

DESCRIPTION

Invention Title: 3D RECONSTRUCTION SYSTEM AND METHOD THEREOF

Technical Field

- [1] The present invention relates to 3D reconstruction technology, and in detail, relates to a 3D reconstruction system and method thereof that can be applied to a vehicle automatic assembly line requiring robots and scanning devices.

Background Art

- [2] In computer vision technology, 3D reconstruction is a process of determining the shape and/or appearance of real objects. 3D reconstruction can be based on data and/or images of objects obtained from various types of sensors.
- [3] As 3D reconstruction technologies, there are lidar-based systems, structured light-based systems, stereo vision-based systems, and the like.
- [4] A lidar-based system uses the time-of-flight principle by irradiating pulsed light to the surrounding environment that is reflected from objects and returns to the detector of the sensor, but has problems of providing only sparse depth and not providing sufficient data for measurement, and being bulky.
- [5] A structured light-based system projects a structured light pattern onto the surface of a measurement target, and then simultaneously tracks the light pattern using a camera to calculate the position of the object, but has problems that the time required to acquire data is relatively long and that it is difficult to apply to large objects at a long distance.

- [6] A stereo vision-based system acquires three-dimensional depth information from images acquired by two cameras arranged in parallel on the same baseline, but has a problem of being sensitive to objects without texture and reflective objects commonly seen in manufacturing factories.
- [7] Conventional 3D reconstruction technology has limitations in that it is not suitable for application to vehicle automatic assembly lines requiring robots and scanning devices.
- [8] Therefore, there is a demand for 3D reconstruction technology that can acquire 3D depth information more efficiently compared to conventional technology and can be applied to vehicle automatic assembly lines requiring robots and scanning devices.
- [9] This background art is technical information that the inventor possessed for derivation of the present invention or acquired during the derivation process of the present invention, and cannot necessarily be said to be known art disclosed to the general public before filing of the present invention.

Disclosure

Technical Problem

- [10] The embodiment disclosed in the present invention is devised according to the aforementioned demand, and has as a technical problem to provide a 3D reconstruction system and method thereof that can be applied to vehicle automatic assembly lines requiring robots and scanning devices.
- [11] Also, the embodiment has as a technical problem to provide a 3D reconstruction system and method thereof that can perform both scanning of vehicles and scanning of vehicle components in one work space.
- [12] Also, the embodiment has as a technical problem to provide a 3D reconstruction system and method thereof that can acquire

motion information related to robot arms/end-effectors used for estimating the pose of scan sensors of scanning devices in real-time during scanning.

[13] Also, the embodiment has as a technical problem to provide a 3D reconstruction system and method thereof that can acquire position change information about mounting points of vehicles/vehicle components.

[14] The technical problems of the present invention are not limited to the matters mentioned above, and other problems intended by the present invention can also be clearly understood by those having ordinary knowledge in the technical field to which the present invention belongs from the following description.

Technical Solution

[15] As a technical means for achieving the above-described technical problems, a 3D reconstruction system and method thereof that can be applied to vehicle automatic assembly lines requiring robots and scanning devices can be provided.

[16] A 3D reconstruction system according to an embodiment of the present invention may comprise a position checking device configured to check a position of a vehicle entering into a work space, a scanning device configured to scan interior and exterior of the vehicle entering into the work space, while scanning vehicle components located within the work space, a 3D depth information generation device configured to generate 3D depth information about the vehicle and the vehicle components based on scan images generated by the scanning device, and a controller configured to control the scanning device based on information generated by the position checking device and information generated by the scanning device.

[17] According to an embodiment, the position checking device may comprise a tag installed on the vehicle and configured to

provide position information of itself, and a position information generation unit configured to generate position and pose information about the vehicle based on the position information provided from the tag.

- [18] According to an embodiment, the controller may compare the 3D depth information generated by the 3D depth information generation device with an original CAD model, and calculate position changes of mounting points of the vehicle and the vehicle components.
- [19] According to an embodiment, the scanning device may comprise a first scanning device configured to scan exterior of the vehicle located in a first scan area set outside an entrance of the work space, a second scanning device configured to scan exterior of the vehicle located in a second scan area set adjacent to the entrance of the work space inside the work space, and a third scanning device configured to scan interior of the vehicle located in a third scan area set within the work space, while scanning vehicle components located in a fourth scan area within the work space.
- [20] According to an embodiment, the first and second scanning devices may comprise robot arms equipped with scan sensors, and the third scanning device may comprise an articulated robot arm including a scan sensor.
- [21] According to an embodiment, the scanning device may comprise a plurality of first scanning devices, and the plurality of first scanning devices may scan exterior of the vehicle within the first scan area from different positions.
- [22] According to an embodiment, the scanning device may comprise a plurality of second scanning devices, and the plurality of second scanning devices may scan exterior of the vehicle within the second scan area from different positions.
- [23] According to an embodiment, the first through third scanning devices may perform scan operations individually or perform

scan operations together according to the position of the vehicle.

- [24] According to an embodiment, a conveyor may be installed within the work space, and the third scanning device may be installed on the conveyor.
- [25] According to an embodiment, the third scanning device may generate a scan trajectory based on vehicle-related position and pose information generated by the position checking device, and scan interior of the vehicle while moving according to the scan trajectory.
- [26] According to an embodiment, the third scanning device may scan interior of the vehicle while moving according to scan trajectory information provided from the controller.
- [27] According to an embodiment, when the controller determines that the vehicle has departed from a preset scan area based on position information about the vehicle generated by the position checking device, the controller may control the third scanning device to scan the vehicle components.
- [28] According to an embodiment, the third scanning device may generate motion information about a robot arm and an end-effector while scanning interior of the vehicle.
- [29] According to an embodiment, the third scanning device may generate motion information about a robot arm and an end-effector while scanning the vehicle components.
- [30] According to an embodiment, when the controller determines that a robot arm is in an idle state based on motion information generated while the third scanning device scans interior of the vehicle, the controller may control the third scanning device to scan the vehicle components.
- [31] A 3D reconstruction method according to an embodiment of the present invention may comprise checking a position of a vehicle entering into a work space using a position checking

device, scanning interior and exterior of the vehicle entering into the work space using a scanning device, scanning vehicle components located within the work space using the scanning device, and generating 3D depth information about the vehicle and the vehicle components using a 3D depth information generation device based on scan images generated by the scanning device.

- [32] According to an embodiment, the scanning of interior and exterior of the vehicle using the scanning device may comprise scanning exterior of the vehicle located in a first scan area set outside an entrance of the work space using a first scanning device, scanning exterior of the vehicle located in a second scan area set adjacent to the entrance of the work space inside the work space using a second scanning device, and scanning interior of the vehicle located in a third scan area set within the work space using a third scanning device.
- [33] According to an embodiment, the scanning using the third scanning device may comprise generating motion information about an articulated robot arm and an end-effector included in the third scanning device while scanning interior of the vehicle.
- [34] According to an embodiment, the scanning of vehicle components using the scanning device may comprise scanning vehicle components located in a fourth scan area set within the work space using a third scanning device.
- [35] According to an embodiment, the scanning of vehicle components using the scanning device may comprise generating motion information about an articulated robot arm and an end-effector included in the third scanning device while scanning the vehicle components.
- [36] According to an embodiment, the checking using the position checking device may comprise a tag installed on the vehicle providing position information of itself, and a position

information generation unit generating position and pose information about the vehicle based on position information from the tag.

- [37] According to an embodiment, the 3D reconstruction method may further comprise a controller comparing the 3D depth information generated by the 3D depth information generation device with an original CAD model, and calculating position changes of mounting points of the vehicle and the vehicle components.
- [38] According to an embodiment, the scanning using the first scanning device may be performed using a plurality of first scanning devices that scan exterior of the vehicle within the first scan area from different positions.
- [39] According to an embodiment, the scanning using the second scanning device may be performed using a plurality of second scanning devices that scan exterior of the vehicle within the second scan area from different positions.
- [40] According to an embodiment, the scanning of interior and exterior of the vehicle using the scanning device may comprise the first through third scanning devices performing scan operations individually according to the position of the vehicle.
- [41] According to an embodiment, the scanning of interior and exterior of the vehicle using the scanning device may comprise the first through third scanning devices performing scan operations together according to the position of the vehicle.
- [42] According to an embodiment, the scanning of interior of the vehicle using the third scanning device may comprise the third scanning device generating a scan trajectory based on vehicle-related position and pose information generated by the position checking device, and scanning interior of the vehicle while moving according to the scan trajectory.

- [43] Specific details according to various examples of the present invention other than the means for solving the problems mentioned above are included in the following description and drawings.

Advantageous Effects

- [44] According to the present invention, by performing path planning for a logistics robot based on a movement area having directionality, interference or crossing between logistics robots can be prevented.

According to an embodiment of the present invention, a 3D reconstruction system and method thereof that can be applied to vehicle automatic assembly lines requiring robots and scanning devices can be provided.

- [45] According to an embodiment, since both scanning of vehicles and scanning of vehicle components are possible in one work space, time required for scanning vehicles and vehicle components can be shortened.
- [46] According to an embodiment, since motion information related to robot arms/end-effectors used for estimating poses of scan sensors of scanning devices can be acquired in real-time during scanning, time required for estimating poses of scan sensors of scanning devices can be shortened.
- [47] According to an embodiment, since position change information about mounting points of vehicles/vehicle components can be acquired, tolerance models for manufacturing errors of parts and processes can be established.
- [48] The effects of the present invention are not limited to the effects mentioned above, and other unmentioned effects can be clearly understood by those skilled in the art from the following description.
- [49] The contents of the problems to be solved, means for solving problems, and effects mentioned above do not specify

essential features of the claims, so the scope of rights of the claims is not limited by matters described in the disclosure.

Description of Drawings

- [50] The drawings attached below are for helping understanding of embodiments of the present invention, and provide embodiments together with detailed descriptions. However, technical features of the present embodiments are not limited to specific drawings, and features disclosed in each drawing can be combined with each other to constitute new embodiments.
- [51] FIG. 1 is a block diagram showing a configuration of a 3D reconstruction system according to an embodiment of the present invention.
- [52] FIG. 2 is a drawing schematically showing a work space according to an embodiment of the present invention.
- [53] FIG. 3 is a drawing showing an example in which a scanning device according to an embodiment of the present invention scans exterior of a vehicle located in a first scan area.
- [54] FIG. 4 is a drawing showing an example in which a scanning device according to an embodiment of the present invention scans exterior and interior of a vehicle located across first through third scan areas.
- [55] FIG. 5 is a drawing showing an example in which a scanning device according to an embodiment of the present invention scans vehicle components located in a fourth scan area.
- [56] FIG. 6a is a drawing of a scan sensor included in a scanning device according to an embodiment of the present invention viewed from the front.
- [57] FIG. 6b is a drawing schematically showing the scan sensor viewed from direction A of FIG. 6a.

[58] FIG. 6c is a drawing schematically showing the scan sensor viewed from direction B of FIG. 6a.

[59] FIG. 7 is a drawing for explaining a 3D reconstruction method according to an embodiment of the present invention.

Mode for Disclosure

[60] The advantages and features of the present invention, and methods for achieving them, will become clear by referring to the embodiments described in detail below together with the accompanying drawings. However, the present invention is not limited to the embodiments disclosed below but will be implemented in various different forms, and the present embodiments are provided only to make the disclosure of the present invention complete and to completely inform those having ordinary knowledge in the technical field to which the present invention belongs of the scope of the invention, and the present invention is defined only by the scope of the claims.

[61] The shapes, sizes, ratios, angles, numbers, and the like disclosed in the drawings for describing embodiments of the present invention are exemplary, so the present invention is not limited to the illustrated matters. Throughout the specification, like reference numerals refer to like components. Also, in describing the present invention, when it is determined that detailed descriptions of related known technologies may unnecessarily obscure the gist of the present invention, the detailed descriptions are omitted. When "comprises," "has," "is made of," and the like are used in the present specification, other parts can be added unless "only" is used. When a component is expressed in singular form, it includes the case of including plural unless there is a specific explicit description.

- [62] In interpreting components, it is interpreted as including an error range even if there is no separate explicit description of the error range.
- [63] In the case of description of time relationships, when temporal precedence relationships are described as "after," "subsequently," "next," "before," and the like, non-continuous cases can also be included unless "immediately" or "directly" is used.
- [64] First, second, and the like are used to describe various components, but these components are not limited by these terms. These terms are only used to distinguish one component from another component. Therefore, a first component mentioned below may also be a second component within the technical spirit of the present invention.
- [65] In describing the components of the present invention, terms such as first, second, A, B, (a), (b), and the like can be used. These terms are only for distinguishing the component from other components, and the essence, order, sequence, or number of the corresponding component is not limited by the term. When it is described that a component is "connected," "coupled," or "connected" to another component, the component can be directly connected or connected to the other component, but it should be understood that another component may be "interposed" between each component that can be indirectly connected or connected unless there is a specific explicit description.
- [66] "At least one" should be understood as including all combinations of one or more of the associated components. For example, the meaning of "at least one of first, second, and third components" can be said to include combinations of all components of two or more of the first, second, and third components as well as the first, second, or third component.

- [67] Each feature of the various embodiments of the present specification can be partially or entirely combined or combined with each other, and various interlocking and driving are technically possible, and each embodiment can be implemented independently of each other or can be implemented together in an associated relationship.
- [68] Hereinafter, embodiments of the present invention will be examined through the attached drawings and embodiments as follows. The scale of the components shown in the drawings has a different scale from reality for convenience of explanation, so it is not limited to the scale shown in the drawings.
- [69] Hereinafter, a method and system for improving image quality of a vehicle display device according to an embodiment of the present invention will be described with reference to the attached drawings.
- [70]
- [71] FIG. 1 is a block diagram showing the configuration of a 3D reconstruction system 1 according to an embodiment of the present invention, and FIG. 2 is a drawing schematically showing a work space according to an embodiment of the present invention.
- [72] For explanation, hereinafter, the 3D reconstruction system 1 according to an embodiment of the present invention will be described by taking as an example that it performs work targeting vehicles, but the 3D reconstruction system 1 according to an embodiment of the present invention is not applicable only to vehicles.
- [73] The 3D reconstruction system 1 according to an embodiment can scan vehicles and vehicle components that are work targets (here, scan targets), and perform 3D reconstruction based on scan results to generate 3D depth information about vehicles.

- [74] The 3D reconstruction system 1 can scan the exterior (or appearance or body) and interior of vehicles. According to this, the 3D reconstruction system 1 can perform scanning of vehicle exterior, scanning of vehicle interior, and scanning of vehicle components, and generate 3D depth information about vehicles based on vehicle exterior scan results, vehicle interior scan results, and vehicle components scan results.
- [75] The 3D reconstruction system 1 can perform scanning when vehicles and vehicle components are located in preset spaces (or areas). For example, the 3D reconstruction system 1 can track the position of vehicles and perform scanning of vehicles based on the position of vehicles.
- [76] According to an embodiment, the 3D reconstruction system 1 can perform scanning when vehicles are located adjacent to the outside of the entrance of a work space WC, when vehicles enter and are located inside the work space through the entrance, when vehicles are located in preset areas (e.g., interior scan work areas) within the work space, and when vehicle components containers (e.g., pallet) are located in preset areas (or spaces).
- [77]
- [78] Referring to FIGS. 1 and 2, the 3D reconstruction system 1 according to an embodiment may include a position checking device 100, a scanning device 200, a 3D depth information generation device 300, a controller 400, and a storage device 500, but the configuration of the 3D reconstruction system 1 is not limited thereto.
- [79] The position checking device 100 can check the position of a vehicle V that is a scan target, and generate information about position and pose related to the vehicle V. For example, the position checking device 100 can generate information

related to position and pose of the vehicle V and transmit it to the controller 400, and store it in the storage device 500.

- [80] The 3D reconstruction system 1 according to an embodiment performs scanning of the interior of the vehicle V, and to provide space for scanning the interior of the vehicle V, the upper portion of the vehicle V includes an open area.
- [81] The position checking device 100 can check the position and pose of the vehicle V entering into the work space WC in real-time. For example, the vehicle V can enter into the work space WC by a conveyor. According to an embodiment, the vehicle V can enter into the work space WC in a state mounted on a moving body moved by a conveyor.
- [82] According to an embodiment, the position checking device 100 may include a tag 110 installed on the vehicle V and configured to provide position information of itself, and a position information generation unit 120 installed within the work space WC and configured to generate information about position and pose of the vehicle V based on position information from the tag 110.
- [83] For example, the tag 110 can provide 3D coordinate information (X, Y, Z) as position information of itself, and the position information generation unit 120 can be installed in a fixed form within the work space WC.
- [84] For example, the position checking device 100 may include a plurality of tags 110 and a plurality of position information generation units 120, and can be implemented as an ultra-wideband (UWB) based system, an ultrasound-based system, a laser triangulation-based system, and the like.
- [85] According to an embodiment, information generated by the position checking device 100 can be used to generate optimal trajectories for scanning and collision avoidance.

- [86] The scanning device 200 can scan the vehicle V and vehicle components, and generate (or output) scan results (or scan images). Scan results can be provided to the 3D depth information generation device 300 and stored in the storage device 500.
- [87] According to an embodiment, the scanning device 200 can scan the exterior (or appearance or body) and interior of the vehicle V.
- [88] The scanning device 200 according to an embodiment can perform scanning of vehicle exterior, scanning of vehicle interior, and scanning of vehicle components, and can generate vehicle exterior scan results, vehicle interior scan results, and vehicle components scan results.
- [89] According to an embodiment, the scanning device 200 may include a first scanning device 210, a second scanning device 220, and a third scanning device 230.
- [90] FIG. 3 is a drawing showing an example in which the scanning device 200 according to an embodiment of the present invention scans the exterior of a vehicle V located in a first scan area SR1.
- [91] As shown in FIG. 3, the first scanning device 210 can scan the exterior of the vehicle V located within a first scan area SR1 set adjacent to the outside of the entrance of the work space WC.
- [92] For example, the first scanning device 210 can be installed adjacent to the entrance of the work space WC so as to face the first scan area SR1. For example, the first scanning device 210 can be installed outside or inside the entrance of the work space WC so as to face the first scan area SR1. For example, the first scanning device 210 can be fixedly installed at the entrance of the work space WC so as to scan the vehicle V from a certain direction.

- [93] Here, being fixedly installed can mean that the first scan area for the first scanning device 210 is not changed according to movement of the vehicle V during scanning.
- [94] For example, the first scan area SR1 for the first scanning device 210 can be changed before scan work according to system reset, size of the vehicle V, and the like, but once scan work is performed, the first scan area SR1 may not be changed before scan work is completed.
- [95] According to an embodiment, the first scanning device 210 may include a first-1 scanning device 211 and a first-2 scanning device 212 installed at both upper edges of the entrance of the work space WC respectively, but is not limited thereto.
- [96] For example, the first scanning device 210 may include three or more scanning devices that scan the exterior of the vehicle V within the first scan area SR1 from different positions.
- [97] As such, by scanning the exterior of the vehicle V from different directions using a plurality of first scanning devices 211, 212, more accurate scan results can be generated than when scanning the exterior of the vehicle V using one scanning device.
- [98] For example, the first-1 scanning device 211 and the first-2 scanning device 212 may include scan sensors SS1 SS. As an example, the first-1 scanning device 211 and the first-2 scanning device 212 may be in the form of robot arms on which scan sensors SS1 are installed.
- [99] According to an embodiment, the first scanning device 210 can perform scan operations in response to trigger signals from the controller 400.
- [100] FIG. 4 is a drawing showing an example in which the scanning device 200 according to an embodiment of the present invention scans the exterior and interior of a vehicle V located across first through third scan areas SR1 to SR3.

- [101] As shown in FIG. 4, the second scanning device 220 can scan the exterior of the vehicle V located within a second scan area SR2 set adjacent to the entrance inside the work space WC.
- [102] When the vehicle V is located across the first scan area SR1 and the second scan area SR1, both the first and second scanning devices 220 can perform scan operations.
- [103] For example, the second scanning device 220 can be installed adjacent to the entrance inside the work space WC so as to face the second scan area SR2. According to an embodiment, the second scanning device 220 may also be installed outside the entrance of the work space WC so as to face the second scan area SR2. For example, the second scanning device 220 can be fixedly installed so as to scan the vehicle V from a certain direction.
- [104] Here, being fixedly installed can mean that the second scan area SR2 for the second scanning device 220 is not changed according to movement of the vehicle V during scanning.
- [105] For example, the second scan area SR2 for the second scanning device 220 can be changed before scan work according to system reset, size of the vehicle V, and the like, but once scan work is performed, the second scan area SR2 may not be changed before scan work is completed.
- [106] According to an embodiment, the second scanning device 220 may include a second-1 scanning device 221 and a second-2 scanning device 222 installed at both upper edges of the entrance of the work space WC respectively, but is not limited thereto.
- [107] For example, the second scanning device 220 may include three or more scanning devices that scan the exterior of the vehicle V within the second scan area SR2 from different positions.

- [108] As such, by scanning the exterior of the vehicle V from different directions using a plurality of second scanning devices 221, 222, more accurate scan results can be generated than when scanning the exterior of the vehicle V using one scanning device.
- [109] For example, the second-1 scanning device 221 and the second-2 scanning device 222 may include scan sensors SS2 SS. As an example, the second-1 scanning device 221 and the second-2 scanning device 222 may include robot arms on which scan sensors SS2 are installed.
- [110] As such, the scanning device 200 includes the first scanning device 210 and the second scanning device 220 that scan the exterior of the vehicle V from different directions for different areas SR1, SR2, and accordingly can scan the exterior of the vehicle V from various angles. Therefore, since it is possible to generate 3D depth information about the vehicle V based on images scanned from various angles, the completeness of 3D depth information can be improved.
- [111] According to an embodiment, the second scanning device 220 can perform scan operations in response to trigger signals from the controller 400.
- [112] As shown in FIG. 4, the third scanning device 230 can scan the interior of the vehicle V located within a preset third scan area SR3 inside the work space WC. Here, the third scan area SR3 can overlap with the second scan area SR2, and when the vehicle V is located across the second and third scan areas SR2, SR3, the second scanning device 220 and the third scanning device 230 can perform scan operations together for a predetermined time.
- [113] According to an embodiment, the third scanning device 230 can be rotated in various directions and implemented in a movable form so as to scan the interior of the vehicle V in detail.

- [114] For example, the third scanning device 230 can be installed on a conveyor C provided at the upper portion within the work space WC, and can scan the interior of the vehicle V while moving corresponding to operation of the conveyor C.
- [115] For example, the third scanning device 230 and the conveyor C can operate according to control of the controller 400.
- [116] One or a plurality of third scanning devices 230 can be installed within the work space WC, and in this embodiment, it is exemplified that two third scanning devices 231, 232 are installed within the work space WC.
- [117] According to an embodiment, conveyors C1, C2 can be installed at both upper edges within the work space WC in parallel with the vehicle entry direction, and the third scanning devices 231, 232 can be installed one each on the two conveyors C1, C2.
- [118] Of course, the installation structure of the conveyor C is not limited thereto, and for example, the conveyor C may be installed in a direction crossing the vehicle entry direction, or may be installed in an X-shape.
- [119] According to this arrangement, the third scanning device 230 can move corresponding to operation of the conveyor C, and can scan the interior of the vehicle V in more detail.
- [120] According to an embodiment, the third scanning device 230 may include an articulated robot arm equipped with a scan sensor SS3 SS.
- [121] As such, as the third scanning device 230 including an articulated robot arm moves on the conveyor C, the scan sensor SS3 of the third scanning device 230 can be moved to a position where high-resolution scanning is possible.
- [122] According to an embodiment, the third scanning device 230 can scan the interior of the vehicle V while moving

according to optimal trajectories generated for scanning and collision avoidance based on information about position and pose of the vehicle V.

[123] For example, the third scanning device 230 can generate scan trajectories based on information about position and pose of the vehicle V, and scan the interior of the vehicle V based on the generated scan trajectories. For example, the third scanning device 230 can scan the interior of the vehicle V based on scan trajectory information transmitted from the controller 400.

[124] According to an embodiment, the third scanning device 230 can generate information related to movement of robot arms and end-effectors while scanning the interior of vehicles. Motion information about robot arms and end-effectors can be used to estimate the pose of the scan sensor SS3 of the third scanning device 230.

[125] The third scanning device 230 can generate (or output) vehicle interior scan information including vehicle interior scan images and motion information, and the vehicle interior scan information can be provided to the 3D depth information generation device 300 and stored in the storage device 500.

[126] According to an embodiment, the third scanning device 230 can scan vehicle components located in a preset fourth scan area SR4 within the work space WC.

[127] FIG. 5 is a drawing showing an example in which the scanning device 200 according to an embodiment of the present invention scans vehicle components VP located in a fourth scan area SR4.

[128] Referring to FIG. 5, a plurality of fourth scan areas SR4 can exist within the work space WC and can be located at edges within the work space WC. For example, the fourth scan area SR4 can be set so as not to interfere with movement of the third scanning device 230.

- [129] For example, the fourth scan area SR4 can be formed spaced a predetermined distance from the upper portion of the conveyor C. For example, the fourth scan area SR4 may also be formed on the floor within the work space WC.
- [130] According to an embodiment, vehicle components containers (e.g., pallet) P containing vehicle components VP can be disposed in the fourth scan area SR4. For example, vehicle components containers P can be disposed in the fourth scan area SR4 by separate transport systems.
- [131] For example, when transport systems dispose vehicle components containers P in the fourth scan area SR4 or retrieve vehicle components containers P located in the fourth scan area SR4, they can provide count information to the controller 400.
- [132] As an example, transport systems can up-count (+1) from current count information when disposing vehicle components containers P in the fourth scan area SR4, and down-count (-1) from current count information when retrieving vehicle components containers P from the fourth scan area SR4, and then provide updated count information to the controller 400.
- [133] The third scanning device 230 can generate information related to movement of robot arms and end-effectors while scanning vehicle components VP. Motion information about robot arms and end-effectors can be used to estimate the pose of the scan sensor SS3 of the third scanning device 230.
- [134] The third scanning device 230 can generate (or output) vehicle components scan information including vehicle components scan images and motion information, and the vehicle components scan information can be provided to the 3D depth information generation device 300 and stored in the storage device 500.
- [135] The 3D depth information generation device 300 can generate 3D depth information based on scan results (or scan

images) generated by the scanning device 200. The 3D depth information generated by the 3D depth information generation device 300 can be provided to the controller 400 and stored in the storage device 500.

[136] According to an embodiment, the 3D depth information generation device 300 can generate 3D depth information about the vehicle V based on vehicle exterior scan images and vehicle interior scan images, and generate 3D depth information about vehicle components VP based on vehicle components scan images.

[137] According to an embodiment, the 3D depth information generation device 300 can generate 3D depth information about the vehicle V considering motion information about robot arms and end-effectors related to vehicle interior scan images.

[138] According to an embodiment, the 3D depth information generation device 300 can generate 3D depth information about vehicle components VP considering motion information about robot arms and end-effectors related to vehicle components scan images.

[139] The controller 400 can receive various information generated (or output) from components within the 3D reconstruction system 1, and can perform control of components within the 3D reconstruction system 1.

[140] According to an embodiment, the controller 400 can output trigger signals for controlling the scanning device 200 based on vehicle V related position information. For example, the controller 400 can output trigger signals for controlling the first and second scanning devices 210, 220 based on vehicle V related position information.

[141] When the controller 400 determines that the vehicle V is located in the first scan area based on vehicle V related position information, it can output trigger signals to the first scanning device 210.

- [142] And when the controller 400 determines that the vehicle V is located in the second scan area based on vehicle V related position information, it can output trigger signals to the second scanning device 220.
- [143] According to an embodiment, the controller 400 can control the scanning device 200 based on vehicle V related position and pose information generated from the position checking device 100.
- [144] The controller 400 can generate scan trajectories for controlling the scanning device 200 based on vehicle V related position and pose information.
- [145] For example, the controller 400 can generate scan trajectories for controlling the third scanning device 230 based on vehicle V related position and pose information.
- [146] Also, the controller 400 can control the conveyor C while performing control of the third scanning device 230 based on scan trajectories.
- [147] That is, the controller 400 can control the third scanning device 230 and the conveyor C so that the scan sensor SS of the third scanning device 230 scans the interior of the vehicle V in detail.
- [148] According to an embodiment, when the controller 400 determines that the robot arm of the third scanning device 230 is in an idle state based on motion information of robot arms/end-effectors, when it determines that the vehicle has departed from scan areas based on vehicle V related position information, when it determines that new vehicle components containers P are located in the fourth scan area SR4 based on count information from transport systems, when there are requests from upper systems, and the like, in cases where preset conditions are satisfied, it can control the third scanning device 230 to perform scanning of vehicle components VP.

- [149] According to an embodiment, the controller 400 can compare 3D depth information with original CAD models, and calculate position changes of mounting points of the vehicle V and vehicle components VP.
- [150] For example, the controller 400 can calculate position changes of mounting points of the vehicle V/vehicle components VP using subtraction methods. As an example, the controller 400 can calculate position changes of mounting points of the vehicle V/vehicle components VP based on six DOF (Degrees of Freedom) transformation coordinates and rotation (Roll, Pitch, Yaw).
- [151] Position change information of mounting points related to the vehicle V/vehicle components VP generated by the controller 400 can be provided to upper systems and stored in the storage device 500.
- [152] Position change information about mounting points of vehicles/vehicle components can be used as manufacturing statistics and can be usefully used for automated robot teaching.
- [153] The controller 400 can control conveyors that move the vehicle V into the work space WC or move the vehicle V outside the work space WC.
- [154]
- [155] FIGS. 6a to 6c are drawings showing scan sensors SS included in the scanning device 200 according to an embodiment of the present invention, where FIG. 6a is a drawing of the scan sensor SS viewed from the front, FIG. 6b is a drawing schematically showing the scan sensor SS viewed from direction A of FIG. 6a, and FIG. 6c is a drawing schematically showing the scan sensor SS viewed from direction B of FIG. 6a.

- [156] Referring to FIGS. 6a to 6c, the scan sensor SS according to an embodiment of the present invention can irradiate light and scan objects based on reflected light that returns after the irradiated light is reflected from objects.
- [157] According to an embodiment, the scan sensor SS may be configured to include a light source 1100, a camera 1200, a first polarizer 1300, a second polarizer 1400, and a distance sensor 1500, but the configuration of the scan sensor SS is not limited thereto.
- [158] For example, the light source 1100, camera 1200, first polarizer 1300, second polarizer 1400, and distance sensor 1500 can be disposed in a main body 1600.
- [159] The light source 1100 is a component that irradiates light, and for example, can be an LED (light emitting diode) that irradiates infrared or visible light, but is not limited thereto.
- [160] A plurality of light sources 1100 can be disposed in the main body 1600, and when a plurality of light sources 1100 are disposed, the plurality of light sources 1100 can be arranged and disposed in one direction X.
- [161] The camera 1200 can be disposed adjacent to the side of the light source 1100, and can acquire images of objects by receiving light (reflected light) that returns after light irradiated from the light source 1100 is reflected from objects.
- [162] The camera 1200 forms a pair with the light source 1100 and can be disposed adjacent to the light source 1100 that forms a pair.
- [163] A plurality of cameras 1200 can be disposed in the main body 1600, and when a plurality of cameras 1200 are disposed, the plurality of cameras 1200 can be arranged and disposed in one direction X.

- [164] The light source 1100 and camera 1200 that form a pair can be arranged and disposed in another direction Y perpendicular to one direction X.
- [165] The first polarizer 1300 can be disposed spaced a predetermined distance from the front of the light source 1100, and can prevent glare caused by light irradiated from the light source 1100.
- [166] When a plurality of light sources 1100 are disposed in the main body 1600, a plurality of first polarizers 1300 are also disposed correspondingly, and the plurality of disposed first polarizers 1300 can be arranged and disposed in one direction X.
- [167] The second polarizer 1400 can be disposed spaced a predetermined distance from the front of the camera 1200, and can filter natural light that is reflected from objects and enters the camera 1200.
- [168] When a plurality of cameras 1200 are disposed in the main body 1600, a plurality of second polarizers 1400 are also disposed correspondingly, and the plurality of disposed second polarizers 1400 can be arranged and disposed in one direction X.
- [169] The distance sensor 1500 can measure distances to objects, and for example, can measure distances using TOF (Time of Flight) methods capable of measuring distances even to objects at long distances, but is not limited thereto.
- [170] For example, the distance sensor 1500 can be arranged and disposed in another direction Y with the camera 1200.
- [171]
- [172] FIG. 7 is a drawing for explaining a 3D reconstruction method according to an embodiment of the present invention.

- [173] The step-by-step operations shown in FIG. 7 can be performed by the 3D reconstruction system described with reference to FIGS. 1 to 6c.
- [174] The 3D reconstruction method according to an embodiment of the present invention will be described with reference to FIGS. 1 to 7, assuming that a vehicle V that is a work target is moving to a work space WC.
- [175] First, as the vehicle V moves to the work space WC, the position checking device 100 can check the position of the vehicle V in real-time and generate position and pose information related to the vehicle V in real-time in step S700.
- [176] Generating vehicle V related position and pose information can be continuously performed until scanning of the vehicle V is completed. For example, vehicle V related position and pose information can be provided to the controller 400 and stored in the storage device 500.
- [177] When the vehicle V is located in the first scan area SR1, the first scanning device 210 can scan the exterior of the vehicle V in step S710.
- [178] In step S710, the first scanning device 210 can perform scanning of the vehicle V in response to trigger signals from the controller 400.
- [179] Scan images (first vehicle exterior scan images) generated by scanning of the first scanning device 210 can be provided to the 3D depth information generation device 300 and stored in the storage device 500.
- [180] When the vehicle V is located in the second scan area SR2, the second scanning device 220 can scan the exterior of the vehicle V in step S720.

- [181] In step S720, the second scanning device 220 can perform scanning of the vehicle V in response to trigger signals from the controller 400.
- [182] Scan images (second vehicle exterior scan images) generated by scanning of the second scanning device 220 can be provided to the 3D depth information generation device 300 and stored in the storage device 500.
- [183] When the vehicle V is located in the third scan area SR3, the third scanning device 230 can scan the interior of the vehicle V in step S730.
- [184] In step S730, the third scanning device 230 can generate scan trajectories based on vehicle V related position and pose information generated by the position checking device 100, and scan the interior of the vehicle V according to the generated scan trajectories.
- [185] In step S730, the third scanning device 230 can scan the interior of the vehicle V according to scan trajectory information generated by the controller 400 based on vehicle V related position and pose information generated by the position checking device 100.
- [186] In step S730, the third scanning device 230 can scan the interior of the vehicle V while moving corresponding to operation of the conveyor C on which it is installed.
- [187] Scan images (vehicle interior scan images) generated by scanning of the third scanning device 230 can be provided to the 3D depth information generation device 300 and stored in the storage device 500.
- [188] In step S730, the third scanning device 230 can generate information related to movement of robot arms and end-effectors while scanning the interior of the vehicle V.
- [189] Motion information of robot arms/end-effectors generated by the third scanning device 230 can be provided to the 3D

depth information generation device 300 and stored in the storage device 500.

[190] Subsequently, the third scanning device 230 can perform scanning of vehicle components VP located in the fourth scan area SR4 in step S740.

[191] In step S740, the third scanning device 230 can perform scanning of vehicle components VP in response to instructions from the controller 400.

[192] According to an embodiment, when the controller 400 determines that the robot arm of the third scanning device 230 is in an idle state based on motion information of robot arms/end-effectors, it can output vehicle components scan instruction signals to the third scanning device 230.

[193] According to an embodiment, when the controller 400 determines that the vehicle has departed from scan areas (first through third scan areas) based on vehicle V related position information, it can output vehicle components scan instruction signals to the third scanning device 230.

[194] According to an embodiment, when the controller 400 determines that new vehicle components VP are located in the fourth scan area SR4 based on count information from transport systems that transport vehicle components VP into the work space WC, it can output vehicle components scan instruction signals to the third scanning device 230.

[195] According to an embodiment, when there are requests from upper systems, the controller 400 can output vehicle components scan instruction signals to the third scanning device 230.

[196] Scan images (vehicle components scan images) generated by scanning of the third scanning device 230 can be provided to the 3D depth information generation device 300 and stored in the storage device 500.

- [197] In step S740, the third scanning device 230 can generate information related to movement of robot arms and end-effectors while scanning vehicle components VP.
- [198] Motion information of robot arms/end-effectors generated by the third scanning device 230 can be provided to the 3D depth information generation device 300 and stored in the storage device 500.
- [199] When scanning of the vehicle V and vehicle components VP is completed according to steps S710 to S740, the 3D depth information generation device 300 can generate 3D depth information based on scan images in step S750.
- [200] In step S750, the 3D depth information generation device 300 can generate 3D depth information about the vehicle V based on vehicle exterior scan images and vehicle interior scan images, and generate 3D depth information about vehicle components VP based on vehicle components scan images.
- [201] In step S750, the 3D depth information generation device 300 can generate 3D depth information about the vehicle V considering robot arm/end-effector related motion information related to vehicle interior scan images.
- [202] In step S750, the 3D depth information generation device 300 can generate 3D depth information about vehicle components VP considering robot arm/end-effector related motion information related to vehicle components scan images.
- [203] The 3D depth information generated by the 3D depth information generation device 300 can be provided to the controller 400 and stored in the storage device 500.
- [204] Subsequently, the controller 400 can compare the 3D depth information with original CAD models and calculate position changes of mounting points of the vehicle V and vehicle components VP in step S760.

[205] In step S760, the controller 400 can calculate position changes of mounting points of the vehicle V/vehicle components VP using subtraction methods. As an example, the controller 400 can calculate position changes of mounting points of the vehicle V/vehicle components VP based on six DOF (Degrees of Freedom) transformation coordinates and rotation (Roll, Pitch, Yaw).

[206] Position change information of mounting points related to the vehicle V/vehicle components VP generated by the controller 400 can be provided to upper systems and stored in the storage device 500.

[207] According to such an embodiment of the present invention, since both scanning of the vehicle V and scanning of vehicle components VP can be performed in one work space WC, time required for scanning the vehicle V/vehicle components VP can be shortened.

[208] Also, since motion information related to robot arms/end-effectors used for estimating poses of scan sensors SS of the third scanning device 230 is acquired in real-time while scanning the interior of the vehicle V and vehicle components VP, time required for estimating poses of scan sensors SS of the third scanning device 230 can be shortened.

[209] Also, since position change information about mounting points of the vehicle V/vehicle components VP can be acquired by comparing 3D depth information generated based on scan images with original CAD models, tolerance models for manufacturing errors of parts and processes can be established.

[210]

[211] The embodiments of the present invention have been described in more detail with reference to the attached drawings above, but the present invention is not necessarily limited to these embodiments, and can be variously modified

and implemented within the scope without departing from the technical spirit of the present invention. Therefore, the embodiments disclosed in the present specification are not for limiting the technical spirit of the present invention but for explaining it, and the scope of the technical spirit of the present invention is not limited by these embodiments. Therefore, the embodiments described above should be understood as exemplary in all aspects and not restrictive. The protection scope of the present invention should be interpreted by the claims, and all technical spirits within equivalent scope should be interpreted as being included in the scope of rights of the present invention.

[212] Description of Reference Numerals

- [213]** 1: 3D reconstruction system 100: position checking device
- [214]** 110: tag 120: position information generation unit
- [215]** 200: scanning device 210: first scanning device
- [216]** 220: second scanning device 230: third scanning device
- [217]** 300: 3D depth information generation device 400: controller
- [218]** 500: storage device

CLAIMS

[Claim 1] A 3D reconstruction system comprising:

a position checking device configured to check a position of a vehicle entering into a work space;

a scanning device configured to scan interior and exterior of the vehicle entering into the work space, while scanning vehicle components located within the work space;

a 3D depth information generation device configured to generate 3D depth information about the vehicle and the vehicle components based on scan images generated by the scanning device; and

a controller configured to control the scanning device based on information generated by the position checking device and information generated by the scanning device.

[Claim 2] The 3D reconstruction system of claim 1, wherein the position checking device comprising:

a tag installed on the vehicle and configured to provide position information of itself; and

a position information generation unit configured to generate position and pose information about the vehicle based on the position information provided from the tag.

[Claim 3] The 3D reconstruction system of claim 1, wherein the controller is configured to compare the 3D depth information generated by the 3D depth information generation device with an original CAD model, and calculate position changes of mounting points of the vehicle and the vehicle components.

[Claim 4] The 3D reconstruction system of claim 1, wherein the scanning device comprising:

a first scanning device configured to scan exterior of the vehicle located in a first scan area set outside an entrance of the work space;

a second scanning device configured to scan exterior of the vehicle located in a second scan area set adjacent to the entrance of the work space inside the work space; and

a third scanning device configured to scan interior of the vehicle located in a third scan area set within the work space, while scanning the vehicle components located in a fourth scan area within the work space.

[Claim 5] The 3D reconstruction system of claim 4, wherein the first and second scanning devices comprise robot arms equipped with scan sensors, and the third scanning device comprises an articulated robot arm including a scan sensor.

[Claim 6] The 3D reconstruction system of claim 4, wherein the scanning device comprises a plurality of first scanning devices, and the plurality of first scanning devices scan the exterior of the vehicle within the first scan area from different positions.

[Claim 7] The 3D reconstruction system of claim 4, wherein the scanning device comprises a plurality of second scanning devices, and the plurality of second scanning devices scan the exterior of the vehicle within the second scan area from different positions.

[Claim 8] The 3D reconstruction system of claim 4, wherein the first through third scanning devices are configured to perform scan operations individually or perform scan operations together according to the position of the vehicle.

[Claim 9] The 3D reconstruction system of claim 4, wherein a conveyor is installed within the work space, and the third scanning device is installed on the conveyor.

[Claim 10] The 3D reconstruction system of claim 4, wherein the third scanning device is configured to generate a scan trajectory based on the vehicle-related position and pose information generated by the position checking device, and scan

the interior of the vehicle while moving according to the scan trajectory.

[Claim 11] The 3D reconstruction system of claim 4, wherein the third scanning device is configured to scan the interior of the vehicle while moving according to scan trajectory information provided from the controller.

[Claim 12] The 3D reconstruction system of claim 4, wherein when the controller determines that the vehicle has departed from a preset scan area based on the position information about the vehicle generated by the position checking device, the controller is configured to control the third scanning device to scan the vehicle components.

[Claim 13] The 3D reconstruction system of claim 5, wherein the third scanning device is configured to generate motion information about a robot arm and an end-effector while scanning the interior of the vehicle.

[Claim 14] The 3D reconstruction system of claim 5, wherein the third scanning device is configured to generate motion information about a robot arm and an end-effector while scanning the vehicle components.

[Claim 15] The 3D reconstruction system of claim 12, wherein when the controller determines that a robot arm is in an idle state based on the motion information generated while the third scanning device scans the interior of the vehicle, the controller is configured to control the third scanning device to scan the vehicle components.

[Claim 16] A 3D reconstruction method comprising:

checking a position of a vehicle entering into a work space using a position checking device;

scanning interior and exterior of the vehicle entering into the work space using a scanning device;

scanning vehicle components located within the work space using the scanning device; and

generating 3D depth information about the vehicle and the vehicle components using a 3D depth information generation device based on scan images generated by the scanning device.

[Claim 17] The 3D reconstruction method of claim 16, wherein the scanning of the interior and exterior of the vehicle using the scanning device comprises:

scanning exterior of the vehicle located in a first scan area set outside an entrance of the work space using a first scanning device;

scanning exterior of the vehicle located in a second scan area set adjacent to the entrance of the work space inside the work space using a second scanning device; and

scanning interior of the vehicle located in a third scan area set within the work space using a third scanning device.

[Claim 18] The 3D reconstruction method of claim 17, wherein the scanning using the third scanning device comprises generating motion information about an articulated robot arm and an end-effector included in the third scanning device while scanning the interior of the vehicle.

[Claim 19] The 3D reconstruction method of claim 16, wherein the scanning of the vehicle components using the scanning device comprises scanning the vehicle components located in a fourth scan area set within the work space using a third scanning device.

[Claim 20] The 3D reconstruction method of claim 19, wherein the scanning of the vehicle components using the scanning device comprises generating motion information about an articulated robot arm and an end-effector included in the third scanning device while scanning the vehicle components.

[Claim 21] The 3D reconstruction method of claim 16, further comprising comparing the 3D depth information with an original CAD

model, and calculating position changes of mounting points of the vehicle and the vehicle components.