(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 December 2010 (23.12.2010)

PCT

(10) International Publication Number
WO 2010/146930 A1

(51) International Patent Classification:
H04N 13/04 (2006.01) *G06T 17/40* (2006.01)

(21) International Application Number:
PCT/JP2010/056962

(22) International Filing Date:
14 April 2010 (14.04.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
12/456,600 19 June 2009 (19.06.2009) US

(71) Applicant *(for all designated States except US)*: **SHARP KABUSHIKI KAISHA** [JP/JP]; 22-22, Nagaike-cho, Abeno-ku, Osaka-shi, Osaka, 5458522 (JP).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **DALY, Scott J.**. **YUAN, Chang**.

(74) Agent: **HARAKENZO WORLD PATENT & TRADEMARK**; Daiwa Minamimorimachi Building, 2-6, Tenjinbashi 2-chome Kita, Kita-ku, Osaka-shi, Osaka, 5300041 (JP).

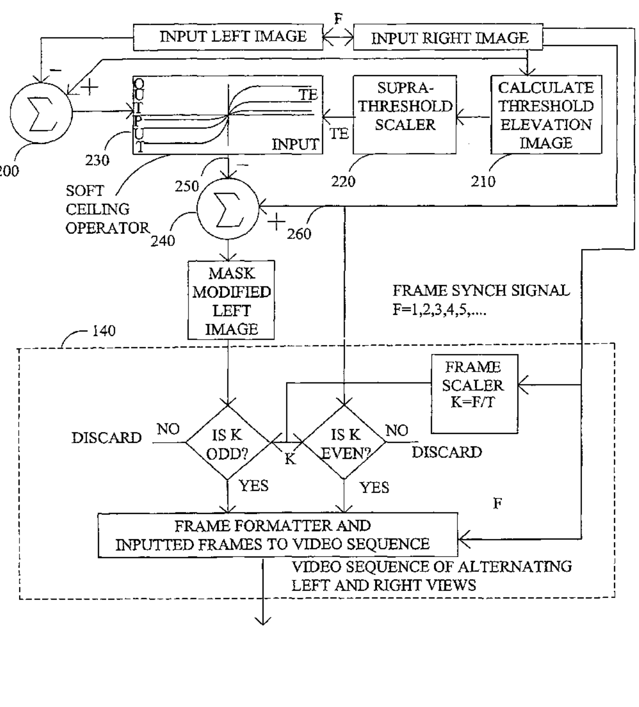
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

(54) **Title**: SYSTEM USING A TEMPORAL PARALLAX INDUCED DISPLAY AND METHOD THEREOF

FIG. 4



(57) **Abstract**: A temporal parallax induced display includes a system and method for presenting different views of an image to a viewer. The system comprises a display for selectively presenting at least a pair of images of a scene or object, where the images are images of the scene or object from different viewpoints such that a viewer observes the scene or object in a three dimensional manner without requiring glasses of the viewer, and a filter that modifies at least one of the images by attenuating parallax distortions between the images above a visual threshold of the human visual system to a greater extent than parallax distortions between the images below the visual threshold of the human visual system.

WO 2010/146930 A1

DESCRIPTION

TITLE OF INVENTION: SYSTEM USING A TEMPORAL PARALLAX INDUCED DISPLAY AND METHOD THEREOF

TECHNICAL FIELD

The present invention relates generally to systems and methods that use temporal parallax induced displays.

BACKGROUND ART

One technique to present an image that has a three dimensional appearance is to use a three dimensional display. One type of three dimensional display uses a liquid crystal display shutter glass worn by the viewer. The shutter glass may be controlled by an emitter and alternatively darken over one eye then the other in synchronization with the refresh rate of the screen. Unfortunately, many viewers do not prefer to wear glasses while viewing a display.

Another technique to display a three dimensional image to the viewer is using an autostereoscopic display. In general, an autostereoscopic display includes view dependent pixels, each of which may include different intensities and colors, based upon the viewing angle of the viewer. This viewing angle dependency may be achieved through a variety of different techniques, such as including a parallax barrier within the display. The result, without the use of special headgear or glasses being worn by the viewer, is that the viewer will perceive a different image with each eye. If the image data is controlled for each eye's viewing angle, the viewer will sense a three dimensional image. Unfortunately, incorporating a parallax barrier reduces the spatial resolution of the display and reduces brightness while adding additional manufacturing complexity to the display together with an increase in expense. Also, the cross talk between multiple overlapped views deteriorates the three dimensional viewing experience.

Another limitation for both types of stereoscopic displays is that in the home there can be an accommodation and vergence mis-match. This occurs because the eyes can be focused on the distance of the screen, yet can be converged to the apparent depth within the image. These differences can lead to eyestrain, headache, or nausea.

What is desired is a three dimensional type display that has no spatial resolution loss, no brightness reduction, without requiring the viewer to wear glasses, and does not cause accommodation and vergence mis-matches.

SUMMARY OF INVENTION

The present invention relates to systems and methods for presenting an image to a viewer.

Some embodiments comprise a system for presentation of an image. The system comprises a display for selectively presenting at least a pair of images of a scene or object, where the images are images of the scene or object from different viewpoints such that a viewer observes the scene or object in a three dimensional manner without requiring glasses of the viewer, and a filter that modifies at least one of the images by attenuating parallax distortions between the images above a visual threshold of the human visual system to a greater extent than parallax distortions between the images below the visual threshold of the human visual system.

Some embodiments comprise a method for presentation of an image on a display. The method comprises receiving at least a pair of images of a scene or object, where the images are images of the scene or object from different viewpoints, selectively presenting the images on the display such that a viewer observes the scene or object in a three dimensional manner without requiring glasses of the viewer, and filtering at least one of the images with a filter that modifies the at least one of the images by attenuating parallax distortions between the images above a visual threshold of the human visual system to a greater extent than parallax distortions between the images below the visual threshold of the human visual system.

The foregoing and other objectives, features, and advantages of the invention will be more readily understood upon consideration of the following detailed description of the invention, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 illustrates a horizontal parallax system.

FIG. 2 illustrates a vertical parallax system.

FIG. 3 illustrates an image capture technique using temporal parallax.

FIG. 4 illustrates a temporal parallax system to reduce rocking distortions and flicker from a stereo pair of images.

FIG. 5 illustrates a temporal parallax system to reduce rocking distortions and flicker from two dimensional images and a depth map.

FIG. 6 illustrates calculation of a threshold elevation due to masking.

FIG. 7 illustrates calculation of a threshold elevation due to visual filtering.

FIG. 8 illustrates a method for using temporal parallax.

DESCRIPTION OF EMBODIMENTS

Referring to FIG. 1, one technique to achieve three dimensional characteristics on a flat two dimensional display, typically used for displaying two dimensional images, is to use a temporal parallax induction technique. The imaged object 100 is viewed by a pair of image capture devices 102, 104 offset from one another by an aperture distance 110 thereby defining a parallax angle 120. The captured images are displayed on a standard 2D display 130 (i.e., not a stereoscopic display) alternating the different views in time by a sequencing process 140. The viewer's mind builds a mental three dimensional perception of the scene from these alternating views by reconstruction from his short-term memory.

Preferably the system receives the left and right images in alternating synchronization, each of which having the same format and pixel dimensions as the other. Alternatively, the system may receive the left and right images in synchronization. Depending on the sequence of the presentation, un-necessary images may be discarded and otherwise not presented to the viewer. In either case, the number of pixels presented by the left image is the same as the number of pixels presented by the right image, thus not requiring a display with an increase in the pixel density for three dimensional presentation over what is used for two dimensional presentation (or a subsequent loss of resolution relevant to the maximum display resolution). Preferably the image has substantially the same number of pixels as the display. The left image and right image are not necessarily images offset in only a horizontal direction, but rather, are indicative of a pair of images that are offset from one another in any direction relatively to the object, at any scale, format, or pixel dimensions.

The sequencing process 140 includes a frame scaler 150 that determines the rate that the left image and right image are switched relative to the overall frame rate. The alternating frequencies are preferably in the range of 4-8 hertz, so with a 60 frames per second (fps) video system, a 6 hertz alternating of views can be achieved by selecting five left image frames, followed by five right image frames, followed by five left image frames, and so on. The period, T, of the alternating sequence is 10 frames, given a 6 hertz oscillation. This technique, as can be observed, uses a traditional two dimensional display, so there is no additional cost incurred in the display technology to generate the perception of depth. Further, the vergence of the eyes and the accommodation are both at the display screen surface, so there is no mis-match.

The output of the frame scaler 150 is used to select between images from the left image and the right image. In the event K is odd 160, then the left image is selected and the right image is discarded 162. In the event K is even 164, then the right image is selected and the left image is discarded 166. In this manner, the desired number of images from the desired right images or left images is selected as a sequence. A frame formatter 170 receives the right image or left image, and arranges the right image or left image as a sequence of images for presentation to the display 130. In general, the offsets cause viewpoint parallax, and since it changes in time, it becomes a motion parallax.

Typically, in stereographic imaging, the right and left cameras are arranged from 15 degrees for an object at 0.3 meters, 4 degrees at 1.0 meter, and 0.87 degrees at 5 meters. Preferably for the temporal parallax induction technique of FIG. 1 the cameras are not placed at the typical distance of the eyes, but rather considerably closer, such as a parallax angle as low as 1 degree at 1.0 meter. The reason for such a small parallax is because with the temporal parallax induction technique there tends to cause a "rocking distortion" or a "parallax distortion" because the alternating views are different for different portions of the image. In general "rocking" artifacts / distortions refers to any such offsets in the images being presented. In essence, different portions of the object will tend to be observed to shift different distances between the left image and the right image. Large image shifts can not be fused by the visual system into a depth illusion, as given by data of boundaries in angular disparity and viewing distance referred to as Pannum's fusion area. If disparity fusion does not occur, then the result is two edges of a single object that flicker back and forth (i.e. the rocking distortion). This oscillation between the left image and the right image is very distracting to the viewer.

Referring to FIG. 2, a modified technique uses cameras that are vertically offset, rather than horizontally offset. Having a vertical offset tends to reduce the rocking distortion viewed by the viewer.

Referring to FIG. 3, a further modified technique uses an image capture device that oscillates among a continuum of alternating views (or multiple views) as opposed to switching between just two views. This may be generally considered a sinusoidal or triangular position viewpoint as a function of time as opposed to a square wave as a function of time. In some cases, a system may use both horizontal parallax as well as vertical parallax. Moreover, the system may oscillate together with a combination of horizontal parallax and/or vertical parallax and/or random views.

One technique for two different parallax views to occur to the visual system is for the viewpoint to rotate while the head stays still. This makes the system receive the images from a rotating viewpoint. Since the head is generally still while viewing the temporal parallax induction imagery on a two dimensional display, one side effect of the inherent oscillation of the temporal parallax induction is that it looks like the object or scene is turning back and forth. Due to the common frequency rate used in this technique, it is similar to a rocking motion. This effect can be quite disturbing as it can cause the entire scene to rock back and forth in unison, and since it may be observed as a three dimensional image, the effect tends to be even stronger.

While the temporal parallax induction technique provides the appearance of depth for an image, it unfortunately tends to include some rocking distortions that may be undesirable to the viewer. The temporal parallax induction technique may include a filter based upon the human visual system to reduce the rocking distortions to a level that is less objectionable to the viewer or otherwise generally unnoticeable to the viewer (a level less than they would otherwise have been had the filter not modified the at least one of the images). Thus the benefits of the temporal parallax induction technique may be achieved without the rocking distortion drawbacks associated with the technique. In general, any filter may be used based upon adaptively adjusting at least one of frequency and amplitude as a function of location.

To reduce the rocking/parallax distortions a visual model of the human visual system is used to remove, preferably a majority if not all, of the rocking distortions significantly above the visual threshold of the human visual system. In addition, the rocking distortions near the threshold or slightly above the threshold of the human visual system are likewise significantly reduced or otherwise removed. The rocking distortions below or near the threshold of the human visual system are preferably not modified or otherwise not attenuated a temporal parallax depth impression remains to the viewer. In particular, the visual model may suppress the local spatial image differences (disparities from the views) between the different views of the scene (between the two images). Preferably, the suppression is performed in the two-dimensional space (i.e., the image space that the image is actually displayed). Alternatively, the suppression may be performed in three dimensional space, if desired.

The source data may be in any format, any type of data compression, and represented by any desirable characteristics. For example, in the case of a pair of cameras the representation may be pairs of left images and right images. For example, particularly for computer generated graphics, the representation may be an image together with a depth map. In most cases, the depth map is at the same resolution as or lower than the image. These images can be computer generated synthetic images.

Referring to FIG. 4, a synchronized pair of a left image and a right image are received or otherwise a sequence of frames forming a video. Preferably, the left image and right image are synchronized at the same frame rate and phase. Initially, a difference 200 is determined between the left image and the right image. In general the difference will have a zero mean and will extend to a positive maximum value and to a negative maximum value. An offset may be added to adjust the values so that only positive values exist. The degree to which the viewer may observe rocking artifacts, which sometimes appears as double edges, in the image is generally related to the absolute value of the magnitude of the difference.

Due to the spatial and temporal frequency sensitivities of the human visual system, as well as masking properties of the human visual system, all of the differences between the images that are visible in isolation, or in a static image, will not be readily visible to the viewer. In other words, the visibility of these code values is not equal for equal differences in values. A model of the human visual system may be used to alter the difference image so that the differences that cause the rocking distortion are not readily visible to the viewer when viewed at the desired frame rates, or in the context of a static image. A threshold elevation image 210 is calculated which is based upon the human visual system, described in detail later. The output of the elevation image 210 is a map of the threshold elevation as a function of image position (threshold map or threshold elevation image). The threshold elevation image may operate on the left image, and/or right image, as desired (that is, for the input left image and the right image may be reversed). The values may be scaled by a supra-threshold scaler 220 to permit additional just-noticeable differences above the threshold that may be allowed to appear in the image so to allow visually degrading the image to desired amounts. This allows a tradeoff in the strength of the depth illusion versus the visibility of the rocking distortion.

The output of the elevation image 210 is then processed by a soft-ceiling operator 230 which is preferably pixel dependent, which sets the maximum difference (ceiling) allowed as a function of position in the image (e.g., an absolute value maximum). It is referred to as a 'soft' operator because it uses a soft transition from allowing the image difference to be unaltered (slope of 1 as illustrated in 230), to the region where it is clamped entirely (a slope of 0 as illustrated in 230). The output of the soft ceiling operator is an image whose maximum differences are suppressed by the human visual system models of thresholds, so that the differences are all close to the threshold. In this case a display is used that has substantially the same number of pixels as the number of pixels of the output image.

Next a modified left image 240 is made by adding the modified image difference 250 with a negative sign to the right image 260. At this point the system has a new left image and right image pair of images that are input to the sequence process 140 of the temporal parallax induction. While illustrated for a left image and right image pair, the technique likewise works for any set of temporal parallax pairs of images, no matter the source.

Another modifying technique is illustrated in FIG. 5 using a two dimensional image 300 together with its depth image map 310. For simplification, the resolution of the two dimensional image and depth image may be presumed to be the same, or otherwise scaled to be the same. From the depth map and the two dimensional image, a new view 320 may be synthesized. While the single image and depth map may be used directly, using two of the two dimensional images plus a depth map helps with handling image occlusions. The system may synthesize new views to correspond to smoothly oscillating left image and right image, or vertical parallax angles, or combinations thereof. The oscillation pattern is controlled in 330 by a TPI viewpoint oscillator with fixed patterns (fixed parameters). The fixed patterns or parameters include frequency, gain, and phase of the oscillation for the x,y axes, or a table controlling more random or otherwise complex patterns. Also, other oscillating patterns or parameters may be used such as a random pattern or a pattern that is image dependent. The output image from these sequential varying viewpoints is then saved in a frame buffer (in order to delay) and compared to the next frame (or previous frame) to form a difference image. The delay may need to be scaled by the frame scaler, K. The difference image is operated on by the soft ceiling operator whose amplitude, Te, is based on the human visual model to determine a threshold elevation image in step 210 from either the current or previous frame. The threshold image is also scaled by the desired threshold scaler for the same purpose as in FIG. 4. Next, the modified difference image base from the previous frame 340 is combined with the current frame 350 to generate a frame delayed temporal parallax induced image 360. These steps are preferably done at the frame rate, as indicated by the signal F. The new video sequence consists of a single image frame for each frame of the sequence, and can be consequently shown on a two dimensional display capable of showing video sequences. Depending on the supra threshold, scalar, and oscillation parameters, it may result in a two dimensional image that appears to have its depth enhanced. The images can also be selectively presented based on a viewpoint selector.

The elevation image 210 may be determined using any suitable technique. One such technique includes modeling the effects of the variability of the visual threshold as subject to the image content, often referred to as masking, as shown in FIG. 6. The first step is to take the input image and decompose it into different (multiple) frequency bands 370 ("sub-images" of the input image). Any suitable image decomposition (spatial frequency decomposition) technique that approximates the human visual system spatial frequency analysis may be used. Examples include a two dimensional Cartesian wavelet technique, Gaussian pyramid technique, cortex transform technique, steerable filter pyramid technique, and others. For each of these frequency bands, the contrast is calculated (contrast calculation) in a pixel-dependent manner in step 380. The technique may likewise be spatial in character, such as using a spatial filter bank of sub-images, if desired. In this way the rocking artifacts (parallax distortions) can be reduced to a level above the human threshold for substantially all of the spatial regions and frequencies of the image. As well as this, the spatial frequency decomposition can include a masking function calculation. Next these contrast signals are used to generate a masking signal by known methods for each band and pixel position in step 390. Then, these masking signals are combined across the bands to generate a single masking threshold elevation image in step 400. This masking threshold can also be used in a human visual system model. The combination may be a Minkowski summation (terms raised to a power, p, then summed, then the sum subject to an inverse power function (1/p)). Other types of combinations may likewise be used. One technique for scaling the threshold map is to use a value of 1.0 for just at threshold elevation. In a simple implementation, a threshold can correspond to one gray level difference. Higher levels of threshold elevation, such as a value of 2.0, means the differences are two times the ordinary threshold will be allowed to remain in the image. Those higher than two would be generally suppressed to a difference of two. Similarly for other threshold elevation values that are greater than 1.0.

Referring to FIG. 7, another technique includes calculating a threshold elevation map to focus on the retinal image capture limits of the visual system, which are primarily manifest in the contrast sensitivity function of the human visual system, which describe visibility as a function of frequency. In particular, one may use a spatio or a spatiotemporal contrast sensitivity function, which may be implemented as a filter. This filter can be a spatial-temporal filter with low-pass characteristics in both spatial and temporal directions. The first step is to apply a spatiotemporal filter (ST-CSF filter) 500 that has characteristics of the visual system, to give an image FP(i,j) 510. The imaging system and display may be calibrated in 520 to the visual threshold (using parameters like viewing distance, display contrast and tonescale) for determining a filtered pixel value. This threshold can also include a disparity measure. Since the ST-CSF has a zero DC response, the images become zero mean, and the pixel amplitudes are close to describing contrasts (this can be made more accurate by scaling by the mean of the image, or local mean). These contrasts are divided in 530 by the threshold giving an image FP*(i,j) 540. Next a comparator against 1 is used, on a per-pixel basis. If the division output is < 1, then this means the difference image at that point is below threshold, and no modification of the difference image at that location is needed. The other branch path is that for the division output being > 1, in which case the TE value is 1/division output (TE= 1/ FP*(i,j)). This will suppress it to the threshold value. Next the pixels from the two paths are combined in a manner based on which path they took, without interaction from each other in the combination step. Values higher than 1.0 may be used for the reasons as in step 220 in FIG. 5.

The above systems can be implemented by a method for presentation of an image on a display to a viewer, such as that shown in FIG. 8. This method includes receiving 600 at least a pair of images of a scene or object, where the images are images of the scene or object from different viewpoints, sequentially (selectively) presenting 620 the images on the display such that a viewer observes the scene or object in a three dimensional manner without requiring glasses of the viewer.

This method also includes filtering (modifying) 610 at least one of the images that modifies the at least one of the images by attenuating parallax distortions between the images above a visual threshold of the human visual system to a greater extent than parallax distortions between the images below the visual threshold of the human visual system.

The terms and expressions which have been employed in the foregoing specification are used therein as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding equivalents of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

CLAIMS

1. A system for presentation of an image comprising:

(a) a display for selectively presenting at least a pair of images of a scene or object, where said images are images of said scene or object from different viewpoints such that a viewer observes said scene or object in a three dimensional manner without requiring glasses of said viewer; and

(b) a filter that modifies at least one of said images by attenuating parallax distortions between said images above a visual threshold of the human visual system to a greater extent than parallax distortions between said images below said visual threshold of the human visual system.

2. The system of claim 1 wherein said parallax distortions are determined based upon a magnitude of the disparities between said images where said magnitude is further modified based upon the human visual system.

3. The system of claim 1 wherein said filter is a spatial-temporal filter with low-pass characteristics in both spatial and temporal directions.

4. The system of claim 1 wherein said visual threshold is a masking threshold for a human visual system model that is

applied to different values for each sub-image of said images in a spatial filter bank of sub-images.

5. The system of claim 1 wherein said at least a pair of images are horizontally offset from one another.

6. The system of claim 1 wherein said at least a pair of images are vertically offset from one another.

7. The system of claim 1 wherein an offset of at least a pair of images is modified as a function of time.

8. The system of claim 1 wherein an orientation of said different viewpoints is random.

9. The system of claim 1 wherein said display has substantially the same number of pixels as the number of pixels of said at least one of said pair of images.

10. The system of claim 1 wherein said at least a pair of images are obtained from a pair of image capture devices, said at least a pair of images having the same format and pixel dimensions.

11. The system of claim 1 wherein said at least a pair

of images are obtained in synchronization.

12. The system of claim 1 wherein said selectively presenting said image is based upon a frame scaler that determines the rate that said images are displayed.

13. The system of claim 12 wherein said scaler is used to select between two viewpoints of images.

14. The system of claim 1 wherein said different viewpoints have a parallax angle of less than 1 degree at a distance of 1.0 meter to the said scene or object.

15. The system of claim 1 wherein said at least a pair of images are obtained from a pair of image capturing devices from a rotating viewpoint.

16. The system of claim 15 wherein said pair of image capture devices provides more than two different viewpoints.

17. The system of claim 1 wherein said parallax distortions are reduced in one region of said at least one of said images while not reduced in other regions of said at least one of said images.

18. The system of claim 1 wherein said parallax distortions are reduced to a level less than a visual threshold of the human visual system.

19. The system of claim 1 wherein said parallax distortions are reduced to a level less than a threshold greater than a visual threshold of the human visual system.

20. The system of claim 1 wherein said parallax distortions are reduced to a level above the human threshold for substantially all of at least one of spatial regions and frequencies of said at least one of said images.

21. The system of claim 1 wherein said parallax distortions are reduced in the two-dimensional space of said at least one pair of images of said scene or object.

22. The system of claim 1 wherein said pair of images includes a depth map.

23. The system of claim 1 wherein said filter includes a soft-ceiling operator.

24. The system of claim 1 wherein said filter is pixel dependent.

25. The system of claim 1 wherein said filter is based upon image decomposition into multiple frequency bands.

26. The system of claim 1 wherein said filter is based upon a contrast sensitivity function of the human visual system.

27. The system of claim 1 wherein said pair of images is based upon a two dimensional image and a depth map.

28. The system of claim 27 wherein said two dimensional image and depth map are used to render two dimensional views.

29. The system of claim 28 wherein at least a pair of images from said two dimensional views are used for said selectively presenting images on said display.

30. The system of claim 29 wherein said selectively presenting images is based upon a viewpoint selector.

31. The system of claim 30 wherein a threshold elevation image is calculated based upon at least one of said two dimensional views.

32. The system of claim 31 wherein a soft ceiling operator is based upon said threshold elevation image for said selectively presenting images on said display.

33. The system of claim 31 wherein said threshold elevation image is based upon a spatial frequency decomposition.

34. The system of claim 33 wherein said spatial frequency decomposition includes a contrast calculation.

35. The system of claim 33 wherein said spatial frequency decomposition includes a masking function calculation.

36. The system of claim 31 wherein said threshold elevation image is based upon a spatiotemporal filter.

37. The system of claim 36 wherein said spatiotemporal filter includes a contrast sensitivity function.

38. The system of claim 37 wherein said threshold elevation image uses a threshold to determine a filtered pixel value.

39. The system of claim 38 wherein said threshold includes a disparity measure.

40. The system of claim 1 wherein said images are computer generated synthetic images.

41. The system of claim 26 wherein said contrast sensitivity function is based upon a spatial contrast sensitivity function.

42. The system of claim 26 wherein said contrast sensitivity function is based upon a spatiotemporal contrast sensitivity function.

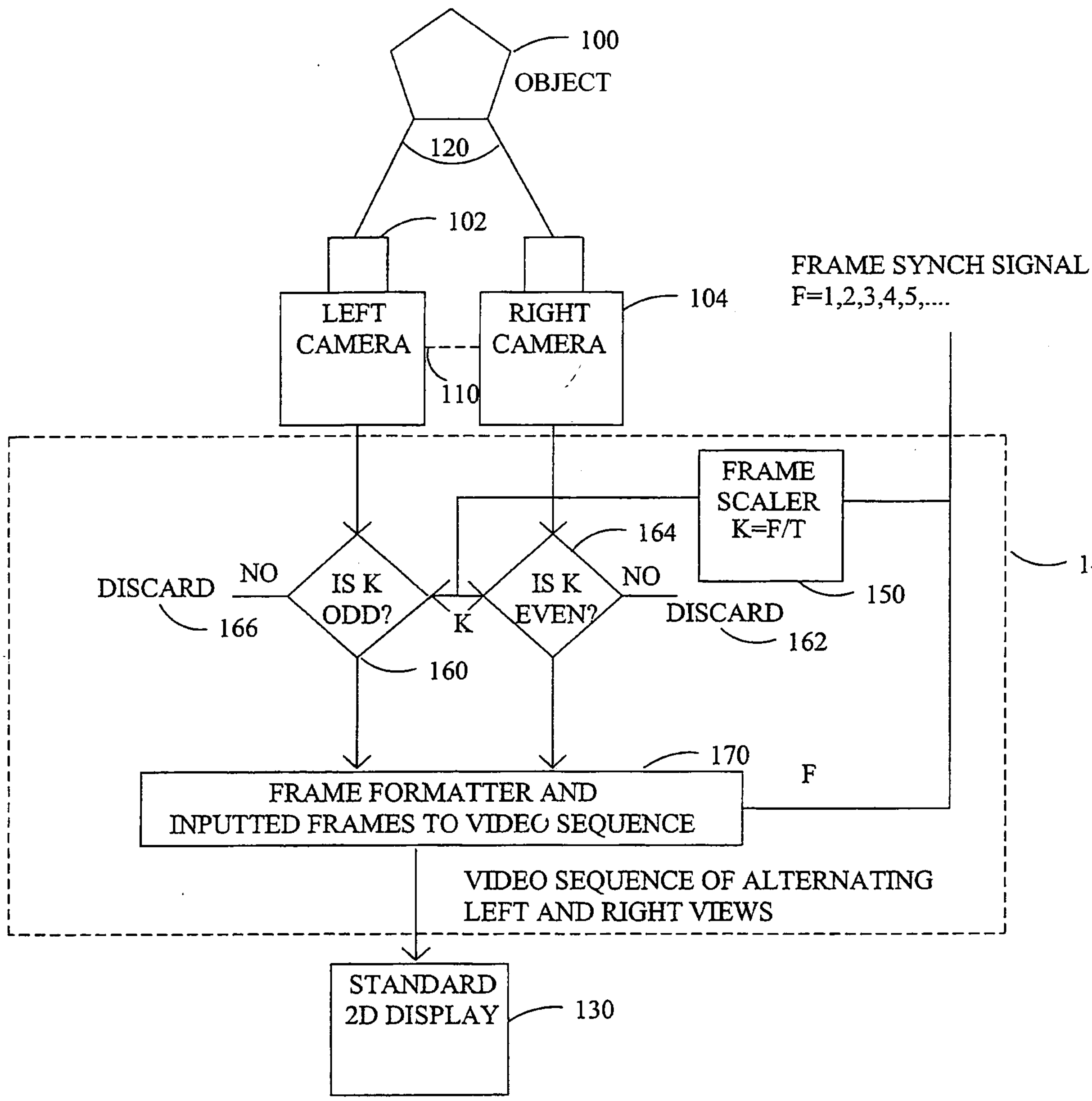
43. A method for presentation of an image on a display comprising:

(a) receiving at least a pair of images of a scene or object, where said images are images of said scene or object from different viewpoints;

(b) selectively presenting said images on said display such that a viewer observes said scene or object in a three dimensional manner without requiring glasses of said viewer; and

(c) filtering at least one of said images with a filter that modifies said at least one of said images by attenuating parallax distortions between said images above a visual threshold of the human visual system to a greater extent than parallax distortions between said images below said visual threshold of the human visual system.

FIG. 1


100
OBJECT
120
102
LEFT CAMERA
RIGHT CAMERA
104
110
FRAME SYNCH SIGNAL
F=1,2,3,4,5,....
FRAME SCALER
K=F/T
164
140
DISCARD
NO
IS K ODD?
K
IS K EVEN?
NO
DISCARD
166
150
162
160
170
F
FRAME FORMATTER AND
INPUTTED FRAMES TO VIDEO SEQUENCE
VIDEO SEQUENCE OF ALTERNATING
LEFT AND RIGHT VIEWS
STANDARD
2D DISPLAY
130

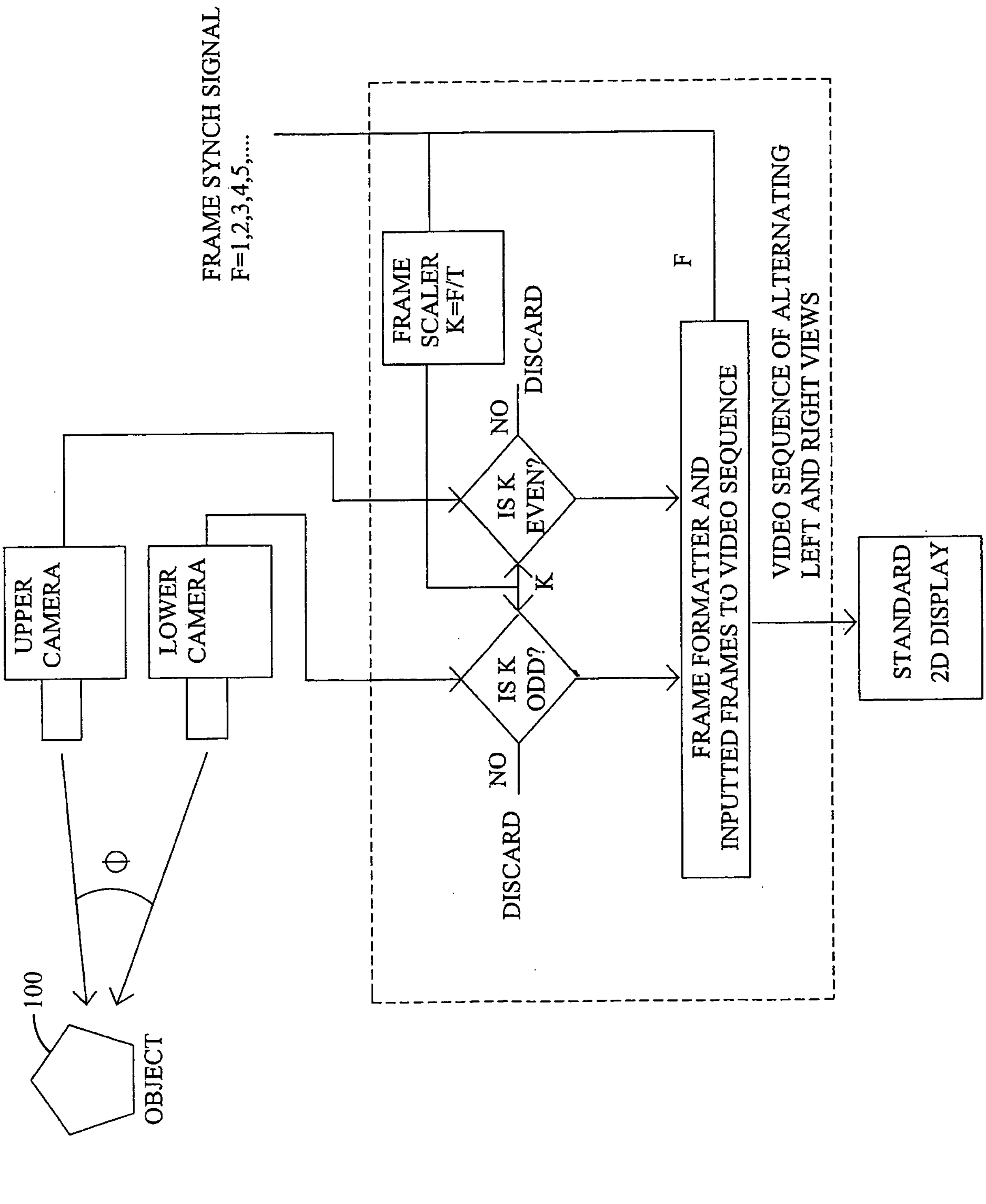

FRAME SYNCH SIGNAL
F=1,2,3,4,5,....
FRAME SCALER
K=F/T
F
UPPER CAMERA
LOWER CAMERA
IS K EVEN?
IS K ODD?
NO
DISCARD
NO
DISCARD
K
FRAME FORMATTER AND INPUTTED FRAMES TO VIDEO SEQUENCE
VIDEO SEQUENCE OF ALTERNATING LEFT AND RIGHT VIEWS
STANDARD 2D DISPLAY
Φ
100
OBJECT

FIG. 2

FIG. 3

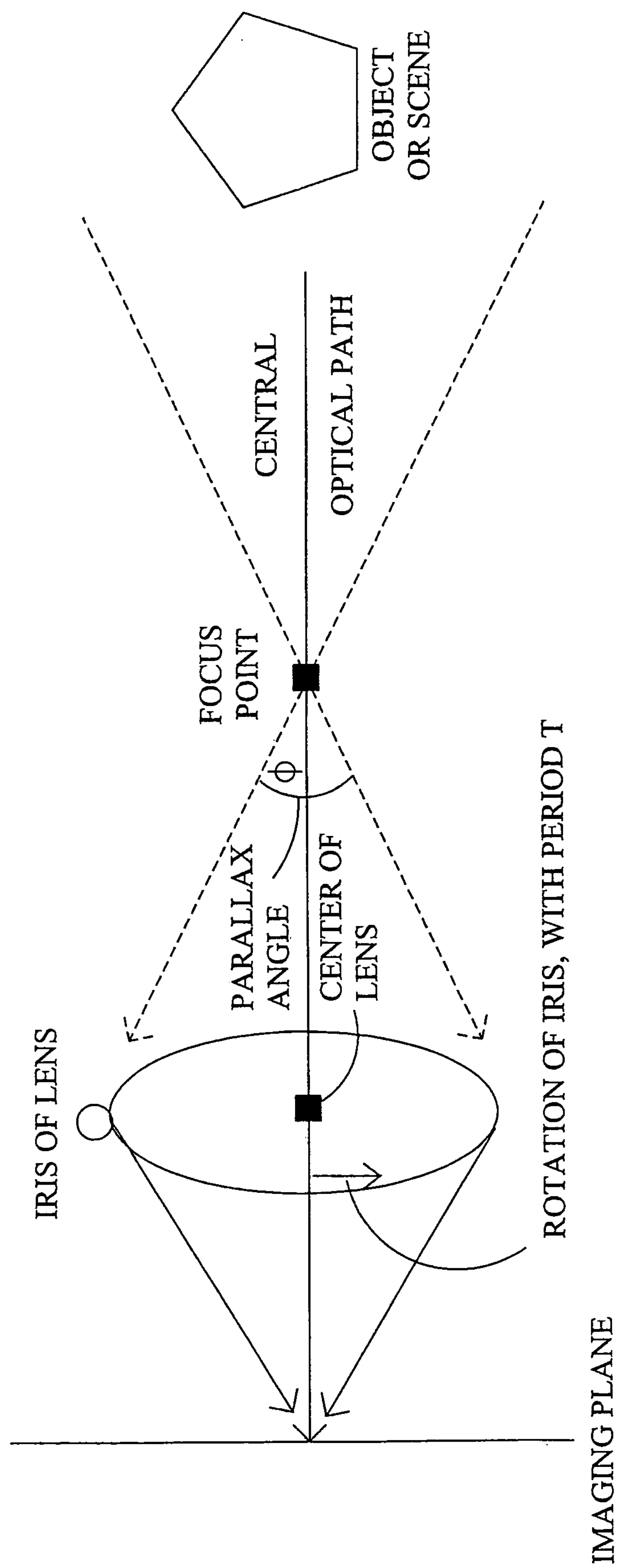
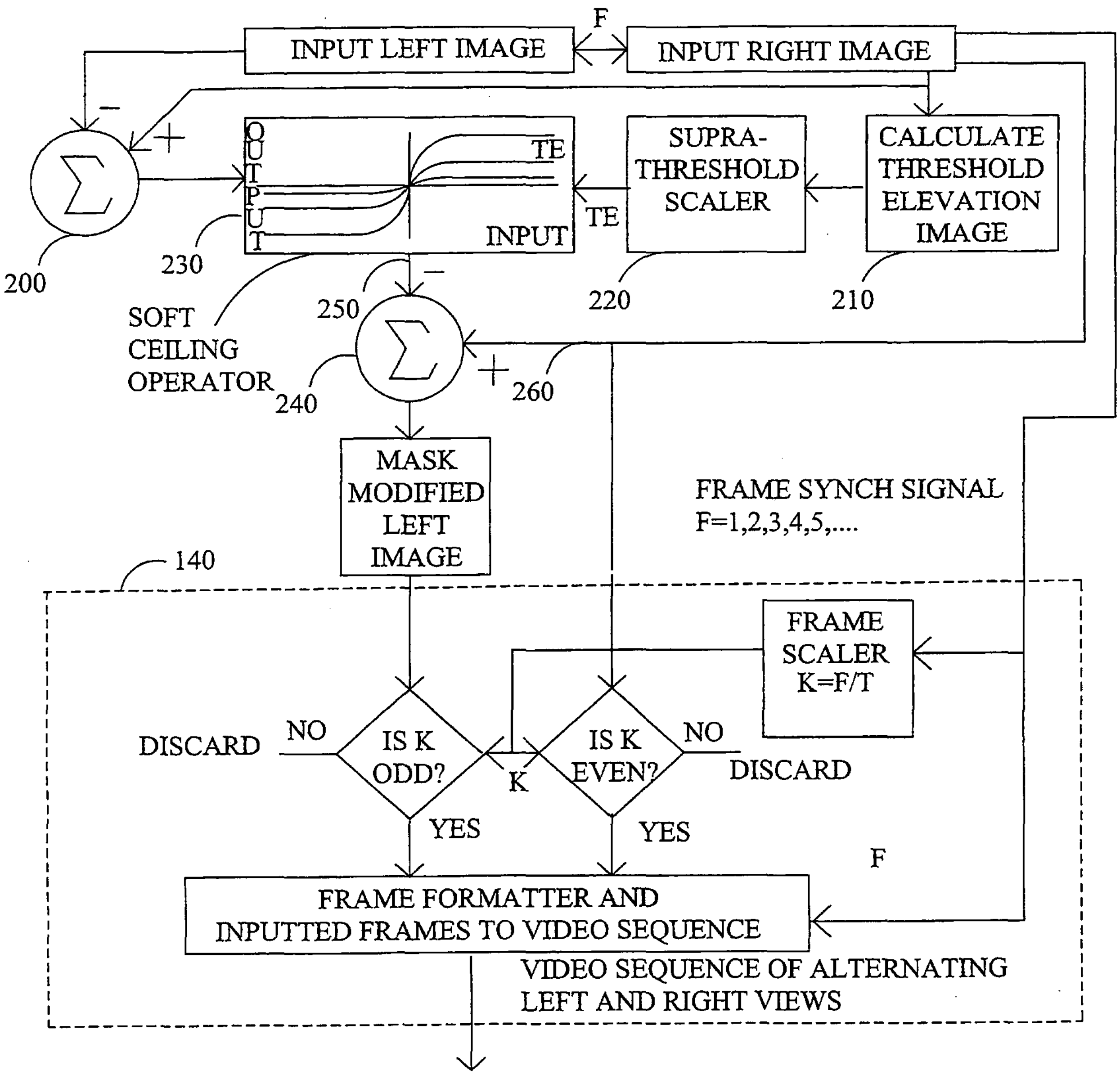
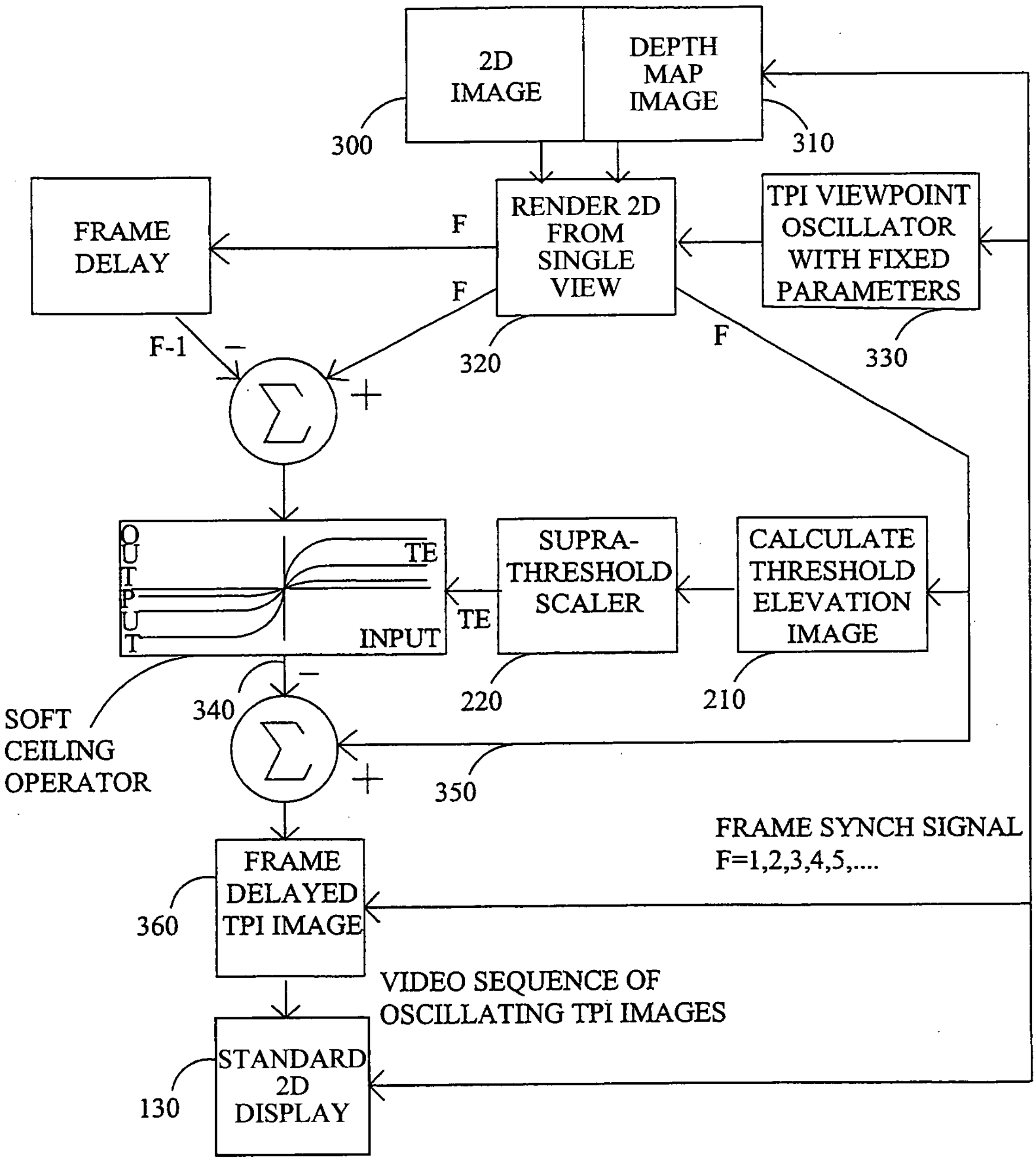

OBJECT OR SCENE
CENTRAL OPTICAL PATH
FOCUS POINT
φ
PARALLAX ANGLE
CENTER OF LENS
IRIS OF LENS
ROTATION OF IRIS, WITH PERIOD T
IMAGING PLANE

FIG. 4



INPUT LEFT IMAGE
F
INPUT RIGHT IMAGE
-
+
OUTPUT
TE
INPUT
TE
SUPRA-THRESHOLD SCALER
CALCULATE THRESHOLD ELEVATION IMAGE
200
230
220
210
SOFT CEILING OPERATOR
250
240
260
MASK MODIFIED LEFT IMAGE
FRAME SYNCH SIGNAL F=1,2,3,4,5,....
140
FRAME SCALER K=F/T
DISCARD
NO
IS K ODD?
K
IS K EVEN?
NO
DISCARD
YES
YES
F
FRAME FORMATTER AND INPUTTED FRAMES TO VIDEO SEQUENCE
VIDEO SEQUENCE OF ALTERNATING LEFT AND RIGHT VIEWS

FIG. 5


2D IMAGE
DEPTH MAP IMAGE
300
310
FRAME DELAY
F
RENDER 2D FROM SINGLE VIEW
TPI VIEWPOINT OSCILLATOR WITH FIXED PARAMETERS
F
F-1
320
F
330
OUTPUT
TE
INPUT
TE
SUPRA-THRESHOLD SCALER
CALCULATE THRESHOLD ELEVATION IMAGE
SOFT CEILING OPERATOR
340
220
210
350
FRAME SYNCH SIGNAL F=1,2,3,4,5,....
FRAME DELAYED TPI IMAGE
360
VIDEO SEQUENCE OF OSCILLATING TPI IMAGES
STANDARD 2D DISPLAY
130

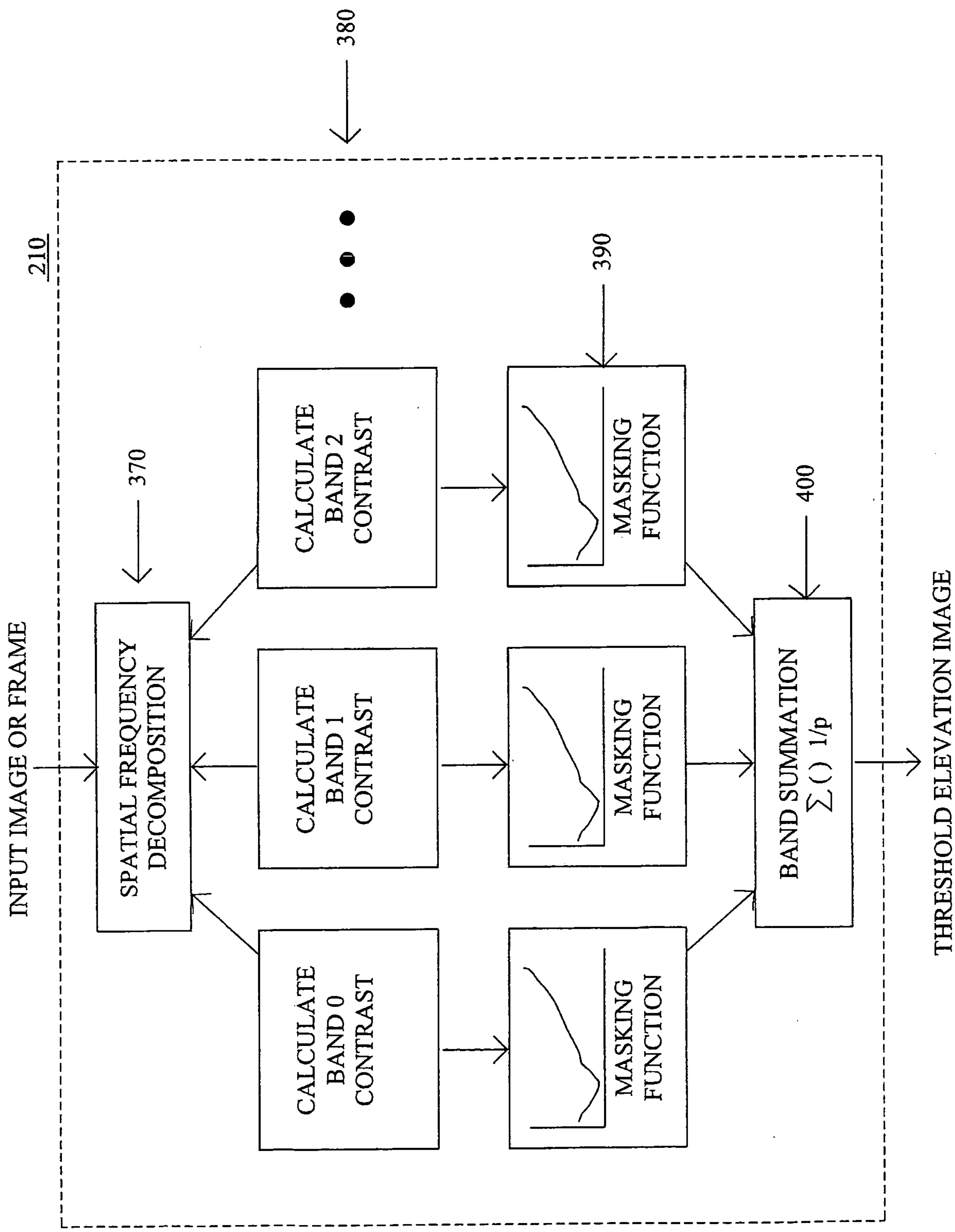

210
380
INPUT IMAGE OR FRAME
370
SPATIAL FREQUENCY DECOMPOSITION
CALCULATE BAND 0 CONTRAST
CALCULATE BAND 1 CONTRAST
CALCULATE BAND 2 CONTRAST
390
MASKING FUNCTION
MASKING FUNCTION
MASKING FUNCTION
400
BAND SUMMATION
∑( ) 1/p
THRESHOLD ELEVATION IMAGE

FIG. 6

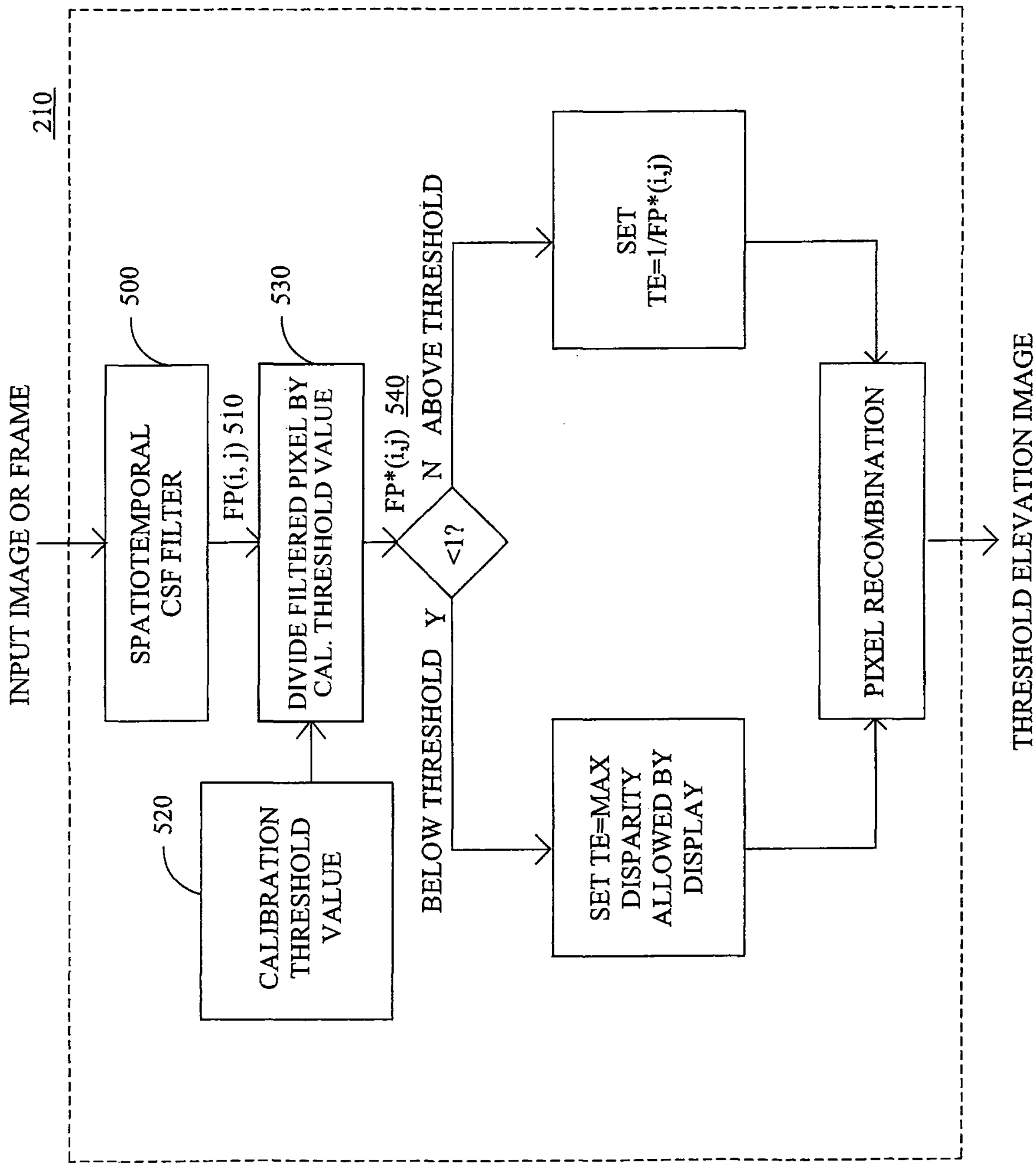
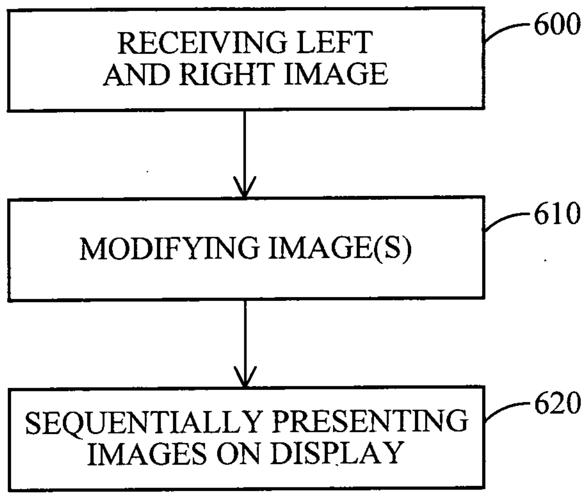

210
INPUT IMAGE OR FRAME
SPATIOTEMPORAL CSF FILTER
500
FP(i,j) 510
DIVIDE FILTERED PIXEL BY CAL. THRESHOLD VALUE
530
CALIBRATION THRESHOLD VALUE
520
FP*(i,j) 540
<1?
N ABOVE THRESHOLD
BELOW THRESHOLD Y
SET TE=1/FP*(i,j)
SET TE=MAX DISPARITY ALLOWED BY DISPLAY
PIXEL RECOMBINATION
THRESHOLD ELEVATION IMAGE

FIG. 7

FIG. 8


RECEIVING LEFT AND RIGHT IMAGE
600
MODIFYING IMAGE(S)
610
SEQUENTIALLY PRESENTING IMAGES ON DISPLAY
620

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2010/056962

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. H04N13/04(2006.01)i, G06T17/40(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)

Int.Cl. H04N13/04, G06T17/40

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2010
Registered utility model specifications of Japan 1996-2010
Published registered utility model applications of Japan 1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2005-229560 A (ITO HIROBUMI) 2005.08.25, entire document (No Family)	1-43
A	JP 2008-153805 A (Kyushu Univ.) 2008.07.03, entire document (No Family)	1-43

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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	Date of mailing of the international search report
08.07.2010	20.07.2010

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office	Kazushige Ito 5P 8839
3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No. +81-3-3581-1101 Ext. 3581