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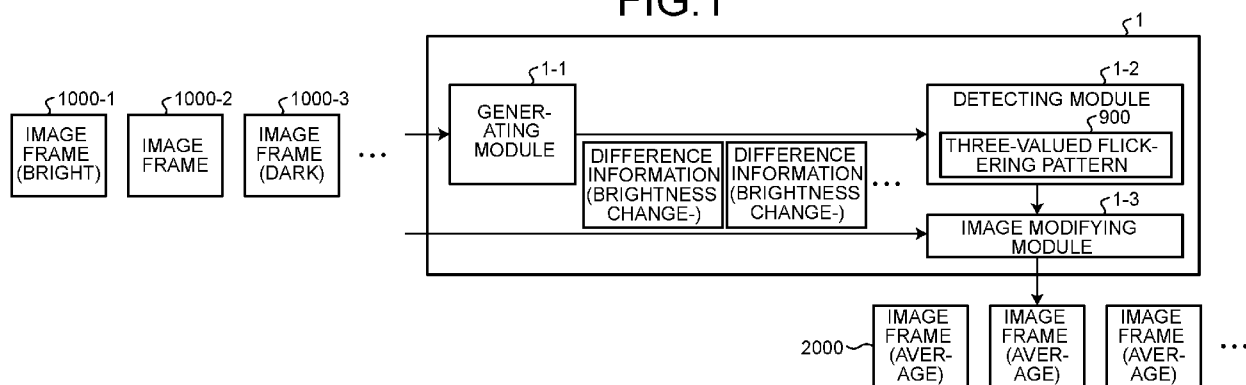
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FIG.1



(57) Abstract: An aim of the present disclosure is to reduce the flickering based on a flicker light source even with video shooting of short exposure shorter than the flicker period. An image processing device according to one aspect of the present disclosure includes: a generating module configured to generate a plurality of difference images indicating a brightness change between consecutive images in a time axis direction of an input captured video; a detecting module configured to detect a brightness change pattern that is a flickering pattern of a flicker light source from the plurality of difference images consecutive in the time axis direction; and an image modifying module configured to modify an image of a flicker spot in the input captured video, based on a detection result of the pattern detection.



[Type of Document] Description

[Title of the Invention] IMAGE PROCESSING DEVICE, METHOD, AND PROGRAM

[Technical Field]

[0001] The present disclosure relates to an image processing device, a method, and a program.

[Background Art]

[0002] The flickering of a light source may be confirmed in the captured video. Although the flickering of a flicker light source that flickers with a flicker period cannot be directly recognized by human eyes due to its high speed, the flickering of the flicker light source is confirmed from the video captured by a camera when there is a mismatch between an exposure time during shooting and a flicker period. Conventionally, if the camera that includes a dimming means such as the appropriate ND filter and Iris performs shooting by setting an exposure time that is an integral multiple of a flicker period, the occurrence of the flickering of the flicker light source at the flicker period is suppressed.

[Disclosure of Invention]

[Problem to be Solved by the Invention]

[0003] However, because the conventional method has a long exposure time, it is necessary to sufficiently perform dimming by a dimming means such as the ND filter and Iris to reduce an amount of light. On the other hand, a camera such as a smartphone may not perform sufficient dimming because the camera does not include any dimming means such as the ND filter and Iris or the camera includes a simple dimming means. If a user sets a long exposure time for a camera in which sufficient dimming is not performed, a bright spot with natural light different from a flicker spot becomes overexposed. The setting of a long exposure time is appropriate only when a camera that includes a dimming means in which sufficient dimming can be performed is used.

[0004] The present disclosure has been made in view of the above-described problem, and an aim of the present disclosure is to provide an image processing device, a method, and a program, which can reduce the flickering based on the flicker light source even with video shooting of short exposure shorter than the flicker period.

[Means for Solving Problem]

[0005] To solve the problem described above and achieve an aim of the present disclosure, an image processing device according to one aspect of the present disclosure includes: a generating module configured to generate a plurality of difference images indicating a (three-valued) brightness change between consecutive images in a time axis direction of an input captured video; a detecting module configured to detect a brightness change pattern that is a flickering pattern of a flicker light source from the plurality of difference images consecutive in the time axis direction; and an image modifying module configured to modify an image of a flicker spot in the input captured video, based on a detection result of the pattern detection.

[Effect of the Invention]

[0006] One aspect of the present disclosure has an effect that the flickering based on the flicker light source can be reduced even with video shooting of short exposure shorter than the flicker period.

[Brief Description of Drawings]

[0007]

FIG. 1 is a diagram illustrating an example of a configuration of an image processing device according to an embodiment;

FIG. 2 is a diagram illustrating an example of a relationship between an exposure time of a camera during video shooting and a flicker period of a flicker light source according to the embodiment;

FIG. 3 is a graph illustrating a relationship between a value obtained by taking a difference between frames and ternarizing it and the flicker period of the flicker light source according to the embodiment;

FIG. 4 is a diagram illustrating an example of setting a three-valued flickering pattern according to the embodiment;

FIG. 5 is a diagram illustrating an example of a configuration of detail blocks of a processor according to the embodiment;

FIG. 6 is an explanatory diagram illustrating processing of a first brightness generating module according to the embodiment;

FIG. 7 is a diagram illustrating an example of processing of a Global MV extracting module according to the embodiment;

FIG. 8 is an explanatory diagram of a Euclidean distance obtained from MV of a corresponding frame and a calculated average MV according to the embodiment;

FIG. 9 is an explanatory diagram illustrating processing for obtaining Global MV from the Euclidean distance according to the embodiment;

FIG. 10 is an explanatory diagram (continued) illustrating processing for obtaining the Global MV from the Euclidean distance according to the embodiment;

FIG. 11 is an explanatory diagram illustrating processing in which the Global MV extracting module determines the Global MV value of "1" or "4" according to the embodiment;

FIG. 12 is an explanatory diagram illustrating general image transformation according to the embodiment;

FIG. 13 is an explanatory diagram illustrating processing of an off MV conversion module according to the embodiment;

FIG. 14A is a diagram explaining an example of conversion to the approximate direction of the vector and the length of the vector of the off MV according to the embodiment;

FIG. 14B is diagram (continued) explaining the example of the conversion to the approximate direction of the vector and the length of the vector of the off MV according to the embodiment;

FIG. 15 is an explanatory diagram illustrating processing of a position correcting module, a difference image acquiring module, and a ternarization module according to the embodiment;

FIG. 16 is a reference diagram for comparison with FIG. 15 according to the embodiment;

FIG. 17A is an explanatory diagram illustrating processing of a differential moving object detecting module according to the embodiment;

FIG. 17B is an explanatory diagram (continued) illustrating processing of the differential moving object detecting module according to the embodiment;

FIG. 17C is an explanatory diagram (continued) illustrating processing of the differential moving object detecting module according to the embodiment;

FIG. 17D is an explanatory diagram (continued) illustrating processing of the differential moving object detecting module according to the embodiment;

FIG. 18 is an explanatory diagram illustrating processing of a subtraction module according to the embodiment;

FIG. 19 is an explanatory diagram illustrating processing of the position correcting module according to the embodiment;

FIG. 20 is an explanatory diagram illustrating processing of an MV moving object detecting module according to the embodiment;

FIG. 21 is an explanatory diagram illustrating processing of a position aligning module according to the embodiment;

FIG. 22 is a diagram illustrating an example of a brightness matching degree determining module included

in a determining module according to the embodiment;

FIG. 23 is a diagram illustrating an example of an image mismatching degree determining module included in the determining module according to the embodiment;

FIG. 24 is an explanatory diagram illustrating processing of a matching filter according to the embodiment;

FIG. 25 is an explanatory diagram illustrating an averaging module and a selecting module according to the embodiment;

FIG. 26 is a diagram illustrating an example of an output result after modifying the flickering of a flicker spot according to the embodiment;

FIG. 27 is a diagram illustrating an appearance of a smartphone that is one of application examples of the image processing device according to the embodiment;

FIG. 28 is a diagram illustrating an appearance of a camera including an image sensor, which is another of the application examples of the image processing device according to the embodiment;

FIG. 29 is a diagram illustrating an example of hardware blocks of a computer configuration of the image processing device according to the embodiment; and

FIG. 30 is a diagram illustrating an example of an image processing flow performed by the processor of the image processing device according to the embodiment.

[Embodiment(s) of Carrying Out the Invention]

[0008] Hereinafter, an image processing device, a method, and a program according to an embodiment will be described in detail with reference to the accompanying drawings. Note that the present invention is not limited to the embodiment.

[0009] Embodiment

A light source that is used for a signboard etc. is flickering even though it repeatedly turns ON and OFF at high speed so as not to be directly caught by human eyes. Because the flickering is confirmed in the captured video, the flickering is reduced from the video by using a method to be described below.

[0010] First, a term for flicker that is used in the following explanations will be described. A light source that repeats the flickering at a predetermined frequency is referred to as a "flicker light source". The ON and OFF repetition frequency of the flicker light source is referred to as a "flicker frequency". Moreover, one obtained by expressing a frequency of "flicker frequency" as a period is referred to as a "flicker period". Moreover, a spot flickering in the video by the flicker light source is referred to as a "flicker spot". Moreover, flickering that is mainly confirmed from the video is referred to as "flickering".

[0011] FIG. 1 is a diagram illustrating an example of a configuration of an image processing device 1 according to the embodiment. The image processing device 1 illustrated in FIG. 1 includes a processor that reduces the flickering of flicker spots on consecutive image frames 1000 (image frame 1000-1, image frame 1000-2, image frame 1000-3, and ...) of an input captured video and outputs the frames.

[0012] Herein, it is applicable to the image processing device 1 even if the image processing device 1 has a configuration that includes a camera or a configuration that does not include a camera. In this case, the camera includes at least image sensor.

[0013] If the image processing device 1 has a configuration including a camera, the image processing device 1 includes a processor that reduces the flickering of flicker spots on the consecutive image frames 1000 (image frame 1000-1, image frame 1000-2, image frame 1000-3, and ...) of the captured video input from the camera and outputs the frames. In addition, the processor may read the previously captured video shooting data from a storage medium and reduce the flickering of flicker spots.

[0014] Note that, when the image processing device 1 has the configuration including the camera, the image

processing device 1 may include a dimming means such as the ND filter and Iris. Moreover, the image processing device 1 may have a configuration such as a smartphone that includes a camera and does not include a dimming means such as the ND filter and Iris. The image processing device 1 may include another configuration such as a shooting device that shoots a video, a playback device that can play back the captured images of the video, and a device that performs image processing on the video.

[0015] As illustrated in FIG. 1, the image processing device 1 includes a generating module 1-1, a detecting module 1-2, and an image modifying module 1-3 as the processor that reduces the flickering of flicker spots on the video.

[0016] The generating module 1-1 generates difference images indicating brightness change between consecutive images in the time axis direction of the input captured video (image frame 1000-1, image frame 1000-2, image frame 1000-3, and ...).

[0017] From the plurality of difference images consecutive in the time axis direction generated by the generating module 1-1, the detecting module 1-2 detects a brightness change pattern that is a flickering pattern 900 of the flicker light source. The flickering pattern 900 of the flicker light source is a pattern obtained by expressing the brightness change with three-valued data. For example, a pattern of plus of the brightness change is "+1", a pattern of minus is "-1", and the other pattern is "0".

[0018] The image modifying module 1-3 modifies the images of the flicker spots in the input captured video (image frame 1000-1, image frame 1000-2, image frame 1000-3, and ...), based on the result of the pattern detection of the detecting module 1-2. For example, when a pattern is the predetermined pattern 900, the image modifying module 1-3 modifies a target image frame for processing of the captured video based on the front and rear image frames thereof, and outputs a target image frame for modification among the consecutive image frames 1000 (image frame 1000-1, image frame 1000-2, image frame 1000-3, and ...) as an image frame after modification 2000. In other words, the processor inputs the captured video (image frame 1000-1, image frame 1000-2, image frame 1000-3, and ...), reduces the flickering of flicker spots by image modification, and outputs the frames.

[0019] The captured image after modification output from the image modifying module 1-3 may be output onto a display unit via a display processing module, or may be stored in a storage medium via a storage processing module.

[0020] FIG. 2 is a diagram illustrating an example of a relationship between an exposure time of the camera during video shooting and a flicker period of the flicker light source. The timing of exposure of the image sensor included in the camera and the timing of flicker of the flicker light source are illustrated in FIG. 2.

[0021] The camera performs video shooting by setting short exposure in which an exposure time $t1$ is shorter than a flicker period $T1$ of the flicker light source. As illustrated in FIG. 2, when the camera performs video shooting by setting of the exposure time $t1$ of 1/250s, the flickering is confirmed from the video once every three frames with respect to the 100 Hz flicker light source. This is caused by a mismatch between the exposure time $t1$ and the flicker period $T1$ of the flicker light source. Thus, because the timing of exposure is shifted for each frame and the exposure time in the bright time of the flicker light source is changed, the flickering occurs on flicker spots in the video.

[0022] In the example illustrated in FIG. 2, among the consecutive image frames (image frame 1000-1, image frame 1000-2, image frame 1000-3, and image frame 1000-4), in the first frame 1000-1, a time of exposure overlaps the light-on time and a flicker light source 1002 becomes bright. In the second frame 1000-2, the time of exposure overlaps a time that includes the latter half of the light-on time and the former half of the light-out time, and the flicker light source 1002 becomes slightly dark. In the third frame 1000-3, the time of exposure overlaps a time that includes just before the end of the light-on time and the light-out time, and the flicker light source 1002 becomes dark. In the fourth frame 1000-4, similar to the first frame 1000-1, the time of exposure overlaps the light-on time and the flicker light source 1002 becomes bright.

[0023] Therefore, in this example, the flickering is confirmed from the video once every three frames.

[0024] The case where the flickering in the video is required to be reduced is a case where the flickering occurs in synchronization with the 50 Hz power supply system at the frame rate of 60 fps and 30 fps. This is because the flickering does not occur in the video because the frame rate and the power supply frequency are synchronized with each other if one synchronized with the 60 Hz power supply system has a representative frame rate (fps).

[0025] The frequency of the flicker light source to be generated by the 50 Hz power supply system is an integral multiple of 50 Hz, and the most of the flicker light sources are inverter-controlled and are equal to or greater than 100 Hz of two times of 50 Hz. A period at which the camera captures flickers is least common multiple of the frame rate (fps) and the flicker frequency of the flicker light source. In the correspondence relationship between the main frame rate (fps) of the camera and the period to be recorded in the camera of the flicker frequency of the 50 Hz power supply system, a table obtained by summarizing the flickering periods at which the camera captures flickers is Table 1.

[0026] [Table 1]

FLICKER FREQUENCY (Hz)	FRAME RATE (fps)		
	60	30	24
100	3	3	6
200	3	3	3
400	3	3	3

[0027] From Table 1, at the representative frame rate (fps), it turns out that the flickering period at which the camera captures flickers is a three-frame period.

[0028] If the period is a three-frame period, a spot that is flickering at the three-frame period is specified, the most of flicker spots can be modified by interchanging an image with the average image of three images, and the flickering of flicker spots in the video can be reduced.

[0029] A bandpass filter of $1/3$ fs is a primary FIR (Finite Impulse Response) filter, requires about 13 Taps, is required to take a filter in a time direction, and requires images for consecutive 13 frames. In 30 fps, a processing delay time is around 0.22 seconds and this is a large problem for the processing delay time. The FFT requires a processing time larger than the bandpass filter. According to the present embodiment, because the detecting module 1-2 performs pattern detection by the ternarization on the input captured video, the detection is performed in a comparatively short time, and a delay time is also short due to modification by consecutive three frames.

[0030] A signal level of the flickering on flicker spots in the video is various by the situation of the shooting place and luminous matter and thus the determination by the absolute value is difficult, but detection independent of a signal level difference of the flickering is possible and processing is also simplified by taking a difference between frames and performing ternarization (see FIG. 3).

[0031] FIG. 3 is a graph illustrating a relationship between a value obtained by taking a difference between frames and ternarizing it and the flicker period of the flicker light source. FIG. 3 also includes a graph in which a value is taken by only the difference for comparison. As illustrated in FIG. 3, the case where a difference is ternarized has a simpler pattern than the case of only the difference, and thus it is easy to determine a flicker spot from the image. When ternarizing a difference image, the difference image has values of "plus", "minus", and "other", and "plus" and "minus" are changed in accordance with the flicker period. Therefore, if the pattern of "plus" and "minus" is

determined, a flicker spot can be specified.

[0032] FIG. 4 is a diagram illustrating an example of setting the three-valued flickering pattern 900. An example of combination of the flickering pattern 900 of three values (-1, 0, 1) of difference images 1 to 6, which are obtained by taking differences between the front and rear two frames from consecutive seven frames, is illustrated in FIG. 4.

[0033] The flickering pattern 900 in this case is six patterns of No. 1 to No. 6. Even when considering the phase difference of the flicker light source and the frame rate (fps), only the six patterns may be determined.

[0034] Note that three patterns are hatched in FIG. 4. When three values are treated as the absolute value, "No. 1 and No. 6", "No. 2 and No. 5", and "No. 3 and No. 4" have the same pattern. Therefore, if three values are treated as the absolute value, only the remaining three patterns of No. 1 to No. 3 without hatching can be determined.

[0035] Moreover, the sixth difference image is hatched in FIG. 4. The number of difference images in the time axis direction that are used for the determination is six when observing one or more flicker periods, but the detection is possible while preventing constant false detection if there are five difference images at the shortest.

[0036] However, in the case of a shooting environment of misdetecting a moving object that moves at a speed equivalent to $1/3$ fs, the detection result by the moving object may be canceled.

[0037] Next, the processor of the image processing device 1 will be described in detail.

[0038] FIG. 5 is a diagram illustrating an example of a configuration of detail blocks of the processor. As illustrated in FIG. 5, the processor performs the storage and taking out of processing data into and from a memory 200 such as DRAM or SRAM, and performs modification of the flickering images of the flicker spots on the input captured video.

[0039] From here, each block of the processor in FIG. 5 will be described with reference to FIGS. 6 to 26.

[0040] FIG. 6 is an explanatory diagram illustrating processing of a first brightness generating module 11. The first brightness generating module 11 reduces an image every one image frame 1000 to be a thumbnail image, and takes out a low frequency image from the thumbnail image by an LPF (low-pass filter) to generate a brightened image 1100. When the image is a color image such as RGB, the first brightness generating module 11 generates the brightened image 1100 from the color image.

[0041] Note that the image frame 1000 is also stored in a FIFO area 207 in addition to the first brightness generating module 11. The FIFO area is a storage area in which the storage and taking out of data are performed with the type of FIFO (First-in First-out). The consecutive different-time three image frames 1000 of the captured video are sequentially stored in the FIFO area 207. According to the present embodiment, the FIFO area 207 stores therein the required number of frames with the same image quality as the original up to the plus one frame from the time center of processing. The image processing of the image frame 1000 stored in the FIFO area 207 will be described later.

[0042] The first brightness generating module 11 outputs the generated brightened image 1100 to the memory 200 and a difference image acquiring module 12. The memory 200 has a memory area 201 in which the consecutive different-time two brightened images 1100 are held.

[0043] As described above, the first brightness generating module 11 as an example performs processing of reducing an image to take out a low frequency image. This is because detail such as letters and patterns is not required to be modified when a flicker spot 1001 illustrated in FIG. 6 is a signboard etc., and this processing is performed for the sake of the reduction of the processing load and abstraction.

[0044] FIGS. 7 to 14 are explanatory diagrams illustrating processing of an MV (motion vector) acquiring module 21 and a Global MV (global motion vector) extracting module 22.

[0045] The MV acquiring module 21 divides each of the different-time thumbnail images in the memory area 201 into $m \times n$ (m and n are natural number) areas, and acquires MV of each of the divided areas and outputs it to the

Global MV extracting module 22.

[0046] The acquisition of MV by the MV acquiring module 21 is to calculate a movement from a degree of similarity by template matching to acquire MV as an example. The degree of similarity employs SSD (Sum of Squared Difference), SAD (Sum of Absolute Difference), or the like, as an index of the degree of similarity.

[0047] The Global MV extracting module 22 sorts MVs of the divided areas of $m \times n$, and extracts the Global MV of "1" or "4". The Global MV extracting module 22 outputs one or four Global MVs for performing the total position alignment to a position correcting module 24.

[0048] Moreover, the Global MV extracting module 22 outputs the one or four Global MVs to the memory 200. The memory 200 stores the one or four Global MVs in a memory area 202 to be used for the moving object detection to avoid false flicker detection by the moving object. Note that the moving object detection will be described later.

[0049] The processing of the Global MV extracting module 22 will be described further in detail. FIG. 7 is a diagram illustrating an example of processing of the Global MV extracting module 22. The $m \times n$ MVs acquired by dividing the thumbnail image 1100 into $m \times n$ areas by the MV acquiring module 21 are illustrated in FIG. 7.

[0050] The Global MV extracting module 22 sets a search center 801 and a search range 802 in the coordinate of $m \times n$ MVs, and performs average calculation within the search range 802 on an MV 803 used for the average calculation within the search range 802 and an MV 804 excluded from the average calculation. As illustrated in FIG. 7, the MV 804 is excluded from the average calculation because it is in a marginal area of the search range 802.

Therefore, an actual search size 805 becomes small with reference to the search range 802 as illustrated in FIG. 7.

[0051] FIG. 8 is an explanatory diagram of a Euclidean distance obtained from MV of the corresponding frame and the calculated average MV. As illustrated in FIG. 8, the Euclidean distance from the average is calculated by the following Expression (1) from the MV of the corresponding frame and the calculated average MV. Therefore, the Euclidean distance is calculated from the average coordinate of all MVs.

[0052]

$$\sqrt{(X_{(m,n)} - X_{AVE})^2 + (Y_{(m,n)} - Y_{AVE})^2} \quad (1)$$

[0053] Moreover, the Global MV extracting module 22 uses, for the MV search, ones obtained by further taking out a high frequency from the brightened, reduced, and low frequency image, to make it less susceptible to fluctuations in a DC value by flicker.

[0054] FIGS. 9 and 10 are explanatory diagrams illustrating processing for obtaining the Global MV from the Euclidean distance. The Global MV extracting module 22 extracts the Global MVs from the MVs of $m \times n$.

[0055] As illustrated in FIG. 9, the Global MV extracting module 22 generates a histogram of the Euclidean distance and adds adjacent bins until a 50% bin appears.

[0056] Specifically, the Global MV extracting module 22 finds a mountain that exceeds a certain percentage from the histogram of the Euclidean distance. If there is a bin that exceeds the certain percentage, the Global MV extracting module extracts a range of the mountain of the histogram. The Global MV extracting module calculates an addition histogram obtained by adding the adjacent bins of the first acquired histogram, and increases a width of the adjacent bin to be added until bin exceeding the certain percentage appears, like 1, 2, 3, and ..., for example. The bin is finely taken daringly. As an example, it is regarded as about 1/2 to 1/4 of the reasonable width of bin.

[0057] The Global MV extracting module 22 finds the most frequent bins as accurately as possible. Because small peaks may be picked up when bin setting is too fine in peak detection, the Global MV extracting module 22 finely sets bin itself, but integrates the adjacent bins and takes out an integration bin exceeding 50%.

[0058] As illustrated in FIG. 10, the Global MV extracting module 22 extracts a range of the mountain of the histogram of bin reaching 50%. Then, the Global MV extracting module 22 sets the bin exceeding the certain

percentage or the addition bin as a vertex, and aggregates bins up to bin of the histogram where both sides of the mountain of the histogram continues to fall or the addition histogram as a Global MV group. Moreover, because the MV seems to gently change in a screen even the same movement depending on the movement or projection of the camera, all the MVs belonging to the same mountain are treated as the Global MV.

[0059] The number of areas of the Global MV is "1" or "4" in accordance with a required degree of correction accuracy or computing power of the position correcting module 24. Therefore, the Global MV extracting module 22 calculates an average value of the Global MV group in total or in a quadrant area, and sets the average value as the Global MV value of "1" or "4". At this time, the actual MV is determined by using an average value of addresses of the Global MV group of each area as an end point and by using the Global MV value as a starting point. The MV belonging to bin that has not been used as the Global MV is regarded as a moving object MV.

[0060] FIG. 11 is an explanatory diagram illustrating processing in which the Global MV extracting module 22 determines the Global MV value of "1" or "4". The Global MV extracting module 22 calculates an average value of the Global MV group in total or in a quadrant area of the image area, and sets the average value as the Global MV value of "1" or "4".

[0061] An area 1 to an area 4 illustrated in FIG. 11 are an example of the divided four areas. Like this example, because the accuracy of position correction increases if the four Global MVs divided into four areas are calculated, detection accuracy or modification accuracy of flicker can be also increased. When being divided into four areas as described above, the Global MV extracting module 22 calculates an average value of the MVs corresponding to the Global MV group in each area and an average value of search center coordinates, and sets them as the Global MVs. Note that the MV within an area 1002 illustrated by hatching in FIG. 11 is the moving object MV, and is not used for the calculation of the Global MV.

[0062] FIG. 12 is an explanatory diagram illustrating general image transformation. The four Global MVs are used for so-called trapezoidal transformation or projective transformation that is the general image transformation illustrated in FIG. 12.

[0063] The off MV conversion module 23 converts the MV that is out of the Global MV into the direction and length of the vector. As described above, the MV of the area 1002 illustrated by hatching in FIG. 11 is a moving object MV and is not used for the calculation of the Global MV. The off MV conversion module 23 converts the moving object MV into the direction and length of the vector. The off MV conversion module 23 outputs values of the direction and length after conversion to the memory 200. The memory 200 holds values indicating the direction and length of the vector of the moving object MV in a memory area 203 by consecutive different-time plural images.

[0064] FIG. 13 is an explanatory diagram illustrating processing of the off MV conversion module 23. The off MV conversion module 23 converts the off MV within the area 1002 into the approximate direction of the vector and the length of the vector from the search center point coordinates (X coordinate, Y coordinate) and the MV coordinates (X coordinate, Y coordinate).

[0065] FIG. 14A and FIG. 14B are diagrams explaining an example of conversion to the approximate direction of the vector and the length of the vector of the off MV. In FIG. 14A, eight directions of 0 to 7 are illustrated as the conversion destinations of the approximate direction of the vector of the off MV. The off MV conversion module 23 basically determines the image limit and the direction with the sign and magnitude relationship of $\text{atan}(X/Y)$ and XY .

[0066] An example of conversion to the length of the vector of the off MV is illustrated in FIG. 14B. The off MV conversion module 23 sets the Euclidean distance of the MV from the search center point as a length.

[0067] The off MV conversion module 23 outputs a value after conversion to the memory 200. The memory 200 stores it in the FIFO 203 by the required number of images.

[0068] As described above, the off MV conversion module 23 converts the off MV into the direction and length

and stores them in the FIFO 203, and thus can facilitate the subsequent analysis and can reduce an amount of data.

[0069] FIG. 15 is an explanatory diagram illustrating processing of the position correcting module 24, the difference image acquiring module 12, and a ternarization module 13. The position correcting module 24 acquires the consecutive different-time two images generated by the first brightness generating module 11 from the memory area 201, and performs, on one of two images, position correction of aligning the position to one image of two images by using the Global MV extracted by the Global MV extracting module 22.

[0070] The difference image acquiring module 12 acquires a difference between the position-corrected consecutive different-time two images. The ternarization module 13 ternarizes a difference image output from the difference image acquiring module 12.

[0071] The position-corrected consecutive different-time two images 1100-1 and 1100-2 are illustrated in FIG. 15. The two images 1100-1 and 1100-2 correspond to images of consecutive frames sequentially captured in the time axis direction illustrated in FIG. 15. A difference between the two images 1100-1 and 1100-2 position-corrected by the position correcting module 24 is ternarized to output a ternarized image 1200. As an example, the white area of the ternarized image 1200 is "plus (+)", the black area is "minus (-)", and the gray area is "the other". As described above, by taking a difference after performing position correction by the position correcting module 24, a flicker spot 1201 and a moving object (portion that could not be corrected) 1202 as illustrated in FIG. 15 are extracted. The flicker spot 1201 is a signboard etc. that become a flicker light source in the images 1100-1 and 1100-2 before taking the difference. The moving object 1202 is a walker in the images 1100-1 and 1100-2 before taking the difference.

[0072] Note that a dotted line is an image of the position to be taken out when being corrected by the four Global MVs. A portion without the image is supplemented by copying the image of the edge of a portion with the image. As described above, the subsequent processing load can be also reduced by ternarizing.

[0073] FIG. 16 is a reference diagram for comparison with FIG. 15. An example in which position correction is not performed is illustrated in FIG. 16. As illustrated in FIG. 16, because the other information of the flicker spot 1201 and the moving object 1202 also remains as noise when the position correction is not performed, the processing load increases due to the subsequent processing.

[0074] FIG. 17A to FIG. 17D are explanatory diagrams illustrating processing of a differential moving object detecting module 14. The differential moving object detecting module 14 performs differential moving object detection of estimating the moving object by using the polarity of a differential moving object included in the ternarized image 1200 acquired by the ternarization module 13.

[0075] As illustrated in FIG. 17A, in the ternarized image 1200, the flicker spot 1201 corresponds to the response of "-" to change from the bright to the dark or the response of "+" to change from the dark to the bright, but the moving object 1202 has adjacent "+" and "-" in many cases because there are a spot where the moving object becomes a background and a spot where the background becomes the moving object when the moving object moves. From FIG. 17A, because the flicker spot 1201 does not have adjacent white (+) and black (-), it turns out that "+" and "-" are not adjacent. On the other hand, because the moving object 1202 has adjacent black and white, it turns out that "+" and "-" are adjacent.

[0076] Therefore, the differential moving object detecting module 14 takes the following procedure for performing the adjacency determination of "+" and "-". As illustrated in FIG. 17B, the differential moving object detecting module 14 aggregates "+" and "-" of the ternarized image 1200 every area. As an example, the differential moving object detecting module 14 reduces the ternarized image 1200, and aggregates "+" and "-" of cells set in a reduced image 1300. An image 1310 and an image 1320 respectively are images indicating the aggregate results of "+" and "-".

[0077] Next, the differential moving object detecting module 14 scans the aggregated images 1310 and 1320 with

a constant template, adds +1 when there are both of "+" and "-", and normalizes the aggregate result by using an area of the template as 1. The aggregate result 1330 is an absentminded portion inside it.

[0078] FIG. 17D is a diagram illustrating an example of a differential moving object detection result 1350 by the differential moving object detecting module 14. From the differential moving object detection result 1350 illustrated in FIG. 17D, it turns out that the flicker spot 1201 is not detected and the moving object 1202 is detected.

[0079] FIG. 18 is an explanatory diagram illustrating processing of a subtraction module 15. The subtraction module 15 subtracts the ternarized image 1200 acquired from the ternarization module 13 from the differential moving object detection result 1350 acquired from the differential moving object detecting module 14. The subtraction module 15 outputs subtraction results to the memory 200. The memory 200 holds the consecutive different-time subtraction results in a memory area 206.

[0080] As illustrated in FIG. 18, the subtraction module 15 includes a multiplier 151 and a subtractor 152. The subtractor 152 inputs the differential moving object detection result 1350 normalized with the maximum value 1 from an input A, and outputs a result of "1.0 - input A" to the multiplier 151.

[0081] The multiplier 151 multiplies the input of the ternarized image 1200 by the input from the subtractor 152, and outputs a subtracted image 1400 with the reduced moving object 1202 detected by the differential moving object detection to the memory 200. In other words, differential moving object information is reduced from the ternarized image, and the result is stored in the FIFO 206 by the required number of images.

[0082] By providing the subtraction module 15, a portion that seems to be the moving object becomes hard to be miss-detected by the subsequent matching filter.

[0083] FIG. 19 is an explanatory diagram illustrating processing of a position correcting module 16. The position correcting module 16 performs image position alignment of consecutive different-time subtraction results 1400 (e.g., subtraction results 1400-1 to 1400-6) of the FIFO 206.

[0084] As illustrated in FIG. 19, when the position correcting module 16 integrates the Global MVs with reference to either the left or right image of the time center and aligns and superimposes the positions of the remaining five images, an object that does not move overlaps it. The dotted line is an image at the position to be taken out when being corrected by the four Global MVs. A portion without the image is supplemented by copying the image of the edge of a portion with the image.

[0085] FIG. 20 is an explanatory diagram illustrating processing of an MV moving object detecting module 25. The MV moving object detecting module 25 detects a moving object by the MV moving object detection from the direction and length of the off MV stored in the FIFO 203. In FIG. 20, an example in which the movement of a pigeon 1501 is detected is illustrated as an example. The MV moving object detecting module 25 outputs the result of the MV moving object detection to a matching filter 17 so as to cancel false detection of flicker by the MV moving object in the matching filter 17.

[0086] On the other hand, it would be good if the off MV is the moving object, but the fake MV is generated in SSD or SAD when there is not a search image within the search range. A main cause includes a case where the movement is too large, an appearance from the off-screen, a disappearance to the off-screen, a case where image patterns are different by the bright and dark of flicker, and the like. Among them, what an action is required is a distinction between the case where image patterns are different by the bright and dark of flicker and other cases.

[0087] Therefore, the MV moving object detecting module 25 generates a moving object map not to modify the flickering when determining a moving object from among the off MV, and sends the moving object map to the matching filter 17.

[0088] FIG. 21 is an explanatory diagram illustrating processing of position aligning modules 31 and 32. The position aligning modules 31 and 32 perform position alignment on images before and after the time-centered image

among the images held in the FIFO 207 by using the Global MVs held in the memory 202. FIG. 21 illustrates an example of the result after an image 1600-1 before one frame and an image 1600-3 after one frame are aligned to a time-centered image 1600-2.

[0089] FIGS. 22 and 23 are explanatory diagrams illustrating processing of a second brightness generating module 34 and the determining module 35 for brightness matching degree and pattern matching degree.

[0090] The second brightness generating module 34 reduces and brightens the time-centered image and the images after position alignment with respect to images before and after the time center output from the position aligning modules 31 and 32.

[0091] The determining module 35 for brightness matching degree and pattern matching degree determines a brightness matching degree and an image mismatching degree based on three images after brightening output from the second brightness generating module 34, and outputs a map of the determination result to the matching filter 17. The determining module 35 outputs the map of the determination result of brightness matching degree and pattern matching degree, so as to be able to cancel the result of false detection of the matching filter 17.

[0092] FIG. 22 is a diagram illustrating an example of a brightness matching degree determining module included in the determining module 35. The brightness matching degree determining module uses the brightened, reduced, and low frequency image. The brightness matching degree determining module inputs in pixels a time-centered brightness image (Center) 1700-2, a brightness image (-1 frame) 1700-1 before one frame, and a brightness image (+1 frame) 1700-3 after one frame to a first comparator 351 and a second comparator 352, and subtracts the minimum value of a brightness value output from the first comparator 351 from the maximum value of a brightness value output from the second comparator 352 by using a subtractor 353. Then, a calculator 354 outputs from an arithmetic unit (A/B 354) a ratio of an output value (maximum value) B from the second comparator 352 and an output value A from the subtractor 353, and inputs the result to a determining module 356. Based on a brightness matching degree determination table 3550, the determining module 356 outputs a brightness matching degree per pixel.

[0093] In this way, the brightness matching degree determining module generates a map of pushing down pattern matching with the smallness (brightness matching degree) of a flicker level with respect to a signal level.

[0094] FIG. 23 is a diagram illustrating an example of an image mismatching degree determining module included in the determining module 35. The image mismatching degree determining module uses the brightened, reduced, and high frequency image. The image mismatching degree determining module inputs in pixels a time-centered brightness image (Center) 1800-2 and a brightness image (-1 frame) 1800-1 before one frame to a first subtractor 361, and inputs the time-centered brightness image (Center) and a brightness image (+1 frame) 1800-3 after one frame to a second subtractor 362. The first subtractor 361 subtracts the brightness image (-1 frame) 1800-1 before one frame from the time-centered brightness image (Center) 1800-2, and outputs the result to a first ABS 363 that takes the absolute value of the subtraction result. The second subtractor 361 subtracts the brightness image (+1 frame) 1800-3 after one frame from the time-centered brightness image (Center) 1800-2, and outputs the result to a second ABS 364 that takes the absolute value of the subtraction result. The output results of the first ABS 363 and the second ABS 364 are integrated by an adder 365 in pixels, and the image after the integration is output from an $N \times N$ box 366 to a determining module 367. The determining module 367 performs the differential absolute value determination on the image in units of $N \times N$. Based on an image mismatching degree determination table 3670, the determining module 367 determines an image mismatching degree in units of $N \times N$ and outputs the result.

[0095] FIG. 24 is an explanatory diagram illustrating processing of the matching filter 17. To specify whether a unit pixel area is a flicker spot for each unit pixel of the time-centered image among the three-frame images in the memory area 207, the matching filter 17 detects the flicker spot by pattern matching from consecutive difference images (ternarized value). A unit area may be a pixel area of one pixel, or may be a pixel area consisting of multiple

pixels.

[0096] Moreover, in accordance with the results of the MV moving object detecting module 25 and the determining module 35, the matching filter 17 cancels a pixel detected as a flickering spot as misdetecting.

[0097] The matching filter 17 illustrated in FIG. 24 includes pattern detectors 171-1, 171-2, and 171-3 of three patterns that perform parallel processing. Each of the pattern detectors 171-1, 171-2, and 171-3 includes six taps 173 inside a tapping unit 172.

[0098] No. 1, No. 2, and No. 3 of setting the three-valued flickering pattern 900 (see FIG. 4) are respectively set in the six taps 173 of the pattern detectors 171-1, 171-2, and 171-3 without change. For example, No. 1 (-1, 0, 1, -1, 0, 1) is set in the six taps 173 of the pattern detector 171-1, No. 2 (0, 1, -1, 0, 1, -1) is set in the six taps 173 of the pattern detector 171-2, and No. 3 (-1, 1, 0, -1, 1, 0) is set in the six taps 173 of the pattern detector 171-3. Note that setting for the pattern detectors 171-1, 171-2, and 171-3 is an example and thus such the setting is not limited to the setting of No. 1, No. 2, and No. 3.

[0099] The difference images 1400-1, 1400-2, ..., and 1400-6 in the time axis direction after position alignment are respectively input into the six taps 173 of each of the pattern detectors 171-1, 171-2, and 171-3 from the position correcting module 16 in parallel. Herein, the difference images 1400-1, 1400-2, ..., and 1400-6 correspond to the subtraction results 1400-1, 1400-2, ..., and 1400-6.

[0100] When the ternarized pixel value ("plus", "minus", "the other") of the input difference images 1400-1, 1400-2, ..., and 1400-6 and the set value ("+1", "-1", "0") are identical with each other, each tap 173 outputs the value. Note that "0" is equivalent to "don't care". When "plus" comes, because it corresponds to "+1", the tap outputs High "1". When "minus" comes, because it corresponds to "-1", the tap outputs Low "-1". When "the other" comes, because it corresponds to "0", it is "don't care".

[0101] Each of the pattern detectors 171-1, 171-2, and 171-3 adds the outputs of the corresponding six taps 173 by using the corresponding adder, and outputs the addition result to a corresponding one of ABSs 174-1, 174-2, and 174-3 of an ABS unit 174.

[0102] Each of the ABSs 174-1, 174-2, and 174-3 takes an absolute value of the addition result, and outputs the absolute value of the addition result to a maximum value determining module 175.

[0103] When there is the input of the maximum value "4" from one of the ABSs 174-1, 174-2, and 174-3, the maximum value determining module 175 outputs the matching result "4" to a subtractor 177. The subtractor 177 outputs the matching result "4" to a determining module 178, and the determining module 178 determines whether it is the pixel of the flicker spot from the matching result.

[0104] Based on a determination table 1780, the determining module 178 determines that it is the pixel of the flicker spot when the matching result is "4".

[0105] Note that the results from the MV moving object detecting module 25 and the determining module 35 are input into the subtractor 177. When the input from the MV moving object detecting module 25 or the determining module 35 is provided to the subtractor 177, the subtractor 177 performs subtraction (pressing down) from the matching result "4", and outputs the result to the determining module 178. In this case, the determining module 178 determines whether it is the pixel of the flicker spot based on the determination table 1780, and determines that it is not the pixel of the flicker spot when the value is smaller than a threshold. In other words, it is detected as the flicker spot because the matching result indicates "4", but the determination as the flicker spot is canceled if it is a false detection of the moving object etc.

[0106] Note that this example employs the three pattern detectors 171-1, 171-2, and 171-3 because the ABS unit 174 is provided to take the absolute value, but six pattern detectors are used in which patterns of No. 1 to No. 6 are set in taps and are used when not taking the absolute value.

[0107] Moreover, the number of pattern detectors and the number of taps are one example, the present embodiment is not limited to them. For example, the number of taps may be reduced to five etc. as appropriate if the detection is possible while preventing constant false detection.

[0108] As described above, the matching filter 17 detects the pixel area of the flicker spot by applying the matching filter in the time axis direction of the consecutive difference images. A sum of absolute values of coefficients is "4" originally if matching is performed, but because it is subtracted by the result of the differential moving object determination, the brightness mismatching degree, or the image matching degree for the sake of the prevention of false detection, the determination has gradation so as to be an α blend value when modifying the flicker spot.

[0109] FIG. 25 is an explanatory diagram illustrating an averaging module 33 and a selecting module 18. The averaging module 33 inputs the time-centered image 1000-2 in the memory area 207 and the images after position alignment of the images 1000-1 and 1000-3 before and after the time center output from the position aligning modules 31 and 32, and generates an average image of the three images.

[0110] The selecting module 18 receives the time-centered image 1000-2 in the memory area 207 and the average image output from the averaging module 33, and selects either the time-centered image 1000-2 or the average image in accordance with the output result of the matching filter 17. The selecting module 18 selects the average image when the output result of the matching filter 17 is an output result that the flicker spot has been detected, and outputs a modified image replaced with the average image. Moreover, the selecting module 18 selects the time-centered image 1000-2 as it is when the output result of the matching filter 17 is not the output result that the flicker spot has been detected, and outputs the time-centered image 1000-2 without modification. The replacement to the average image may be performed every frame image. Moreover, only the pixel area detected as the flicker spot among the original of the time-centered image 1000-2 may be replaced with the corresponding average image to use one modified image obtained by blending the original image and the average image. In other words, modification of being partially replaced with a value obtained by averaging along with the pixel area may be performed.

[0111] An α blend module 182 illustrated in FIG. 25 includes a first multiplier 183, a second multiplier 184, and an adder 185.

[0112] An averaging module 330 inputs in pixels the time-centered image (Center) 1000-2, the image (-1 frame) 1000-1 before one frame, and the image (+1 frame) 1000-3 after one frame, and outputs the averaged pixels to the second multiplier 184 of the α blend module 182. The pixels of the time-centered image (Center) 1000-2 are input into the first multiplier 183. From the matching filter 17, a value of the matching determination result is expanded by an expansion module 181 at a predetermined level, and this value is input into the α blend module 182 as an α blend value.

[0113] In the α blend module 182, the first multiplier 183 blends the pixels of the time-centered image (Center) 1000-2 at the ratio of $1-\alpha$, and outputs it to the adder 185. The second multiplier 184 blends the pixels of the average image from the averaging module 330 at the ratio of α , and outputs it to the adder 185.

[0114] The adder 185 adds the outputs of the first multiplier 183 and the second multiplier 184, and outputs the blended image as the modified image.

[0115] FIG. 26 is a diagram illustrating an example of the output results after modifying the flickering of flicker spots. The consecutive images illustrated in FIG. 26 are consecutive images before and after modifying the captured video.

[0116] As illustrated in FIG. 26, along the time axis direction in the consecutive images before modification, the flicker spots 1001 and 1002 are "bright" in the first image 1000-1, the flicker spots 1001 and 1002 are "dark" in the second image 1000-2 and the third image 1000-3, and the flicker spots 1001 and 1002 are again "bright" in the fourth

image 1000-4. On the contrary, it is found that, along the time axis direction in the images after modification, the flicker spots 1001 and 1002 in all frames 2000-1 to 2000-4 are modified to the averaged image so as not to have a change in flickering. Herein, as an example, the flicker spots 1001 and 1002 are illustrated as images of "dark", but the present embodiment is not limited to this. If images have equivalent brightness over the consecutive frames, the images may be "bright" images, or may be images with constant brightness between the "bright" and "dark". To prevent impairing an atmosphere of the video, it is sufficient that the flicker spots 1001 and 1002 on the video are not flickered.

[0117] As described above, it is possible to reduce the flickering in the captured video in the present embodiment. Moreover, because the flickering of flicker spots on the video captured by short exposure shorter than the flicker period can be reduced, overexposure can be prevented even when dimming cannot be performed by a dimming means such as the ND filter and Iris.

[0118] FIG. 27 is a diagram illustrating an appearance of a smartphone 2 that is one of application examples of the image processing device 1. The smartphone 2 illustrated in FIG. 27 is a smartphone whose camera does not include a dimming means such as ND filter and Iris or whose camera includes simple Iris. Even in a smartphone that does not include the dimming means such as ND filter and Iris or that includes the simple Iris, it is possible to reduce the flickering of the flicker light source filmed by the camera by applying the image processing device 1 according to the present embodiment.

[0119] FIG. 28 is a diagram illustrating an appearance of a camera 3 including an image sensor, which is another of the application examples of the image processing device 1. The camera 3 illustrated in FIG. 28 includes dimming means such as an ND filter 5 and an Iris 6. The Iris 6 is included in a lens 4. Even in the camera 3 including the dimming means such as the ND filter 5 and the Iris 6, it is possible to reduce the flickering of the flicker light source filmed by the camera 3 by applying the image processing device 1 according to the present embodiment. Of course, a camera that does not include the dimming means such as the ND filter 5 and the Iris 6 can also reduce the flickering of the flicker light source filmed by the camera by applying the image processing device 1 according to the present embodiment.

[0120] Some or all of the configuration of the processor illustrated in FIG. 5 may be realized by hardware such as ASIC (Application Specific Integrated Circuit), or may be realized by software.

[0121] FIG. 29 is a diagram illustrating an example of hardware blocks of a computer configuration of the image processing device 1. FIG. 29 illustrates a configuration that a CPU (Central Processing Unit) 50, a memory 51 such as a ROM (Read Only Memory) and a RAM (Random Access Memory), a recording medium 52, a camera 53, and an output unit 54 are connected via a bus 55.

[0122] The CPU 50 loads a program into the memory 51 such as ROM or RAM and executes the program to realize some functions or all functions of the processor illustrated in FIG. 5.

[0123] The camera 53 includes an image sensor. The camera 53 may be an external camera or a built-in camera.

[0124] The recording medium 52 stores a program for realizing each function of the processor. The program may be a program that is downloaded and stored from a network such as the Internet, or may be a program product or a recording medium that is stored in the recording medium and is distributed.

[0125] The output unit 54 is a display device such as a display as an example. The output destination of the video is not limited to the display device. In addition, the output destination may be a recording medium, a recording device of a communication destination, or the like.

[0126] FIG. 30 is a diagram illustrating an example of an image processing flow performed by the processor of the image processing device 1. As illustrated in FIG. 30, the processor of the image processing device 1 inputs a video captured by the camera etc. (Step S1). Next, the processor generates difference images indicating brightness change

between consecutive images in the time axis direction of the input captured video (Step S2). Next, the processor detects a brightness change pattern that is a flickering pattern of the flicker light source from the plurality of difference images consecutively generated in the time axis direction (Step S3). Next, the processor modifies images of flicker spots in the input captured video based on the detection result of the pattern detection (Step S4). Then, the processor outputs the modified captured video as a modified video whose flickering of flicker spots is reduced (Step S5).

[0127] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

[Explanations of Letters or Numerals]

[0128]

- 1: Image processing device
- 1-1: Generating module
- 1-2: Detecting module
- 1-3: Image modifying module
- 900: Predetermined pattern
- 1000: Image frame

[Type of Document] Scope of claims for patent

1. An image processing device comprising:

a generating module configured to generate a plurality of difference images indicating a brightness change between consecutive images in a time axis direction of an input captured video;

a detecting module configured to detect a brightness change pattern that is a flickering pattern of a flicker light source from the plurality of difference images consecutive in the time axis direction; and

an image modifying module configured to modify an image of a flicker spot in the input captured video, based on a detection result of the pattern detection.

2. The image processing device according to claim 1, wherein the detecting module is configured to detect the brightness change pattern that is the flickering pattern of the flicker light source from the plurality of difference images consecutive in the time axis direction, every unit area of the difference image.

3. The image processing device according to claim 1, further comprising:

a motion vector generating module configured to generate a motion vector from the input captured video; and

a moving object detecting module configured to detect a moving object based on the generated motion vector, wherein

the detecting module is configured to reflect a result of the moving object detection by the moving object detecting module on a result of the pattern detection.

4. The image processing device according to claim 1, further comprising:

a motion vector acquiring module configured to acquire a motion vector from the input captured video; and
a determining module configured to determine a brightness degree or a pattern based on a brightness change of aligned images of a plurality of consecutive frames in the captured video based on the acquired motion vector, wherein

the detecting module is configured to reflect a result of determination by the determining module on a result of the pattern detection.

5. The image processing device according to claim 1, further comprising:

a subtraction module configured to subtract a moving object detected by a polarity of the brightness change from the consecutive difference images generated by the generating module, wherein

the detecting module is configured to detect the brightness change pattern that is the flickering pattern of the flicker light source, from difference images obtained by subtracting the moving object from the plurality of difference images consecutive in the time axis direction.

6. The image processing device according to claim 1, wherein the image modifying module is configured to modify the image of the flicker spot in the input captured video to an averaged image obtained by averaging the image by using anteroposterior images continuous with the image.

7. The image processing device according to claim 6, wherein the image modifying module is configured to perform modification of partially replacing a pixel area of the flicker spot in the input captured video with a value obtained by averaging the pixel area and pixel areas of consecutive anteroposterior images.

8. The image processing device according to claim 2, wherein the pattern detection is performed by matching between a three-valued flickering pattern and a three-valued brightness change pattern, which uses a matching filter.
9. The image processing device according to claim 8, wherein
 - a number of three values of the flickering pattern set for the matching filter is six or less, and
 - the matching is concurrently performed by using consecutive six difference images or less.
10. The image processing device according to claim 1, wherein
 - a frequency of the flicker light source is an integral multiple of 50 Hz, and
 - a frame rate of the video includes 60 fps, 30 fps, or 24 fps.
11. The image processing device according to any one of claims 1 to 10, wherein the detecting module is configured to detect a pattern of flickering of a three-frame period in the input captured video.
12. A method of performing image processing on a video by an image processing device, the method comprising:
 - generating a plurality of difference images indicating a brightness change between consecutive images in a time axis direction of an input captured video;
 - detecting a brightness change pattern that is a flickering pattern of a flicker light source from the plurality of difference images consecutive in the time axis direction; and
 - modifying an image of a flicker spot in the input captured video, based on a detection result of the pattern detection.
13. A program causing a computer of an image processing device to execute:
 - generating a plurality of difference images indicating a brightness change between consecutive images in a time axis direction of an input captured video;
 - detecting a brightness change pattern that is a flickering pattern of a flicker light source from the plurality of difference images consecutive in the time axis direction; and
 - modifying an image of a flicker spot in the input captured video, based on a detection result of the pattern detection.

FIG.1

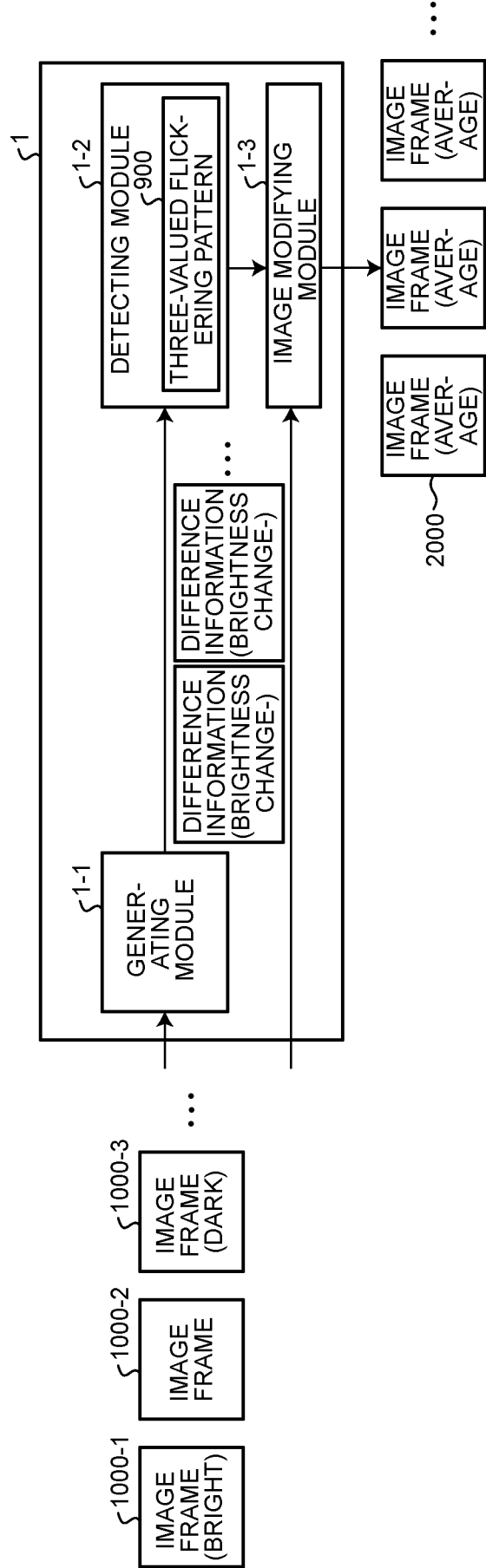


FIG. 2

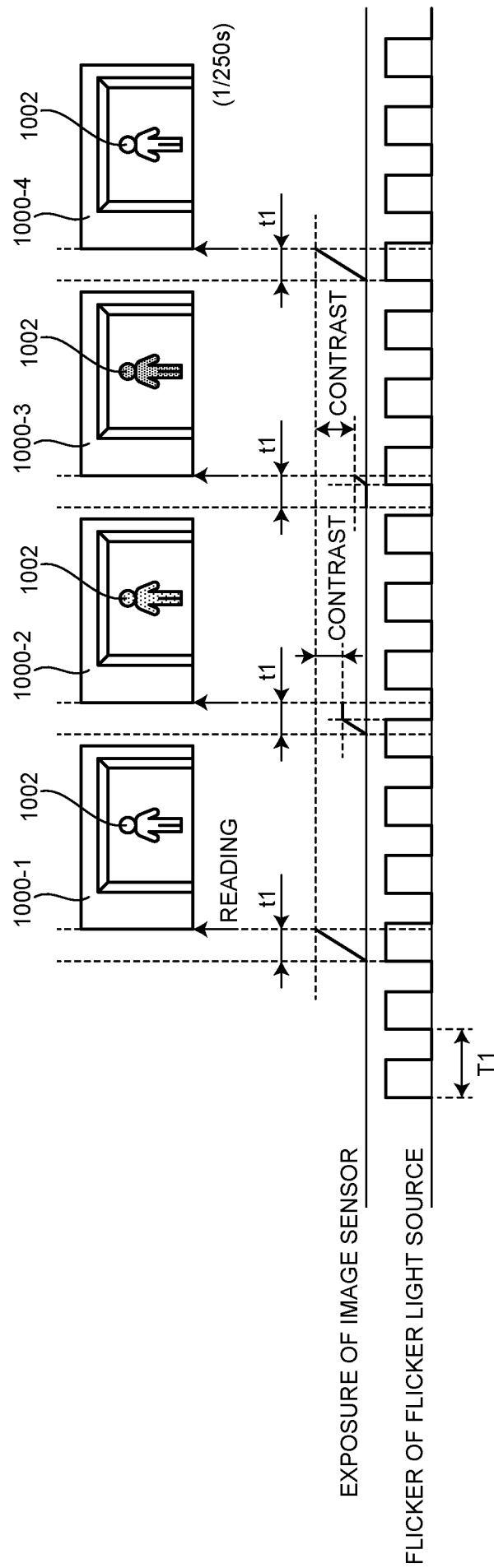


FIG.3

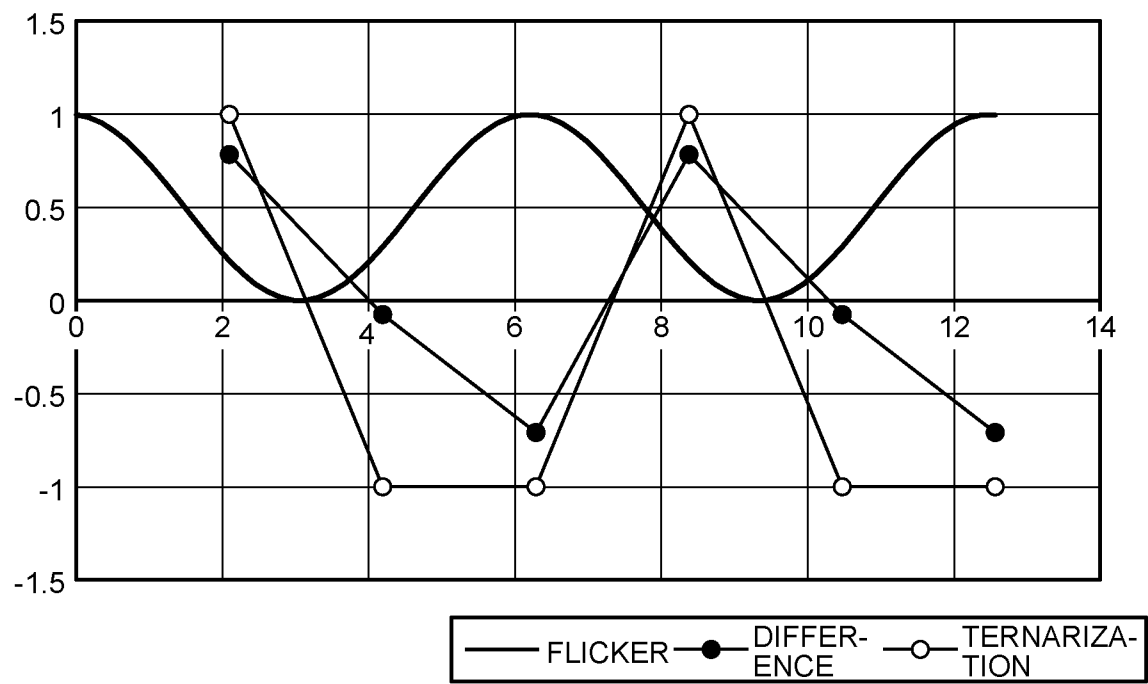


FIG.4

900

No.	DIFFERENCE IMAGE					
	1	2	3	4	5	6
1	-1	0	1	-1	0	1
2	0	1	-1	0	1	-1
3	-1	1	0	-1	1	0
4	1	-1	0	1	-1	0
5	0	-1	1	0	-1	1
6	1	0	-1	1	0	-1

FIG. 5

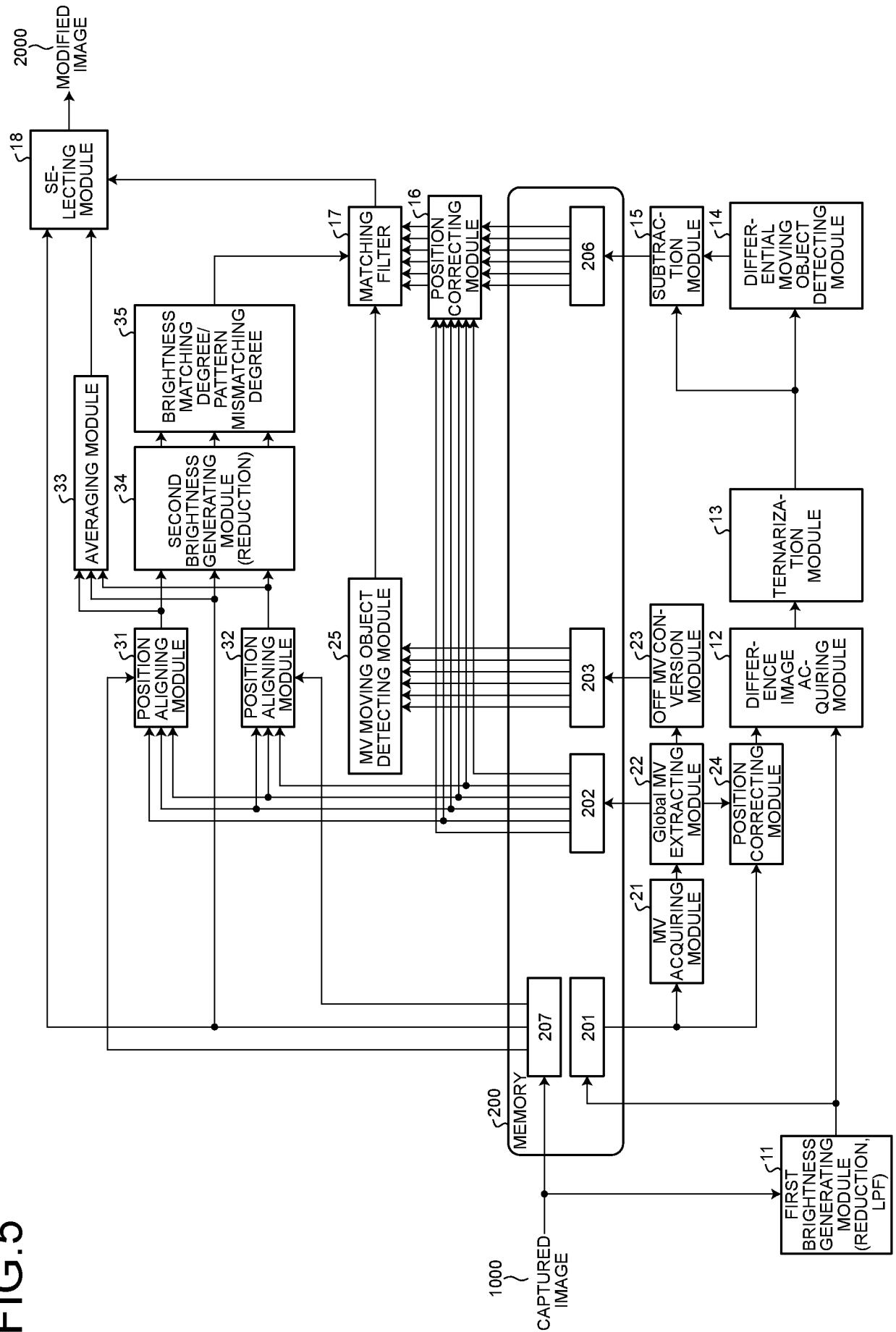


FIG.6

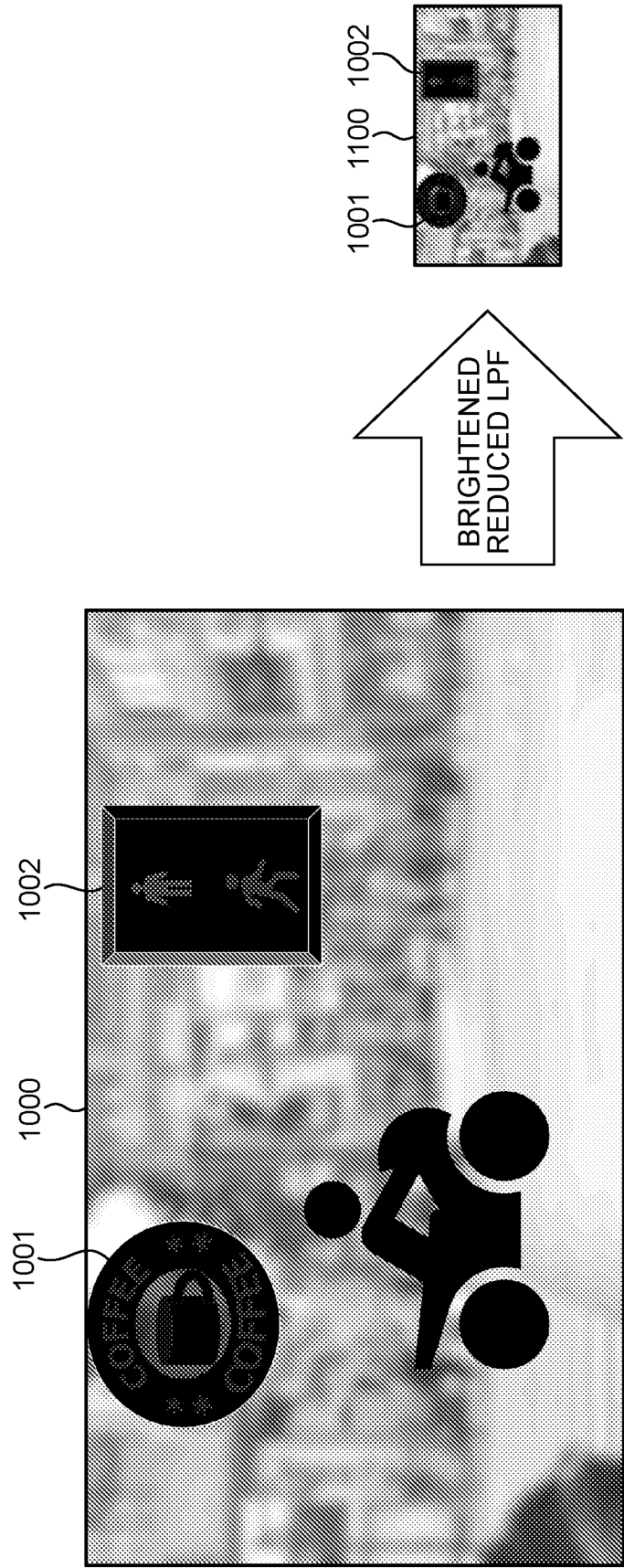


FIG.7

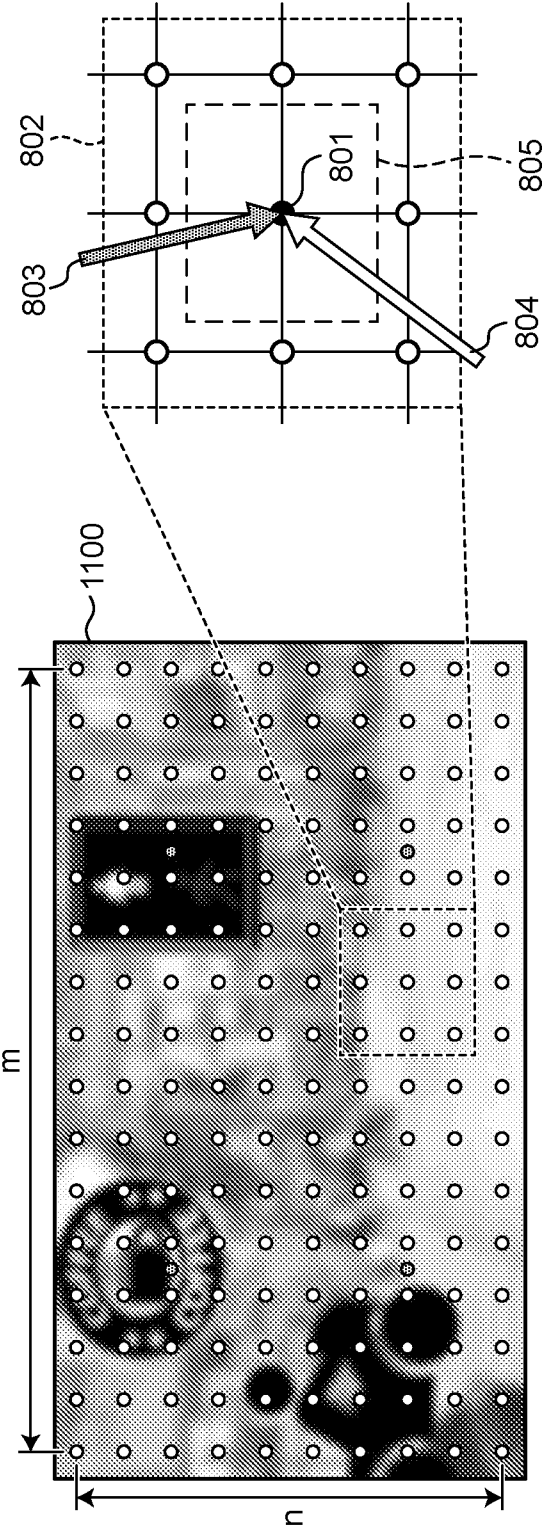


FIG.8

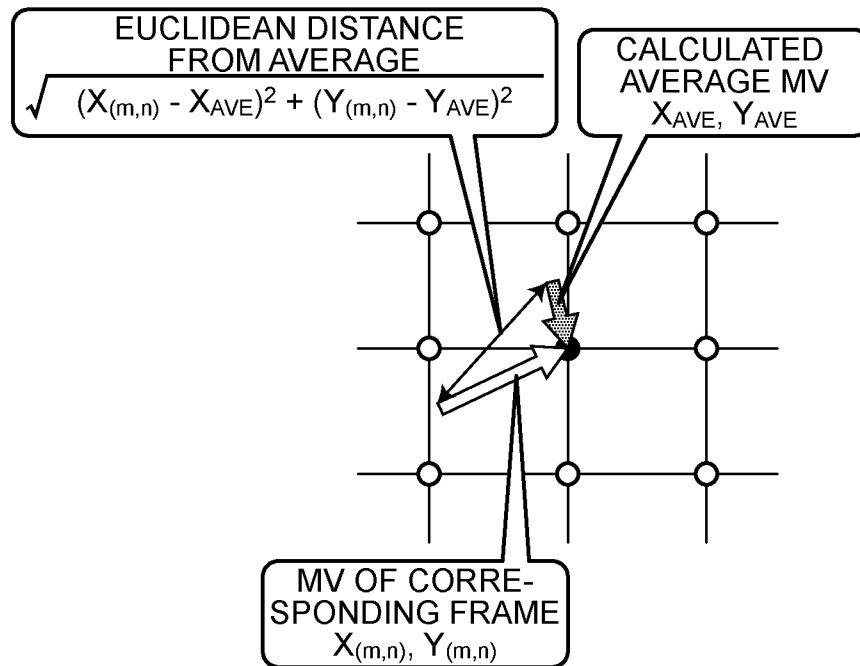


FIG.9

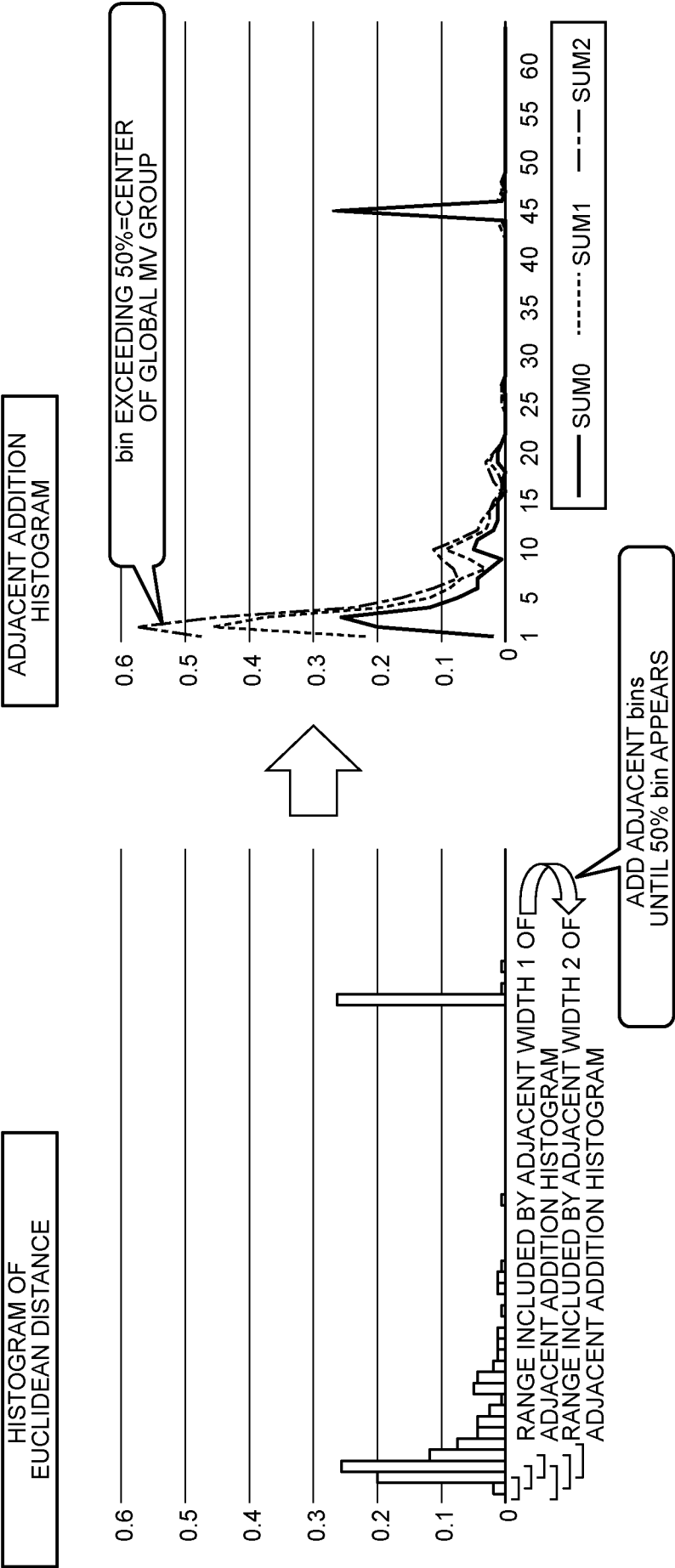
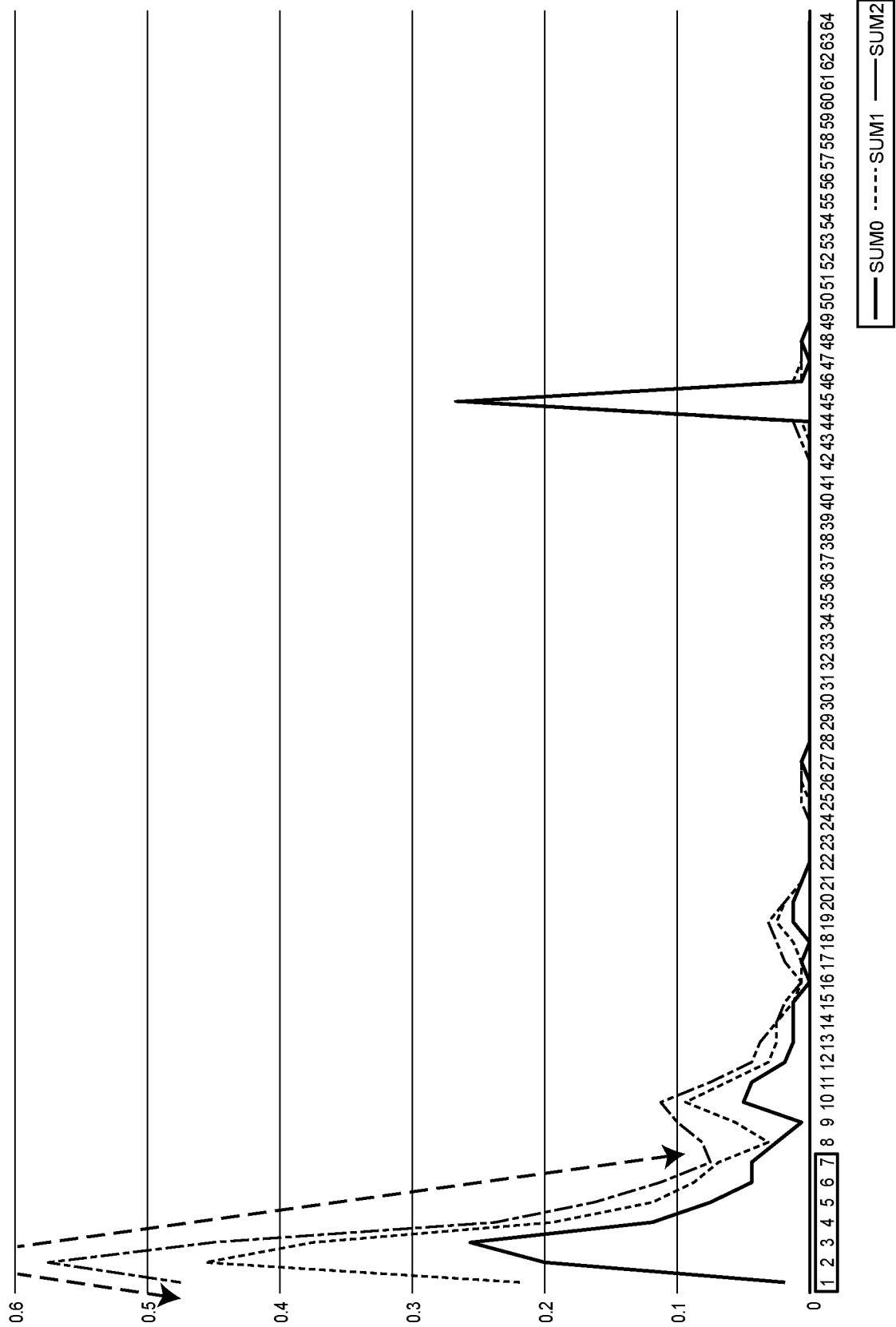


FIG.10



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FIG.11

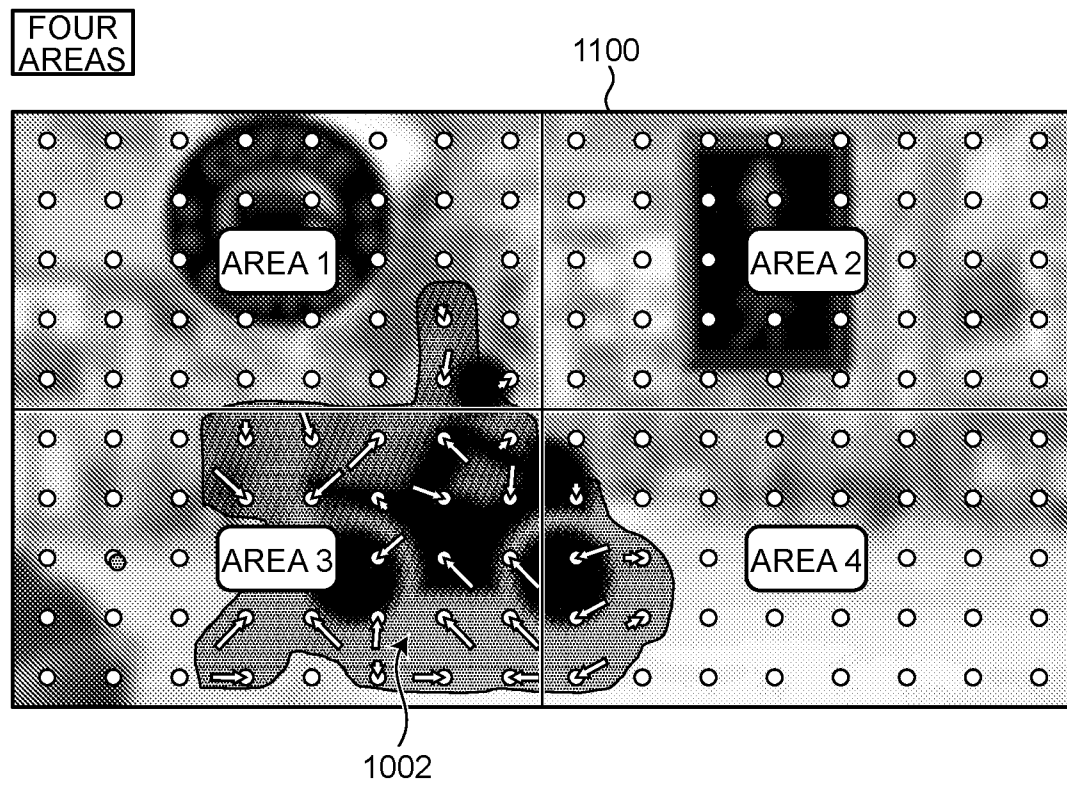


FIG.12

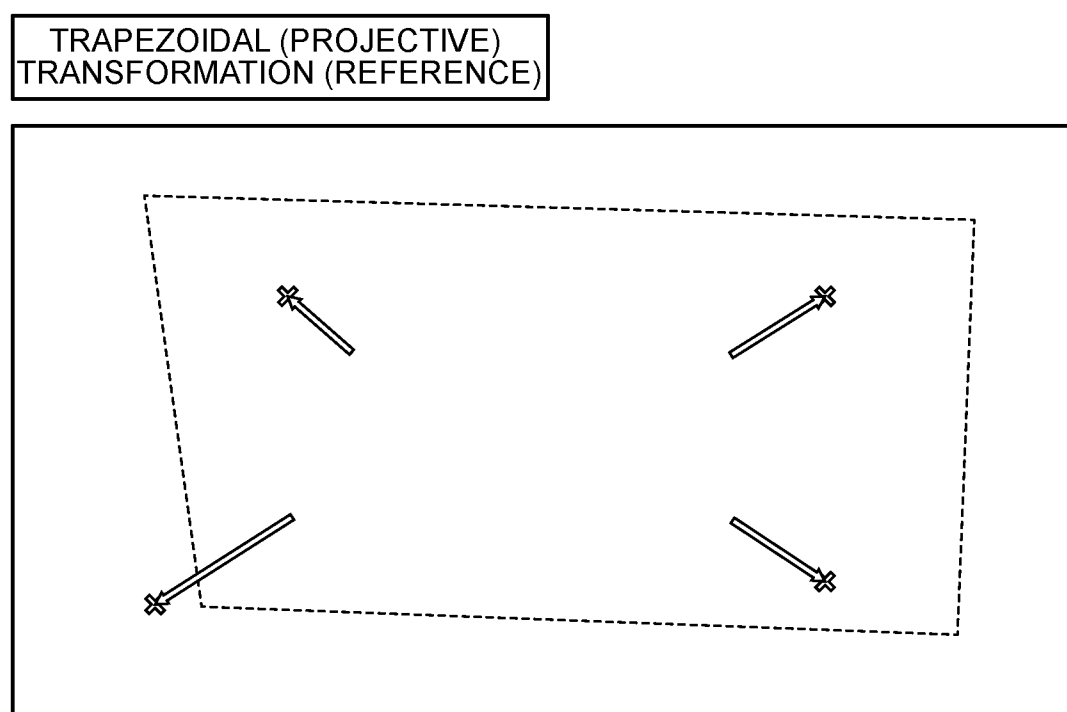


FIG.13

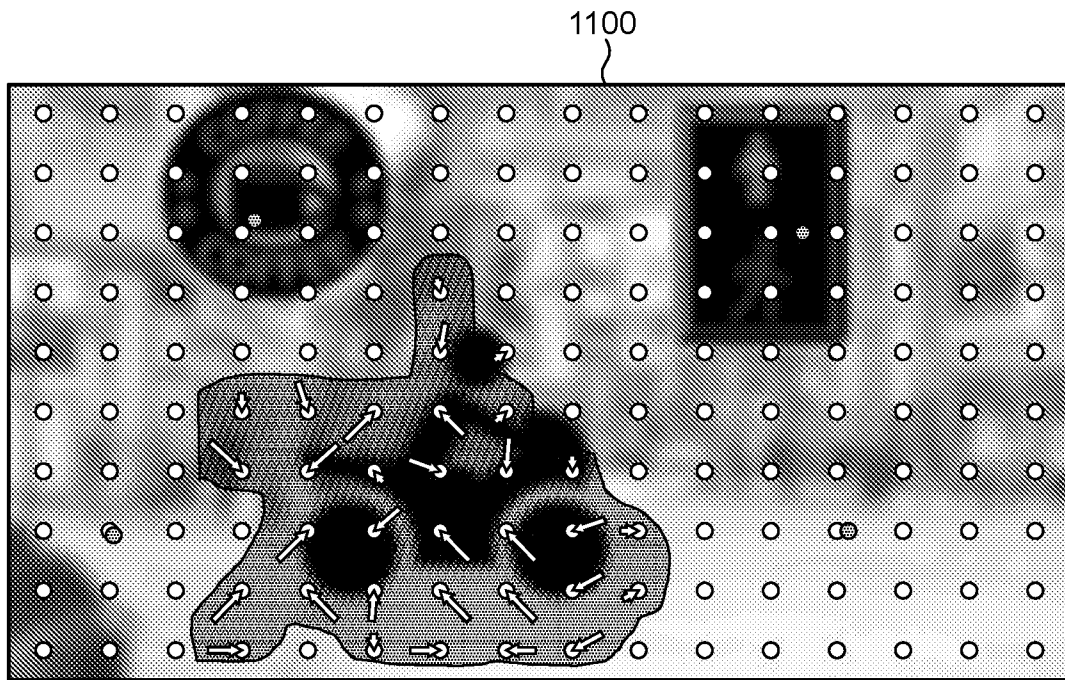


FIG.14A

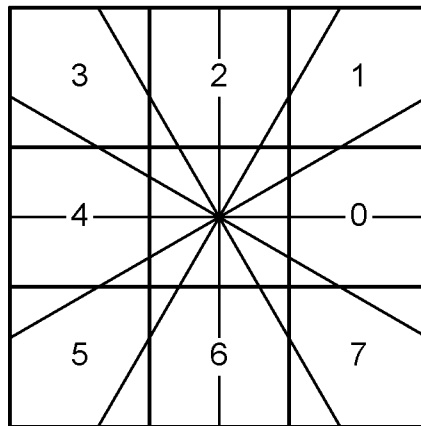


FIG.14B

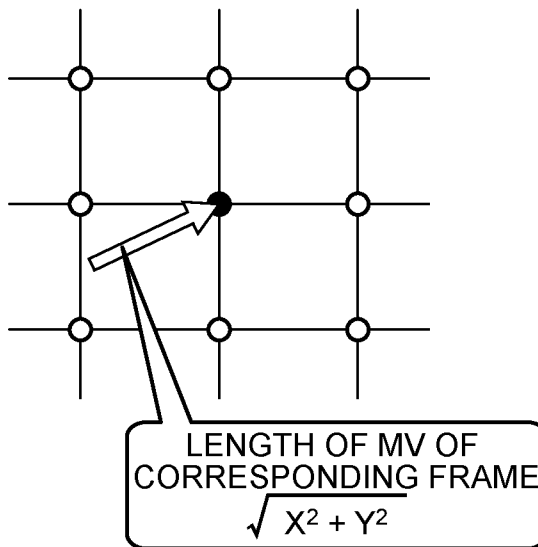


FIG.15

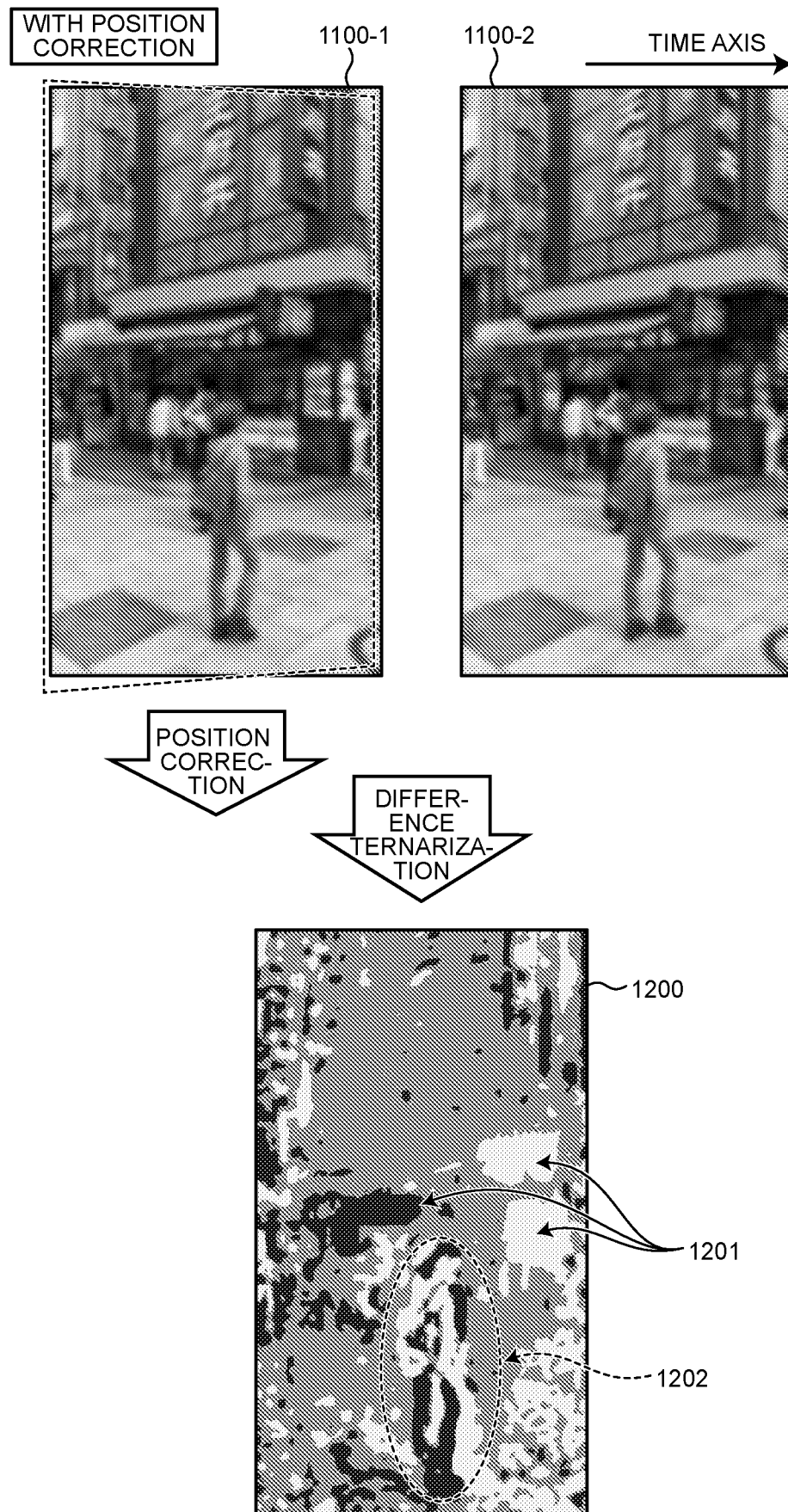


FIG.16

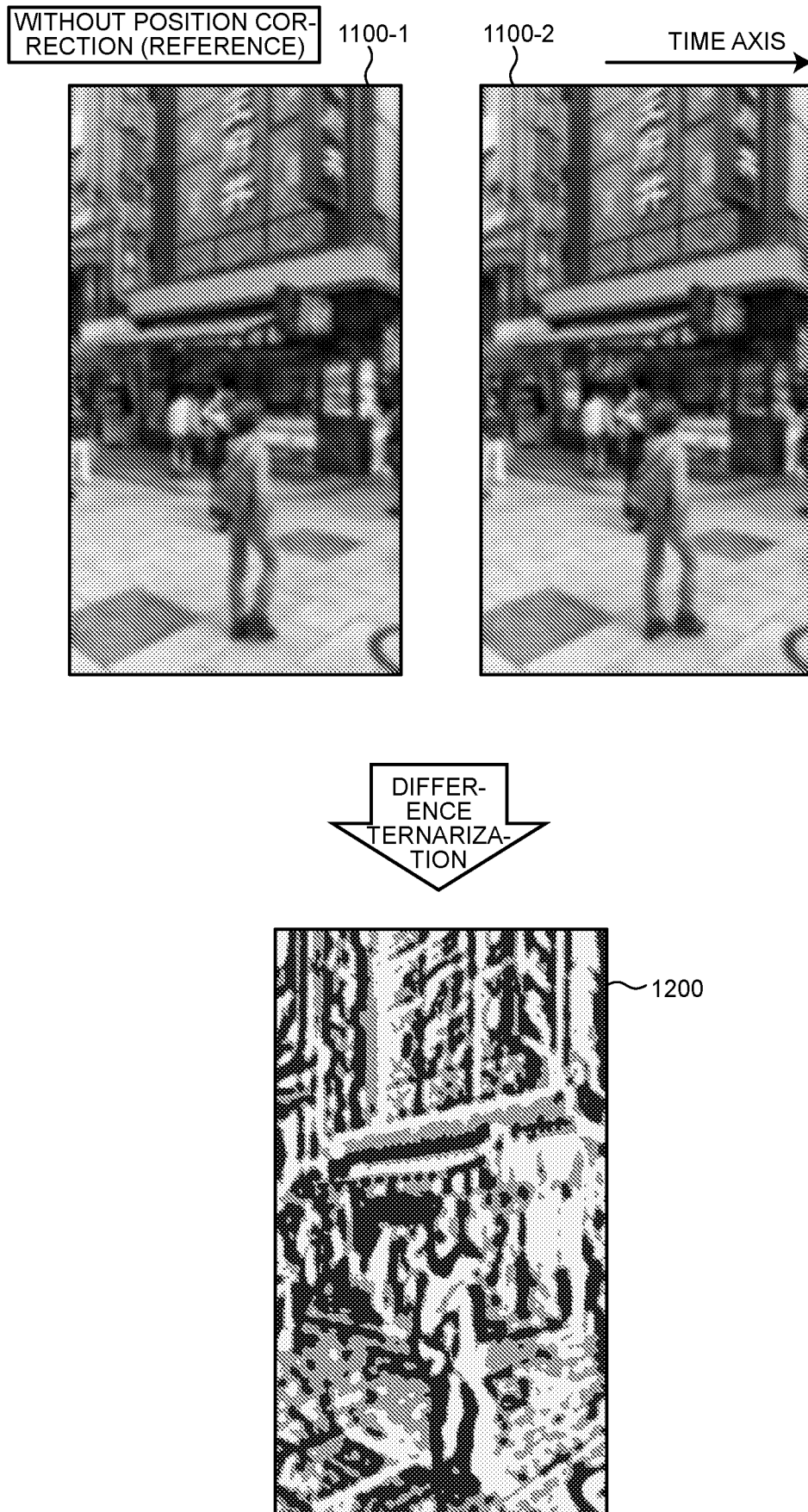


FIG.17A

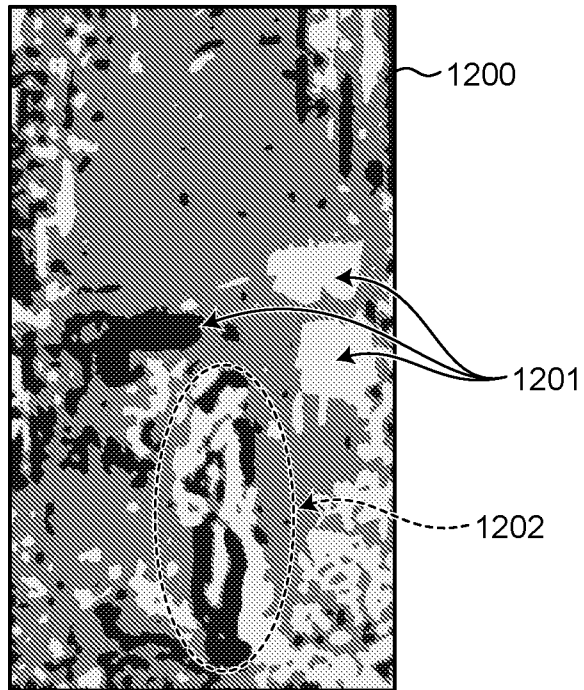


FIG. 17B[

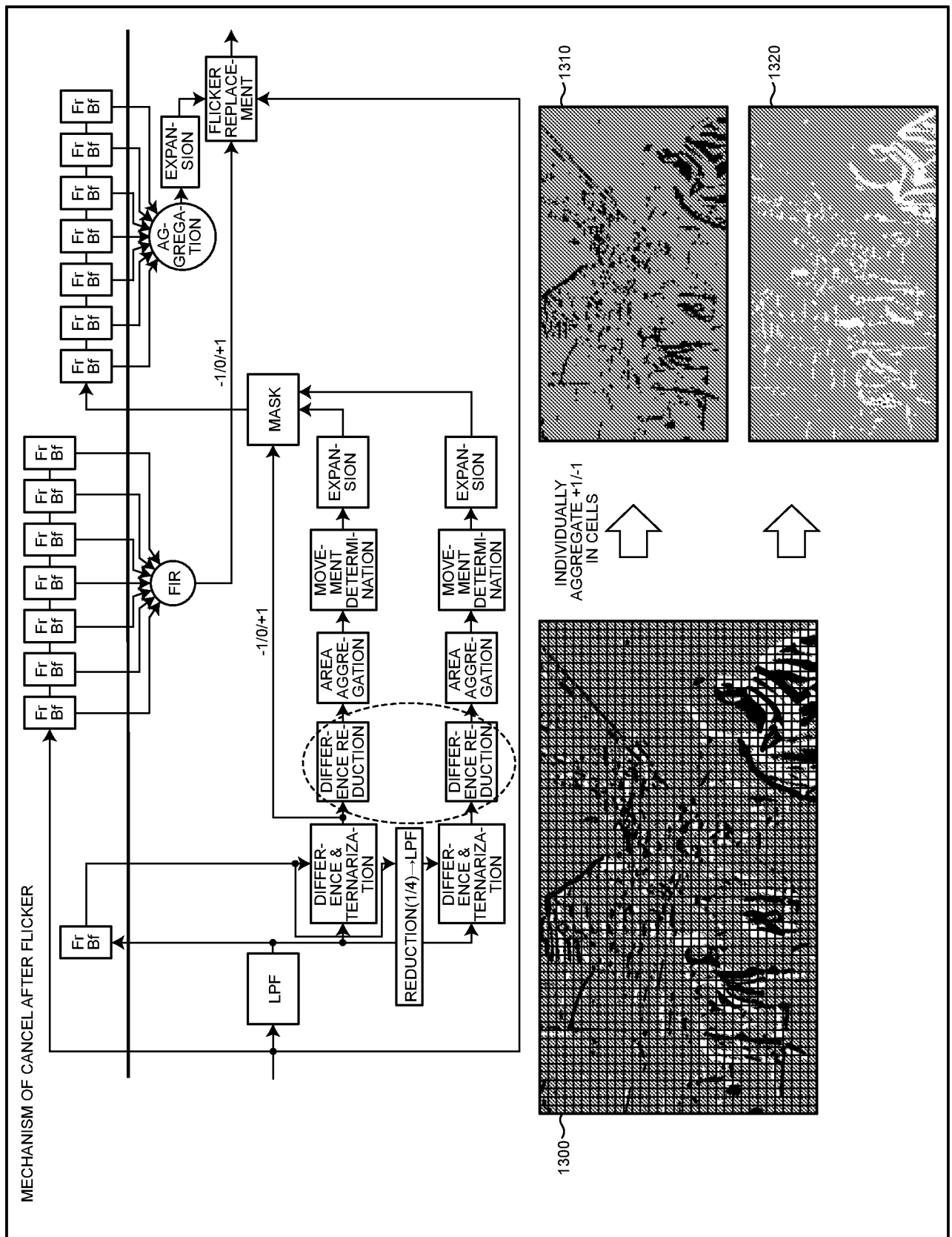


FIG. 17C

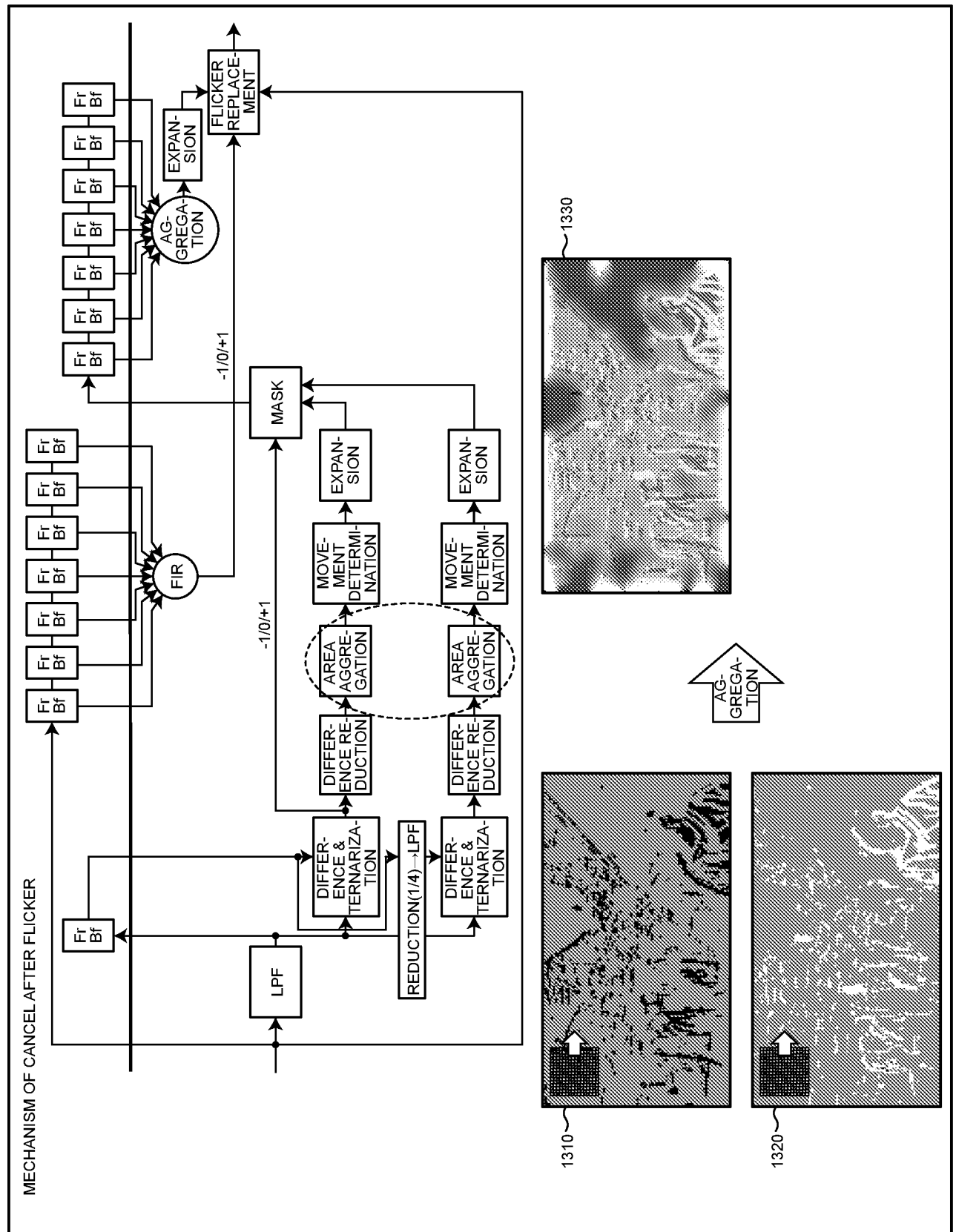


FIG.17D

DIFFERENTIAL MOVING
OBJECT DETECTION RESULT

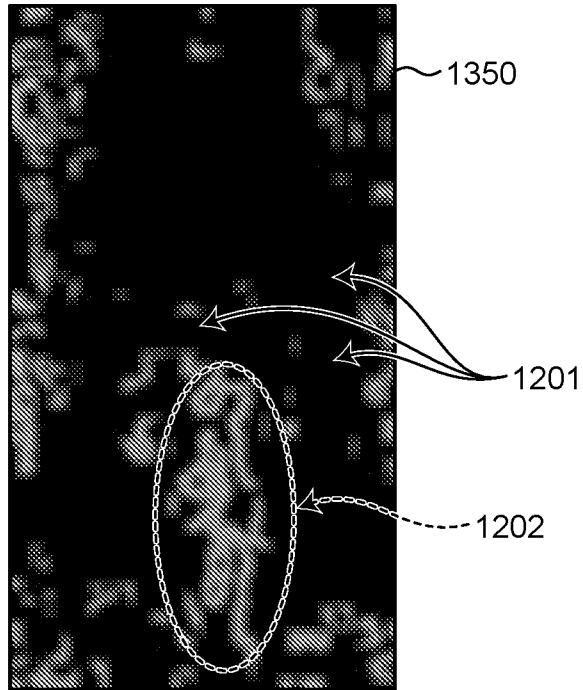


FIG.18

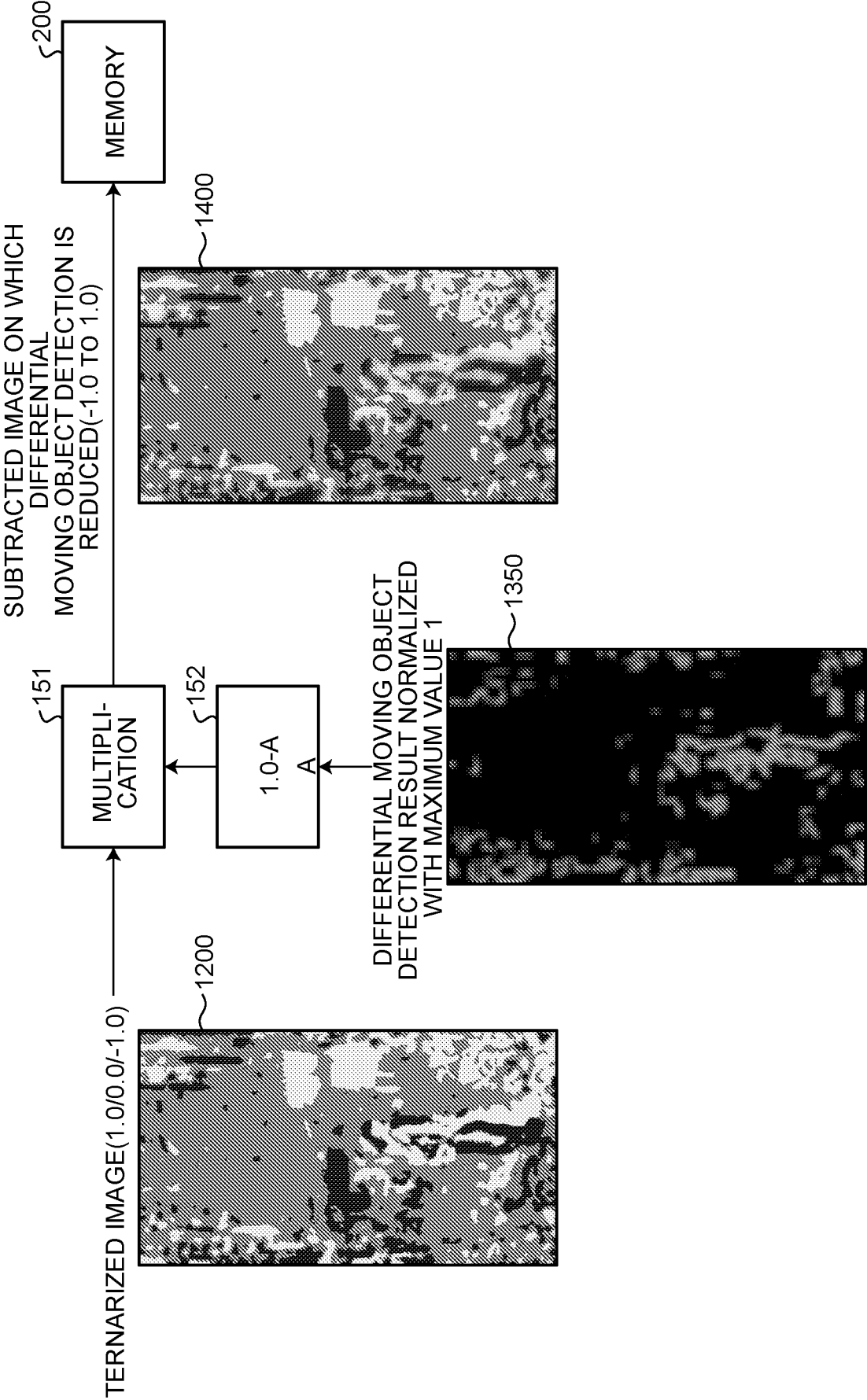


FIG.19

TIME AXIS

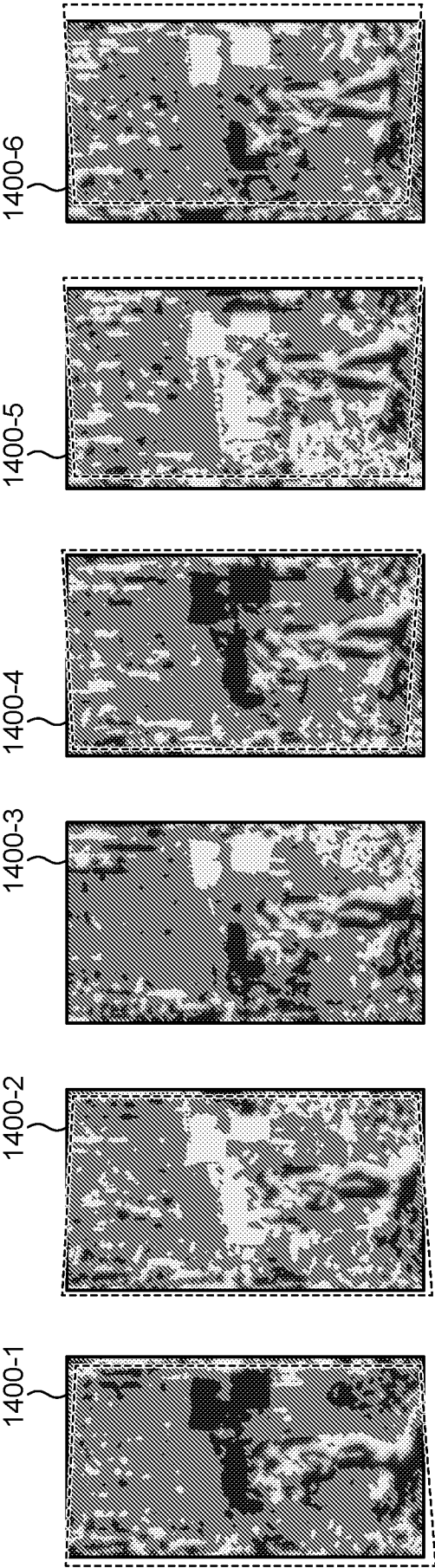


FIG.20

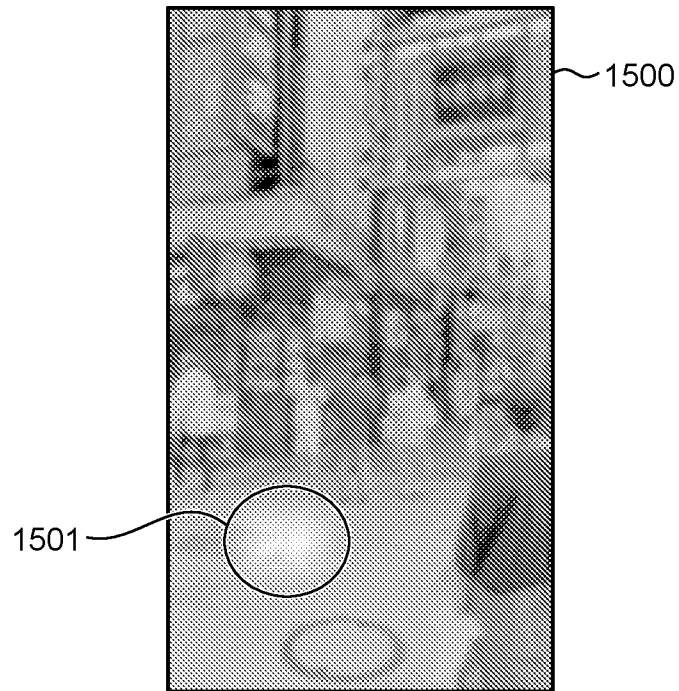


FIG.21

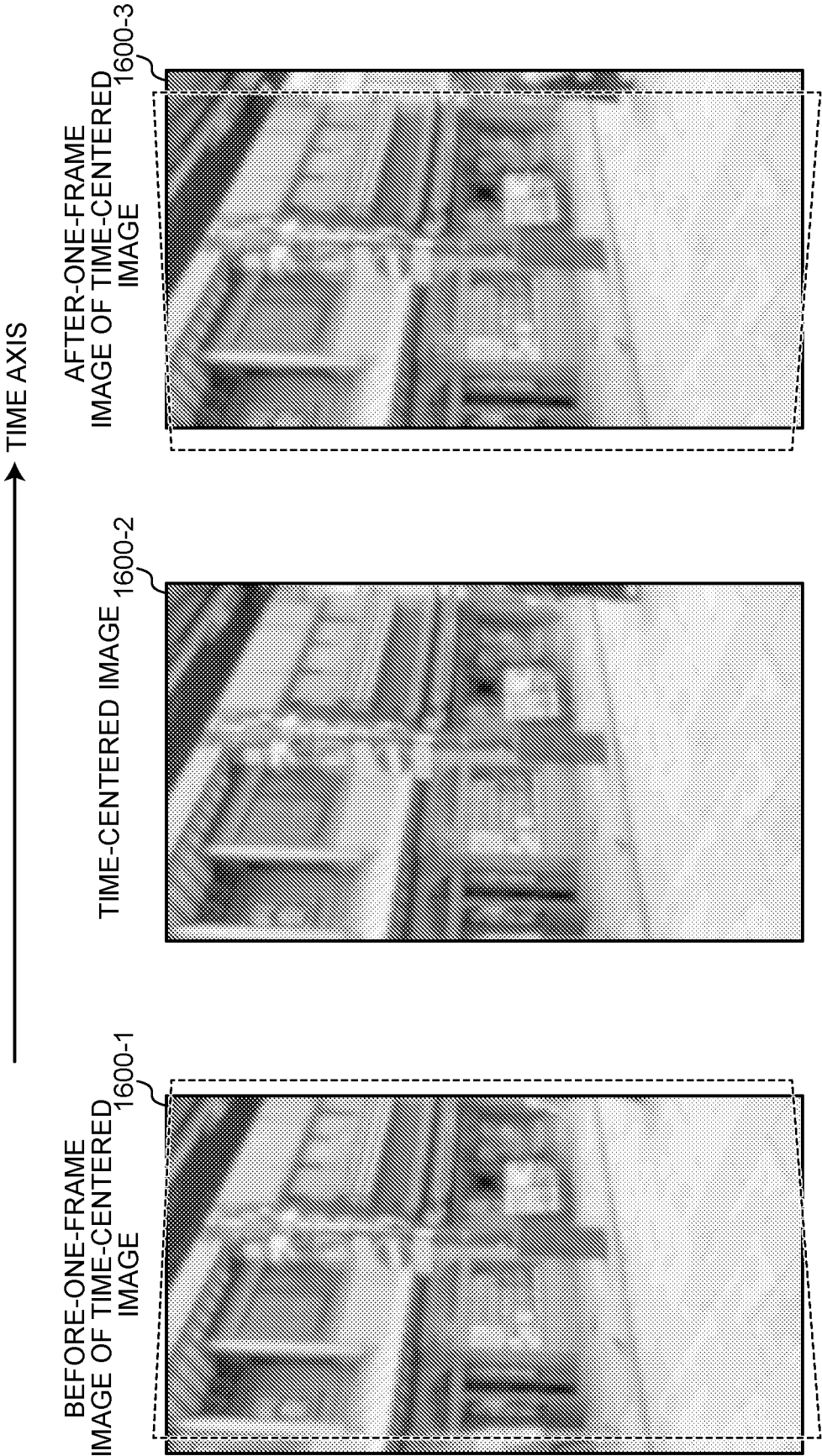


FIG.22

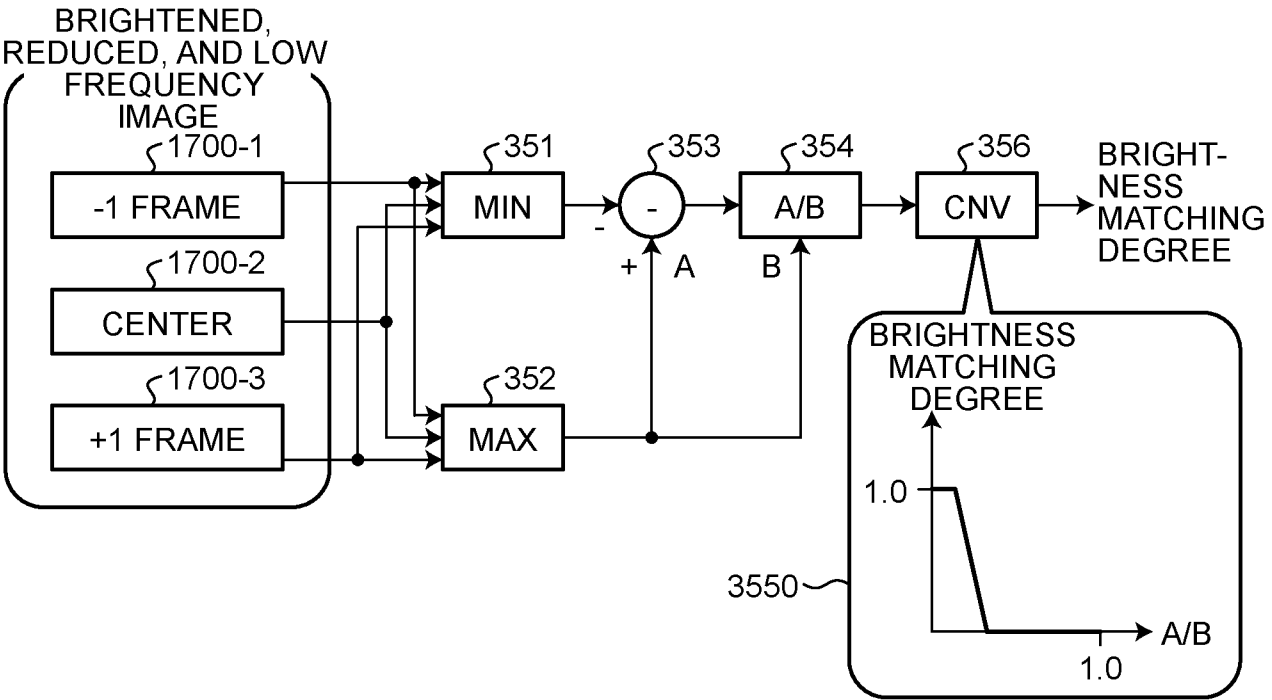


FIG.23

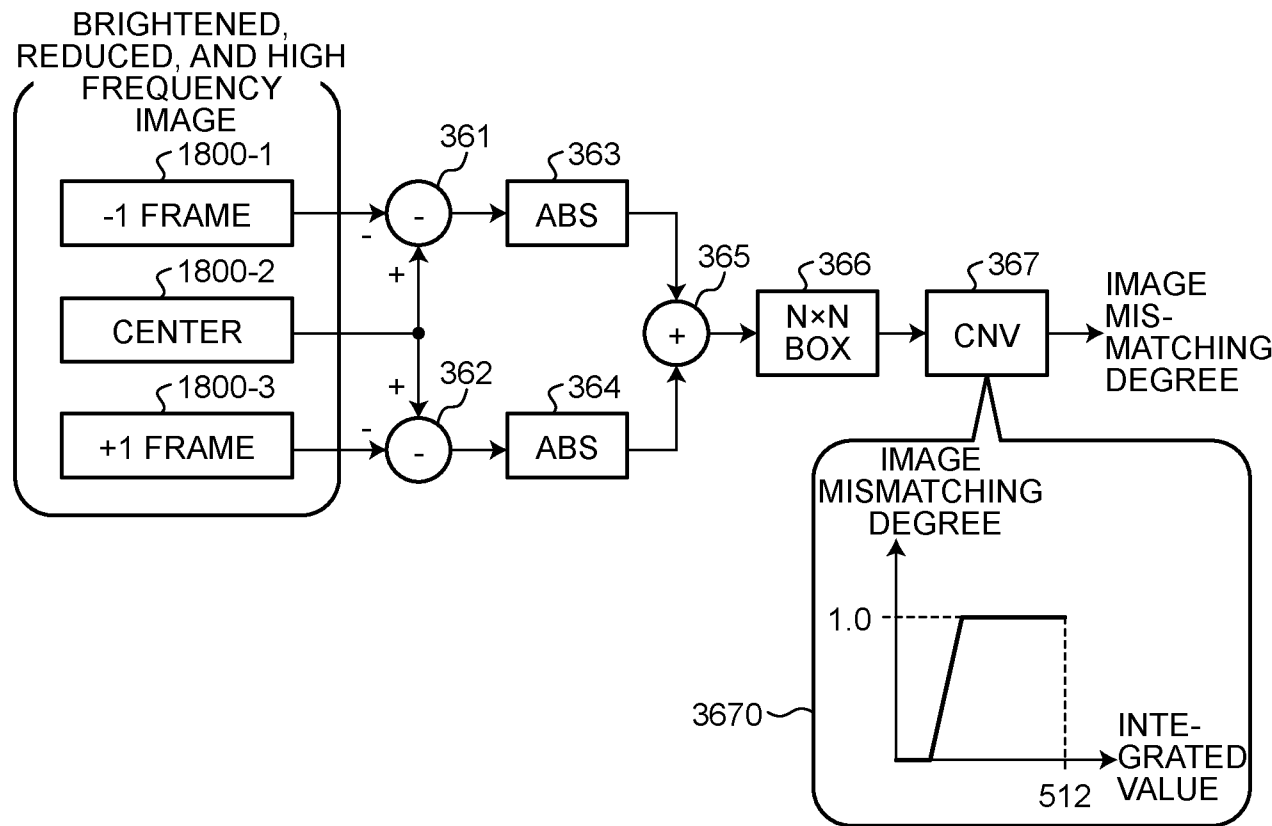


FIG.24

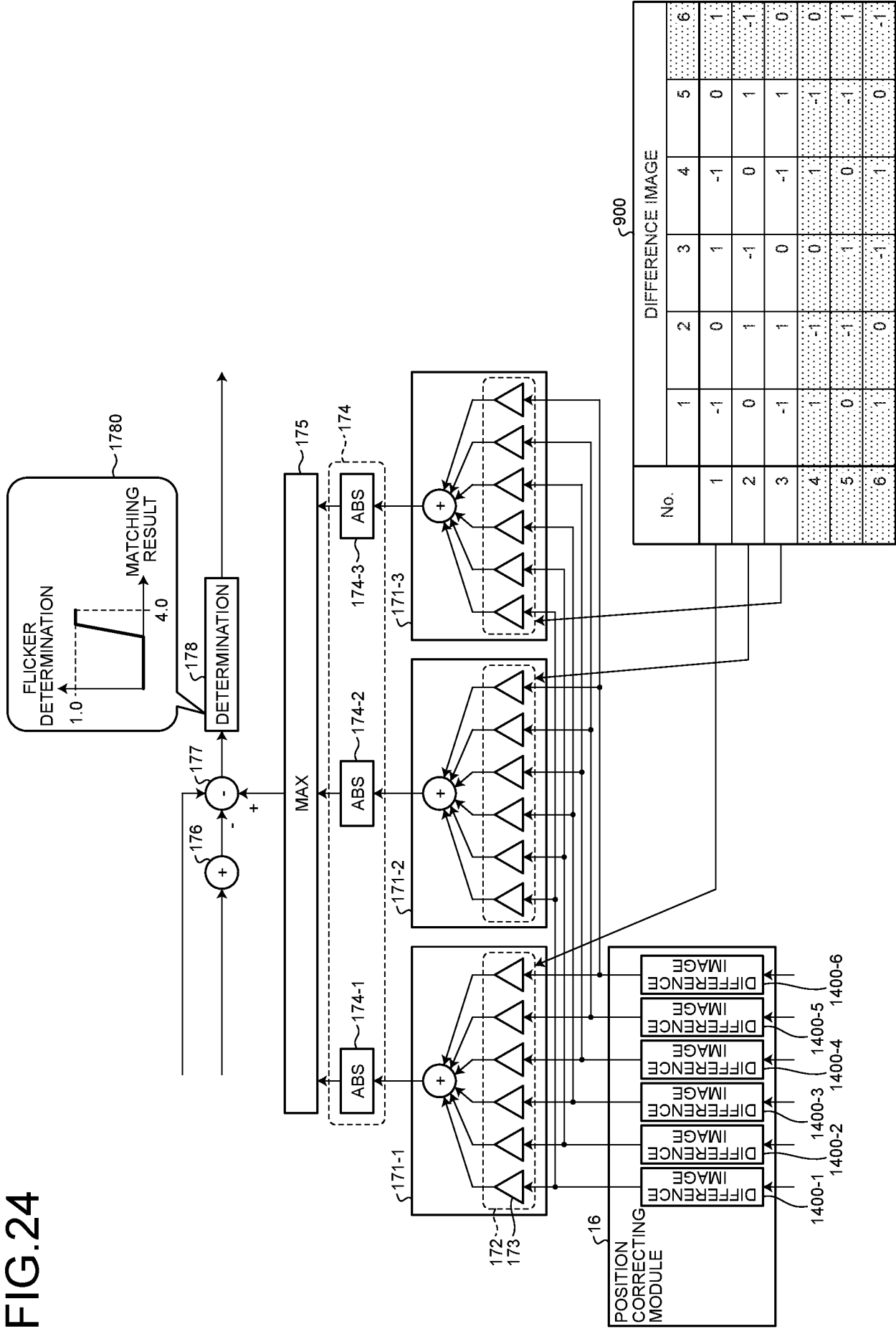


FIG.25

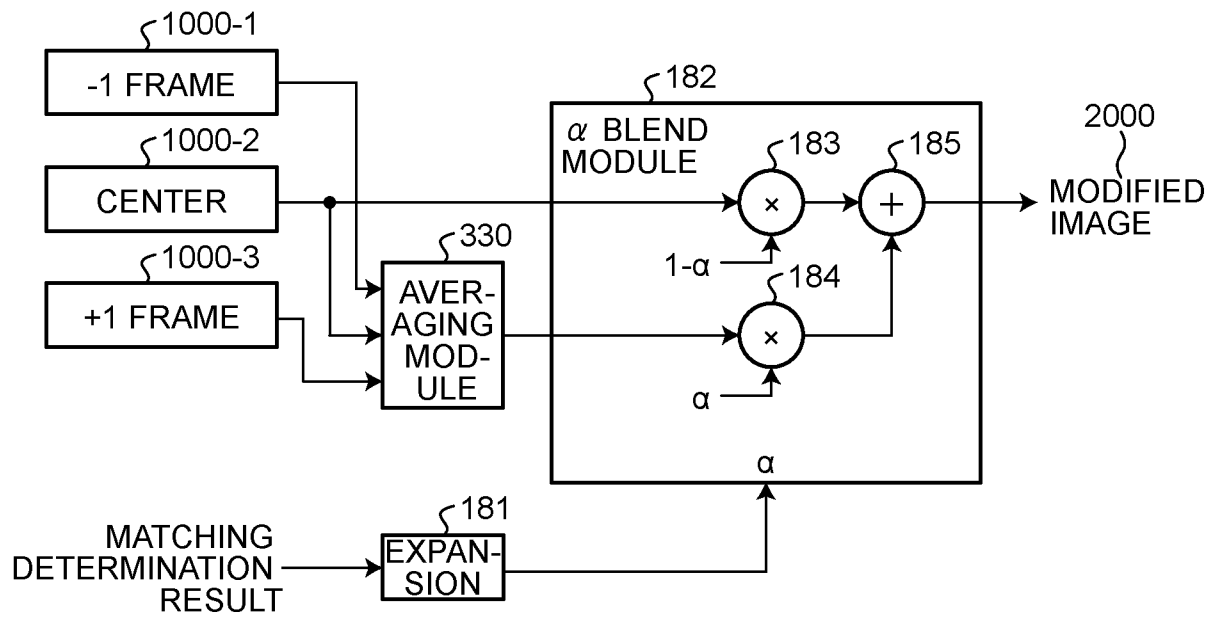


FIG.26

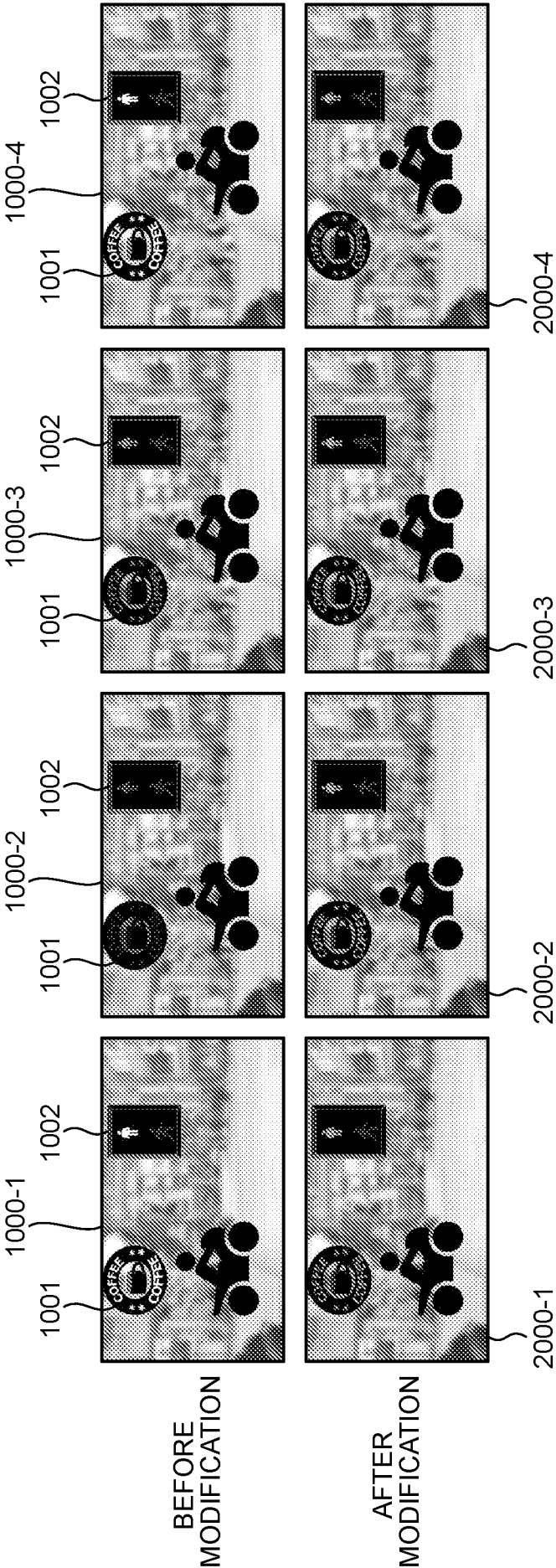


FIG.27

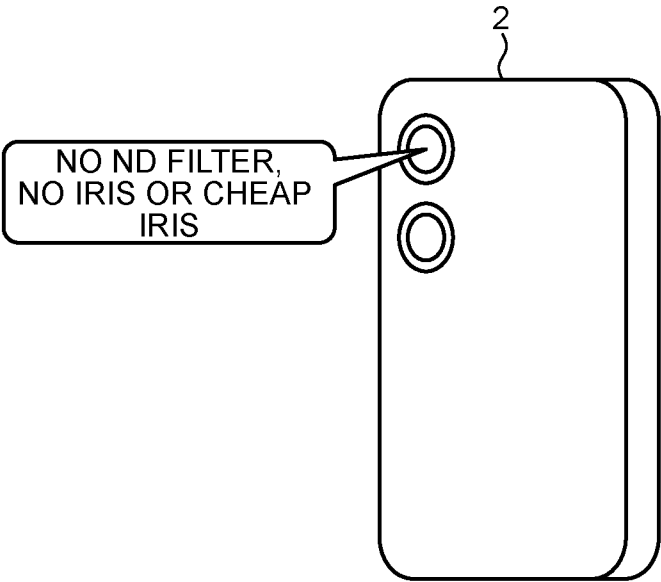


FIG.28

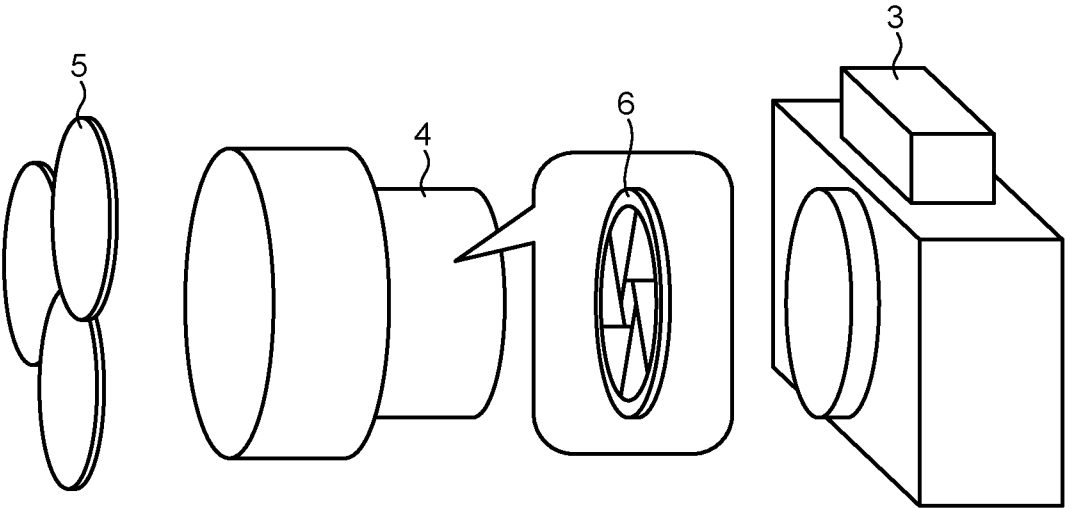


FIG.29

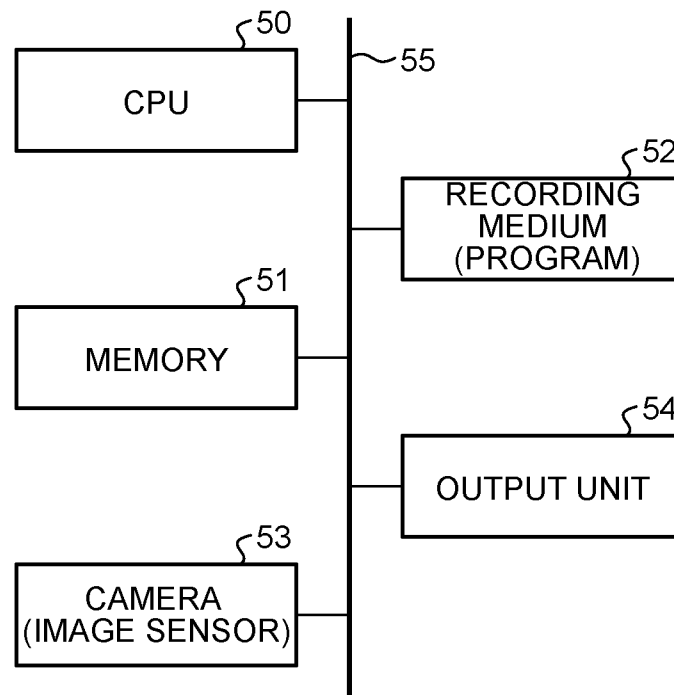
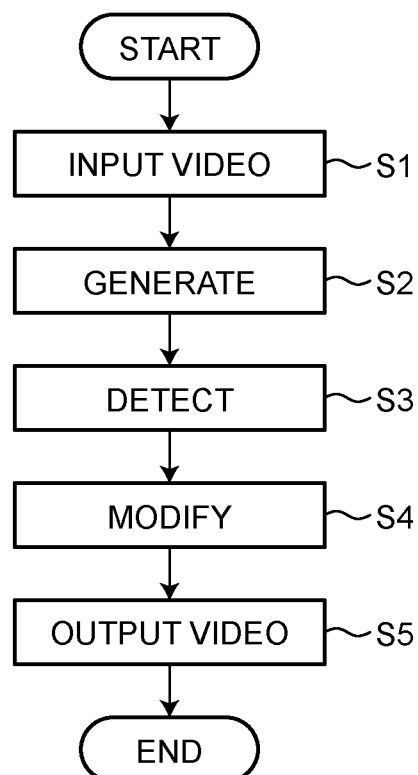


FIG.30



INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/138110

A. CLASSIFICATION OF SUBJECT MATTER

H04L27/00(2006.01)i

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)

IPC: H04L

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)

CNTXT,VCN,ENTXTC,VEN,CNKI: brightness, flicker+, modif+, pattern, change, motion, vector, moving

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 111052726 A (SZ DJI TECHNOLOGY CO., LTD.) 21 April 2020 (2020-04-21) description paragraphs [0009]-[0012], figures 1-3	1-13
Y	US 2021014402 A1 (SAMSUNG ELECTRONICS CO., LTD.) 14 January 2021 (2021-01-14) description paragraphs [0005]-[0011], figures 1-11	1-13
A	US 2014043502 A1 (OLYMPUS CORPORATION) 13 February 2014 (2014-02-13) the whole document	1-13
A	US 2016373684 A1 (GENTEX CORPORATION) 22 December 2016 (2016-12-22) the whole document	1-13
A	CN 103945089 A (SHANGHAI FUKONG HUALONG MICROSYSTEM TECHNOLOGY CO., LTD.) 23 July 2014 (2014-07-23) the whole document	1-13



Further documents are listed in the continuation of Box C.



See patent family annex.

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“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

01 August 2023

Date of mailing of the international search report

07 August 2023

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2022/138110

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
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				US	2020154032	A1	14 May 2020
				EP	3695596	A1	19 August 2020
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				US	2021392261	A1	16 December 2021
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				JPWO	2012147337	A1	28 July 2014
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CN	103945089	A	23 July 2014	None			