

METHOD FOR DETECTING OBJECT TO BE DETECTED, AND DETECTION APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] The present disclosure claims the benefit of and priority to U.S. Provisional Patent Application Serial No. 63/183,643, filed on May 4, 2021, entitled “Surface Micro Feature Recognition Using Blockchain,” (hereinafter referred to as “’643 provisional”). The disclosure of ‘643 provisional is hereby fully incorporated by reference into the present disclosure.

FIELD

[0002] The present disclosure is generally related to object detection and, more specifically, to a method and a detection device for detecting a detected object.

BACKGROUND

[0003] Although anti-counterfeit technologies have been advancing rapidly, there still be a lot of challenges for items, such as art pieces, jewelry, antiques, and the like, in the anti-counterfeit field. Some identification methods require sampling of the detected object, thus destroying the integrity of the detected object. However, it is difficult to comprehensively understand the actual condition of the detected object solely by observing it with the naked eye. Furthermore, if electronic instruments are used for identification, it becomes difficult to ensure whether the information stored in the electronic instruments has been tampered with or replaced. Therefore, if electronic instruments are to be used for identification, it is imperative to ensure the security and the tamper resistance of the data.

SUMMARY

[0004] The present invention is completed in view of the above issue and provides a method and device for detecting a detected object.

[0005] In order to address the above issues, the present invention provides a method of detecting a detected object by a detection device. The method includes: transmitting a request for detecting the detected object; receiving a positioning point of the detected object; obtaining a plurality of detection images along a plurality of detection directions at the positioning point of the detected object; and obtaining a detection result based on the plurality of detection images,

wherein the detection result is generated based on a comparison between the plurality of detection images and a corresponding positioning point of a reference object corresponding to the detected object.

[0006] In order to address the above issues, the present invention further provides a detection device for detecting a detected object. The detection device includes: an image capture unit configured to capture a plurality of detection image; a motion control unit configured to enable the image capture unit to move for detecting the detected object; a processor coupled to the image capture unit and the motion control unit; a transmission unit coupled to the processor; a reception unit coupled to the processor; and a storage device coupled to the processor and storing a plurality of instructions which, when executed by the processor, causes the processor to: transmit a request for detecting the detected object by the transmission unit; receive a positioning point of the detected object by the reception unit; control the image capture unit to obtain a plurality of detection images along a plurality of detection directions at the positioning point of the detected object by the motion control unit; and obtain a detection result based on the plurality of detection images, wherein the detection result is generated based on a comparison between the plurality of detection images and a corresponding positioning point of a reference object corresponding to the detected object.

[0007] In order to address the above issues, the present invention further provides a method of detecting a detected object by a server. The method includes: receiving a request for detecting the detected object; transmitting a positioning point of the detected object; receiving a plurality of detection images obtained along a plurality of detection directions at the positioning point of the detected object; and obtaining a detection result based on the plurality of detection images, wherein the detection result is generated based on a comparison between the plurality of detection images and a reference object corresponding to the detected object.

[0008] Through the aforementioned methods, a detection system stores the information of the reference object and thereby restricts sampling points (i.e., corresponding positioning points) of the reference object. Through these method, the detection device may need to first upload the information of the detected object, allowing the detection system to confirm corresponding reference object, and then obtain the positioning points for the images of the detected object to be captured. This method not only securely preserves the identification information of the reference object but also increases the difficulty for counterfeit items to pass the detection because it is

difficult to directly obtain the sampling points of the reference object. Furthermore, if the information of the reference object is stored in a blockchain storage device, it may further enhance the security and tamper resistance of the information.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Aspects of the present disclosure are best understood from the following detailed disclosure and the corresponding figures. Various features are not drawn to scale and dimensions of various features may be arbitrarily increased or reduced for clarity of discussion.

[0010] FIG. 1A is a block diagram of a sampling system for sampling a reference object to establish identification data according to the present invention.

[0011] FIG. 1B is a block diagram of another sampling system for sampling a reference object to establish identification data, according to the present invention.

[0012] FIG. 2 is a block diagram of a sampling device for sampling a reference object to establish identification data, according to the present invention.

[0013] FIG. 3 is a flowchart of a sampling method for sampling a reference object to establish identification data, according to the present invention.

[0014] FIG. 4A is a block diagram of a detection system for detecting a detected object, according to the present invention.

[0015] FIG. 4B is a block diagram of another detection system for detecting a detected object, according to the present invention.

[0016] FIG. 5 is a block diagram of a detection device for detecting a detected object, according to the present invention.

[0017] FIG. 6 is a flowchart of a detection method for detecting a detected object, according to the present invention.

[0018] FIG. 7A illustrates a schematic diagram of capturing sampling images along a sampling direction at a positioning point of a reference object by an image capture unit, according to an exemplary implementation of the present invention.

[0019] FIG. 7B illustrates a schematic diagram of capturing sampling images along another sampling direction at a positioning point of a reference object by an image capture unit, according to an exemplary implementation of the present invention.

[0020] FIGS. 8A-8E illustrate photos of different sampling images captured on the reference object, according to an exemplary implementation of the present invention.

[0021] FIGS. 8F-8J illustrate photos of different detection images captured on the detected object, according to an exemplary implementation of the present invention.

[0022] FIGS. 9A and 9B illustrate sampling images generated by sampling, along the same sampling direction, different gemstones having the same processing manner, according to an exemplary implementation of the present invention.

[0023] FIG. 10A is a photo of different antique utensils with the same pattern.

[0024] FIGS. 10B and 10C illustrate sampling images generated by sampling, along the same sampling direction, different antique utensils illustrated in FIG. 10A, according to an exemplary implementation of the present invention.

DESCRIPTION

[0025] The following disclosure contains specific information pertaining to exemplary implementations in the present disclosure. The figures and the corresponding detailed disclosure are directed to exemplary implementations. However, the present disclosure is not limited to these exemplary implementations. Other variations and implementations of the present disclosure will occur to those skilled in the art. Unless noted otherwise, like or corresponding elements among the figures may be indicated by like or corresponding reference numerals. The figures and illustrations in the present disclosure are generally not to scale and are not intended to correspond to actual relative dimensions.

[0026] For the purposes of consistency and ease of understanding, like features are identified (although, in some examples, not illustrated) by numeral labels in the exemplary figures. However, the features in different implementations may differ in other respects and shall not be narrowly confined to what is illustrated in the figures.

[0027] The phrases “in one implementation,” “in several implementations,” “different implementations,” “in some implementations,” or “in this implementation” may indicate that the implementations described in the invention include specific features, structure, or characteristics. In addition, the repeated use of the phrases “In one implementation,” or “In the implementation,” does not necessarily refer to the same implementation, although they may be the same. Additionally, phrases like “implementation” used in association with “the present invention” do

not imply that all implementations of the present invention must include specific features, structures, or characteristics. It should be understood as "at least some implementations of the present invention" include the mentioned specific features, structures, or characteristics. The term "coupled" is defined as connected, whether directly or indirectly through intervening components, and is not necessarily limited to physical connections. The term "comprising" means "including, but not necessarily limited to" and specifically indicates open-ended inclusion or membership in the so-described combination, group, series, and the equivalent.

[0028] For purposes of explanation and non-limitation, specific details, such as functional entities, techniques, protocols, and standards, are set forth for providing an understanding of the disclosed technology. Detailed disclosure of well-known methods, technologies, systems, and architectures are omitted so as not to obscure the present disclosure with unnecessary details.

[0029] The terms "first," "second," "third," and so on, used in the description and the accompanying drawings of the present invention, are used to distinguish between different objects and not to describe a particular order. Additionally, the term "comprising" and its variations are intended to cover non-exclusive inclusion. For example, a process, method, system, product, or device that includes a series of steps or modules is not limited to the listed steps or modules but may optionally include additional steps or modules not listed, or may optionally include other steps or modules inherent to these processes, methods, products, or devices.

[0030] Persons skilled in the art will recognize that any disclosed coding function(s) or algorithm(s) described in the present disclosure may be implemented by hardware, software, or a combination of software and hardware. Disclosed functions may correspond to modules that are software, hardware, firmware, or any combination thereof. A software implementation may include computer-executable instructions stored on a computer-readable medium, such as memory or other types of storage devices. For example, one or more microprocessors or general-purpose computers with communication processing capability may be programmed with executable instructions and perform one or more disclosed function(s) or algorithm(s). The microprocessors or general-purpose computers may be formed of application-specific integrated circuits (ASICs), programmable logic arrays, and/or one or more digital signal processors (DSPs). Although some of the disclosed implementations are oriented to software installed and executing on computer hardware, alternative implementations implemented as firmware, as hardware, or as a combination of hardware and software are well within the scope of the present disclosure.

[0031] The computer-readable medium includes, but is not limited to, random-access memory (RAM), read-only memory (ROM), erasable programmable read-only memory (EPROM), electrically erasable programmable read-only memory (EEPROM), flash memory, compact disc read-only memory (CD ROM), magnetic cassettes, magnetic tape, magnetic disk storage, or any other equivalent medium capable of storing computer-readable instructions.

[0032] The coupling between the devices of the invention may adopt customized protocols or follow existing standards or de facto standards including, but not limited to, Ethernet, IEEE 802.11 or IEEE 802.15 series, Wireless USB or telecommunication standards including, but not limited to, Global System for Mobile Communications (GSM), Code Division Multiple Access 200 (CDMA2000), Time Division-Synchronization Code Division Multiple Access (TD-SCDMA), World Interoperability for Microwave Access (WiMAX), 3GPP Long Term Evolution (LTE) or Time Division Long Term Evolution (TD-LTE). In addition, the devices of the invention may each include any device configured to transmit and/or store data to the computer-readable medium and to receive the data from the computer-readable medium. In addition, the devices of the invention may each include a computer system interface that may enable data to be stored on a storage device or to be received from the storage device. For example, the devices of the invention may each include a chipset supporting Peripheral Component Interconnect (PCI) and Peripheral Component Interconnect Express (PCIe) bus protocols, proprietary bus protocols, Universal Serial Bus (USB) protocols, I2C, or any other logical and physical structure that may be used to interconnect peer devices.

[0033] The present invention will be further described in detail below through the implementations in conjunction with the accompanying drawings.

[0034] Please refer to FIG. 1A. FIG. 1A is a block diagram of a sampling system 101 for sampling a reference object to establish identification data according to the present invention. In one implementation, the sampling system 101 includes a server 10 and a sampling device 20. The server 10 may include an internal storage device 11 for storing the sampling results. In one implementation, when the sampling device 20 receives a sampling request, the sampling device 20 may be coupled with the server 10 to complete the sampling method disclosed in the present invention. After the sampling system 101 completes the sampling method, the sampling device 20 may be decoupled from the server 10.

[0035] Please refer to FIG. 1B. FIG. 1B is a block diagram of another sampling system 102 for sampling a reference object to establish identification data, according to the present invention. In one implementation, the sampling system 102 includes a server 10, a sampling device 20, and an online storage device 30. In one implementation, when the sampling device 20 receives a sampling request, the sampling device 20 may be coupled with the server 10 and then the server 10 may further be coupled with the online storage device 30 to complete the sampling method disclosed in the present invention. After the sampling system 102 completes the sampling method, the sampling device 20 may be decoupled from the server 10, and the server 10 may also be decoupled from the online storage device 30. In another implementation, when the sampling device 20 receives a sampling request, the sampling device 20 may be coupled with the server 10 and the online storage device 30 to complete the sampling method disclosed in the present invention. After the sampling system 102 completes the sampling method, the sampling device 20 may be decoupled from the server 10 and the online storage device 30.

[0036] In the implementation, the online storage device 30 may be a network data storage or a blockchain storage device. When the online storage device 30 is a blockchain storage device, the characteristics of the blockchain may reduce the possibility of tampering or substitution of the sampling results. In the implementation, the online storage device 30 may store all of the transaction history, time and results of the detections, and updated images of the reference object.

[0037] Please refer to FIG. 2. FIG. 2 is a block diagram of a sampling device 20 for sampling a reference object to establish identification data, according to the present invention. The sampling device 20 may not be limited to a mobile phone, tablet computer, desktop computer, laptop, camera, camcorder, or other electronic devices. The sampling device 20 includes a motion control unit 21, an image capture unit 22, a processor 23, a storage 24, and a transmission unit 25.

[0038] The motion control unit 21 is used to enable the sampling device 20 to achieve the movement required during the sampling process. In one implementation, the motion control unit 21 is used to move the image capture unit 22 during the sampling of the reference object. In one implementation, the motion control unit 21 may be a display screen on the sampling device 20 or an automatic movement device coupled with the image capture unit 22.

[0039] When a display screen serves as the motion control unit 21, the display screen may be used to provide movement instructions to the user for indicating the user to move the image capture unit 22 to a sampling position. In the implementation, the sampling position may be

determined based on a sampling distance and a sampling direction. For example, when a capture distance between the image capture unit 22 and a positioning point on the reference object is identical to the sampling distance and a capture direction oriented from the image capture unit 22 towards the positioning point on the reference object is identical to the sampling direction, the display screen may indicate that the image capture unit 22 has moved to the sampling position to start to obtain the required sampling images. When the capture distance is not identical to the sampling distance, the display screen may instruct the user to further move the image capture unit 22 to extend or shorten the capture distance. When the capture direction is not identical to the sampling direction, the display screen may instruct the user to further move the image capture unit 22 to the left, right, up, or down the capture direction. In another implementation, the sampling position may be determined based on the sampling direction. In the implementation, the sampling distance may be adjusted by changing the focal length of the image capture unit 22 to ensure the acquisition of detailed surface information of the reference object.

[0040] When an automatic movement device serves as the motion control unit 21, the automatic movement device may be a robotic arm or another device capable of moving the image capture unit 22. This automatic movement device may receive the sampling position instructed from the processor 23 for moving the image capture unit 22 to the sampling position. In another implementation, the sampling distance may be adjusted by changing the focal length of the image capture unit 22 to ensure the acquisition of detailed surface information of the reference object. Therefore, the automatic movement device may only adjust the sampling direction of the image capture unit 22 to obtain the required sampling images.

[0041] The image capture unit 22 is used to obtain a plurality of sampling images. When the reference object is being sampled by the sampling device 20, the image capture unit 22 may move to a plurality of different sampling positions to allow the image capture unit 22 to capture the reference object at different sampling positions for obtaining a plurality of sampling images. The image capture unit 22 may be a Charge-Coupled Device (CCD) image sensor, Complementary Metal-Oxide-Semiconductor (CMOS) image sensor, or a camera. In one implementation, the image capture unit 22 may include a high-magnification image capture lens to capture detailed surface information of the reference object. In the implementation, the image capture unit 22 may include a microscope image capture lens. In one implementation, the plurality of sampling images

captured by the image capture unit 22 may be microscopic surface images of the reference object. In the implementation, the microscopic surface images may be surface texture images.

[0042] The processor 23 is coupled with the storage 24. The storage 24 stores a plurality of instructions for the processor 23 to execute the sampling method of the sampling device 20 based on the plurality of instructions stored in the storage 24. To perform the sampling method of the present invention, the storage 24 stores a sampling program 240. In the implementation, the sampling program 240 further includes a positioning module 241 and a sampling module 242. The positioning module 241 is used to enable the processor 23 to coordinate with the motion control unit 21 in moving the image capture unit 22 to the sampling position. The sampling module 242 is used to enable the processor 23 to coordinate with the image capture unit 22 in capturing the required sampling images at that sampling position.

[0043] The transmission unit 25 may utilize custom protocols or follow existing standards or de facto standards, including but not limited to Ethernet, IEEE 802.11 or IEEE 802.15 series, Wireless USB, or telecommunications standards (including but not limited to GSM, CDMA2000, TD-SCDMA, WiMAX, 3GPP-LTE, or TD-LTE), to transmit sampling feature to other devices different from the sampling device 20.

[0044] FIG. 3 is a flowchart of a sampling method 300 for sampling a reference object to establish identification data, according to the present invention. The sampling method 300 illustrated in FIG. 3 is provided by way of example only, as there are a variety of ways to carry out the sampling method. The sampling method 300 illustrated in FIG. 3 may be carried out using the configurations illustrated in FIGS. 1A, 1B, and 2, for example, and various elements in FIGS. 1A, 1B, and 2 are referenced in explaining the sampling method 300. Each block shown in FIG. 3 represents one or more executed processes, methods, or subroutines. Furthermore, the order of blocks may be adjusted arbitrarily without causing the essence of the sampling method 300 to depart from the scope of the technical solution of the sampling method 300.

[0045] At block S310, the sampling device 20 obtains a positioning point on a reference object.

[0046] In one implementation, the sampling device 20 may set the positioning point on the reference object independently. In one implementation, when the sampling device 20 receives a request to establish identification data for the reference object, the sampling device 20 may set the positioning point on the reference object independently. In one implementation, the image capture

unit 22 of the sampling device 20 may capture an overall image of the reference object, and then the user may select a location within this overall image as the positioning point on the reference object. In another implementation, the image capture unit 22 of the sampling device 20 may capture an overall image of the reference object, and then a location on the reference object may be randomly selected or chosen through a predetermined selection method.

[0047] In one implementation, the sampling device 20 may receive the positioning point of the reference object from devices different from the sampling device 20. In the implementation, the sampling device 20 may further include a reception unit (not shown in the figure). The reception unit may receive data provided to the sampling device 20 from devices different from the sampling device 20. In one implementation, the reception unit may be integrated with the transmission unit 25 into a communication unit.

[0048] In the implementation, when the sampling device 20 receives a request to establish identification data of the reference object, the image capture unit 22 of the sampling device 20 may capture an overall image of the reference object and transmit the overall image to the server 10 through the transmission unit 25. When the server 10 receives the overall image and the request to establish identification data of the reference object, the server 10 may select the positioning point from the overall image based on a predetermined selection method and then send the positioning point back to the reception unit of the sampling device 20. In one implementation, the server 10 may store these positioning point in the internal storage device 11 of the server 10. In another implementation, the server 10 may transmit the positioning point to the online storage device 30 for storage.

[0049] At block S320, the sampling device 20 obtains a plurality of sampling images along a plurality of sampling directions at the positioning point.

[0050] In one implementation, the sampling device 20 may set the plurality of sampling directions for the positioning point independently. In the implementation, when the sampling device 20 starts capturing the sampling images at the positioning point, the sampling device 20 may independently select the plurality of sampling directions for the positioning point. In one implementation, the sampling device 20 further includes a positioning unit (not shown in the figure), and the positioning unit may include a position device, such as a gyroscope. In one implementation, when the image capture unit 22 of the sampling device 20 captures the sampling images at the positioning point, the positioning unit may simultaneously store the sampling

direction corresponding to each sampling image. In another implementation, the sampling device 20 may preselect the plurality of sampling directions based on predetermined orientation mode and use the motion control unit 21 to move the image capture unit 22 to capture the plurality of sampling images along the sampling directions.

[0051] In one implementation, the sampling device 20 may receive the plurality of sampling directions from devices different from the sampling device 20. In the implementation, after transmitting the overall image to the server 10 through the transmission unit 25, the server 10 may set the plurality of sampling directions based on predetermined orientation mode and transmit the set sampling directions back to the reception unit of the sampling device 20 when sending the positioning point to the sampling device 20. In one implementation, the server 10 may store the plurality of sampling directions in the internal storage device 11 of the server 10. In another implementation, the server 10 may transmit the plurality of sampling directions to the online storage device 30 for storage. In another implementation, the server 10 neither stores the plurality of sampling directions in the internal storage device 11 nor transmits them to the online storage device 30. In other words, the sampling system does not store the plurality of sampling directions.

[0052] In one implementation, the image capture unit 22 captures the plurality of sampling images based on the plurality of sampling directions. In the implementation, the image capture unit 22 may capture a plurality of first sampling images based on a first sampling direction among the plurality of sampling directions and a plurality of second sampling images based on a second sampling direction among the plurality of sampling directions.

[0053] At block S330, the sampling device 20 transmits a sampling feature established from the plurality of sampling images for storing in an online device.

[0054] In one implementation, the online device may be the internal storage device 11 of the server 10 or the online storage device 30. In one implementation, the sampling device 20 may transmit the sampling feature established from the plurality of sampling images to the server 10 through the transmission unit 25. In one implementation, the server 10 may store the sampling feature in the internal storage device 11 of the server 10, or the server 10 may transmit the sampling feature to the online storage device 30 for storage. In another implementation, although the sampling device 20 similarly transmits the sampling feature established from the plurality of sampling images to the server 10 through the transmission unit 25, the server 10 obtains a verification feature through a predetermined image processing method and stores the verification

feature in the internal storage device 11 of the server 10, or the server 10 may transmit the verification feature to the online storage device 30 for storage. In another embodiment, the sampling device 20 may directly transmit the sampling feature established from the plurality of sampling images to the online storage device 30 through the transmission unit 25.

[0055] In one implementation, the sampling feature may be a sampling set of the plurality of sampling images. In other words, the whole set of the plurality of sampling images, the plurality of sampling directions, and a sampling correspondence between the plurality of sampling images and the plurality of sampling directions is the sampling feature. In one implementation, when the server 10 receives the plurality of sampling images, the plurality of sampling directions, and the sampling correspondence, the server 10 may obtain the verification feature based on a predetermined image processing method and store the verification feature in the internal storage device 11 or the online storage device 30. In another implementation, when the server 10 receives the plurality of sampling images, the plurality of sampling directions, and the sampling correspondence, the server 10 directly stores the plurality of sampling images, the plurality of sampling directions, and the sampling correspondence in the internal storage device 11 or the online storage device 30, and uses the plurality of sampling images, the plurality of sampling directions, and the sampling correspondence directly as the subsequent verification feature.

[0056] In one implementation, the sampling feature may be the verification feature generated based on the plurality of sampling images, the plurality of sampling directions, and the sampling correspondence. In other words, the processor 23 of the sampling device 20 may independently obtain the verification feature based on the predetermined image processing method. In one implementation, the sampling device 20 may transmit the verification feature to the server 10 through the transmission unit 25. In one implementation, the server 10 may store the verification feature in the internal storage device 11 of the server 10, or the server 10 may transmit the verification feature to the online storage device 30 for storage. In another implementation, the sampling device 20 may transmit the verification feature directly to the online storage device 30 for storage through the transmission unit 25.

[0057] In one implementation, if the positioning point is set by the sampling device 20 itself, the sampling device 20 may also transmit the positioning point to the server 10 or the online storage device 30 for storage when the sampling device 20 transmits the sampling feature to the server 10 or the online storage device 30.

[0058] In one implementation, the sampling device 20 may also transmit object information of the reference object, and the object information is stored in the online storage device 30 or the internal storage device 11. Thus, when a detected object is being subsequently detected, the server 10 may compare the object information with the information of the detected object to determine whether the server 10 may retrieve the positioning point and the verification feature of the reference object as identification information for detecting the detected object.

[0059] In one implementation, the reference object may change slightly over time. Thus, after a long period (e.g., 10 or 20 years), the re-sampling results may be different from the sampling feature or the verification feature stored in the server 10 or the online storage device 30, causing the reference object to be identified as a fake, when the reference object is re-sampled in the same manner. Therefore, when the sampling device 20 transmits the sampling feature to the server 10, change information may be simultaneously transmitted to the server 10. In the implementation, the change information may be material information or object information of the reference object, so the server 10 may independently search for deterioration information of the reference object based on the material information and the object information to consider the possible deterioration of the reference object when using the sampling feature to detect a detected object in the future. In the implementation, the server 10 may store the deterioration information in the internal storage device 11 or the online storage device 30. In another implementation, the server 10 may directly store the change information in the internal storage device 11 or the online storage device 30 for searching for the deterioration information based on the material information and the object information when detecting the detected object in the future. In another implementation, the change information may be the deterioration information of the reference object. In the implementation, the sampling device 20 may independently search for the deterioration information of the reference object based on the material information or the object information of the reference object, and transmit the deterioration information to the server 10 or directly transmit to the online storage device 30 . In the implementation, when the server 10 receives the deterioration information, the server 10 may store the deterioration information in the internal storage device 11 or the online storage device 30 .

[0060] The sampling method 300 of the present invention may include, but is not limited to, all of the following implementations:

[0061] In a first implementation of the sampling method 300 of the present invention, the set of the plurality of sampling images is directly stored as the verification feature in the internal storage device 11 or the online storage device 30, and the positioning point and the plurality of sampling directions are determined by the sampling device 20. In the implementation, the sampling device 20 first sets the positioning point and the plurality of sampling directions independently, obtains the plurality of sampling images based on the positioning point and the plurality of sampling directions. Then, the set of the sampling images is set as the sampling feature, and the set, the positioning point, the plurality of sampling direction, and the sampling correspondence between the plurality of sampling images and the plurality of sampling directions are transmitted to the server 10 or directly transmitted to the online storage device 30 for storage. In the implementation, when the server 10 receives the plurality of sampling images, the positioning point, the plurality of sampling directions, and the sampling correspondence, the server 10 may store the plurality of sampling images, the positioning point, the plurality of sampling directions, and the sampling correspondence in the internal storage device 11 or the online storage device 30. In the implementation, the data transmitted by the sampling device 20 also includes the change information, and the data stored in the internal storage device 11 or the online storage device 30 may also include the material information, the object information, or the deterioration information.

[0062] In the second implementation of the sampling method 300 of the present invention, the set of the plurality of sampling images is directly stored as the verification feature in the internal storage device 11 or the online storage device 30. Either the positioning point or the plurality of sampling directions is determined by the sampling device 20, and the other is determined by the server 10. In one implementation, the plurality of sampling directions is determined by the, and the positioning point is determined by the server 10. Thus, when the sampling device 20 receives a request to establish the verification data of the reference object, the sampling device 20 may obtain the whole image of the reference object and provides to the server 10. Then, the server 10 may select, based on a predetermined selection method, the positioning point from the whole image and provides to the sampling device 20. At the same time, the sampling device 20 may independently select the plurality of sampling directions based on a predetermined orientation method. In another implementation, the positioning point is determined by the sampling device 20, and the plurality of sampling directions is determined by the server 10. Thus, when the sampling device 20 receives a request to establish the verification data for the reference object, the

sampling device 20 may obtain the whole image of the reference object and select the positioning point from the whole image based on a predetermined selection method. At the same time, the sampling device 20 transmits a sampling request to the server 10 for indicating the server 10 to select the plurality of sampling directions based on a predetermined orientation method and to provide to the sampling device 20. In one implementation, after obtaining the positioning point and the plurality of sampling directions, the sampling device 20 further obtains the plurality of sampling images, sets the set of the plurality of sampling images as the sampling feature, and transmits the set, one of the positioning and the plurality of sampling directions, and the sampling correspondence to the server 10 or directly transmits to the online storage device 30 for storage. In the implementation, when the server 10 receives the plurality of sampling images, the server 10 may store the plurality of sampling images, the positioning point, the plurality of sampling directions, and the sampling correspondence in the internal storage device 11 or the online storage device 30. In the implementations, when the online storage device 30 directly receives the sampling images from the sampling device 20, the online storage device 30 may receive, from the server 10, the other one of the positioning point and the plurality of sampling directions which is not received from the sampling device 20. In the implementation, when the positioning point is determined by the server 10, it may be unnecessary for the sampling device 20 to further transmit the positioning point. Similarly, if the plurality of sampling directions is determined by the server 10, the sampling device 20 may only need to transmit the sampling correspondence and it may be unnecessary for the sampling device 20 to further transmit the plurality of sampling directions. In the implementation, the data transmitted by the sampling device 20 also includes the change information, and the data stored in the internal storage device 11 or the online storage device 30 may also include the material information, the object information, or the deterioration information.

[0063] In the third implementation of the sampling method 300 of the present invention, the set of the plurality of sampling images is directly stored as the verification feature in the internal storage device 11 or the online storage device 30, and both the positioning point and the plurality of sampling directions are determined by the server 10. In the implementation, when the sampling device 20 receives a request to establish the verification data for the reference object, the sampling device 20 may obtain the whole image of the reference object and provides to the server 10. Then, the server 10 may select, based on a predetermined selection method and a predetermined orientation method, the positioning point from the whole image and additionally determines the

plurality of sampling directions, and provide them to the sampling device 20. The sampling device 20 obtains the plurality of sampling images based on the received positioning point and the received sampling directions, sets the set of the plurality of sampling images as the sampling feature, and transmits the set and the sampling correspondence to the server 10 or directly transmits to the online storage device 30 for storage. In the implementation, when the server 10 receives the plurality of sampling images and the sampling correspondence, the server 10 may store the plurality of sampling images, the positioning point, the plurality of sampling directions, and the sampling correspondence in the internal storage device 11 or the online storage device 30. In the implementation, when the online storage device 30 directly receives the plurality of sampling images and the sampling correspondence from the sampling device 20, the online storage device 30 may obtain the positioning point and the plurality of sampling directions from the server 10. In the implementation, the data transmitted by the sampling device 20 also includes the change information, and the data stored in the internal storage device 11 or the online storage device 30 may also include the material information, the object information, or the deterioration information.

[0064] In the fourth implementation of the sampling method 300 of the present invention, the verification feature is generated from the plurality of sampling images by using a predetermined image processing method and then stored in the internal storage device 11 or the online storage device 30, and both the positioning point and the plurality of sampling directions are determined by the sampling device 20. In the implementation, the sampling device 20 first sets the positioning point and the plurality of sampling directions independently, obtains the plurality of sampling images based on the positioning point and the plurality of sampling directions. In one implementation, the sampling device 20 generates the verification feature for the positioning point based on the plurality of sampling images, the plurality of sampling directions, and the sampling correspondence by using a predetermined image processing method. The sampling device 20 sets the verification feature as the sampling feature, and transmits the verification feature and the positioning point to the server 10 or directly transmits to the online storage device 30 for storage. In the implementation, when the server 10 receives the verification feature and the positioning point, the server 10 may store the verification feature and the positioning point in the internal storage device 11 or the online storage device 30. In another implementation, the sampling device 20 directly transmits the positioning point, the plurality of sampling directions, the plurality of sampling images, and the sampling correspondence to the server 10. The server 10 generates the

verification feature for the positioning point based on the plurality of sampling images, the plurality of sampling directions, and the sampling correspondence by using a preset image processing method and stores the verification feature and the positioning point in the internal storage device 11 or the online storage device 30. In the implementation, the data transmitted by the sampling device 20 also includes the change information, and the data stored in the internal storage device 11 or the online storage device 30 may also include the material information, the object information, or the deterioration information.

[0065] In the fifth implementation of the sampling method 300 of the present invention, the verification feature is generated from the plurality of sampling images by using a predetermined image processing method and then stored in the internal storage device 11 or the online storage device 30, and the positioning point or the plurality of sampling directions is determined by the sampling device 20. The fifth implementation is performed in the same manner as described in the second implementation. The sampling device 20 and the server 10 independently and respectively generate the positioning point and the plurality of sampling directions based on predetermined selection method and the whole image of the reference object or based on predetermined orientation method for obtaining the plurality of sampling images. In one implementation, the sampling device 20 generates the verification feature for the positioning point based on the plurality of sampling images, the plurality of sampling directions, and the sampling correspondence by using a preset image processing method. The sampling device 20 sets the verification feature as the sampling feature and transmit to the server 10 or directly to the online storage device 30 for storage. In the implementation, if the positioning point is determined by the server 10, it may be unnecessary for the sampling device 20 to further transmit the positioning point. If the positioning point is determined by the sampling device 20, the positioning point may be additionally transmitted to the server 10 or directly to the online storage device 30 for storage. In the implementations, when the server 10 receives the verification feature, the server 10 may store the verification feature and the positioning point in the internal storage device 11 or the online storage device 30. In another implementation, the sampling device 20 directly transmits the plurality of sampling images and the sampling correspondence to the server 10. The server 10 generates the verification feature for the positioning point based on the plurality of sampling images, the plurality of sampling directions, and the sampling correspondence by using a predetermined image processing method and stores the verification feature and the positioning

point in the internal storage device 11 or the online storage device 30. In the implementation, if the plurality of sampling directions is determined by the sampling device 20, the sampling device 20 may additionally transmit the plurality of sampling directions to the server 10. If the positioning point is determined by the sampling device 20, the sampling device 20 may additionally transmit the positioning point to the server 10 or directly to the online storage device 30 for storage. In the implementation, the data transmitted by the sampling device 20 also includes the change information, and the data stored in the internal storage device 11 or the online storage device 30 may also include the material information, the object information, or the deterioration information.

[0066] In the sixth implementation of the sampling method 300 of the present invention, the verification feature is generated from the plurality of sampling images by using a predetermined image processing method and then stored in the internal storage device 11 or the online storage device 30, and both the positioning point and the plurality of sampling directions are determined by the server 10. The sixth implementation is performed in the same manner as described in the third implementation. The server 10 generates the positioning point based on a predetermined selection method and the whole image of the reference object received from the sampling device 20, and generates the plurality of sampling directions based on a predetermined orientation method. Then, both the positioning point and the plurality of sampling directions are provided to the sampling device 20. In one implementation, the sampling device 20 generates the verification feature for the positioning point based on the plurality of sampling images, the plurality of sampling directions, and the sampling correspondence by using a predetermined image processing method. The sampling device 20 sets the verification feature as the sampling feature, and transmits to the server 10 or directly transmits to the online storage device 30 for storage. In the implementation, since the positioning point is determined by the server 10, it may be unnecessary for the sampling device 20 to further transmit the positioning point. In the implementation, when the server 10 receives the verification feature, the server 10 may store the verification feature and the positioning point in the internal storage device 11 or the online storage device 30. In another implementation, the sampling device 20 directly transmits the plurality of sampling images and the sampling correspondence to the server 10. The server 10 generates the verification feature for the positioning point based on the plurality of sampling images, the plurality of sampling directions, and the sampling correspondence by using a predetermined image processing method and stores the verification feature and the positioning point in the internal

storage device 11 or the online storage device 30. In the implementation, the data transmitted by the sampling device 20 also includes the change information, and the data stored in the internal storage device 11 or the online storage device 30 may also include the material information, the object information, or the deterioration information.

[0067] In the implementation, the predetermined selection method may be a random selection method for allowing the sampling device 20 or the server 10 to select the positioning point arbitrarily from the whole image of the reference object. In the implementation, the predetermined selection method may involve a surface analysis technology for allowing the sampling device 20 or the server 10 to select the positioning point from the whole image of the reference object. The surface analysis technology may be an image analysis technology, such as an image complexity analysis, for obtaining a region having high complexity in the whole image as the positioning point. In the implementation, the predetermined selection method may include but is not limited to the above selection method. Any method that may be used to select a specific location on the reference object is applicable to the sampling method 300 described in the present disclosure.

[0068] In the implementation, the predetermined orientation method may be a random orientation method for allowing the sampling device 20 or the server 10 to select the plurality of sampling directions arbitrarily. In the implementation, if the sampling device 20 or the server 10 has already obtained the positioning point in the whole image in advance, it may select the plurality of sampling directions at the positioning point by using a surface analysis technology. The surface analysis technology may set more sampling directions for the parts with higher color changes around the positioning point based on the gradient of the pixel value change, so as to obtain more comprehensive sampling features around the positioning point. In the implementation, the predetermined orientation method may include but is not limited to the above orientation method. Any method that may be used to select the plurality of different sampling directions is applicable to the sampling method 300 described in the present disclosure.

[0069] In this implementation, the predetermined image processing method may be a three-dimensional modeling processing. In the implementation, the sampling device 20 or the server 10 may generate a sampling model for the positioning point by using a machine learning technology based on the plurality of sampling images, the plurality of sampling directions, and the

sampling correspondence between the plurality of sampling images and the plurality of sampling directions. The sampling model may be a three-dimensional sampling model.

[0070] In the implementation, the sampling device 20 may select a plurality of positioning points for the reference object and obtain a plurality of sampling images for each positioning point along a plurality of sampling directions. This allows to obtain different sampling feature for different positioning points on the reference object. In one implementation, the plurality of sampling directions for each positioning point may be completely different. In another implementation, the same sampling set having a plurality of sampling directions may be used for all positioning points. Thus, the plurality of sampling directions for each positioning point may be identical to each other. In another approach, the plurality of sampling directions for different positioning points may be partially identical to and partially different from each other.

[0071] Please refer to FIG. 4A. FIG. 4A is a block diagram of a detection system 401 for detecting a detected object, according to the present invention. In one implementation, the detection system 401 includes a server 10 and a detection device 40. The server 10 may include an internal storage device 11 for pre-storing sampling feature obtained from the sampling device 20 illustrated in FIG. 2. In one implementation, when the detection device 40 receives a detection request, the detection device 40 may be coupled to the server 10 to complete the detection method described in the present invention. After the detection system 401 completes the detection method, the detection device 40 may be decoupled from the server 10.

[0072] Please refer to FIG. 4B. FIG. 4B is a block diagram of another detection system 402 for detecting a detected object, according to the present invention. In one implementation, the detection system 402 includes a server 10, a detection device 40, and an online storage device 30. In one implementation, when the detection device 40 receives a detection request, the detection device 40 may be coupled to the server 10, and the server 10 may further be coupled to the online storage device 30 to complete the detection method described in the present invention. After the detection system 402 completes the detection method, the detection device 40 may be decoupled from the server 10, and the server 10 may also be decoupled from the online storage device 30. In another implementation, when the detection device 40 receives a detection request, the detection device 40 may be coupled to the server 10 and the online storage device 30 to complete the detection method described in the present invention. After the detection system 402 completes the

detection method, the detection device 40 may be decoupled from the server 10 and the online storage device 30.

[0073] In the implementations, the online storage device 30 may be a network data storage or a blockchain storage device. When the online storage device 30 is a blockchain storage device, the characteristics of the blockchain may reduce the possibility of tampering or replacing the pre-stored sampling feature. In the implementations, the online storage device 30 may store all of the of the transaction history, times and results of the detections, and updated images of the reference object.

[0074] Please refer to FIG. 5. FIG. 5 is a block diagram of a detection device 40 for detecting a detected object, according to the present invention. The detection device 40 may not be limited to a mobile phone, tablet computer, desktop computer, laptop, camera, camcorder, or other electronic devices. The detection device 40 includes a motion control unit 41, an image capture unit 42, a processor 43, a storage 44, a transmission unit 45, and a reception unit 46.

[0075] The motion control unit 41 is used to enable the detection device 40 to achieve the movement required during the detection process. In one implementation, the motion control unit 41 is used to move the image capture unit 42 during the detection of the reference object. In one implementation, the motion control unit 41 may be a display screen on the detection device 400 or an automatic movement device coupled with the image capture unit 42.

[0076] When a display screen serves as the motion control unit 41, the display screen may be used to provide movement instructions to the user for indicating the user to move the image capture unit 42 to a detection position. In the implementation, the detection position may be determined based on a detection distance and a detection direction. For example, when a capture distance between the image capture unit 42 and a positioning point on the detected object is identical to the detection distance and a capture direction oriented from the image capture unit 42 towards the positioning point on the detected object is identical to the detection direction, the display screen may indicate that the image capture unit 42 has moved to the detection position to start to obtain the required detection images. When the capture distance is not identical to the detection distance, the display screen may instruct the user to further move the image capture unit 42 to extend or shorten the capture distance. When the capture direction is not identical to the detection direction, the display screen may instruct the user to further move the image capture unit 42 to the left, right, up, or down the capture direction. In another implementation, the detection

position may be determined based on the detection direction. In the implementation, the detection distance may be adjusted by changing the focal length of the image capture unit 42 to ensure the acquisition of detailed surface information of the detected object.

[0077] When an automatic movement device serves as the motion control unit 41, the automatic movement device may be a robotic arm or another device capable of moving the image capture unit 42. This automatic movement device may receive the detection position instructed from the processor 43 for moving the image capture unit 42 to the detection position. In another implementation, the detection distance may be adjusted by changing the focal length of the image capture unit 42 to ensure the acquisition of detailed surface information of the detected object. Therefore, the automatic movement device may only adjust the detection direction of the image capture unit 42 to obtain the required detection images.

[0078] The image capture unit 42 is used to obtain a plurality of detection images. When the detected object is being detected by the detection device 40, the image capture unit 42 may move to a plurality of different detection positions to allow the image capture unit 42 to capture the detected object at different detection positions for obtaining a plurality of detection images. The image capture unit 42 may be a Charge-Coupled Device (CCD) image sensor, Complementary Metal–Oxide–Semiconductor (CMOS) image sensor, or a camera. In one implementation, the image capture unit 42 may include a high-magnification image capture lens to capture detailed surface information of the detected object. In the implementation, the image capture unit 42 may include a microscope image capture lens. In one implementation, the plurality of detection images captured by the image capture unit 42 may be microscopic surface images of the detected object. In the implementation, the microscopic surface images may be surface texture images.

[0079] The processor 43 is coupled with the storage 44. The storage 44 stores a plurality of instructions for the processor 43 to execute the detection method of the detection device 40 based on the plurality of instructions stored in the storage 44. To perform the detection method of the present invention, the storage 44 stores a detection program 440. In the implementation, the detection program 440 further includes a positioning module 441 and a detection module 442. The positioning module 441 is used to enable the processor 43 to coordinate with the motion control unit 41 in moving the image capture unit 42 to the detection position. The detection module 442 is used to enable the processor 43 to coordinate with the image capture unit 42 in capturing the required detection images at that detection position.

[0080] The transmission unit 45 and the reception unit 46 may utilize custom protocols or follow existing standards or de facto standards, including but not limited to Ethernet, IEEE 802.11 or IEEE 802.15 series, Wireless USB, or telecommunications standards (including but not limited to GSM, CDMA2000, TD-SCDMA, WiMAX, 3GPP-LTE, or TD-LTE), to transmit detection feature to other devices different from the detection device 40 and to receive sampling feature transmitted from other devices different from the detection device 40.

[0081] FIG. 6 is a flowchart of a detection method for detecting a detected object, according to the present invention. The sampling method 600 illustrated in FIG. 3 is provided by way of example only, as there are a variety of ways to carry out the detection method. The detection method 600 illustrated in FIG. 6 may be carried out using the configurations illustrated in FIGS. 4A, 4B, and 5, for example, and various elements in FIGS. 4A, 4B, and 5 are referenced in explaining the detection method 600. Each block shown in FIG. 6 represents one or more executed processes, methods, or subroutines. Furthermore, the order of blocks may be adjusted arbitrarily without causing the essence of the detection method 600 to depart from the scope of the technical solution of the detection method 600.

[0082] At block S610, the detection device 40 transmits a request for detecting a detected object.

[0083] In one implementation, the detection device 40 needs to know which region of the detected object will be used for image detection before capturing the detection images, in order to compare it with the verification feature stored in the online storage device 30 or the internal storage device 11. Thus, the detection device 40 may first transmit a request for obtaining the positioning point for detecting the detected object to obtain the positioning point of the detected object. In the implementation, the detection device 40 may transmit the request to the server 10, and the request may include the object information of the detected object. Therefore, the server 10 may confirm, based on the object information of the detected object, which corresponding positioning point and verification feature of the reference object should be retrieved as the identification information required for detecting the detected object. In the implementation, the corresponding positioning point of the reference object may be the positioning point of the detected object.

[0084] In one implementation, when the corresponding positioning point and the verification feature of the reference object corresponding to the detected object are stored in the internal storage device 11, the server 10 transmits the corresponding positioning point of the

reference object to the detection device 40. In another implementation, when the corresponding positioning point and the verification feature of the reference object corresponding to the detected object are stored in the online storage device 30, the server 10 first transmits a request to obtain the positioning point of the detected object to the online storage device 30, so that the online storage device 30 may confirm which positioning point and verification feature of the reference object should be retrieved as the identification information required for detecting the detected object. Then, the online storage device 30 returns the positioning point and the verification feature to the server 10, and then the server 10 transmits the positioning point to the detection device 40. In the implementation, the online storage device 30 also transmits the change information of the reference object to the server 10.

[0085] At block S620, the detection device 40 receives information having a positioning point of the detected object.

[0086] In one implementation, the server 10 transmits the positioning point of the detected object to the detection device 40 for use in subsequent image capture. In one implementation, if the verification feature obtained from the server 10 is a plurality of sampling images for the corresponding positioning point of the reference object, the information transmitted by the server 10 will also provide the sampling directions of the plurality of sampling images. Thus, the detection device 40 may capture the detection images along the same detection direction.

[0087] In one implementation, if the detection device 40 will perform the comparison between the plurality of detection images and the verification feature independently, the server 10 may also transmit the verification feature of the reference object to the detection device 40. In the implementation, the server 10 will also transmit the change information of the reference object to the detection device 40. In another implementation, if the comparison is performed by the server 10, then the server 10 may not transmit the verification feature of the reference object to the detection device 40 and directly keep it in the server 10 for subsequent comparison.

[0088] At block S630, the detection device 40 obtains a plurality of detection images along a plurality of detection directions at the positioning point.

[0089] In one implementation, the detection device 40 may independently set the plurality of detection directions for the positioning point. In the implementation, when the detection device 40 starts to capture the detection images at the positioning point, the detection device 40 may independently select the plurality of detection directions for the positioning point. In one

implementation, the detection device 40 further includes a positioning unit (not shown in the figure). The positioning unit may include a gyroscope or other positioning device. In one implementation, the detection device 40 may store the detection direction corresponding to the detection image by the positioning unit when capturing the detection images at the positioning point. In another implementation, the detection device 40 may pre-select the plurality of detection directions based on a predetermined orientation method and use the motion control unit 41 to move the image capture unit 42 to capture the plurality of detection images along the plurality of detection directions.

[0090] In one implementation, the detection device 40 may receive the plurality of detection directions from a device different from the detection device 40. In the implementation, the detection device 40 may obtain the plurality of detection directions through the reception unit 46. In one implementation, if the internal storage device 11 and the online storage device 30 do not store the plurality of sampling directions for the corresponding positioning point of the reference object, the server 10 may pre-select the plurality of detection directions based on a predetermined orientation method and send to the reception unit 46. In another implementation, if the plurality of sampling directions for the corresponding positioning point of the reference object are stored in the internal storage device 11 or the online storage device 30, the plurality of sampling directions may be resent to the detection device 40 as the plurality of detection directions for the positioning point of the detected object. In one implementation, if the plurality of sampling directions is stored in the internal storage device 11, the server 10 may send the plurality of sampling directions to the reception unit 46 as the plurality of detection directions. In another implementation, if the plurality of sampling directions is stored in the online storage device 30, the online storage device 30 may directly send the plurality of sampling directions to the reception unit 46 as the plurality of detection directions or indirectly transmit the plurality of sampling directions to the reception unit 46 through the server 10 as the plurality of detection directions.

[0091] In one implementation, the image capture unit 42 captures the plurality of detection images based on the plurality of detection directions. In the implementation, the image capture unit 42 may capture a plurality of first detection images based on a first detection direction among the plurality of detection directions, and may capture a plurality of second detection images based on a second detection direction among the plurality of detection directions.

[0092] At block S640, the detection device 40 obtains a detection result based on the plurality of detection images.

[0093] In one implementation, the detection result is generated based on the comparison between the plurality of detection images and the reference object corresponding to the detected object. In one implementation, the detection device 40 may independently compare the plurality of detection images with the verification feature of the reference object to obtain the detection result. In another implementation, the detection device 40 may generate a detection feature based on the plurality of detection images and send the detection feature to the server 10 for the server 10 to compare the detection feature with the verification feature. Finally, the server 10 sends the detection result to the detection device 40.

[0094] In one implementation, when the detection result is generated by the detection device 40 independently, the detection device 40 compares the plurality of detection images with the received verification feature. In the implementation, the verification feature may be a sampling model of the reference object at the corresponding positioning point. This sampling model may be a three-dimensional sampling model. In one implementation, the detection device 40 may generate the detection feature based on the plurality of detection images, the plurality of detection directions, and a detection correspondence between the plurality of detection images and the plurality of detection directions. In other words, the processor 43 of the detection device 40 may independently obtain the detection feature based on a predetermined image processing method. In the implementation, the detection feature is a detection model at the positioning point of the detected object. The detection model may be a three-dimensional detection model. Therefore, the detection device 40 may directly compare the similarity between the three-dimensional sampling model and the three-dimensional detection model to generate the detection result. In another implementation, the detection device 40 may compare the three-dimensional sampling model with the plurality of detection images, the plurality of detection directions, and the detection correspondence. In the implementation, the detection device may derive a plurality of verification images based on the three-dimensional sampling model through the plurality of detection directions. Then, based on the detection correspondence, the similarity between each of the plurality of verification images and the plurality of detection images may be determined one by one to generate the detection result. In one implementation, the verification feature may include a plurality of sampling images, a plurality of sampling directions, and a sampling correspondence

for the corresponding positioning point of the reference object. In the implementation, the plurality of sampling directions may be identical to the plurality of detection directions, so the detection device 40 may compare the similarity between the plurality of sampling images and the plurality of detection images one by one based on the sampling correspondence and the detection correspondence to generate the detection result.

[0095] In one implementation, when the detection result is generated by the server 10, the detection device 40 transmits the detection feature to the server 10. In the implementation, the transmitted detection feature may be the three-dimensional sampling model or a set of the plurality of detection images, the plurality of detection directions, and the detection correspondence. In one implementation, the detection device 40 may generate the three-dimensional detection model based on the plurality of detection images, the plurality of detection directions, and the detection correspondence. In other words, the processor 43 of the detection device 40 may independently obtain the three-dimensional detection model based on a predetermined image processing method. Therefore, the detection device 40 may directly transmit the three-dimensional detection model to the server 10, and the server 10 compares the similarity between the three-dimensional sampling model and the three-dimensional detection model to provide the detection result to the detection device 40.

[0096] In another implementation, the detection device 40 may transmit the set of the plurality of detection images, the plurality of detection directions, and the detection correspondence to the server 10. In one implementation, the server 10 may generate the three-dimensional detection model based on the plurality of detection images, the plurality of detection directions, and the detection correspondence. In other words, the server 10 may obtain the three-dimensional detection model based on a predetermined image processing method. In the implementation, the server 10 may directly compare the similarity between the three-dimensional sampling model and the three-dimensional detection model to provide the detection result to the detection device 40. In another implementation, the server 10 may compare the three-dimensional sampling model with the plurality of detection images, the plurality of detection directions, and the detection correspondence. In the implementation, the server 10 may derive a plurality of verification images based on the three-dimensional sampling model along the plurality of detection directions, and then compare the similarity between the plurality of verification images and the plurality of detection images, respectively, based on the detection correspondence to provide the

detection result to the detection device 40. In another embodiment, the verification feature may include a plurality of sampling images, a plurality of sampling directions, and a sampling correspondence for the corresponding positioning point of the reference object. In the implementation, the plurality of sampling directions may be identical to the plurality of detection directions, so the server 10 may compare the similarity between the plurality of sampling images and the plurality of detection images, respectively, based on the sampling correspondence and the detection correspondence to provide the detection result to the detection device 40. In the implementation, the plurality of detection directions may be obtained from the online storage device 30 or the internal storage device 11.

[0097] In one implementation, if the detection result indicates a high similarity between the reference object and the detected object, the detection result obtained by the detection device 40 may determine that the detected object is the same as the reference object. If the detection result indicates a low similarity between the reference object and the detected object, the detection result obtained by the detection device 40 may determine that the detected object is different from the reference object. In another implementation, if the detection result indicates a low similarity between the reference object and the detected object, such that the detection result determines that the detected object is different from the reference object, the detection device 40 or the server 10 may update the detection result based on the change information of the reference object. In the implementation, the detection device 40 or the server 10 may adjust the verification feature based on the change information of the reference object, and update the detection result based on an adjustment feature and the comparison of the plurality of detection images.

[0098] In one implementation, the change information may be the material information, the object information, or the deterioration information of the reference object. If the change information is the material information or the object information, the detection device 40 or the server 10 may search for the deterioration information of the reference object through a network or an internal database based on the material information or object information. The detection device 40 or the server 10 may estimate a possible degree of deterioration of the reference object based on the deterioration information and the time interval between the detection time and the sampling time. Therefore, the detection device 40 or the server 10 may obtain the adjustment feature based on the verification feature and the degree of deterioration.

[0099] In one implementation, the deterioration information may be material aging information. The material aging information may be related to color changes (e.g., fading). If the deterioration information is the material aging information, the actual degree of material aging may be estimated based on the material aging information and the time interval. For example, the degree of fading may be estimated. In another implementation, the deterioration information may be material condition information. The material condition information may be related to material decomposition or damage. If the deterioration information is the material condition information, the actual degree of material damage may be estimated based on the material condition information and the time interval. For example, the size or quantity of cracks may be estimated.

[0100] In one implementation, if the updated detection result indicates a high similarity between the reference object and the detected object, the detection result obtained by the detection device 40 may determine that the detected object is the same as the reference object. In the implementation, the detection device 40 or the server 10 may store the detection feature generated by the plurality of detection images in the internal storage device 11 or the online storage device 30. In one implementation, the detection feature may directly replace the verification feature as a basis for future detections. If the change information has been used to predict the changes of the reference object for a long time, it may be difficult to correctly verify the detected object in the future when a significant difference between the actual change status and the predicted change status of the reference object is occurred. Therefore, if the updated detection result indicates a high similarity between the reference object and the detected object, it means that the detection feature may show the actual change status of the reference object, set as the detected object, during the detection. The detection device 40 or the server 10 may transmit to store the detection feature. In this way, the actual change status of the reference object may be appropriately tracked to avoid the actual change status exceeding the expected change status. Thus, the correctness of the verification feature or the detection feature may remain continuously in subsequent detections.

[0101] In another implementation, if the updated detection result indicates a high similarity between the reference object and the detected object, the detection device 40 or the server 10 may store the detection feature generated by the plurality of detection images together with the verification feature. In other words, the online storage device 30 or the internal storage device 11 will have feature information of the reference object generated at two different times. Therefore, if a new detected object is compared with the detection feature and the verification feature after a

time interval (e.g., 1 year later), the new detected object may be evaluated not only for whether the new detected object is similar to the detection feature and the verification feature, but also whether the degree of deterioration of the new detected object relative to the verification feature is greater than the degree of deterioration of the detection feature. When the degree of deterioration of the new detected object is smaller than the degree of deterioration of the detection feature, the detection system may still issue a warning for the new detected object if the new detected object is similar to the detection feature and the verification feature. In this way, the detection accuracy may be further improved due to the irreversibility of the degree of deterioration.

[0102] The detection method 600 of the present invention may include, but is not limited to, all of the following implementations:

[0103] In a first implementation of the detection method 600 of the present invention, the comparison between the plurality of detection images and the verification feature is performed by the detection device 40. The verification feature includes the plurality of sampling images, the plurality of sample directions, and the sample correspondence between the plurality of sampling images and the plurality of sample directions for the corresponding positioning point of the reference object corresponding to the detected object. In one implementation, the detection device 40 transmits a request to detect the detected object. After receiving this request, the server 10 retrieves the corresponding positioning point and the verification feature of the reference object corresponding to the detected object from the internal storage device 11 or online storage device 30, and transmits the plurality of sample directions determined from the corresponding positioning point and the verification feature to the detection device 40. In one implementation, the server 10 may also transmit the plurality of sampling images and the sample correspondence to the detection device 40 at the same time.

[0104] In one implementation, after receiving the corresponding positioning point and the plurality of sample directions, the detection device 40 directly sets the corresponding positioning point and the plurality of sample directions as the positioning point and the plurality of detection directions for the detected object, respectively, and thereby obtains the plurality of detection images. In one implementation, if the detection device 40 has obtained the plurality of sampling images before obtaining the plurality of detection images, it may directly start the comparison. In another implementation, if the detection device 40 has not obtained the plurality of sampling images before obtaining the plurality of detection images, the detection device 40 may transmit a

request to the server 10 again for comparing with the reference object. Upon receiving this request, the server 10 will provide the plurality of sampling images and the sample correspondence to the detection device 40. By transmitting the second request in this manner, the server 10 may prevent users from simply sending out the first request to fraudulently obtain all the verification information. In the implementation, the request sent again by the detection device 40 may include the plurality of detection images for the server 10 to perform an initial verification. If the server 10 determines that the plurality of detection images is definitely unrelated to the sampling images, the server 10 may refuse to provide the plurality of sampling images. If the server 10 determines that there is a slightly correlation between the plurality of detection images and the plurality of sampling images, the server 10 may transmit the plurality of sampling images for comparison by the detection device 40.

[0105] In one implementation, the detection device 40 compares the plurality of sampling images with the plurality of detection images based on the sample correspondence and the detection correspondence. If the similarity between the plurality of sampling images and the plurality of detection images is high, the detection device 40 may determine that the detected object is the reference object and transmit the detection result to the server 10. If the similarity between the plurality of sampling images and the plurality of detection images is low, the detection device 40 may determine that the detected object is not the reference object and transmit the detection result to the server 10. In another implementation, if the similarity between the plurality of sampling images and the plurality of detection images is low, the detection device 40 may transmit a request to the server 10 for obtaining the change information of the reference object. In the implementation, the server 10 may also perform another preliminary verification (e.g., by requesting all of the plurality of detection images) based on the request for obtaining the change information to confirm whether the detection device 40 needs the change information. In one implementation, the detection device 40 adjusts the plurality of sampling images based on the change information to generate a plurality of adjusted images as part of the adjustment feature. The detection device 40 then compares the plurality of adjusted images with the plurality of detection images based on the sample correspondence and the detection correspondence. If the similarity between the plurality of adjusted images and the plurality of detection images is low, the detection device 40 may determine that the detected object is not the reference object and transmit the detection result to the server 10. If the similarity between the plurality of adjusted

images and the plurality of detection images is high, the detection device 40 may update the original detection result, indicating a difference, to determine that the detected object is the reference object, and transmit the detection result to the server 10. In the implementation, the detection device 40 may upload the plurality of detection images to the server 10 for the server 10 to store the plurality of detection images in the internal storage device 11 or the online storage device 30. In one implementation, the plurality of detection images and the plurality of sampling images may correspond to the reference object to be stored in the internal storage device 11 or the online storage device 30 together as the verification feature of the reference object. In another implementation, the plurality of detection images may directly replace the plurality of sampling images to be the verification feature of the reference object. In one implementation, when receiving the plurality of detection images, the server 10 may also perform further confirmation on the plurality of detection images to confirm the similarity between the plurality of detection images and the plurality of adjusted images, to avoid storing incorrect verification feature.

[0106] In a second implementation of the detection method 600 of the present invention, the comparison between the plurality of detection images and the verification feature is performed by the detection device 40, and the verification feature includes a sampling model for the corresponding positioning point of the reference object corresponding to the detected object. In one implementation, the detection device 40 transmits a request for detecting the detected object. After receiving this request, the server 10 retrieves the corresponding positioning point and the verification feature for the reference object corresponding to the detected object from the internal storage device 11 or the online storage device 30, and transmits the corresponding positioning point to the detection device 40. In one implementation, the server 10 may also transmit the sampling model to the detection device 40 at the same time.

[0107] In one implementation, when receiving the corresponding positioning point, the detection device 40 may directly set the corresponding positioning point as the positioning point for the detected object and independently select a plurality of detection directions to obtain a plurality of detection images. In one implementation, if the detection device 40 has already obtained the sampling model before obtaining the plurality of detection images, the detection device 40 may start the comparison directly. In another implementation, if the detection device 40 has not obtained the sampling model before obtaining the plurality of detection images, the detection device 40 may transmit a request to the server 10 again for comparing with the reference

object. Upon receiving this request, the server 10 will provide the sampling model to the detection device 40. By transmitting the second request in this manner, the server 10 may prevent users from simply sending out the first request to fraudulently obtain all the verification information. In the implementation, the request sent again by the detection device 40 may include the plurality of detection images for the server 10 to perform an initial verification. If the server 10 determines that the plurality of detection images is definitely unrelated to the sampling model, the server 10 may refuse to provide the sampling model. If the server 10 determines that there is a slightly correlation between the plurality of detection images and the sampling model, the server 10 may transmit the sampling model for comparison by the detection device 40.

[0108] In one implementation, the detection device 40 may generate a detection model based on the plurality of detection images, the plurality of detection directions, and the detection correspondence, and generate the detection result by comparing the similarity between the detection model and the sampling model. In another implementation, the detection device 40 may derive a plurality of validation images based on the sampling model along the plurality of detection directions. Then, based on the detection correspondence between the plurality of detection images and the plurality of detection directions, the similarity between the plurality of validation images and the plurality of detection images may be compared respectively to generate the detection result.

[0109] In one implementation, if the similarity between the plurality of validation images and the plurality of detection images or the similarity between the sampling model and the detection model is high, the detection device 40 may determine that the detected object is the reference object and transmit the detection result to the server 10. If the similarity between the plurality of validation images and the plurality of detection images or the similarity between the sampling model and the detection model is low, the detection device 40 may determine that the detected object is not the reference object and transmit the detection result to the server 10. In another implementation, if the similarity between the plurality of validation images and the plurality of detection images or the similarity between the sampling model and the detection model is low, the detection device 40 may transmit a request to the server 10 for obtaining the change information of the reference object. In the implementation, the server 10 may also perform another preliminary verification (e.g., by requesting all of the plurality of detection images or the detection model) based on the request for obtaining the change information to confirm whether the detection device 40 needs the change information. In one implementation, the detection device 40 adjusts

the sampling model based on the change information to generate an adjusted model as the adjustment feature. The detection device 40 then compares the plurality of detection images with the adjusted model based on the detection correspondence or directly compares the detection model with the adjusted model. If the similarity between the adjusted model and the plurality of detection images or the similarity between the adjusted model and the detection model is low, the detection device 40 may determine that the detected object is not the reference object and transmit the detection result to the server 10. If the similarity between the adjusted model and the plurality of detection images or the similarity between the adjusted model and the detection model is high, the detection device 40 may update the original detection result, indicating a difference, to determine that the detected object is the reference object, and transmit the detection result to the server 10. In the implementation, the detection device 40 may upload the plurality of detection images or the detection model to the server 10. If the detection device 40 uploads the plurality of detection images to the server 10, the detection device 40 may also upload the plurality of detection directions and the detection correspondence for the server 10 to generate the detection model. In the implementation, the server 10 stores the detection model in the internal storage device 11 or online storage device 30. In one implementation, the detection model and the plurality of sampling models corresponding to the reference object may be stored in the internal storage device 11 or online storage device 30 simultaneously, serving as the verification feature of the reference object together. In another implementation, the detection model may directly replace the plurality of sampling models to serve as the verification feature of the reference object. In one implementation, when obtaining the detection model, the server 10 may also perform further confirmation on the detection model to determine the similarity between the detection model and the sampling model to avoid storing incorrect verification feature.

[0110] In a third implementation of the detection method 600 of the present invention, the comparison between the plurality of detection images and the verification feature is performed by the server 10. The verification feature includes the plurality of sampling images, the plurality of sample directions, and the sample correspondence between the plurality of sampling images and the plurality of sample directions for the corresponding positioning point of the reference object corresponding to the detected object. In one implementation, the detection device 40 transmits a request to detect the detected object. After receiving this request, the server 10 retrieves the corresponding positioning point and the verification feature of the reference object corresponding

to the detected object from the internal storage device 11 or online storage device 30, and transmits the plurality of sample directions determined from the corresponding positioning point and the verification feature to the detection device 40. In the implementation, it may be unnecessary for the server 10 to transmit the plurality of sampling images and the sampling correspondence to the detection device 40, so there is no need to worry about the plurality of sampling images and the sampling correspondence being obtained improperly.

[0111] In one implementation, after receiving the corresponding positioning point and the plurality of sample directions, the detection device 40 directly sets the corresponding positioning point and the plurality of sample directions as the positioning point and the plurality of detection directions for the detected object, respectively, and thereby obtains the plurality of detection images. In one implementation, the detection device 40 transmits the plurality of detection images and the detection correspondence between the plurality of detection images and the plurality of detection directions to the server 10 for the server to comparison with the verification feature.

[0112] In one implementation, the server 10 compares the plurality of sampling images with the plurality of detection images based on the sample correspondence and the detection correspondence. If the similarity between the plurality of sampling images and the plurality of detection images is high, the server 10 may determine that the detected object is the reference object and return the detection result to the detection device 40. If the similarity between the plurality of sampling images and the plurality of detection images is low, the server 10 may determine that the detected object is not the reference object and transmit the detection result to the detection device 40. In another implementation, if the similarity between the plurality of sampling images and the plurality of detection images is low, the server 10 may obtain the change information of the reference object from the internal storage device 11 or the online storage device 30. In the implementation, it may be unnecessary for the server 10 to transmit the change information to the detection device 40, so there is no need to worry about the change information being obtained improperly.

[0113] In one implementation, the server 10 adjusts the plurality of sampling images based on the change information to generate a plurality of adjusted images as part of the adjustment feature. The server 10 then compares the plurality of adjusted images with the plurality of detection images based on the sample correspondence and the detection correspondence. If the similarity between the plurality of adjusted images and the plurality of detection images is low,

the server 10 may determine that the detected object is not the reference object and transmit the detection result to the detection device 40. If the similarity between the plurality of adjusted images and the plurality of detection images is high, the server 10 may update the original detection result, indicating a difference, to determine that the detected object is the reference object, and transmit the detection result to the detection device 40. In the implementation, the server 10 may store the plurality of detection images in the internal storage device 11 or the online storage device 30. In one implementation, the plurality of detection images and the plurality of sampling images may correspond to the reference object to be stored in the internal storage device 11 or the online storage device 30 together as the verification feature of the reference object. In another implementation, the plurality of detection images may directly replace the plurality of sampling images to be the verification feature of the reference object. In one implementation, since the server has performed the complete comparison, there is no need to worry about storing incorrect verification feature.

[0114] In a fourth implementation of the detection method 600 of the present invention, the comparison between the plurality of detection images and the verification feature is performed by the server 10, and the verification feature includes a sampling model for the corresponding positioning point of the reference object corresponding to the detected object. In one implementation, the detection device 40 transmits a request for detecting the detected object. After receiving this request, the server 10 retrieves the corresponding positioning point and the verification feature for the reference object corresponding to the detected object from the internal storage device 11 or the online storage device 30, and transmits the corresponding positioning point to the detection device 40. In the implementation, it may be unnecessary for the server 10 to transmit the sampling model to the detection device 40, so there is no need to worry about the sampling model being obtained improperly.

[0115] In one implementation, when receiving the corresponding positioning point, the detection device 40 may directly set the corresponding positioning point as the positioning point for the detected object and independently select a plurality of detection directions to obtain a plurality of detection images. In one implementation, the detection device 40 transmits the plurality of detection images, the plurality of detection directions, and the detection correspondence between the plurality of detection images and the plurality of detection directions to the server 10 for the server 10 to compare with the verification feature. In another implementation, the detection device 40 may generate the detection model based on the plurality of detection images, the plurality

of detection directions, and the detection correspondence, and transmit the detection model to the server 10 for the server 10 to compare with the verification feature.

[0116] In one implementation, the server 10 may generate a detection model based on the plurality of detection images, the plurality of detection directions, and the detection correspondence, and generate the detection result by comparing the similarity between the detection model and the sampling model. In another implementation, the server 10 may generate the detection result by comparing the similarity between the sampling model and the received detection model. In another implementation, the server 10 may derive a plurality of validation images based on the sampling model along the plurality of detection directions. Then, based on the detection correspondence between the plurality of detection images and the plurality of detection directions, the similarity between the plurality of validation images and the plurality of detection images may be compared respectively to generate the detection result.

[0117] In one implementation, if the similarity between the plurality of validation images and the plurality of detection images or the similarity between the sampling model and the detection model is high, the server 10 may determine that the detected object is the reference object and transmit the detection result to the detection device 40. If the similarity between the plurality of validation images and the plurality of detection images or the similarity between the sampling model and the detection model is low, the server 10 may determine that the detected object is not the reference object and transmit the detection result to the detection device 40. In another implementation, if the similarity between the plurality of validation images and the plurality of detection images or the similarity between the sampling model and the detection model is low, the server 10 can receive the change information of the reference object from the internal storage device 11 or the online storage device 30. In the implementation, it may be unnecessary for the server 10 to transmit the change information to the detection device 40, so there is no need to worry about the change information being obtained improperly.

[0118] In one implementation, the server 10 adjusts the sampling model based on the change information to generate an adjusted model as the adjustment feature. The detection device 40 then compares the plurality of detection images with the adjusted model based on the detection correspondence or directly compares the detection model with the adjusted model. If the similarity between the adjusted model and the plurality of detection images or the similarity between the adjusted model and the detection model is low, the server 10 may determine that the detected

object is not the reference object and transmit the detection result to the detection device 40. If the similarity between the adjusted model and the plurality of detection images or the similarity between the adjusted model and the detection model is high, the server 10 may update the original detection result, indicating a difference, to determine that the detected object is the reference object, and transmit the detection result to the detection device 40. In the implementation, the server 10 may store the detection model in the internal storage device 11 or the online storage device 30. If the server 10 only has the plurality of detection images and the detection correspondence, the server 10 may generate the detection model based on the plurality of detection images, the plurality of detection directions, and the detection correspondence for storing in the internal storage device 11 or the online storage device 30. In one implementation, the detection model and the sampling model corresponding to the reference object may be stored in the internal storage device 11 or online storage device 30 simultaneously, serving as the verification feature of the reference object together. In another implementation, the detection model may directly replace the plurality of sampling models to serve as the verification feature of the reference object. In one implementation, since the server has performed the complete comparison, there is no need to worry about storing incorrect verification feature.

[0119] FIGS. 7A and 7B illustrate schematic diagrams of capturing sampling images along different sampling directions at a positioning point of a reference object by an image capture unit 22, according to an exemplary implementation of the present invention. The image capture unit 22 in FIG. 7A is located directly above the reference point of the reference object, and the image capture unit 22 in FIG. 7B has a deflection angle compared to the image capture unit 22 in FIG. 7A.

[0120] In one implementation, the image capture unit 22 is aimed at the positioning point of the reference object and captures a first sampling image 760 within a first imaging range 710. The sampling device 20 or server 10 may then extract a first sampling area 761 from the first sampling image 760 and further divide the first sampling area 761 into a plurality of first sampling blocks 7611-7616. The sampling device 20 or server 10 may calculate values for the plurality of first sampling blocks 7611-7616. In the implementation, the first sampling area 761 corresponds to an imaging area 711 within the first imaging range 710, and the plurality of first sampling blocks 7611-7616 correspond to a plurality of imaging blocks 7111-7116.

[0121] In one implementation, the image capture unit 22 is aimed at the positioning point of the reference object with the deflection angle and captures a second sampling image 770 within a second imaging range 720. The sampling device 20 or server 10 may then extract a second sampling area 771 from the second sampling image 770 and further divide the second sampling area 771 into a plurality of second sampling blocks 7711-7716. The sampling device 20 or server 10 may calculate values for the plurality of second sampling blocks 7711-7716. In the implementation, both the first sampling area 761 and the second sampling area 771 corresponds to the same imaging area 711 for ensuring that the sampling results of the first sampling area 761 and the second sampling area 771 are generated from the same area along different direction. Thus, the sampling device 20 or server 10 may project the first sampling area 761 onto the second sampling image 770 using the deflection angle to find the second sampling area 771. Therefore, if the first sampling area 761 and the second sampling area 771 are projected onto the first imaging range 710 and the second imaging range 720, respectively, the same imaging area 711 may be obtained, and the plurality of second sampling blocks 7711-7716 may correspond to the plurality of imaging blocks 7111-7116 in the same manner.

[0122] In the implementation, the sampling device 20 or server 10 may calculate a value for each of the plurality of first sampling blocks 7611-7616 and the plurality of second sampling blocks 7711-7716. The values are used to represent the plurality of first sampling blocks 7611-7616 and the plurality of second sampling blocks 7711-7716. In one implementation, the values may be, for example, averages, modes, or medians of a plurality of pixels within each block. For example, the values for the plurality of first sampling blocks 7611-7616 may be a11, a12, a13, a14, a15, and a16, and the values for the plurality of second sampling blocks 7711-7716, they may be a21, a22, a23, a24, a25, and a26. In one implementation, the sampling device 20 or server 10 may respectively obtain more values along other sampling angles, such as a31, a32, a33, a34, a35, a36, ..., an1, an2, an3, an4, an5, and an6. Thus, the sampling device 20 or server 10 may obtain a plurality of image data training sets as follows:

$$A1 = [a11, a21, a31, \dots, an1]$$

$$A2 = [a12, a22, a32, \dots, an2]$$

$$A3 = [a13, a23, a33, \dots, an3]$$

A4= [a14, a24, a34, ..., an4]

A5= [a15, a25, a35, ..., an5]

A6= [a16, a26, a36, ..., an6]

In the implementation, the sampling device 20 or server 10 may use the large amount of sampling point data based on the plurality of image data training sets to generate the sampling model in a three-dimensional modeling method by using machine learning techniques. In one implementation, the detection device 40 or server 10 may use the same method to capture the large amount of detection point data from the plurality of detection images to establish a plurality of image data training sets, and use the large amount of detection point data to generate the detection model in the three-dimensional modeling method by using machine learning techniques.

[0123] FIGS. 8A-8E illustrate photos of different sampling images captured on the reference object, according to an exemplary implementation of the present invention. Please refer to both FIGS. 1 and 2. The image capture unit 22 captures the plurality of sampling images on the reference object, and the sampling device 20 or server 10 may generate a verification feature based on the plurality of sampling images. In one implementation, the verification feature may directly be the plurality of sampling images. In another implementation, the verification feature may be generated by analyzing and training the plurality of sample samples through machine learning techniques to generate the required verification feature. In the implementation, the verification feature may be the sampling model generated by three-dimensional modeling.

[0124] FIGS. 8F-8J illustrate photos of different detection images captured on the detected object, according to an exemplary implementation of the present invention. Please refer to both FIGS. 4 and 5. The image capture unit 42 captures the plurality of detection images on the detected object, and the detection device 40 or server 10 may compare the plurality of detection images with the verification feature.

[0125] In one implementation, if the verification feature is the plurality of sampling images, the detection device 40 or server 10 may directly compare FIGS. 8A to 8E with FIGS. 8F to 8J to identify that the detected object is significantly different from the reference object. In another implementation, if the verification feature is the sampling model, based on FIGS. 8A to 8E, the sampling model has a steeper slope without significant irregularities. Therefore, when the

detection device 40 or server 10 compares the detection images in FIGS. 8F to 8J with the sampling model, significant differences in slope may be found to verify that the detected object is different from the reference object.

[0126] Please refer to FIGS. 9A and 9B. FIGS. 9A and 9B illustrate sampling images generated by sampling, along the same sampling direction, different gemstones having the same processing manner, according to an exemplary implementation of the present invention. As shown in FIGS. 9A and 9B, even if the sampling direction and the processing method are exactly the same, the factors of the gems, such as its color or its clarity, may influence the gems to generate different sampling images. Therefore, as long as a gemstone is used as the reference object and the sampling images are captured in advance to generate the verification feature, the detection device may confirm whether the detected object is the previously sampled gemstone by using the detection method.

[0127] Please refer to FIGS. 10A-10C. FIG. 10A is a photo of different antique utensils with the same pattern. FIGS. 10B and 10C illustrate sampling images generated by sampling, along the same sampling direction, different antique utensils illustrated in FIG. 10A, according to an exemplary implementation of the present invention. As shown in FIGS. 10B and 10C, even if the antique objects have the same patterns, the slight differences in the glaze distribution of the antique objects during the firing process may influence the antique objects to generate different pattern variations. Therefore, as long as an antique object is used as the reference object and the sampling images are captured in advance to generate the verification feature, the detection device may confirm whether the detected object is the previously sampled antique object by using the detection method.

[0128] The methods described in the present invention are not limited to use with artworks (including but not limited to paintings, sculptures, etc.), gemstones (including but not limited to diamonds, sapphires, jade, etc.), or antique items (including but not limited to ceramics, porcelain, etc.). As long as the verification feature of the reference object is obtained in advance (including but not limited to color distribution, pattern details, scratches, defects, etc.), it may be used as a basis for subsequent verification of the detected object.

[0129] Thus, in an aspect of the present disclosure, a method of detecting a detected object by a detection device is provided. The method includes transmitting a request for detecting the detected object; receiving the positioning point of the detected object; obtaining a plurality of

detection images along a plurality of detection directions at the positioning point of the detected object; and wherein the detection result is generated based on a comparison between the plurality of detection images and a corresponding positioning point of a reference object corresponding to the detected object.

[0130] In an aspect of the present disclosure, a detection device for detecting a detected object. The detection device includes an image capture unit configured to capture a plurality of detection image; a motion control unit configured to enable the image capture unit to move for detecting the detected object; a processor coupled to the image capture unit and the motion control unit; a transmission unit coupled to the processor; a reception unit coupled to the processor; and a storage device coupled to the processor and storing a plurality of instructions which, when executed by the processor, causes the processor to: transmit a request for detecting the detected object by the transmission unit; receive a positioning point of the detected object by the reception unit; control the image capture unit to obtain a plurality of detection images along a plurality of detection directions at the positioning point of the detected object by the motion control unit; and obtain a detection result based on the plurality of detection images, wherein the detection result is generated based on a comparison between the plurality of detection images and a corresponding positioning point of a reference object corresponding to the detected object.

[0131] In some implementations of the detection device or its detection method of the present invention, an adjustment feature is generate based on change data of the reference object and a verification feature of the reference object when the detection result indicates that the detected object is different from the reference object; wherein: the comparison is generated by comparing the plurality of detection images with the verification feature, the change data of the reference object is received from an online storage device; and the detection result is updated based on the plurality of detection images and the adjustment feature.

[0132] In some implementations of the detection device or its detection method of the present invention, a detection feature is transmitted to the online storage device for storing the detection feature in the online storage device when the updated detection result indicates that the detected object is identical to the reference object, wherein: the detection feature is generated based on the plurality of detection images, and the detection feature stored in the online storage device corresponds to the reference object.

[0133] In some implementations of the detection device or its detection method of the present invention, the detection feature replaces the verification feature of the reference object stored in the online storage device.

[0134] In some implementations of the detection device or its detection method of the present invention, the plurality of detection images is compared with a verification feature of the reference object to generate the detection result, the verification feature is a sampling model reconstructed based on a plurality of sampling images, the plurality of sampling images is obtained along a plurality of sampling directions at the corresponding positioning point on the reference object, and the detection result is a similarity generated by comparing the detection images with the sampling model along the plurality of detection directions.

[0135] In some implementations of the detection device or its detection method of the present invention, the plurality of detection images is compared with a verification feature of the reference object to generate the detection result, the verification feature is a sampling model reconstructed based on a plurality of sampling images, the plurality of sampling images is obtained along a plurality of sampling directions at the corresponding positioning point on the reference object, a detection model is reconstructed based on the plurality of detection images along the detection directions, and the detection result is a similarity generated by comparing the detection model with the sampling model.

[0136] In some implementations of the detection device or its detection method of the present invention, the plurality of detection images is compared with a verification feature of the reference object to generate the detection result, the verification feature is a plurality of sampling images obtained along a plurality of sampling directions at the corresponding positioning point on the reference object, the detection result is a similarity generated by comparing the plurality of detection images with the plurality of sampling images, and the plurality of detection directions is the plurality of sampling directions received from an online storage device.

[0137] In an aspect of the present disclosure, a method of detecting a detected object by a server is provided. The method includes receiving a request for detecting the detected object; transmitting a positioning point of the detected object; receiving a plurality of detection images obtained along a plurality of detection directions at the positioning point of the detected object; and obtaining a detection result based on the plurality of detection images, wherein the detection result is generated based on a comparison between the plurality of detection images and a reference

object corresponding to the detected object.

[0138] In an aspect of the present disclosure, a server for detecting a detected object. The server includes a processor; a transmission unit coupled to the processor; a reception unit coupled to the processor; and a storage device coupled to the processor and storing a plurality of instructions which, when executed by the processor, causes the processor to: receive a request for detecting the detected object by the reception unit; transmit a positioning point of the detected object by the transmission unit; receive a plurality of detection images obtained along a plurality of detection directions at the positioning point of the detected object by the reception unit; and obtain a detection result based on the plurality of detection images, wherein the detection result is generated based on a comparison between the plurality of detection images and a reference object corresponding to the detected object.

[0139] In some implementations of the server or its detection method of the present invention, an adjustment feature is generated based on change data of the reference object and a verification feature of the reference object when the detection result indicates that the detected object is different from the reference object; wherein: the comparison is generated by comparing the plurality of detection images with the verification feature, the change data of the reference object is received from an online storage device; and the detection result is updated based on the plurality of detection images and the adjustment feature.

[0140] In some implementations of the server or its detection method of the present invention, a detection feature is transmitted to the online storage device for storing the detection feature in the online storage device when the updated detection result indicates that the detected object is identical to the reference object, wherein: the detection feature is generated based on the plurality of detection images, and the detection feature stored in the online storage device corresponds to the reference object.

[0141] In some implementations of the server or its detection method of the present invention, the detection feature replaces the verification feature of the reference object stored in the online storage device.

[0142] In some implementations of the server or its detection method of the present invention, the plurality of detection images is compared with a verification feature of the reference object to generate the detection result, the verification feature is a sampling model reconstructed based on a plurality of sampling images, the plurality of sampling images is obtained along a

plurality of sampling directions at the corresponding positioning point on the reference object, and the detection result is a similarity generated by comparing the detection images with the sampling model along the plurality of detection directions.

[0143] In some implementations of the server or its detection method of the present invention, the plurality of detection images is compared with a verification feature of the reference object to generate the detection result, the verification feature is a sampling model reconstructed based on a plurality of sampling images, the plurality of sampling images is obtained along a plurality of sampling directions at the corresponding positioning point on the reference object, a detection model is reconstructed based on the plurality of detection images along the detection directions, and the detection result is a similarity generated by comparing the detection model with the sampling model.

[0144] In some implementations of the server or its detection method of the present invention, the plurality of detection images is compared with a verification feature of the reference object to generate the detection result, the verification feature is a plurality of sampling images obtained along a plurality of sampling directions at the corresponding positioning point on the reference object, the detection result is a similarity generated by comparing the plurality of detection images with the plurality of sampling images, and the plurality of detection directions is the plurality of sampling directions received from an online storage device.

[0145] In an aspect of the present disclosure, a method for sampling a reference object to establish identification data by a sampling device is provided. The method includes obtaining a positioning point on a reference object; capturing a plurality of sampling images along a plurality of sampling directions at the positioning point of the reference object; generating a sampling feature for the positioning point of the reference object based on the plurality of sampling image and the plurality of sampling direction; transmitting the sampling feature for storing in an online device.

[0146] In an aspect of the present disclosure, a sampling device for sampling a reference object to establish identification data. The sampling device includes an image capture unit configured to capture a plurality of sampling image; a motion control unit configured to enable the image capture unit to move for sampling the reference object; a processor coupled to the image capture unit and the motion control unit; a transmission unit coupled to the processor; and a storage device coupled to the processor and storing a plurality of instructions which, when executed by

the processor, causes the processor to: obtain a positioning point on a reference object; move the image capture unit to be above the positioning point of the reference object by the motion control unit; capture a plurality of sampling images along a plurality of sampling directions; generate a sampling feature for the positioning point of the reference object based on the plurality of sampling image and the plurality of sampling direction; transmitting the sampling feature for storing in an online device by the transmission unit.

[0147] In some implementations of the sampling device or its sampling method of the present invention, the positioning point set for the reference object is received from a server, wherein: when the server is the online device, the server stores the positioning point, and when the server is an online storage device, the server transmits the positioning point to the online storage device.

[0148] In some implementations of the sampling device or its sampling method of the present invention, when the positioning point is set by the sampling device, the positioning is transmitted to the online device.

[0149] As mentioned above, the above implementations are provided for the purpose of illustrating the technical solutions of the present invention, rather than limiting the present invention. Although the present invention has been described in detail with reference to the above-mentioned implementations, those skilled in the art may understand that: they may still modify the technical solutions described in the above-mentioned implementations or make equivalent replacements for some technical features thereof, and such modifications or replacements do not cause the essence of the corresponding technical solutions to depart from the scope of the technical solutions of the above-mentioned implementations of the present invention.

[0150] In summary, the present invention meets the requirements for a patent application. Therefore, a patent application is filed in accordance with the law. However, it should be noted that the above descriptions are merely exemplary implementations of the present invention. Those skilled in the art will recognize that various modifications or variations made in the spirit of the present invention are all within the scope of the patent application.

CLAIMS

WHAT IS CLAIMED IS:

1. A method of detecting a detected object by a detection device, the method comprising:
transmitting a request for detecting the detected object;
receiving a positioning point of the detected object;
obtaining a plurality of detection images along a plurality of detection directions at the positioning point of the detected object; and
obtain a detection result based on the plurality of detection images, wherein the detection result is generated based on a comparison between the plurality of detection images and a corresponding positioning point of a reference object corresponding to the detected object.
2. The method according to claim 1, further comprising:
generating an adjustment feature based on change data of the reference object and a verification feature of the reference object when the detection result indicates that the detected object is different from the reference object; wherein:
the comparison is generated by comparing the plurality of detection images with the verification feature,
the change data of the reference object is received from an online storage device; and
updating the detection result based on the plurality of detection images and the adjustment feature.
3. The method according to claim 2, further comprising:
transmitting a detection feature to the online storage device for storing the detection feature in the online storage device when the updated detection result indicates that the detected object is identical to the reference object, wherein:
the detection feature is generated based on the plurality of detection images, and
the detection feature stored in the online storage device corresponds to the reference object.
4. The method according to claim 3, wherein the detection feature replaces the verification feature of the reference object stored in the online storage device.

5. The method according to claim 1, wherein:

the plurality of detection images is compared with a verification feature of the reference object to generate the detection result,

the verification feature is a sampling model reconstructed based on a plurality of sampling images,

the plurality of sampling images is obtained along a plurality of sampling directions at the corresponding positioning point on the reference object, and

the detection result is a similarity generated by comparing the detection images with the sampling model along the plurality of detection directions.

6. The method according to claim 1, wherein:

the plurality of detection images is compared with a verification feature of the reference object to generate the detection result,

the verification feature is a sampling model reconstructed based on a plurality of sampling images,

the plurality of sampling images is obtained along a plurality of sampling directions at the corresponding positioning point on the reference object,

a detection model is reconstructed based on the plurality of detection images along the detection directions, and

the detection result is a similarity generated by comparing the detection model with the sampling model.

7. The method according to claim 1, wherein:

the plurality of detection images is compared with a verification feature of the reference object to generate the detection result,

the verification feature is a plurality of sampling images obtained along a plurality of sampling directions at the corresponding positioning point on the reference object,

the detection result is a similarity generated by comparing the plurality of detection images with the plurality of sampling images, and

the plurality of detection directions is the plurality of sampling directions received from an

online storage device.

8. A detection device for detecting a detected object, the detection device comprising:
an image capture unit configured to capture a plurality of detection image;
a motion control unit configured to enable the image capture unit to move for detecting the detected object;
a processor coupled to the image capture unit and the motion control unit;
a transmission unit coupled to the processor;
a reception unit coupled to the processor; and
a storage device coupled to the processor and storing a plurality of instructions which, when executed by the processor, causes the processor to:

- transmit a request for detecting the detected object by the transmission unit;
- receive a positioning point of the detected object by the reception unit;
- control the image capture unit to obtain a plurality of detection images along a plurality of detection directions at the positioning point of the detected object by the motion control unit; and
- obtain a detection result based on the plurality of detection images, wherein the detection result is generated based on a comparison between the plurality of detection images and a corresponding positioning point of a reference object corresponding to the detected object.

9. The detection device according to claim 8, wherein the plurality of instructions, when executed by the processor, further causes the processor to:

generate an adjustment feature based on change data of the reference object and a verification feature of the reference object when the detection result indicates that the detected object is different from the reference object; wherein:

- the comparison is generated by comparing the plurality of detection images with the verification feature,
- the change data of the reference object is received from an online storage device; and
- update the detection result based on the plurality of detection images and the adjustment feature;

and

transmit a detection feature to the online storage device for storing the detection feature in the

online storage device when the updated detection result indicates that the detected object is identical to the reference object, wherein:

the detection feature is generated based on the plurality of detection images, and
the detection feature stored in the online storage device corresponds to the reference object.

10. A method of detecting a detected object by a server, the method comprising:
receiving a request for detecting the detected object;
transmitting a positioning point of the detected object;
receiving a plurality of detection images obtained along a plurality of detection directions at the positioning point of the detected object; and
obtaining a detection result based on the plurality of detection images, wherein the detection result is generated based on a comparison between the plurality of detection images and a reference object corresponding to the detected object.