

(19)



(11)

EP 4 819 087 A1

(12)

EUROPEAN PATENT APPLICATION

published in accordance with Art. 153(4) EPC

(43) Date of publication:
07.10.2026 Bulletin 2026/41

(51) International Patent Classification (IPC):
G08B 13/196 (2006.01) G08B 29/18 (2006.01)

(21) Application number: **24895919.9**

(86) International application number:
PCT/CN2024/119587

(22) Date of filing: **19.09.2024**

(87) International publication number:
WO 2025/112821 (05.06.2025 Gazette 2025/23)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

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(30) Priority: **02.12.2023 CN 202311638046**

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(54) MONITORING AREA PROTECTION METHOD AND APPARATUS, ELECTRONIC DEVICE, AND STORAGE MEDIUM

(57) A monitoring area protection method, comprising: establishing a correspondence table $\sigma_i \rightarrow F(d_i)$ of measurement distances and repeatabilities, and fitting a correspondence relationship on the basis of the correspondence table; setting a protection area distance and an alarm area distance on the basis of a measurement distance required by a target monitoring area; then substituting the protection area distance and the alarm area distance into the correspondence relationship of the measurement distances and the repeatabilities to obtain distance hystereses corresponding to the protection area distance and the alarm area distance, performing calculation on the basis of the alarm area distance, the protection area distance and the distance hystereses to obtain a first transition area distance and a second transition area distance; then obtaining an intrusion distance of an intrusion object, and determining a state flag bit of the intrusion object on the basis of the distance relationships between the intrusion distance and the protection area distance, the first transition area distance, the alarm area distance, and the second transition area distance; and then performing determination on the basis of a current state of the state flag bit so as to give an alarm or take a protection action. The method can avoid a measurement distance deviation that is caused by the repeatability problem of a camera and thus would cause misjudgment

that leads to false alarms or protection actions.

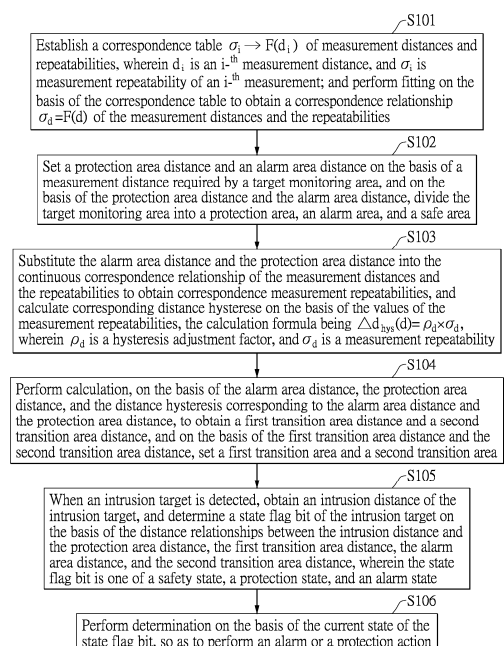


FIG. 1

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Description

FIELD OF THE DISCLOSURE

[0001] The present disclosure relates to the technical field of monitoring area protection, and particularly relates to a monitoring area protection method, a monitoring area protection apparatus, an electronic device, and a storage medium.

BACKGROUND OF THE DISCLOSURE

[0002] In the field of monitoring area protection, an area is usually divided into multiple areas. A ranging device for single-point ranging, two-dimensional plane ranging, or three-dimensional space ranging scans and measures distances from an origin of the ranging device toward various directions within an FOV range, or an identification device is installed at a specific point in each area, so as to identify whether a target intrudes into the protection area and which area the intrusion target is located in, thereby performing a corresponding protection action or alarm action.

[0003] However, a problem is that a camera has a performance parameter of repeatability. The repeatability refers to consistency of measuring a distance to a same point of the intrusion target. If the repeatability is lower, a distance value measured each time fluctuates more. Meanwhile, if a measured distance value of the intrusion target switches back and forth between two adjacent areas, the camera cannot stably identify which area the intrusion target is currently located in, and correspondingly switches corresponding actions frequently, thereby performing an erroneous protection action.

SUMMARY OF THE DISCLOSURE

[0004] To solve the technical defects proposed in the above background art, an objective of the present disclosure is to provide a monitoring area protection method, aiming to solve a problem that, when an intrusion target enters a monitoring area, a repeatability problem existing in the camera itself causes unstable determination when the intrusion target enters a boundary of the monitoring area, thereby causing misjudgment.

[0005] The present disclosure adopts the following technical solutions.

[0006] In a first aspect, the present disclosure provides a monitoring area protection method, wherein the method includes:

establishing a correspondence table $\sigma_i \rightarrow F(d_i)$ between measurement distances and repeatabilities, wherein d_i is an i -th measurement distance, and σ_i is measurement repeatability of an i -th measurement d_i ; and performing fitting, according to the correspondence table $\sigma_i \rightarrow F(d_i)$, a continuous correspondence

relationship $\sigma_d = F(d)$ between the measurement distances and the repeatabilities;

setting a protection area distance and an alarm area distance based on a measurement distance required by a target monitoring area, and dividing the target monitoring area into a protection area, an alarm area, and a safe area according to the protection area distance and the alarm area distance;

substituting the alarm area distance and the protection area distance into the continuous correspondence relationship between the measurement distances and the repeatabilities to obtain a corresponding measurement repeatability, and calculating on a distance hysteresis corresponding to the alarm area and the protection area distance according to a value of the measurement repeatability, wherein a calculation formula is $\Delta d_{hys}(d) = \rho_d \times \sigma_d$, wherein ρ_d is a hysteresis adjustment factor, and σ_d is the measurement repeatability;

performing calculation to obtain a first transition area distance and a second transition area distance based on the alarm area distance, the protection area distance, and the distance hysteresis corresponding to the alarm area and the protection area distance, and setting a first transition area and a second transition area according to the first transition area distance and the second transition area distance;

when an intrusion target is detected, obtaining an intrusion distance of the intrusion target, and determining a state flag bit of the intrusion target according to distance relationships between the intrusion distance and the protection area distance, the first transition area distance, the alarm area distance, and the second transition area distance, wherein the state flag bit is one of a safe state, a protection state, and an alarm state; and

performing a determination according to a current state of the state flag bit, so as to perform an alarm action or a protection action.

[0007] Optionally, determining the state flag bit of the intrusion target includes: during initialization, if the intrusion distance is less than or equal to the protection area distance, determining that the intrusion target is in the protection area, and presetting the current state of the state flag bit as the protection state; if the intrusion distance is greater than the protection area distance and less than or equal to the alarm area distance, determining that the intrusion target is in the alarm area, and presetting the current state of the state flag bit as the alarm state; if the intrusion distance is greater than the alarm area distance, determining that the intrusion target is in the safe area, and presetting the current state of the state flag bit as the safe state.

[0008] Optionally, determining the state flag bit of the intrusion target further includes:

when the intrusion target approaches or moves away, if the intrusion distance $d_{\min}$ is less than or equal to the protection area distance d_r , determining that the intrusion target is in the protection area, and the current state of the state flag bit at this time is the protection state, wherein a formula can be expressed as $d_{\min} \leq d_r$;

if the intrusion distance $d_{\min}$ is greater than the protection area distance d_r and less than or equal to the protection area distance d_r plus the second transition area distance $\Delta d_{\text{hys}}(d_r)$, determining that the intrusion target is currently in the second transition area, and, if a previous state of the state flag bit is the safe state or the alarm state, the current state of the state flag bit at this time is the alarm state, and if the previous state of the state flag bit is the protection state, the current state of the state flag bit is the protection state, wherein a formula is expressed as $d_r < d_{\min} \leq d_r + \Delta d_{\text{hys}}(d_r)$;

if the intrusion distance $d_{\min}$ is greater than the protection area distance d_r plus the second transition area distance $\Delta d_{\text{hys}}(d_r)$ and less than or equal to the alarm area distance d_a , determining that the intrusion target is in the alarm area, and the current state of the state flag bit at this time is the alarm state, wherein a formula is expressed as $d_r + \Delta d_{\text{hys}}(d_r) < d_{\min} \leq d_a$;

if the intrusion distance $d_{\min}$ is greater than the protection area distance d_a and less than or equal to the alarm area distance d_a plus the first transition area distance $\Delta d_{\text{hys}}(d_a)$, determining that the intrusion target is currently in the first transition area or the alarm area, and, if the previous state is the safe state, determining that the current state is the safe state, and if the previous state is the alarm state or the protection state, the current state of the state flag bit at this time is the alarm state, wherein a formula is expressed as $d_a < d_{\min} \leq d_a + \Delta d_{\text{hys}}(d_a)$; and
if the intrusion distance $d_{\min}$ is greater than the alarm area distance d_a plus the first transition area distance $\Delta d_{\text{hys}}(d_a)$, determining that the intrusion target is in the safe area, and the current state of the state flag bit at this time is the safe state, wherein a formula is expressed as $d_{\min} > d_a + \Delta d_{\text{hys}}(d_a)$.

[0009] Optionally, determining the state flag bit of the intrusion target further includes:

when the intrusion target is relatively stationary, if the previous state of the state flag bit is the safe state, the current state of the state flag bit at this time is the safe state;

if the previous state of the state flag bit is the alarm state, the current state of the state flag bit at this time is the alarm state;

if the previous state of the state flag bit is the protection state, the current state of the state flag bit at this time is the protection state.

[0010] Optionally, performing the determination according to the current state of the state flag bit, so as to perform the alarm action or the protection action, includes:

if the current state of the state flag bit is the safe state, not performing the alarm action or the protection action;

if the current state of the state flag bit is the alarm state, performing the alarm action;

if the current state of the state flag bit is the protection state, performing the protection action.

[0011] In a second aspect, the present disclosure provides a monitoring area protection apparatus, including:

an establishing module, configured to establish a correspondence table $\sigma_i \rightarrow F(d_i)$ between measurement distances and repeatabilities and fit a continuous correspondence relationship $\sigma_d = F(d)$ between the measurement distances and the repeatabilities;

a presetting module, configured to set a protection area distance and an alarm area distance according to a requirement of a target monitoring area;

a first calculating module, configured to calculate a corresponding distance hysteresis according to the alarm area distance, the protection area distance, and a value of a measurement repeatability corresponding thereto;

a second calculating module, configured to perform calculation according to the alarm area distance, the protection area distance, and the distance hysteresis corresponding thereto, to obtain a first transition area distance and a second transition area distance;

an obtaining module, configured to obtain an intrusion distance of an intrusion target when the intrusion target is detected;

a comparing module, configured to compare distance relationships between the intrusion distance and the protection area distance, the first transition area distance, the alarm area distance, and the second transition area distance;

a determining module, configured to determine that a state flag bit is one of a safe state, a protection state, and an alarm state; and

a response module, configured to perform a state determination according to a current state of the state flag bit, so as to give an alarm action or a protection action.

[0012] In a third aspect, the present disclosure further provides an electronic device, including: a memory, a processor, and a computer program stored on the memory and executable on the processor, wherein the processor, when executing the computer program, implements steps in the monitoring area protection method on the basis of embodiments of the present disclosure.

[0013] In a fourth aspect, the present disclosure further provides a computer-readable storage medium, wherein a computer program is stored on the computer-readable storage medium, and the computer program, when executed by a processor, implements steps in the monitoring area protection method on the basis of embodiments of the present disclosure.

[0014] In summary, beneficial effects of the present disclosure are as follows.

[0015] By setting the first transition area between the alarm area distance and the safe area distance, and setting the second transition area between the alarm area distance and the protection area distance, and further by introducing a concept of distance hysteresis, the present disclosure can avoid inaccurate identification of which area the intrusion target is currently located in due to the repeatability problem of the camera. Meanwhile, by setting the state flag bit as one of the safe state, the alarm state, and the protection state, the camera can send a corresponding alarm action or protection action according to the current state of the state flag bit.

[0016] The above description is merely an overview of the technical solutions of the present disclosure. In order to make the technical means of the present disclosure clearer and enable implementation on the basis of contents of the specification, and in order to make the above and other objectives, features, and advantages of the present disclosure more apparent and understandable, preferred embodiments are provided below and described in detail with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIG. 1 is a flowchart of a monitoring area protection method according to an embodiment of the present disclosure;

FIG. 2 is a schematic view of a monitoring area protection apparatus according to an embodiment of the present disclosure; and

FIG. 3 is a schematic view of an electronic device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[0018] In order to make contents of the present disclosure more easily and clearly understood, the present disclosure is further described below according to specific embodiments and in conjunction with the accompanying drawings.

[0019] As shown in FIG. 1, FIG. 1 is a flowchart of a monitoring area protection method provided by the present embodiment. The monitoring area protection method includes the following steps.

[0020] S101: Establishing a correspondence table $\sigma_i \rightarrow F(d_i)$ between measurement distances and repeatabilities, wherein d_i is an i -th measurement distance, and σ_i is measurement repeatability of an i -th measurement d_i ; and performing fitting, according to the correspondence table $\sigma_i \rightarrow F(d_i)$, a continuous correspondence relationship $\sigma_d = F(d)$ between the measurement distances and the repeatabilities.

[0021] In the embodiment of the present disclosure, because differences in repeatability exist in the camera itself, and the repeatability is determined by performance of the camera itself, a distance deviation occurs when distance measurement is performed. Therefore, a discrete correspondence table between measurement distances and repeatabilities needs to be established. The correspondence table can be obtained by performing multiple measurements by the camera at a same measurement distance to obtain the repeatability of the camera at the distance, and corresponding repeatability is obtained by measuring multiple distances, so as to obtain a discrete correspondence table $\sigma_i \rightarrow F(d_i)$ between d_i and σ_i . According to the measurement distance, a method of piecewise linear fitting, piecewise setting of fixed repeatability, global linear fitting, or curve fitting is selected to fit and obtain a continuous relationship $\sigma_d = F(d)$ between the measurement distance d and the measurement repeatability σ_d at the distance. Because only a discrete correspondence relationship $\sigma_i \rightarrow F(d_i)$ between d_i and σ_i exists, a continuous correspondence relationship $\sigma_d = F(d)$ between a continuous distance d and repeatability σ_d needs to be established, namely any distance has a corresponding repeatability, such that a corresponding repeatability is determined for each of different measurement distances.

[0022] S102: Setting a protection area distance and an alarm area distance on the basis of a measurement distance required by a target monitoring area, and dividing the target monitoring area into a protection area, an alarm area, and a safe area according to the protection area distance and the alarm area distance.

[0023] In the embodiment of the present disclosure, specifically, the protection area distance and the alarm area distance can be set on the basis of a distance range required by each area. For example, when a ranging device is powered on and set, the protection area distance can be set as 2 meters, or the protection area distance can be set as 1 meter. A safe area distance does not need to be set. Protection levels of the areas are different. The protection area has the highest level, the alarm area has a next level, and the safe area does not need protection. It should be noted that the three areas are divided on the basis of requirements of different area protection levels. By dividing the three areas, which area the intrusion target is currently located in can be determined, so as to perform a corresponding alarm action or protection action.

[0024] Specifically, an intrusion target in the monitoring area can be measured by one-dimensional measure-

ment, two-dimensional measurement, or three-dimensional measurement. The one-dimensional measurement is performed by single-point measurement, and a TOF ranging technology can be used for measurement. The TOF ranging technology measures a distance of an object by emitting pulsed laser light to a surface of the object and calculating round-trip time. The two-dimensional measurement can be performed by single-line LiDAR. More specifically, the single-line LiDAR is formed by rotating a single-point laser measurement module for one circle, so as to measure a target in a two-dimensional plane (namely having x and y coordinates and Z=0). The three-dimensional measurement usually includes area-array measurement (multi-point direct measurement, or 3D reconstruction measurement), or 3D measurement in which one or more single-point ranging modules are combined with moving scanning components such as MEMS, a rotating mirror, or a prism, or 3D measurement in which multiple single-point ranging modules are combined with motor rotation scanning (which can be understood as being formed by superimposing multiple single-line measurements at different vertical angles). It can be understood that a set of multiple single-point protection areas can form a protection area in a two-dimensional plane or a three-dimensional space, a set of multiple single-point alarm areas can form an alarm area in a two-dimensional plane or a three-dimensional space, and a set of multiple single-point safe areas can form a safe area in a two-dimensional plane or a three-dimensional space, so that the protection area, the alarm area, and the safe area in a single-point, a two-dimensional planar, or a three-dimensional spatial form can be obtained correspondingly.

[0025] S103: Substituting the alarm area distance and the protection area distance into the continuous correspondence relationship between the measurement distances and the repeatabilities to obtain a corresponding measurement repeatability, and calculating a distance hysteresis corresponding to the alarm area and the protection area distance according to a value of the measurement repeatability, wherein a calculation formula is $\Delta d_{hys}(d) = \rho_d \times \sigma_d$, wherein ρ_d is a hysteresis adjustment factor, and σ_d is the measurement repeatability.

[0026] In the embodiment of the present disclosure, the correspondence relationship of the repeatability includes measurement repeatability of the protection area distance and measurement repeatability of the alarm area distance. The two measurement repeatabilities can be multiple. A regulation range of the hysteresis adjustment factor σ_d is $1 \leq \rho_d \leq 10$. The measurement repeatability at the corresponding distance is calculated with a preset hysteresis adjustment factor, thereby obtaining the distance hysteresis at the corresponding distance. Because differences in repeatability exist in the camera, deviations may occur when the intrusion distance, the alarm area distance, and the protection area distance are calculated and measured, and a measured distance value of the intrusion target has jumps. When

the distance value jumps back and forth between the protection area and the alarm area, or between the alarm area and the safe area, a protection action easily switches back and forth, thus affecting normal operation. By setting distance hysteresis, a transition area effect can be provided when detecting whether the intrusion target belongs to the protection area or the alarm area, thereby effectively solving the above problems.

[0027] S104: Performing calculation to obtain a first transition area distance and a second transition area distance on the basis of the alarm area distance, the protection area distance, and the distance hysteresis corresponding to the alarm area and the protection area distance, and setting a first transition area and a second transition area according to the first transition area distance and the second transition area distance.

[0028] In the embodiment of the present disclosure, first, the alarm area distance and the protection area distance are respectively calculated with alarm area distance hysteresis and protection area distance hysteresis in sequence. After the first transition area distance and the second transition area distance are obtained, area division is performed according to the first transition area distance and the second transition area distance, so as to obtain the first transition area and the second transition area. The division method can be setting the first transition area and the second transition area on the basis of specific distance values. By setting the first transition area and the second transition area as described above, misjudgment caused by the repeatability problem of the camera when determining which area the intrusion target is currently located in can be effectively avoided. If the intrusion target jumps back and forth between an alarm area boundary and a protection area boundary, measurement results of the camera may have deviations, thereby causing the camera to frequently alarm or perform a protection action, or even causing misjudgment. For example, by introducing the first transition area and the second transition area, a problem of frequent switching of protection actions caused by a difference in repeatability of the camera can be effectively solved.

[0029] S105: When an intrusion target is detected, obtaining an intrusion distance of the intrusion target, and determining a state flag bit of the intrusion target according to distance relationships between the intrusion distance and the protection area distance, the first transition area distance, the alarm area distance, and the second transition area distance, wherein the state flag bit is one of a safe state, a protection state, and an alarm state.

[0030] In the embodiment of the present disclosure, by confirming a nearest portion of the intrusion target from a boundary of the monitoring area, a distance between the nearest portion of the intrusion target and the camera can be calculated, thereby obtaining the intrusion distance. By obtaining the intrusion distance, the intrusion distance can be compared and determined with distance relation-

ships among the first transition area distance, the alarm area distance, the second transition area distance, and the protection area distance, thereby determining which area the intrusion target is currently located in, so that the camera can perform a corresponding alarm or protection determination. Further, by setting the state flag bit as one of the safe state, the protection state, and the alarm state, it should be noted that, when the intrusion target intrudes from the safe area into the protection area and when the intrusion target is initially in the protection area and then keeps exiting to the safe area, distances for the camera to switch between alarm or protection actions are different. By setting the three states to control the camera to perform corresponding alarm or protection actions, environmental changes can be effectively adapted to. For example, when the intrusion target intrudes from the safe area into the first transition area, a previous state of the camera is the safe state, and the camera does not perform any alarm or protection action at this time. When the intrusion target exits from the alarm area to the first transition area, the previous state of the camera is the alarm state, and the camera still performs the alarm action at this time until the intrusion target exits to the safe area, and only then does the camera stop alarming. Such arrangement can effectively remind operators to inspect, thereby improving safety.

[0031] Specifically, by performing calculation on the intrusion distance and the protection area distance, whether the intrusion target is outside or inside the protection area can be determined, thereby enabling the camera to send a protection action. By comparing the intrusion distance with the alarm area distance, whether the intrusion target is inside or outside the alarm area can be determined, thereby enabling the camera to send an alarm action. If the intrusion distance is greater than the alarm area distance, the intrusion target is in the safe area. Accordingly, according to which area the intrusion target is currently located in, the camera can set the current state of the state flag bit as the protection state, the alarm state, or the safe state. Further, when the intrusion distance is compared with the alarm area distance and the protection area distance, the first transition area distance and the second transition area distance are added. By comparing the intrusion distance with different combinations of the first transition area distance, the alarm area distance, the second transition area distance, and the protection area distance, and by continuous combined comparison, which area the intrusion target is currently located in can be accurately determined, such that the current state flag bit is the safe state, the alarm state, or the protection state, and a corresponding alarm action, protection action, or no action is then performed according to the above three states.

[0032] S106: Performing a determination according to the current state of the state flag bit, so as to perform the alarm action or the protection action.

[0033] In the present embodiment, by determining whether the current state of the state flag bit is the safe

state, the alarm state, or the protection state, the camera performs a corresponding action. By setting the current state of the state flag bit to determine which area the intrusion target is located in, the camera can effectively perform the corresponding action according to an intrusion condition of the intrusion target.

[0034] Optionally, determining the state flag bit of the intrusion target includes: during initialization, if the intrusion distance is less than or equal to the protection area distance, determining that the intrusion target is in the protection area, and presetting the current state of the state flag bit as the protection state; if the intrusion distance is greater than the protection area distance and less than or equal to the alarm area distance, determining that the intrusion target is in the alarm area, and presetting the current state of the state flag bit as the alarm state; if the intrusion distance is greater than the alarm area distance, determining that the intrusion target is in the safe area, and presetting the current state of the state flag bit as the safe state.

[0035] In the present embodiment, when the camera is initialized, for example, when powered on, if the intrusion target is in the protection area or the alarm area, the current state of the state flag bit is directly preset as the protection state or the alarm state. Specifically, according to comparison between the intrusion distance and the protection area distance, if the intrusion distance of the intrusion target is within the protection area distance, the intrusion target is in the protection area before the camera is powered on, and the state flag bit is directly set as the protection state. If the intrusion distance of the intrusion target is within the alarm area range, the state flag bit is directly set as the alarm state. If the intrusion distance of the intrusion target is outside the protection area distance and the alarm area distance, no intrusion target intrudes at power-on, and the state flag bit of the camera is the safe state.

[0036] Optionally, determining the state flag bit of the intrusion target further includes:

[0037] when the intrusion target approaches or moves away, if the intrusion distance $d_{\min}$ is less than or equal to the protection area distance d_r , determining that the intrusion target is in the protection area, and the current state of the state flag bit at this time is the protection state, wherein a formula can be expressed as $d_{\min} \leq d_r$; if the intrusion distance $d_{\min}$ is greater than the protection area distance d_r and less than or equal to the protection area distance d_r plus the second transition area distance $\Delta d_{\text{hys}}(d_r)$, determining that the intrusion target is currently in the second transition area, and, if the previous state of the state flag bit is the safe state or the alarm state, the current state of the state flag bit at this time is the alarm state, and if the previous state of the state flag bit is the protection state, the current state of the state flag bit is the protection state, wherein a formula is expressed as $d_r < d_{\min} \leq d_r + \Delta d_{\text{hys}}(d_r)$. If the intrusion distance $d_{\min}$ is greater than the protection area distance d_r plus the second transition area distance $\Delta d_{\text{hys}}(d_r)$ and less than or

equal to the alarm area distance d_a , determining that the intrusion target is in the alarm area, and the current state of the state flag bit at this time is the alarm state, wherein a formula is expressed as $d_r + \Delta d_{hys}(d_r) < d_{min} \leq d_a$. If the intrusion distance d_{win} is greater than the protection area distance d_a and less than or equal to the alarm area distance d_a plus the first transition area distance $\Delta d_{hys}(d_a)$, determining that the intrusion target is currently in the first transition area or the alarm area, and if the previous state is the safe state, determining that the current state is the safe state, and if the previous state is the alarm state or the protection state, the current state of the state flag bit at this time is the alarm state, wherein a formula is expressed as $d_a < d_{min} \leq d_a + \Delta d_{hys}(d_s)$. If the intrusion distance d_{min} is greater than the alarm area distance d_a plus the first transition area distance $\Delta d_{hys}(d_a)$, determining that the intrusion target is in the safe area, and the current state of the state flag bit at this time is the safe state, wherein a formula is expressed as $d_{min} > d_a + \Delta d_{hys}(d_a)$.

[0038] In the embodiment of the present disclosure, when the intrusion target approaches or moves away from the camera, the target monitoring area is divided into the alarm area distance, the protection area distance, and the safe area distance through a measurement distance required by the target monitoring area, and the alarm area distance d_a , the protection area distance d_r , and a nearest target point distance d_{min} are set. Accordingly, according to the above determination, if the intrusion distance d_{min} is less than or equal to the protection area distance d_r , the intrusion target is determined to be in the protection area, and the current state at this time is the protection state, wherein a formula can be expressed as $d_{min} \leq d_r$. If the intrusion distance d_{min} is greater than the protection area distance d_r and less than or equal to the protection area distance d_r plus the second transition area distance $\Delta d_{hys}(d_r)$, the target is determined to be currently in the second transition area. If the previous state of the camera is the safe state or the alarm state, the intrusion target enters the second transition area from the safe area or the alarm area, and the current state of the camera at this time remains the alarm state. If the previous state is the protection state, the intrusion target exits from the protection area to the second transition area, and the current state of the camera at this time remains the protection state, wherein a formula is expressed as $d_r < d_{min} \leq d_r + \Delta d_{hys}(d_r)$. It should be noted that the previous state of the state flag bit is a preceding state of the state flag bit of the camera, and the current state is the state of the state flag bit of the camera at this time. If the intrusion distance d_{min} is greater than the protection area distance d_r plus the second transition area distance $\Delta d_{hys}(d_r)$ and less than or equal to the alarm area distance d_a , the intrusion target is determined to be in the alarm area, and the current state is updated as the alarm state, wherein a formula is expressed as $d_r + \Delta d_{hys}(d_r) < d_{min} \leq d_a$. If the intrusion distance is greater than the alarm area distance and less than or equal to the

alarm area distance plus the first transition area distance, the intrusion target is determined to be in the first transition area. If the previous state of the camera is the protection state or the alarm state, the intrusion target exits from the protection area or the alarm area to the first transition area, and therefore the camera still sends the alarm action at this time. If the previous state of the camera is the safe state, the intrusion target enters the first transition area from the safe area, and the camera does not perform any alarm action or protection action at this time, wherein a formula is expressed as $d_a < d_{min} \leq d_a + \Delta d_{hys}(d_a)$. If the intrusion distance is greater than the alarm area distance plus the first transition area distance, the intrusion target is determined to be in the safe area, and the current state is updated as the safe state. The camera does not perform any alarm action or protection action, wherein a formula is $d_{min} > d_a + \Delta d_{hys}(d_a)$. expressed as

[0039] Optionally, determining the state flag bit of the intrusion target further includes:

[0040] when the intrusion target is relatively stationary, if the previous state of the state flag bit is the safe state, the current state of the state flag bit at this time is the safe state; if the previous state of the state flag bit is the alarm state, the current state of the state flag bit at this time is the alarm state; if the previous state of the state flag bit is the protection state, the current state of the state flag bit at this time is the protection state.

[0041] In the present embodiment, in the prior art, when areas are switched, because of fluctuation of detection distance, determination results are unstable in a critical area and switch back and forth, causing a system to frequently switch alarm actions and protection actions, or even perform erroneous actions. When repeatability of the camera is lower, ranging jitter is greater, a range in which stable determination cannot be achieved is larger, determination is more unstable, and probability of performing erroneous determination is greater. By introducing the concept of distance hysteresis in the present embodiment, determination conditions for entering the alarm area and the protection area from the safe area and retreating from the protection area to the alarm area and then to the safe area are different, thereby avoiding back-and-forth switching of determination results caused by measurement changes, avoiding false alarm or no alarm, and further avoiding failure to start corresponding alarm or protection actions.

[0042] Optionally, performing the determination according to the current state of the state flag bit, so as to perform the alarm action or the protection action, includes:

if the current state of the state flag bit is the safe state, not performing the alarm action or the protection action; if the current state of the state flag bit is the alarm state, performing the alarm action; if the current state of the state flag bit is the protection state, performing the protection action.

[0043] In the present embodiment, it should be noted

that when the camera performs a corresponding action, the camera must perform a determination according to the current state of the state flag bit (the safe state, the alarm state, and the protection state), so as to perform the corresponding action. By setting the state flag bit of the camera as the safe state, the protection state, and the alarm state, it should be noted that, when the intrusion target enters the alarm area and the protection area from the safe area and retreats from the protection area to the alarm area and the safe area, state determination conditions are different. By setting the three states to control the camera to perform corresponding alarm or protection actions, environmental changes can be effectively adapted to. For example, when the intrusion target intrudes from the safe area into the first transition area, the previous state of the camera is the safe state, and the camera does not perform any alarm or protection action at this time. When the intrusion target exits from the alarm area to the first transition area, the previous state of the camera is the alarm state, and the camera still performs the alarm action at this time until the intrusion target exits to the safe area, and only then does the camera stop alarming. Such arrangement can effectively remind the operators to inspect, thereby improving stability.

[0044] As shown in FIG. 2, FIG. 2 is a schematic view of a monitoring area protection apparatus provided by the present disclosure. The monitoring area protection apparatus includes:

an establishing module 201, configured to establish a correspondence table $\sigma_i \rightarrow F(d_i)$ between measurement distances and repeatabilities and fit a continuous correspondence relationship $\sigma_d = F(d)$ between measurement distances and repeatabilities; a presetting module 202, configured to set a protection area distance and an alarm area distance according to a requirement of a target monitoring area; a first calculating module 203, configured to calculate a corresponding distance hysteresis according to the alarm area distance, the protection area distance, and a value of a measurement repeatability corresponding thereto;

a second calculating module 204, configured to perform calculation according to the alarm area distance, the protection area distance, and the distance hysteresis corresponding thereto, to obtain a first transition area distance and a second transition area distance;

an obtaining module 205, configured to obtain an intrusion distance of an intrusion target when the intrusion target is detected;

a comparing module 206, configured to compare distance relationships between the intrusion distance and the protection area distance, the first transition area distance, the alarm area distance, and the second transition area distance;

a determining module 207, configured to determine that a state flag bit is one of a safe state, a protection

state, and an alarm state; and

a response module 208, configured to perform a state determination according to a current state of the state flag bit, so as to perform an alarm action or a protection action.

[0045] Optionally, the comparing module 206 further includes:

a first comparing submodule, configured to compare distance relationships between the intrusion distance and the protection area distance, the alarm area distance, and the safe area distance during initialization; and

a second comparing submodule, configured to compare distance relationships between the intrusion distance and the protection area distance, the protection area distance plus the second transition area distance, the alarm area distance, and the alarm area distance plus the first transition area distance when the intrusion target approaches or moves away.

[0046] Optionally, the determining module 207 includes:

a first determining submodule, configured to set the current state of the state flag bit according to distance relationships between the intrusion distance and the protection area distance and the alarm area distance during initialization;

a second determining submodule, configured to determine the current state of the intrusion target according to the previous state of the state flag bit and a current area in which the intrusion target is located when the intrusion target approaches or moves away; and

a third determining submodule, configured to determine the current state of the state flag bit according to the previous state of the state flag bit when the intrusion target is relatively stationary.

[0047] Optionally, the response module 208 includes:

a first response submodule, configured to not perform an alarm action or a protection action according to the safe state of the state flag bit;

a second response submodule, configured to perform the alarm action according to the alarm state of the state flag bit; and

a third response submodule, configured to perform a protection action according to the protection state of the state flag bit.

[0048] The monitoring area protection apparatus provided by the embodiments of the present disclosure can implement each process implemented by the monitoring area protection method in the above method embodi-

ments, and can achieve the same beneficial effects. To avoid repetition, details are not repeated herein.

[0049] As shown in FIG. 3, FIG. 3 is a schematic structural view of an electronic device provided by the present disclosure. The electronic device includes: a processor 301, a memory 302, and a computer program stored on the memory 302 and executable on the processor, wherein the processor 301, when executing the computer program, implements steps in the monitoring area protection method according to embodiments of the present disclosure.

[0050] The electronic device provided by the embodiments of the present disclosure can implement each process implemented by the monitoring area protection method in the above method embodiments, and can achieve the same beneficial effects. To avoid repetition, details are not repeated herein.

[0051] The embodiments of the present disclosure further provide a computer-readable storage medium. A computer program is stored on the computer-readable storage medium, and when the computer program is executed by a processor, each process of the monitoring area protection method or the application-side monitoring area protection method provided by the embodiments of the present disclosure is implemented, and the same technical effects can be achieved. To avoid repetition, details are not repeated herein.

[0052] The embodiments of the present detailed description are all preferred embodiments of the present application, and do not limit the protection scope of the present application accordingly. Same components are represented by same reference numerals. Therefore, all equivalent changes made according to structures, shapes, and principles of the present application shall be included within the protection scope of the present application.

Claims

1. A monitoring area protection method, comprising:

establishing a correspondence table $\sigma_i \rightarrow F(d_i)$ between measurement distances and repeatabilities, wherein d_i is an i -th measurement distance, and σ_i is measurement repeatability of an i -th measurement d_i ; and performing fitting, according to the correspondence table $\sigma_i \rightarrow F(d_i)$, a continuous correspondence relationship $\sigma_d = F(d)$ between the measurement distances and the repeatabilities;
setting a protection area distance and an alarm area distance based on a measurement distance required by a target monitoring area, and dividing the target monitoring area into a protection area, an alarm area, and a safe area according to the protection area distance and the alarm area distance;

substituting the alarm area distance and the protection area distance into the continuous correspondence relationship between the measurement distances and the repeatabilities to obtain a corresponding measurement repeatability, and performing calculation on a distance hysteresis corresponding to the alarm area and the protection area distance according to a value of the measurement repeatability, wherein a calculation formula is $\Delta d_{\text{hys}}(d) = \rho_d \times \sigma_d$, wherein ρ_d is a hysteresis adjustment factor, and σ_d is the measurement repeatability;

performing calculation to obtain a first transition area distance and a second transition area distance based on the alarm area distance, the protection area distance, and the distance hysteresis corresponding to the alarm area and the protection area distance, and setting a first transition area and a second transition area according to the first transition area distance and the second transition area distance;

when an intrusion target is detected, obtaining an intrusion distance of the intrusion target, and determining a state flag bit of the intrusion target according to distance relationships between the intrusion distance and the protection area distance, the first transition area distance, the alarm area distance, and the second transition area distance, wherein the state flag bit is one of a safe state, a protection state, and an alarm state; and

performing a determination according to a current state of the state flag bit, so as to perform an alarm action or a protection action.

2. The monitoring area protection method according to claim 1, wherein determining the state flag bit of the intrusion target includes:

during initialization, if the intrusion distance is less than or equal to the protection area distance, determining that the intrusion target is in the protection area, and presetting the current state of the state flag bit as the protection state;
if the intrusion distance is greater than the protection area distance and less than or equal to the alarm area distance, determining that the intrusion target is in the alarm area, and presetting the current state of the state flag bit as the alarm state; and
if the intrusion distance is greater than the alarm area distance, determining that the intrusion target is in the safe area, and presetting the current state of the state flag bit as the safe state.

3. The monitoring area protection method according to claim 1, wherein determining the state flag bit of the intrusion target further includes:

when the intrusion target approaches or moves away, if the intrusion distance $d_{\min}$ is less than or equal to the protection area distance d_r , determining that the intrusion target is in the protection area, and the current state of the state flag bit at this time is the protection state, wherein a formula is expressed as $d_{\min} \leq d_r$;

if the intrusion distance $d_{\min}$ is greater than the protection area distance d_r and less than or equal to the protection area distance d_r plus the second transition area distance $\Delta d_{\text{hys}}(d_r)$, determining that the intrusion target is currently in the second transition area, and, if a previous state of the state flag bit is the safe state or the alarm state, the current state of the state flag bit at this time is the alarm state, and if the previous state of the state flag bit is the protection state, the current state of the state flag bit is the protection state, wherein a formula is expressed as $d_r < d_{\min} \leq d_r + \Delta d_{\text{hys}}(d_r)$;

if the intrusion distance $d_{\min}$ is greater than the protection area distance d_r plus the second transition area distance $\Delta d_{\text{hys}}(d_r)$ and less than or equal to the alarm area distance d_a , determining that the intrusion target is in the alarm area, and the current state of the state flag bit at this time is the alarm state, wherein a formula is expressed as $d_r + \Delta d_{\text{hys}}(d_r) < d_{\min} \leq d_a$;

if the intrusion distance $d_{\min}$ is greater than the protection area distance d_a and less than or equal to the alarm area distance d_a plus the first transition area distance $\Delta d_{\text{hys}}(d_a)$, determining that the intrusion target is currently in the first transition area or the alarm area, and, if the previous state is the safe state, determining that the current state is the safe state, and if the previous state is the alarm state or the protection state, the current state of the state flag bit at this time is the alarm state, wherein a formula is expressed as $d_a < d_{\min} \leq d_a + \Delta d_{\text{hys}}(d_a)$; and
if the intrusion distance $d_{\min}$ is greater than the alarm area distance d_a plus the first transition area distance $\Delta d_{\text{hys}}(d_a)$, determining that the intrusion target is in the safe area, and the current state of the state flag bit at this time is the safe state, wherein a formula is expressed as $d_{\min} > d_a + \Delta d_{\text{hys}}(d_a)$.

4. The monitoring area protection method according to claim 1, wherein determining the state flag bit of the intrusion target further includes:

when the intrusion target is relatively stationary, if a previous state of the state flag bit is the safe state, the current state of the state flag bit at this time is the safe state;

if the previous state of the state flag bit is the alarm state, the current state of the state flag bit

at this time is the alarm state; and

if the previous state of the state flag bit is the protection state, the current state of the state flag bit at this time is the protection state.

5. The monitoring area protection method according to any one of claims 1 to 4, wherein performing the determination according to the current state of the state flag bit, so as to perform the alarm action or the protection action, includes:

if the current state of the state flag bit is the safe state, not performing the alarm action or the protection action;

if the current state of the state flag bit is the alarm state, performing the alarm action; and

if the current state of the state flag bit is the protection state, performing the protection action.

6. A monitoring area protection apparatus, comprising:

an establishing module, configured to establish a correspondence table $\sigma_i \rightarrow F(d_i)$ between measurement distances and repeatabilities and fit a continuous correspondence relationship $\sigma_d = F(d)$ between the measurement distances and the repeatabilities;

a presetting module, configured to set a protection area distance and an alarm area distance according to a requirement of a target monitoring area;

a first calculating module, configured to calculate a corresponding distance hysteresis according to the alarm area distance, the protection area distance, and a value of a measurement repeatability corresponding thereto;

a second calculating module, configured to perform calculation according to the alarm area distance, the protection area distance, and the distance hysteresis corresponding thereto, to obtain a first transition area distance and a second transition area distance;

an obtaining module, configured to obtain an intrusion distance of an intrusion target when the intrusion target is detected;

a comparing module, configured to compare distance relationships between the intrusion distance and the protection area distance, the first transition area distance, the alarm area distance, and the second transition area distance; a determining module, configured to determine that a state flag bit is one of a safe state, a protection state, and an alarm state; and a response module, configured to perform a state determination according to a current state of the state flag bit, so as to perform an alarm action or a protection action.

7. An electronic device, comprising: a memory, a processor, and a computer program stored on the memory and executable on the processor, wherein the processor, when executing the computer program, implements steps in the monitoring area protection method as claimed in any one of claims 1 to 5. 5
8. A computer-readable storage medium, wherein a computer program is stored on the computer-readable storage medium, and the computer program, when executed by a processor, implements steps in the monitoring area protection method as claimed in any one of claims 1 to 5. 10

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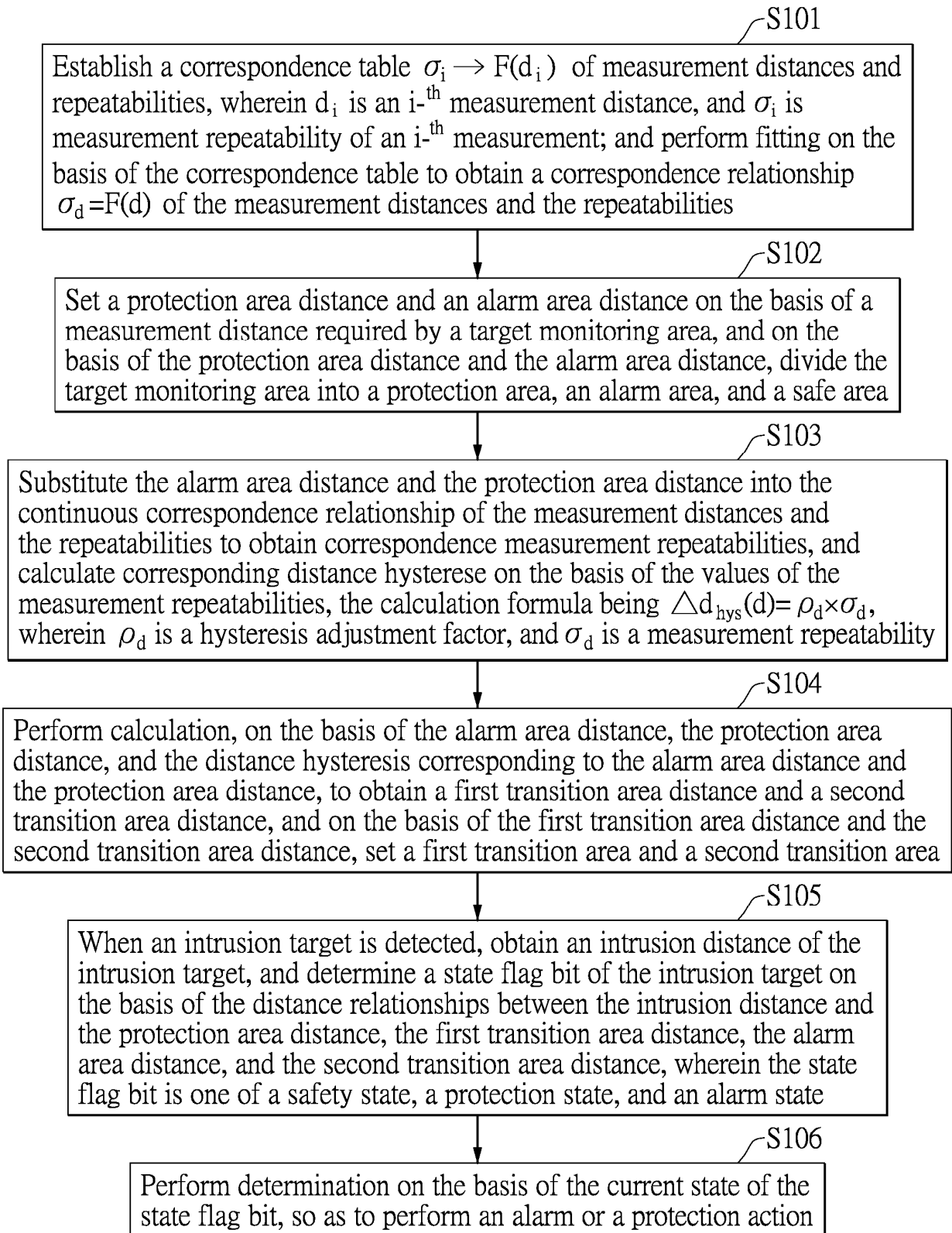


FIG. 1

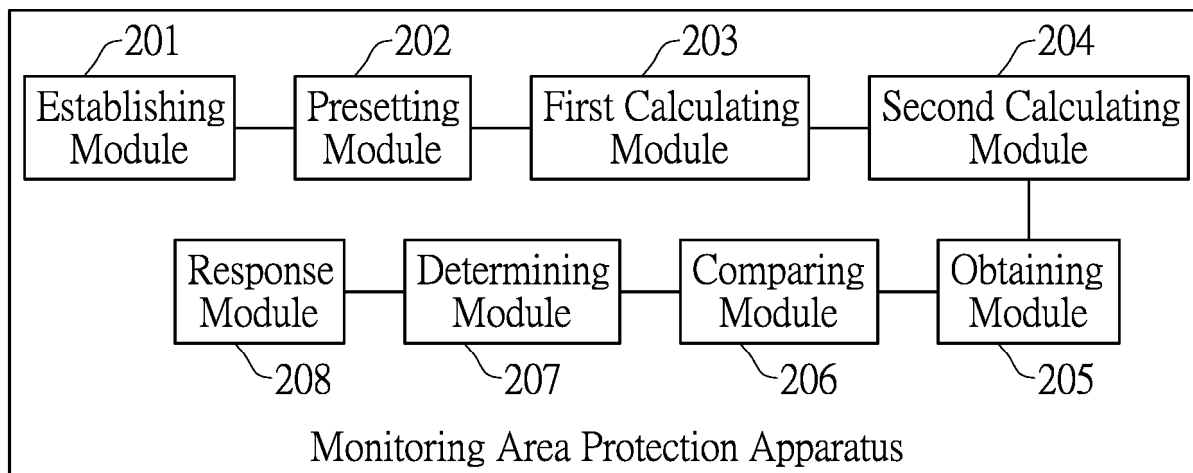


FIG. 2

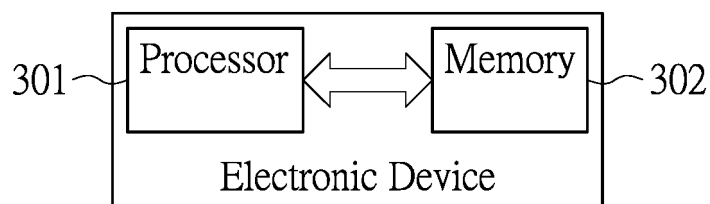


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/119587

A. CLASSIFICATION OF SUBJECT MATTER

G08B13/196(2006.01)i; G08B29/18(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:G08B

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)

CNABS, CNTXT, CJFD, VEN, ENTXTC: 安全区, 保护区, 报警区, 补偿, 测, 距, 距离, 迟滞, 区间, 对应, 表, 过渡区, 偏差, 侵入, 入侵, 稳定性, 系数, 相机, 校正, 重复, 精度, 误判, table, distance, repeatability, repetition, accuracy, measurement, alarm, protection, area, hysteresis, camera, misjudgment

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 117690242 A (SHENZHEN WANCE TECHNOLOGY CO., LTD.) 12 March 2024 (2024-03-12) claims 1-8	1-8
Y	CN 114495398 A (BEIJING INSTITUTE OF MECHANICAL EQUIPMENT) 13 May 2022 (2022-05-13) description, paragraphs 0033-0066	1-8
Y	CN 116985804 A (CHONGQING CHANG'AN AUTOMOBILE CO., LTD.) 03 November 2023 (2023-11-03) description, paragraphs 0047-0120	1-8
A	CN 109285309 A (STATE GRID HEILONGJIANG ELECTRIC POWER CO., LTD., ELECTRIC POWER RESEARCH INSTITUTE et al.) 29 January 2019 (2019-01-29) entire document	1-8
A	CN 111724558 A (HANGZHOU HIKVISION DIGITAL TECHNOLOGY CO., LTD.) 29 September 2020 (2020-09-29) entire document	1-8

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"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
"D" document cited by the applicant in the international application	"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
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"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	

Date of the actual completion of the international search 06 January 2025	Date of mailing of the international search report 08 January 2025
Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/119587

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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 20210050702 A (HANCOM NFLUX CO., LTD.) 10 May 2021 (2021-05-10) entire document	1-8
A	JP H1079934 A (NIPPON KOEI CO., LTD.) 24 March 1998 (1998-03-24) entire document	1-8

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2024/119587

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CN	117690242	A	12 March 2024	None			
CN	114495398	A	13 May 2022	None			
CN	116985804	A	03 November 2023	None			
CN	109285309	A	29 January 2019	None			
CN	111724558	A	29 September 2020	CN	111724558	B	19 October 2021
KR	20210050702	A	10 May 2021	KR	102269098	B1	24 June 2021
JP	H1079934	A	24 March 1998	None			