

OBJECT TRACKING APPARATUS AND METHOD

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DESCRIPTION

The present invention relates to an object tracking apparatus for causing a camera to track a moving object.

10 Recent developments in technology have led to camcorders becoming ever smaller and more highly automated.

Prominent is the rapidly progressing development of an object tracking function, which can automatically track
15 and record objects, and an auto-focusing function.

In Japanese laid open patent application No. 62-208783 entitled, "Automatic Tracking Video camera", a technique is disclosed wherein the infra-red received
20 from an object is converted into an electrical signal, the centre of the object detected from the electrical

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signal and the camera controlled to remain directed at the centre of the detected object.

However, the technique disclosed in Japanese laid open patent application No. 62-208783 has the disadvantage of over complexity. The apparatus detects the centre of the object after infra-red has been received from the object and converted into electrical signals. This results in an increase in video camera size which is undesirable. Furthermore, additional means are needed to provide an auto-focussing function, thus causing an inevitable increase in unit price and the size of the apparatus.

In other words, separate auto-focusing apparatus is needed, as depicted in Figures 1 and 2, in order to provide both auto-focusing and object tracking.

Referring to Figure 1, an auto-focusing apparatus 100 is mounted under the lens 10 of a camcorder, on the front of the main body 20. The auto-focusing apparatus 100 comprises a light emitter 1, a light receiver 2 for receiving incident infra-red reflected from objects,

and a controller (not shown), wherein the distance between a camcorder and an object is caculated by the time difference between the time infra-red is emitted from the light emitter 1 and the time infra-red is received by the light receiver 2, and then the lens 10 is driven by the calculated value to perform focusing. The light receiver 2 comprises a light receiving lens 3 for collecting incident infra-red and a photoelectric conversion element of a photosensor (such as a photodiode) 4 for converting the light collected from said light receiving lens 3 into an electrical signal.

Referring to Figure 2, a photosensor 4 of the photoelectric conversion is enlarged for illustration. The infra-red collected at light receiving lens 3 of light receiver 2 is detected by two photosensors 4, converted into an electrical signal and output to a controller (not shown), which, by utilising the infra-red received by the photosensor 4, calculates the distance between the camera and an object for performing the focusing.

Accordingly, in order to provide auto-focusing and automatic object tracking for a camcorder, an auto-focusing apparatus and an automatic object tracking apparatus have both been needed, thereby resulting in a
5 bulky camcorder.

According to a first aspect of the present invention, there is provided an object tracking apparatus for a camera, comprising support means including drive means
10 for movably supporting a camera, a tracking light source for emitting light having a first frequency, a focusing light source for emitting light having a second frequency, light detecting means responsive to light of said first and second frequencies and outputting a
15 bearing signal in dependence on light of said first frequency and a focus signal in dependence on light of said second frequency, and tracking means for producing a control signal in dependence on the bearing signal, wherein the drive means is responsive to the control
20 signal to cause a camera mounted to the support means to track the tracking light source.

5 The source of light is preferably an infra-red emitter mounted on an object to be tracked. However, it could comprise a reflective means mounted on an object to be tracked.

10 Preferably, the light detecting means and the processing means are mounted on a camera. However, they may be mounted on the support means.

15 Preferably the light detecting means comprises a plurality of photosensitive elements. Conveniently, there are four photosensitive elements comprising square quarters of a larger square.

20 Preferably, the bearing signal comprises the outputs of the photosensitive elements and the processing means compares the relative magnitudes of the outputs of the photosensitive elements to produce a drive signal to operate the drive means.

Conveniently, the drive means is operable to change the azimuth of a supported camera. The apparatus is thereby capable of responding to horizontal changes in the bearing of the light source with respect to the
5 light detecting means.

Preferably, the drive means comprises a motor drivingly coupled to a gear portion of the support means. The motor may be drivingly coupled to the gear
10 portion of the support means via a speed reducing train. The gear portion of the support means may comprise radially outwardly extending teeth or radially inwardly extending teeth.

15 Conveniently, the drive means is operable to change the elevation of a supported camera. Thus, the apparatus is capable of responding to vertical changes in the bearing of the light source with respect to the light detecting means.

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The drive means, for changing the elevation of a supported camera, preferably comprises a motor

drivingly coupled to a pivotable camera receiving portion of the support means.

As an alternative or in addition to the drive means for
5 changing the elevation of a supported camera, there is provided drive means capable to change the height of a supported camera. Preferably, such a drive means comprises a motor coupled to a rack gear portion of the support means via a pinion gear.

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According to a second aspect of the present invention, there is provided a combined optical tracking and focusing apparatus for a camera, including drive means for redirecting the camera in response to a bearing
15 signal indicative of the bearing of an object to be tracked, wherein a common photosensor is employed for both generating the bearing signal and a focusing signal for focusing the camera on the object to be tracked.

Embodiments of the present invention will now described, by way of example, with reference to the accompanying drawings, in which:

5 Figure 1 is a schematic side view of a conventional auto-focusing apparatus;

Figure 2 is a constructional drawing of a light receiver as depicted in Figure 1;

10 Figure 3 is a schematic side view of a camcorder equipped with an object tracking apparatus in accordance with the present invention;

Figure 4 is a block diagram of an object tracking apparatus in accordance with the present invention;

Figure 5 is a constructional drawing of a light receiver as depicted in Figure 3;

15 Figure 6 is a constructional drawing of one embodiment of an up/down driving means in accordance with the present invention;

20 Figure 7 is a constructional drawing of one embodiment of rotary means in accordance with the present invention;

Figure 8 is a constructional drawing of a second embodiment of an up/down driving means in accordance with the present invention;

Figure 9 is a constructional drawing of a second embodiment of a rotary means in accordance with the present invention;

5 Figure 10 is a circuit diagram of one embodiment of a motor driving circuit;

Figures 11A and 11B are drawings for explaining the operational principle of an object tracking apparatus in accordance with the present invention; and

10 Figure 12 is a flow chart illustrating a method according to the second aspect of the present invention.

Referring to Figure 3, an object tracking apparatus in accordance with the present invention includes
15 photoelectric conversion means 120 for converting into electric signals the incident, infra-red generated by a focusing light emitter 1 and the incident light generated by a light emitting means 110, for object detection, attached to an object 500; an object
20 movement detecting means 200 for detecting the movement of an object by utilising signals output by the photoelectric conversion means 120; and direction changing means 300 for changing the shooting direction

of a camcorder supported by a tripod 400 in accordance with a moving object detected by the object movement detection means.

5 Light emitting means 110 emits light having a different frequency to that emitted by the focusing infra-red emitted by the focusing light emitter 1 and is attached to an object 500 or a remote controller (not shown).

10 The photoelectric conversion means 120 is composed of at least four photosensors 122, 124, 126, 128 (Figure 4), and among these photosensors, two photosensors are used for the dual purposes of auto-focusing and object tracking.

15 Referring to Figure 4, an object tracking apparatus of a camcorder in accordance with the present invention, comprises photoelectric conversion means 120 for converting into electrical signals the incident
20 focusing infra-red generated by the focusing light emitter 1 and reflected by objects and the incident light generated by the light emitting means 110 for object detection attached to the object; object

movement detection means 200 for detecting object
movements by utilising the signals from said
photoelectric conversion means; direction changing
means 400 for changing the shooting direction of a
5 camcorder so that the camcorder follows the movement of
moving objects detected by the object movement
detection means 200.

Focusing light emitting 1 is usually attached to a
10 camcorder. The light (infra-red) emitted from the
focusing light emitter 1 is reflected by an object 500
and incident upon photosensor 126, 128 of photoelectric
conversion means 120, attached to the camcorder. The
photosensors 126, 128 convert incident light into
15 electrical signals and output them to a controller (not
shown) which, utilising a measurement of the time
between emission of the infra-red and its reception by
the photosensors 126, 128, performs focusing by
calculating the distance between the camcorder and the
20 object 500.

The light emitting means 110 for object detection is attached to an object or a remote controller (not shown) for controlling the camcorder at a distance.

5 When the light generated by the light emitting means 110 is incident on the photoelectric conversion means 120, photoelectric conversion means 120 converts the light into electrical signals. The photoelectric conversion means 120 comprises at least four
10 photosensors 122, 124, 126, 128 and the light incident on the respective photosensors 122, 124, 125, 128 changes according to the movement of the object 500. Accordingly, the electrical signals respectively output by photosensors 122, 124, 126, 128 also change
15 according to the movement of the object 500.

In other words, if the object 500 is moved to the right, using the centre of the photoelectric conversion means as a reference, the light incident on the
20 photoelectric conversion means 120 is predominantly incident on the photosensors 122, 126 mounted on the left. The ratio of light incident on the left photosensors 122, 126 to that incident on the right

photosensors 124, 128, is proportional to the magnitude of movement of the object 500. If the object 500 moves to the left, the light incident on the photoelectric conversion means 120 is predominantly incident on the
5 photosensors 124, 128 mounted on the right. The ratio of light incident on the left 122, 126 and the right 124, 128 photosensors is proportional to the magnitude of movement of the object 500. Consequently, the magnitudes of the electrical signals P1, P2, P3, P4
10 output by the photosensors 122, 124, 126, 128 of photoelectric conversion means 120 become different.

The object movement detection means 200 comprises an amplifier 210 for amplifying the electrical signals P1, P2, P3, P4, a comparator for comparing mutually the
15 signal amplified by the amplifier 210, and the controller 230 for outputting the shooting direction changing signal by determining the object movement direction and magnitude in accordance with the
20 comparison results from the comparator 220. The travelling object detection means 200 outputs a control signal in accordance with movement of the object 500 by

utilising the electrical signals P1, P2, P3, P4 from the photoelectric conversion means 120.

5 In other words, at the amplifier 210, the electrical signals P1, P2, P3, P4 are amplified for output, and the comparator 220 converts the amplified signals P1, P2, P3, P4 to digital signals for mutual comparison and determines in which direction the object has moved from the centre of the field of view of the camcorder.

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In accordance with the output of the comparator 220, the controller 230 outputs a control signal in order to correct the shooting direction.

15 Direction changing means 300 comprises an up/down (elevation) drive 310 for moving the shooting direction of the camcorder in the vertical plane, and a left/right (azimuth) drive 340 for changing the shooting direction of the camcorder in the horizontal
20 plane. The direction changing means 300 changes the shooting direction of the camcorder so that an object is positioned in the centre of the camcorder field of

view in response to the control signals output by the controller 230.

5 The direction changing means 300 is mounted between the supportive means of a tripod 400 and the main body 20 of the camcorder, and rotates the camcorder about a vertical axis and a transverse axis so that the lens 10 is always directed towards the object 500. In this way the object tracking apparatus of a camcorder in
10 accordance with the present invention changes the shooting direction in response to movement of an object so that the object remains in the centre of the field of view of the camcorder.

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Referring to Figure 5, the photoelectric conversion means 120 comprises four photosensors 122, 124, 126, 128 in order to monitor the movement of objects irrespective of direction. The photosensors 122, 124,
20 126, 128 are mounted in a square at the upper left, upper right, lower left and lower right positions respectively, and output the electrical signals P1, P2,

P3, P4 in dependence upon the light magnitude incident thereon.

Referring to Figure 6, the up/down drive 310 comprises
5 a motor 38, a gear 40 fixed to a shaft 38a of said
motor 38, a semicircular gear 36 for rotating about a
hinge 32 mounted on the upperside of a supporting shaft
30 engaged with the gear 40 and a supporting plate 34
formed integrally with the semicircular gear 36 fixed to
10 the lower portion of the main body of a camcorder 20.

When the object movement detection means 200 detects
that the object 500 has deviated upwardly from the
centre of the field of view of the camcorder, the
15 output control signal causes the motor 38 to rotate
clockwise (as viewed in the drawing). When the motor 38
rotates clockwise, so does the gear 40, and the
semicircular gear 36 rotates anticlockwise about the
hinge 32. When the semicircular 36 rotates
20 anticlockwise about the hinge 32 so does the supporting
plate 34. When the supporting plate 34 rotates
anticlockwise, the front of the main body of the

camcorder, fixed to the supporting plate 34, moves upwardly.

5 If the object 500 moves down from the centre of the field of view, the front of the main body 20 of the camcorder is moved down by anticlockwise rotation of the motor 38.

10 In this manner, when the shooting direction is corrected by way of rotation of the motor 38, the shooting direction corresponds to the bearing of the object 500 with respect to the camcorder and the electrical signals P1, P2, P3, P4 output by the photoelectric conversion means 120 become identical.

15 When the electrical signals P1, P2, P3, P4 output by the photoelectric conversion means 120 become identical the direction changing means 400 stops further changing of the shooting direction by way of the control signal output from the object movement detection means 200.

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Referring to Figure 7, the left/right drive 340 comprises a motor 42, a gear 44 fixed to a shaft 42a of the motor 42, a speed reducing gear 46, and a

supporting shaft 30 wherein a gear 48a engaged with the speed reducing gear 46 is formed and a lug rod 48b formed underneath is inserted rotatably within a cylindrical hole 58 formed in the upper end of a shaft rod 50. The camcorder is installed on the upper end of the supporting shaft 30. Thus, when it is determined that the object has deviated to the right from the centre of the field of view of a camcorder by the object movement detection means 200, a control signal output thereby causes the motor 42 to rotate anticlockwise (when viewed from above in Figure 7). When the motor 42 rotates anticlockwise, so does the gear 44 and the speed reducing gear 46 rotates anticlockwise also. When the speed reducing gear 46 rotates anticlockwise, the gear 48a, formed on the supporting shaft 30 rotates clockwise, as does the supporting shaft 30. The lug rod 48b formed at the lower end of the supporting shaft 30 rotates within the cylindrical hole 58 of the shaft rod 50. In this manner, when the supporting shaft 30 rotates clockwise, the front of the camcorder (not shown), fixed to the upper end of the supporting shaft 30, turns to the right.

If the object is judged to have deviated to the left of the centre of the field of view of the camcorder by the object movement detection means 200, the motor 42 rotates anticlockwise according to the control signal produced by the object movement detection means 200. When the motor 42 rotates anticlockwise, so does the gear 44, and the speed reducing gear 46 rotates clockwise. When the speed reducing gear 46 rotates clockwise, the gear 48a formed on the supporting shaft 30 is caused to rotate anticlockwise, causing the supporting shaft to move likewise. In this way, when the supporting shaft 30 rotates anticlockwise, the front of the camcorder (not shown) fixed to the upper end of the supporting shaft 30 turns to the left.

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Thus, the shooting direction is corrected by rotating the motor 42, and when the object is positioned in the centre of the field of view of the camcorder, the electrical signals P1, P2, P3, P4 output by the photoelectric conversion means 120 become identical. When the electrical signals P1, P2, P3, P4 become identical, the direction changing means 300 stops the change of shooting direction of the camcorder.

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Referring to Figure 8, an up/down drive 310 comprises a motor 52, a pinion gear 54 fixed to the shaft 52a of the motor 52, and a supporting shaft 30 wherein a ratchet gear 56 is so formed that it can move up and down within a cylindrical shaft rod 58 under the influence of the pinion gear 54.

Thus, when the object deviates upwardly in the field of view of the camcorder, the object movement detection means 200 outputs a control signal and rotates the motor 52 clockwise (as viewed in Figure 8) driving the pinion gear 54 likewise. When the pinion gear 54 rotates clockwise, the supporting shaft 30 formed with the ratchet gear 56 is guided in the shaft rod 58 and moves up. When the supporting shaft moves up, the camcorder installed on the upper end of the supporting shaft 30 moves up also. Therefore, the object remains positioned in the centre of the field of view of the camcorder.

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When the object is positioned in the centre of the field of view of the camcorder, the electrical signal P1, P2, P3, P4 output by the photoelectric conversion

means 120 are identical and, therefore, the movement of the camcorder ceases.

5 When the object moves down from the centre of the field of view of the camcorder, the motor 52 is driven anticlockwise thereby lowering the front of the camcorder.

10 Referring to Figure 9, a left right drive comprises a motor 62, a gear 64 fixed to the shaft 62a of the motor 62, a speed reducing gear 66, and a supporting shaft having a gear 68a engaged by the speed reducing gear 66, formed inside the lower end thereof rotatably mounted on a shaft rod 70.

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Thus, when the object is judged to have been moved towards the right of the centre of the field of view of the camcorder by the object movement detection means 200, the motor 62 is caused to rotate anticlockwise (viewed from above in Figure 9) by the control signal from the object movement detection means 200. When the motor 62 rotates anticlockwise, so does the gear 64 and the speed reducing gear 66 rotates clockwise. When the

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speed reducing gear 66 rotates clockwise, the supporting shaft 30 having a gear 68a engaged with the speed reducing gear 66 rotates clockwise. In this manner, when the supporting shaft 30 rotates anticlockwise, the front of the camcorder (not shown) fixed to the upper end of the supporting shaft 30 turns towards the right.

If the object moves towards the left of the centre of the field of view of the camcorder, the object movement detection means 200 outputs a control signal, causing the motor 62 to rotate anticlockwise. When the motor rotates anticlockwise, so does the gear 64 and the speed reducing gear 62 rotates clockwise. When the speed reducing gear 62 rotates clockwise, so does the supporting shaft 30. When the supporting shaft 30 rotates anticlockwise, the front (not shown) of the camcorder fixed to the upper end of the supporting shaft 30 turns to the left.

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This means that when the shooting direction is corrected by rotating the motor and the object is positioned in the centre of the field of view of the

camcorder, the electrical signals P1, P2, P3, P4
output by the photoelectric conversion 120 become
identical. When the electrical signals P1, P2, P3, P4
output by the photoelectric conversion means 120 become
5 identical, direction changing means 300 stops changing
the shooting direction of the camcorder by way of the
control signal output by the object movement detection
means 200.

10 Referring to Figure 10, in the motor driving circuit,
when the control signal CT1 or CT2 output by the object
movement detection means 200 become high, transistors
Q1, Q4 or Q2, Q3 start operating, causing the motor M
to rotate clockwise or anticlockwise. This causes the
15 up/down drive and the left/right drive to start
operating to change the shooting direction.

B+ is the motor driving voltage and R1, R2, R3, R4,
R5, R6 are resistors.

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Referring to Figure 11a, the shooting direction and the
position of the object 500 are normal, which means that
the object 500 is in the centre of the field of view of

the camcorder. Under this condition, the light emitted by the light emitting means 110 is incident upon the centre of the photoelectric conversion means 120. When the light generated by the light emitting means 110 is incident upon the centre of the photoelectric conversion means 120, the magnitudes of the electrical signals P1, P2, P3, P4 are identical.

In order words,

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$$P1 = P2 = P3 = P4.$$

Thus, the object movement detection means 200, determines that the object is positioned in the centre of the field of view of the camcorder when the electrical signals P1, P2, P3 and P4 are identical.

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Referring to Figure 11b, the shooting direction of the camcorder and the position of an object are abnormal, which means that the object has moved down from the centre of the field of view of the camcorder. Under this condition, the light emitted from light emitting means 110 is primarily incident on the upper part of

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the photoelectric conversion means 120 through light receiving lens 3.

5 When the light emitted from the light emitting means 110 is primarily incident upon the upper half of the photoelectric conversion means 120, the electrical signals P_1 , P_2 , P_3 , P_4 become $P_1 = P_2 = P_3 = P_4$, $P_1 > P_3$ and $P_2 > P_4$.

10 Likewise, when the object moves up from the centre of the field of view of the camcorder, the electrical signals become $P_1 = P_2$, $P_3 = P_4$, $P_1 < P_3$ and $P_2 < P_4$.

15 When the object moves towards the right from the centre of the field of view of the camcorder, the electrical signals become $P_1 < P_2$, $P_3 < P_4$, $P_1 = P_3$ and $P_2 = P_4$ and when the object moves to the left of the centre of the field of view of the camcorder the electrical signals become $P_1 < P_2$, $P_3 < P_4$, $P_1 = P_3$ and $P_2 = P_4$.

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Based on the relative magnitudes of P_1 , P_2 , P_3 and P_4 , the object movement detections means 200 recognises that the object has moved from the centre of the field

of view of the camcorder and an output control signal drives the motor to turn the camcorder so as to keep the object 500 in the centre of its field of view.

5 Referring to Figure 12, an object tracking method comprises a first step of comparing mutually the magnitudes of electrical signals output respectively from at least four photosensors which convert light incident from an object into electrical signals, and a
10 second step of changing the shooting direction of a camcorder according to the comparison results of the first step.

The first step of the object tracking method comprises:
15 left/right comparison steps, steps 102, 104 for comparing whether the magnitudes of electrical signals (P1, P3,) (P2, P4) are identical; up/down comparison steps, of steps 106, 108 for comparing whether the magnitudes of electrical signals (P1, P3) (P2, P4) are
20 identical; left/right magnitude comparison steps, steps 110, 112, 118 for comparing the magnitudes of electrical signals (P1, P2,) (P3, P4) if they are not identical; and up/down magnitude comparison steps,

steps 114, 116, and steps 120, 122 for comparing the magnitudes of electrical signals (P1, P3) (P2, P4) if they not identical.

5 Further explanations of the above are given below.

When the electrical signals P1, P2, P3, P4 are input into the object movement detection means 200, the electrical signals are amplified by the amplifier 210 at step 100. The comparator 220, when amplified signals P1, P2, P3, P4 are input, compares the signals one with another, and outputs the comparison results to the controller 230. The controller 230, according to the results from the comparator 220, determines whether the magnitudes of the signals, P1 and P2, are identical, step 102.

If the result of step 102 shows that $P1 = P2$ the controller 230 determines, at step 104, whether the magnitudes of the signals P3, P4 are identical.

If the result of step 104 shows that $P3 = P4$ it is determined that there is no error in the shooting direction in the horizontal plane.

5 If the shooting direction is correct in the horizontal plane, the controller 230 determines whether the magnitude of the signals $P1$, $P3$ are identical at step 106.

10 At step 106, if it is determined that the signals $P1$, $P4$ are identical, the result will be the same.

 If the result of step 106 shows that $P1 = P3$, $P1 = P2$, $P3 = P4$ and $P1 = P3$, it is determined that the shooting
15 direction of the camcorder is correct. Therefore, the controller does not output control signals to the direction changing means 300. However, if the results of step 106 shows that $P1$ does not equal $P3$, the controller determines whether $P1$ is larger than $P3$ at
20 step 108.

If $P1 > P3$ at step 108, which implies that the object is positioned in the lower half of the field of view of the camcorder the controller 230 outputs control signals to the direction changing means 300 and changes the shooting direction of the camcorder towards the lower half of its field of view.

If the result at step 108 reveals that $P1$ is not smaller than $P3$, bearing in mind the result of step 106 is that $P1$ does not equal $P3$, then $P1 < P3$. Therefore, as the objects are positioned in the upper half of the field of view of the camcorder, the controller 230 outputs the control signal to the direction changing means 300 to change the shooting direction of the camcorder towards the upper half of its field of view.

If $P3 = P4$ at step 104, the result is $P1 = P2$ and $P3 = P4$, however as this kind of result seldom exists, the controller 230 decides that this result is an error and does not output a control signal to the direction changing means 300.

If $P1 = P2$ at step 102, the controller determines whether $P1$ is less than $P2$ at step 110. If $P1$ is less than $P2$ at step 110, the controller determines whether $P3$ is less than $P4$ at step 112. If $P3$ is not smaller than $P4$ at step 112, which seldom exists, then the controller determines that this result is an error and does not output a control signal to the direction changing means 300. If $P3$ is less than $P4$ at step 112, it is determined that the object is positioned in the right half of the camcorder's field of view.

If the result of step 112 reveals that the object is positioned in the right half of the camcorder's field of view, the controller determines whether $P1 = P3$ at step 114. If $P1 = P3$ at step 114, the controller determines that the object has not deviated to the upper or lower halves of the camcorder's field of view. Thus, the controller 230 outputs control signals to the direction changing means 300 and changes the shooting direction to the right.

If P1 does not equal P3 at step 114, the controller determines whether $P1 > P3$ at step 116. If $P1 > P3$ at step 116. If $P1 > P3$ at step 116 the controller determines that the object is positioned in the upper half of the camcorder's field of view and then outputs a control signal to direction changing means 300 to change the shooting direction of the camcorder to the lower right.

10 If it revealed that P1 is not larger than P3, the controller 230 determines that the object is positioned to the upper right of the centre of the camcorder's field of view and outputs a control signal to the direction changing means 300 to change the shooting
15 direction of the camcorder to the upper right.

If the result reveals that P1 is not smaller than P2, then the controller 230 determines whether $P3 > P4$ at step 118. If $P3 > P4$ at step 118, the
20 controller determines that the object is positioned on the left side of the centre of the camcorder's field of view, and then determines whether $P2 = P4$, step 120. However, as the condition that P3 is not smaller than

P4 seldom exists, the controller 230 determines this situation to be an error, and does not output a control signal to the direction changing means 300.

5 If $P1 > P2$ at steps 102, 110 which implies that the object has deviated to the left from the centre of the camcorder's field of view, then the result becomes $P3 > P4$. Therefore, the condition of $P3 > P4$ does not exist and this result can be determined as an error.

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 If $P2 = P4$ at step 120, the controller determines that the object has deviated to the left from the centre of the camcorder's field of view, and changes the shooting direction of the camcorder to the left. In other
15 words, if $P2 = P4$, it implies that the object has not deviated up or down from the centre of the camcorder's field of view and as it has already been determined that the object has deviated to the left at steps 102,
20 110, 118, the controller 230 changes the shooting direction to the left.

If P2 does not equal P4 at step 120, the controller determines whether $P2 > P4$, step 122. If $P2 > P4$ at step 122, the controller 230 determines that the object has deviated to the lower left of the centre of the camcorder's field of view and outputs a control signal to the direction changing means 300 to change the shooting direction of the camcorder to the lower left.

If P2 is not geater than P4 at step 122, the controller 230 determines that the object has deviated to the upper left of the centre of the camcorder's field of view and outputs a control signal to the direction changing means 300 to change the shooting direction of the camcorder to the upper left.

Accordingly, an object tracking method for a camcorder in accordance with the present invention detects the movement of an object according to the light incident upon a photoelectric conversion means in order to change the shooting direction of the camcorder.

From the foregoing, the object tracking apparatus and method thereof can obtain the effect of automatically tracking an object using apparatus of simple construction. Therefore, the camcorder can be
5 miniaturised and lightened by providing the object tracking apparatus utilising auto-focusing apparatus.

The foregoing description of the preferred embodiment has been presented for the purpose of illustration and
10 description. It is not intended to limit the scope of this invention. Many modifications and variations are possible in the light of the above teaching.

Specifically, though the described apparatus has only
15 four photosensors, the present invention may be embodied using photoelectric conversion means having more than four photosensors. Besides, in the foregoing object tracking method of the present invention, though comparison of movement to the left and right
20 directions has been firstly performed and then comparison of movement in the up and down directions has been performed later, it should be apparent that

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the present invention provides the same effective results even with simple changes in the procedures.



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Claims

1. An object tracking apparatus for a camera,
comprising support means including drive means for
5 movably supporting a camera, a tracking light source for
emitting light having a first frequency, a focusing light
source for emitting light having a second frequency,
light detecting means responsive to light of said first
and second frequencies and outputting a bearing signal in
10 dependence on light of said first frequency and a focus
signal in dependence on light of said second frequency,
and tracking means for producing a control signal in
dependence on the bearing signal, wherein the drive means
is responsive to the control signal to cause a camera
15 mounted to the support means to track the tracking light
source.

2. An apparatus according to claim 1, wherein the light
detecting means and the tracking means are mounted to a
20 camera.

3. An apparatus according to claim 1 or 2, wherein the
light detecting means comprises a plurality of
photosensitive elements.

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4. An apparatus according to claim 3, wherein the light
detecting means comprises four square photosensitive
elements arranged as quarters of a larger square.



5. An apparatus according to claim 3 or 4, wherein the bearing signal comprises the outputs of the photosensitive elements and the tracking means compares the relative magnitudes of the outputs of the
5 photosensitive elements to produce the control signal.

6. An apparatus according to any preceding claim, wherein the drive means is operable in response to the control signal to change the azimuth of a supported
10 camera.

7. An apparatus according to claim 6, wherein the drive means comprises a motor drivingly coupled to a gear portion of the support means.
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8. An apparatus according to claim 7, wherein the motor is drivingly coupled to the gear portion of the support means via a speed reducing gear train.

20 9. An apparatus according to claim 7 or 8, wherein the gear portion of the support means has radially outwardly extending teeth.

10. An apparatus according to claim 7 or 8, wherein the
25 gear portion of the support means has radially inwardly extending teeth.

11. An apparatus according to any preceding claim,



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wherein the drive means is operable to change the angle of elevation of a supported camera.

12. An apparatus according to claim 11, wherein the
5 drive means comprises a motor drivingly coupled to a pivotal camera receiving portion of the support means.

13. An apparatus according to any preceding claim,
wherein the drive means is operable to change the height
10 of a supported camera.

14. An apparatus according to claim 13, wherein the drive means comprises a motor coupled to a rack gear portion of the support means via a pinion gear.

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15. A combined optical tracking and focusing apparatus for a camera, including drive means for redirecting the camera in response to a bearing signal indicative of the bearing of an object to be tracked, wherein a common
20 photosensor is employed for both generating the bearing signal and a focusing signal for focusing the camera on the object to be tracked.

16. An object tracking apparatus substantially as
25 hereinbefore described with reference to Figures 3 to 12 of the accompanying drawings.