media data processing~~ apparatus according to the second aspect.

[00106] It should be understood that for beneficial effects achieved in the second to the fifth aspects and the corresponding implementations of this application, refer to beneficial effects achieved in the first aspect and the corresponding implementations of this application. Details are not described again.

BRIEF DESCRIPTION OF DRAWINGS

[00107] FIG. 1 is an example of low dynamic mapping from a high dynamic range of the real world to a display device~~a diagram of a PQ optical electro transfer function~~;

[00108] FIG. 2 is a diagram of an ~~HLG~~ PQ optical electro transfer function;

[00109] FIG. 3 is a diagram of an ~~SLF~~ HLG optical electro transfer function;

[00110] FIG. 4 a diagram of an SLF optical electro transfer function~~is a schematic diagram of a dynamic range adjustment curve of a high dynamic range image according to an embodiment of this application~~;

[00111] FIG. 5 is a schematic diagram of a sigmoid curve;

[00112] FIG. 6 is a schematic diagram of a Bezier curve;

[00113] FIG. 7 is an example of a mapping curve when maximum luminance of an image is the same as maximum display luminance of a display device;

[00114] FIG. 8 is a schematic diagram of a system architecture according to an embodiment of this application;

[00115] FIG. 9 is a schematic flowchart of a dynamic range mapping method according to an

the media data processing method in the method embodiments of this application. The processor 1101 may be an integrated circuit chip and has a signal processing capability. In an implementation process, the steps in the foregoing method may be completed by using an integrated logic circuit of hardware in the processor ~~701~~ 1101 or an instruction in a form of software. The processor 1101 may be a general-purpose processor, a digital signal processor (digital signal processor, DSP), an application-specific integrated circuit (ASIC), a field programmable gate array (field programmable gate array, FPGA), another programmable logic device, a discrete gate, a transistor logic device, or a discrete hardware component. The processor may implement or perform the method, the steps, and the logical block diagrams that are disclosed in embodiments of this application. The general-purpose processor may be a microprocessor, or the processor may be any conventional processor or the like. The steps of the method disclosed with reference to embodiments of this application may be directly performed and completed by a hardware decoding processor, or may be performed and completed by using a combination of hardware and software modules in the decoding processor. A software module may be located in a mature storage medium in the art, such as a random access memory, a flash memory, a read-only memory, a programmable read-only memory, an electrically erasable programmable memory, or a register. The storage medium is located in the memory 1102. The processor 1101 reads information in the memory 1102, and completes, in combination with hardware of the processor 1101, a function that needs to be executed by a module included in the media data processing apparatus in embodiments of this application, or performs the media data processing method in the method embodiments of this application.

[00324] The memory 1102 may be a read-only memory (read-only memory, ROM), a static storage device, a dynamic storage device, or a random access memory (random access memory, RAM). The memory 1102 may store an operating system and another application program. When the functions that need to be executed by the modules that are included in the media data processing apparatus in embodiments of this application are implemented or the media data processing method in the method embodiments of this application is performed by using software or firmware, program code used to implement the technical solutions provided in embodiments of this application is stored in the memory 1102, and the processor 1101 performs operations that need to be performed by the modules that are included in the media data processing apparatus, or performs the media data processing method provided in the method embodiments of this application.

CLAIMS

What is claimed is:

1. A dynamic range mapping method, comprising:

obtaining a display parameter of a terminal device;

obtaining feature information of image data;

obtaining a first parameter of a first tone mapping curve of the image data;

when a preset condition is met, obtaining a second parameter of a second tone mapping curve based on the first parameter, the display parameter of the terminal device, and the feature information of the image data, wherein output luminance at a first point on the second tone mapping curve is not greater than input luminance at the first point on the second tone mapping curve; and

performing dynamic range mapping on the image data based on the second parameter of the second tone mapping curve.

2. The method according to claim 1, wherein the preset condition is met when any one of the following conditions is met:

when tone mapping is performed on the image data based on the first parameter, output luminance at a second point on the first tone mapping curve is greater than input luminance at the second point on the first tone mapping curve; or

a parameter p_{P1} in the first parameter is greater than a first value Tp, wherein the first value Tp is obtained based on a_{P1} in the first parameter and a preset correspondence between a_{P1} and p_{P1}; or

a parameter a_{P1} in the first parameter is greater than a second value Ta, wherein the second value Ta is obtained based on p_{P1} in the first parameter and a preset correspondence between a_{P1} and p_{P1}; or

a product of a parameter a_{P1} and a parameter p_{P1} in the first parameter is greater than a third value Tap, wherein the third value Tap is a preset rational number.

3. The method according to claim 1 or 2, wherein the second parameter comprises a first linear spline curve parameter, and the first linear spline curve parameter comprises a slope MB[0][0] of a first linear spline on the second tone mapping curve and/or a maximum value TH3[0] of a luminance value of a range pixel of the first linear spline and/or an intersection point

base_offset of the first linear spline and a vertical coordinate axis.

4. The method according to any one of claims 1 to 3, wherein the first parameter comprises a second linear spline curve parameter, the second linear spline curve parameter comprises a slope MB_mid[0][0] of a second linear spline on the first tone mapping curve and/or a maximum value TH3_mid[0] of a luminance value of a range pixel of the second linear spline, the display parameter comprises maximum display luminance MaxDisplay of the terminal device, and the feature information comprises a maximum luminance correction value max_lum of the image data; and

the obtaining a second parameter of a second tone mapping curve based on the first parameter, the display parameter, and the feature information comprises:

adjusting the curve parameters MB_mid[0][0] and TH3_mid[0] based on the maximum display luminance MaxDisplay and the maximum luminance correction value max_lum to obtain the curve parameters MB[0][0] and TH3[0].

5. The method according to claim 4, wherein the curve parameters MB_mid[0][0] and TH3_mid[0], and the curve parameters MB[0][0] and TH3[0] satisfy the following formulas:

MB[0][0] = min(max(MB_mid[0][0] + (1 – MB_mid[0][0]) * $(WA)^{N_1}$, MB_mid[0][0]),1), and

TH3[0] = min(max(TH3_mid[0] + (max_lum – TH3_mid[0]) * $(WA)^{N_2}$, TH3_mid[0]),1), wherein

$$WA = \frac{\frac{MaxDisplay}{max_lum} - \frac{MaxDisplay}{G(MaxDisplay, m_a_T)}}{1 - \frac{MaxDisplay}{G(MaxDisplay, m_a_T)}},$$

$$G(L, m_a) = \left(\frac{K3 \times \left(\frac{L - m_b}{m_a}\right)^{\frac{1}{m_m}}}{m_p - (K1 \times m_p - K2) \times \left(\frac{L - m_b}{m_a}\right)^{\frac{1}{m_m}}} \right)^{\frac{1}{m_n}}, \text{ or}$$

$$G(L, m_a) = \left(\frac{K3 \times \left(\frac{L}{m_a}\right)^{\frac{1}{m_m}}}{m_p - (K1 \times m_p - K2) \times \left(\frac{L}{m_a}\right)^{\frac{1}{m_m}}} \right)^{\frac{1}{m_n}}, \text{ wherein}$$

L is an input signal, $G(L)$ is an inverse function of a function H(L) corresponding to a tone mapping curve, m_a, m_b, m_m, m_n, k1, k2, and k3 are curve parameters, G(L, m_a_T) indicates a G(L) value corresponding to an input variable L when a value of a parameter M_a of G(L) is m_a_T, N1 and N2 are rational numbers, max(a, b) indicates calculating a larger value of a and b, min(a, b) indicates calculating a smaller value of a and b, and H(L) is

$$H(L) = m_a \times \left(\frac{m_p \times L^{m_n}}{(K1 \times m_p - K2) \times L^{m_n} + K3}\right)^{m_m} + m_b, \text{ or}$$

$$H(L) = m_a \times \left(\frac{m_p \times L^{m_n}}{(K1 \times m_p - K2) \times L^{m_n} + K3}\right)^{m_m}.$$

6. The method according to any one of claims 1 to 5, wherein the second parameter comprises a cubic spline curve parameter, and the cubic spline curve parameter comprises interpolation point values TH1[1], TH2[1], and TH3[1] of a cubic spline on the second tone mapping curve, wherein TH1[1] indicates a minimum value of a luminance value of a first range pixel of the cubic spline, TH2[1] indicates a maximum value of the luminance value of the first range pixel of the cubic spline and a minimum value of a luminance value of a second range pixel of the cubic spline, and TH3[1] indicates a maximum value of the luminance value of the second range pixel of the cubic spline.

7. The method according to claim 6, wherein the interpolation point values TH1[1], TH2[1], and TH3[1] of the cubic spline are obtained based on the second linear spline curve parameter TH3[0] in the first parameter and preset offset values of the interpolation point values TH1[1], TH2[1], and TH3[1], as shown in the following:

TH1[1] = TH3[0],

TH2[1] = TH1[1] + B, and

TH3[1] = TH2[1] + C * TH2[1] – D * TH1[1], wherein

B, C, and D are preset values of correlation values for calculating the interpolation point values TH1[1], TH2[1], and TH3[1] of the cubic spline, B is a preset offset value corresponding to a luminance value of a dark-bright transition region pixel, and C and D are preset weighting coefficients corresponding to a luminance value of a bright region pixel.

8. The method according to claim 6, wherein the interpolation point values TH1[1], TH2[1], and TH3[1] of the cubic spline are calculated based on the second linear spline curve parameter TH3[0] in the first parameter and correlation values for calculating the interpolation point values TH1[1], TH2[1], and TH3[1], as shown in the following:

TH1[1] = 3Spline_TH[i][0][w],

TH2[1] = 3Spline_TH[i][0][w] + 3Spline_TH_Delta1[i][1][w], and

TH3[1] = 3Spline_TH[i][0][w] + 3Spline_TH_Delta1[i][1][w] + 3Spline_TH_Delta1[i][2][w], wherein

3Spline_TH[i][0][w], 3Spline_TH_Delta1[i][1][w], and 3Spline_TH_Delta1[i][2][w] are the

correlation values that are used for calculating the interpolation point values TH1[1], TH2[1], and TH3[1] and that are extracted from metadata.

9. The method according to claim 8, wherein a Y coordinate of a linear spline on the second tone mapping curve at TH3[0] is the same as a Y coordinate of the cubic spline on the second tone mapping curve at TH1[1], and a first-order derivative of the linear spline at TH3[0] is the same as a first-order derivative of the cubic spline at TH1[1].

10. The method according to claim 8 or 9, wherein a Y coordinate of a first cubic spline on the second tone mapping curve at TH2[1] is the same as a Y coordinate of a second cubic spline on the second tone mapping curve at TH2[1], and a first-order derivative of the first cubic spline at TH2[1] is the same as a first-order derivative of the second cubic spline at TH2[1].

11. The method according to any one of claims 8 to 10, wherein a Y coordinate of the second cubic spline on the second tone mapping curve at TH3[1] is the same as a Y coordinate of a third tone mapping function on the second tone mapping curve at TH3[1], and a first-order derivative of the second cubic spline at TH3[1] is the same as a first-order derivative of the third tone mapping function at TH3[1].

12. The method according to any one of claims 1 to 11, wherein the obtaining a first parameter of a first tone mapping curve of the image data comprises:

obtaining the metadata of the image data; and

determining the first parameter of the first tone mapping curve based on the metadata and the display parameter.

13. The method according to any one of claims 1 to 12, wherein the first parameter comprises the second linear spline curve parameter, the second linear spline curve parameter comprises the slope MB_mid[0][0] of the second linear spline on the first tone mapping curve and/or the maximum value TH3_mid[0] of the luminance value of the range pixel of the second linear spline and/or an intersection point base_offset_mid of the first linear spline and the vertical coordinate axis, the display parameter comprises the maximum display luminance MaxDisplay of the terminal device, and the feature information comprises the maximum luminance correction value max_lum of the image data; and

the obtaining a second parameter of a second tone mapping curve based on the first parameter, the display parameter, and the feature information comprises:

adjusting the curve parameters MB_mid[0][0], TH3_mid[0], and/or base_offset_mid based

on the maximum display luminance MaxDisplay and the maximum luminance correction value max_lum to obtain the curve parameters MB[0][0], TH3[0], and/or base_offset.

14. The method according to claim 13, wherein the curve parameters MB_mid[0][0], TH3_mid[0], and/or base_offset_mid, and the curve parameters MB[0][0], TH3[0], and/or base_offset satisfy the following formulas:

MB[0][0] = min(max(MB_mid[0][0] + (1 – MB_mid[0][0]) * $(WA)^{N_1}$, MB_mid[0][0]),1),

TH3[0] = min(max(TH3_mid[0] + (max_lum – TH3_mid[0] * $(WA)^{N_2}$, TH3_mid[0]),1), and

base_offset = min(max(base_offset_mid * (1 – $(WA)^{N_3}$), 0), base_offset_mid), wherein

$$WA = \frac{\frac{MaxDisplay}{max_lum} - \frac{MaxDisplay}{G(MaxDisplay, m_a_T)}}{1 - \frac{MaxDisplay}{G(MaxDisplay, m_a_T)}},$$

$$G(L, m_a) = \left(\frac{K3 \times \left(\frac{L - m_b}{m_a}\right)^{\frac{1}{m_m}}}{m_p - (K1 \times m_p - K2) \times \left(\frac{L - m_b}{m_a}\right)^{\frac{1}{m_m}}} \right)^{\frac{1}{m_n}}, \text{ or}$$

$$G(L, m_a) = \left(\frac{K3 \times \left(\frac{L}{m_a}\right)^{\frac{1}{m_m}}}{m_p - (K1 \times m_p - K2) \times \left(\frac{L}{m_a}\right)^{\frac{1}{m_m}}} \right)^{\frac{1}{m_n}}, \text{ wherein}$$

L is the input signal, $G(L)$ is the inverse function of the function H(L) corresponding to the tone mapping curve, m_a, m_b, m_m, m_n, k1, k2, and k3 are the curve parameters, G(L, m_a_T) indicates the G(L) value corresponding to the input variable L when the value of the parameter M_a of G(L) is m_a_T, N1, N2, and N3 are rational numbers, max(a, b) indicates calculating the larger value of a and b, min(a, b) indicates calculating the smaller value of a and b, and H(L) is

$$H(L) = m_a \times \left(\frac{m_p \times L^{m_n}}{(K1 \times m_p - K2) \times L^{m_n} + K3} \right)^{m_m} + m_b, \text{ or}$$

$$H(L) = m_a \times \left(\frac{m_p \times L^{m_n}}{(K1 \times m_p - K2) \times L^{m_n} + K3} \right)^{m_m}.$$

15. A dynamic range mapping apparatus, comprising:

an obtaining unit, configured to obtain a display parameter of a terminal device, wherein the obtaining unit is further configured to obtain feature information of image data; and

the obtaining unit is further configured to obtain a first parameter of a first tone mapping curve of the image data;

a processing unit, configured to: when a preset condition is met, obtain a second parameter of a second tone mapping curve based on the first parameter, the display parameter of the terminal device, and the feature information of the image data, wherein output luminance at a first point on

the second tone mapping curve is not greater than input luminance at the first point on the second tone mapping curve; and

a mapping unit, configured to perform dynamic range mapping on the image data based on the second parameter of the second tone mapping curve.

16. The apparatus according to claim 15, wherein the preset condition is met when any one of the following conditions is met:

when tone mapping is performed on the image data based on the first parameter, output luminance at a second point on the first tone mapping curve is greater than input luminance at the second point on the first tone mapping curve; or

a parameter p_{P1} in the first parameter is greater than a first value Tp, wherein the first value Tp is obtained based on a_{P1} in the first parameter and a preset correspondence between a_{P1} and p_{P1}; or

a parameter a_{P1} in the first parameter is greater than a second value Ta, wherein the second value Ta is obtained based on p_{P1} in the first parameter and a preset correspondence between a_{P1} and p_{P1}; or

a product of a parameter a_{P1} and a parameter p_{P1} in the first parameter is greater than a third value Tap, wherein the third value Tap is a preset rational number.

17. The apparatus according to claim 15 or 16, wherein the second parameter comprises a first linear spline curve parameter, and the first linear spline curve parameter comprises a slope MB[0][0] of a first linear spline on the second tone mapping curve and/or a maximum value TH3[0] of a luminance value of a range pixel of the first linear spline and/or an intersection point base_offset of the first linear spline and a vertical coordinate axis.

18. The apparatus according to any one of claims 15 to 17, wherein the first parameter comprises a second linear spline curve parameter, the second linear spline curve parameter comprises a slope MB_mid[0][0] of a second linear spline on the first tone mapping curve and/or a maximum value TH3_mid[0] of a luminance value of a range pixel of the second linear spline, the display parameter comprises maximum display luminance MaxDisplay of the terminal device, and the feature information comprises a maximum luminance correction value max_lum of the image data; and

the processing unit is specifically configured to:

adjust the curve parameters MB_mid[0][0] and TH3_mid[0] based on the maximum display

luminance MaxDisplay and the maximum luminance correction value max_lum to obtain the curve parameters MB[0][0] and TH3[0].

19. The apparatus according to claim 18, wherein the curve parameters MB_mid[0][0] and TH3_mid[0], and the curve parameters MB[0][0] and TH3[0] satisfy the following formulas:

MB[0][0] = min(max(MB_mid[0][0] + (1 – MB_mid[0][0]) * (WA)^{N_1}, MB_mid[0][0]),1) and

TH3[0] = min(max(TH3_mid[0] + (max_lum – TH3_mid[0]) * (WA)^{N_2}, TH3_mid[0]),1), wherein

$$\mathrm{WA} = \frac{\frac{\mathrm{MaxDisplay}}{\mathrm{max_lum}} - \frac{\mathrm{MaxDisplay}}{G(\mathrm{MaxDisplay,m_a_T})}}{1-\frac{\mathrm{MaxDisplay}}{G(\mathrm{MaxDisplay,m_a_T})}},$$

$$\mathrm{G(L,m_a)} = \left(\frac{\mathrm{K3}\times\left(\frac{L-m_\mathrm{b}}{\mathrm{m_a}}\right)^{\frac{1}{\mathrm{m_m}}}}{\mathrm{m_p}-(\mathrm{K1}\times\mathrm{m_p}-\mathrm{K2})\times\left(\frac{L-m_\mathrm{b}}{\mathrm{m_a}}\right)^{\frac{1}{\mathrm{m_m}}}}\right)^{\frac{1}{\mathrm{m_n}}}, \text{ or}$$

$$\mathrm{G(L,m_a)} = \left(\frac{\mathrm{K3}\times\left(\frac{L}{\mathrm{m_a}}\right)^{\frac{1}{\mathrm{m_m}}}}{\mathrm{m_p}-(\mathrm{K1}\times\mathrm{m_p}-\mathrm{K2})\times\left(\frac{L}{\mathrm{m_a}}\right)^{\frac{1}{\mathrm{m_m}}}}\right)^{\frac{1}{\mathrm{m_n}}}, \text{ wherein}$$

L is an input signal, G(L) is an inverse function of a function H(L) corresponding to a tone mapping curve, m_a, m_b, m_m, m_n, k1, k2, and k3 are curve parameters, G(L, m_a_T) indicates a G(L) value corresponding to an input variable L when a value of a parameter M_a of G(L) is m_a_T, N1 and N2 are rational numbers, max(a, b) indicates calculating a larger value of a and b, min(a, b) indicates calculating a smaller value of a and b, and H(L) is

$$\mathrm{H(L)} = \mathrm{m_a}\times\left(\frac{m_p\times L^{m_n}}{(K1\times\mathrm{m_p}-\mathrm{K2})\times L^{m_n}+K3}\right)^{m_m} + m_b, \text{ or}$$

$$\mathrm{H(L)} = \mathrm{m_a}\times\left(\frac{m_p\times L^{m_n}}{(K1\times\mathrm{m_p}-\mathrm{K2})\times L^{m_n}+K3}\right)^{m_m}.$$

20. The apparatus according to any one of claims 15 to 19, wherein the second parameter comprises a cubic spline curve parameter, and the cubic spline curve parameter comprises interpolation point values TH1[1], TH2[1], and TH3[1] of a cubic spline on the second tone mapping curve, wherein TH1[1] indicates a minimum value of a luminance value of a first range pixel of the cubic spline, TH2[1] indicates a maximum value of the luminance value of the first range pixel of the cubic spline and a minimum value of a luminance value of a second range pixel of the cubic spline, and TH3[1] indicates a maximum value of the luminance value of the second range pixel of the cubic spline.

21. The apparatus according to claim 20, wherein the interpolation point values TH1[1], TH2[1], and TH3[1] of the cubic spline are obtained based on the second linear spline curve parameter TH3[0] in the first parameter and preset offset values of the interpolation point values TH1[1], TH2[1], and TH3[1], as shown in the following:

TH1[1] = TH3[0],

TH2[1] = TH1[1] + B, and

TH3[1] = TH2[1] + C * TH2[1] – D * TH1[1], wherein

B, C, and D are preset values of correlation values for calculating the interpolation point values TH1[1], TH2[1], and TH3[1] of the cubic spline, B is a preset offset value corresponding to a luminance value of a dark-bright transition region pixel, and C and D are preset weighting coefficients corresponding to a luminance value of a bright region pixel.

22. The apparatus according to claim 20, wherein the interpolation point values TH1[1], TH2[1], and TH3[1] of the cubic spline are calculated based on the second linear spline curve parameter TH3[0] in the first parameter and correlation values for calculating the interpolation point values TH1[1], TH2[1], and TH3[1], as shown in the following:

TH1[1] = 3Spline_TH[i][0][w],

TH2[1] = 3Spline_TH[i][0][w] + 3Spline_TH_Delta1[i][1][w], and

TH3[1] = 3Spline_TH[i][0][w] + 3Spline_TH_Delta1[i][1][w] + 3Spline_TH_Delta1[i][2][w], wherein

3Spline_TH[i][0][w], 3Spline_TH_Delta1[i][1][w], and 3Spline_TH_Delta1[i][2][w] are the correlation values that are used for calculating the interpolation point values TH1[1], TH2[1], and TH3[1] and that are extracted from metadata.

23. The apparatus according to claim 22, a Y coordinate of a linear spline on the second tone mapping curve at TH3[0] is the same as a Y coordinate of the cubic spline on the second tone mapping curve at TH1[1], and a first-order derivative of the linear spline at TH3[0] is the same as a first-order derivative of the cubic spline at TH1[1].

24. The apparatus according to claim 22 or 23, wherein a Y coordinate of a first cubic spline on the second tone mapping curve at TH2[1] is the same as a Y coordinate of a second cubic spline on the second tone mapping curve at TH2[1], and a first-order derivative of the first cubic spline at TH2[1] is the same as a first-order derivative of the second cubic spline at TH2[1].

25. The apparatus according to any one of claims 22 to 24, wherein a Y coordinate of the

second cubic spline on the second tone mapping curve at TH3[1] is the same as a Y coordinate of a third tone mapping function on the second tone mapping curve at TH3[1], and a first-order derivative of the second cubic spline at TH3[1] is the same as a first-order derivative of the third tone mapping function at TH3[1].

26. The apparatus according to any one of claims 15 to 25, wherein the obtaining unit is specifically configured to:

obtain the metadata of the image data; and

determine the first parameter of the first tone mapping curve based on the metadata and the display parameter.

27. The apparatus according to any one of claims 15 to 26, wherein the first parameter comprises the second linear spline curve parameter, the second linear spline curve parameter comprises the slope MB_mid[0][0] of the second linear spline on the first tone mapping curve and/or the maximum value TH3_mid[0] of the luminance value of the range pixel of the second linear spline and/or an intersection point base_offset_mid of the first linear spline and the vertical coordinate axis, the display parameter comprises the maximum display luminance MaxDisplay of the terminal device, and the feature information comprises the maximum luminance correction value max_lum of the image data; and

the processing unit is specifically configured to:

adjust the curve parameters MB_mid[0][0], TH3_mid[0], and/or base_offset_mid based on the maximum display luminance MaxDisplay and the maximum luminance correction value max_lum to obtain the curve parameters MB[0][0], TH3[0], and/or base_offset.

28. The apparatus according to claim 27, wherein the curve parameters MB_mid[0][0], TH3_mid[0], and/or base_offset_mid, and the curve parameters MB[0][0], TH3[0], and/or base_offset satisfy the following formulas:

MB[0][0] = min(max(MB_mid[0][0] + (1 – MB_mid[0][0]) * $(WA)^{N_1}$, MB_mid[0][0]),1),

TH3[0] = min(max(TH3_mid[0] + (max_lum – TH3_mid[0] * $(WA)^{N_2}$, TH3_mid[0]),1), and

base_offset = min(max(base_offset_mid * (1 – $(WA)^{N_3}$), 0), base_offset_mid), wherein

$$WA = \frac{\frac{MaxDisplay}{max_lum} - \frac{MaxDisplay}{G(MaxDisplay,m_a_T)}}{1-\frac{MaxDisplay}{G(MaxDisplay,m_a_T)}},$$

$$G(L, m_a) = \left(\frac{K3 \times \left(\frac{L - m_b}{m_a} \right)^{\frac{1}{m_m}}}{m_p - (K1 \times m_p - K2) \times \left(\frac{L - m_b}{m_a} \right)^{\frac{1}{m_m}}} \right)^{\frac{1}{m_n}}, \text{ or}$$

$$G(L, m_a) = \left(\frac{K3 \times \left(\frac{L}{m_a} \right)^{\frac{1}{m_m}}}{m_p - (K1 \times m_p - K2) \times \left(\frac{L}{m_a} \right)^{\frac{1}{m_m}}} \right)^{\frac{1}{m_n}}, \text{ wherein}$$

L is the input signal, $G(L)$ is the inverse function of the function H(L) corresponding to the tone mapping curve, m_a, m_b, m_m, m_n, k1, k2, and k3 are the curve parameters, G(L, m_a_T) indicates the G(L) value corresponding to the input variable L when the value of the parameter M_a of G(L) is m_a_T, N1, N2, and N3 are rational numbers, max(a, b) indicates calculating the larger value of a and b, min(a, b) indicates calculating the smaller value of a and b, and H(L) is

$$H(L) = m_a \times \left(\frac{m_p \times L^{m_n}}{(K1 \times m_p - K2) \times L^{m_n} + K3} \right)^{m_m} + m_b, \text{ or}$$

$$H(L) = m_a \times \left(\frac{m_p \times L^{m_n}}{(K1 \times m_p - K2) \times L^{m_n} + K3} \right)^{m_m}.$$

29. A computer-readable storage medium, comprising a computer program, wherein when the computer program is executed on a computer, the computer is enabled to perform the method according to any one of claims 1 to 14.

30. A terminal device, comprising:

one or more processors; and

a memory, configured to store one or more programs, wherein

when the one or more programs are executed by the one or more processors, the one or more processors are enabled to perform the method according to any one of claims 1 to 14.