

INSPECTION POSE DETECTION SYSTEM AND METHOD FOR RAIL-TRANSPORTATION ROLLING STOCK

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority of Chinese Patent Application No. 201910108764.5,
5 filed by February 03, 2019, entitled "INSPECTION POSE DETECTION SYSTEM AND
METHOD FOR RAIL-TRANSPORTATION ROLLING STOCK", which is incorporated herein
by reference in its entirety.

TECHNICAL FIELD

[0002] The present application relates to the field of detection of a rail-transportation rolling
10 stock, in particular to an inspection pose detection system and method for the rail-transportation
rolling stock.

BACKGROUND

[0003] With the development of transportation technology, the railway-transportation rolling
stock such as a train, a bullet train, a subway, a high-speed railway, and the like has become an
15 important transportation means for people to travel. The railway-transportation rolling stock
needs regular maintenance to ensure the safety of operation.

[0004] In the conventional technology, the maintenance of the railway-transportation rolling
stock is mainly based on manual detection which is performed by visual inspection or by means
of a hand-held detection device and has problems such as low efficiency, poor quality, and low
20 level of informatization.

[0005] With the gradual development of artificial intelligence, the inspection robot for the
railway-transportation rolling stock is gradually developed. The robot is cooperated with various
detection probes to overhaul the railway-transportation rolling stock. The railway-transportation
rolling stock needs to be accurately located in the overhaul thereof to ensure the accuracy of the
25 detection result.

[0006] However, when the vehicle to be detected is parked on the railway, due to the
influences of locating deviation in the parking, wheel wear, and others, the deviation may be
caused in the process of locating the vehicle to be detected by the inspection robot for the
rail-transportation rolling stock. Moreover, in the travelling of the inspection robot for the

rail-transportation rolling stock, the wheel wear, the errors in the navigation system, the uneven ground, and others can cause final locating deviation. Both of the above deviations affect the accuracy of the locating of the inspection robot for the rail-transportation rolling stock, thereby affecting the accuracy of the detection result.

- 5 **[0007]** Therefore, there is a need to provide a device and a method for detecting the pose in the measurement process of the inspection system for the rail-transportation rolling stock.

SUMMARY

[0008] In view of this, an inspection pose detection system and method for a rail-transportation rolling stock are provided to address the above-described problem.

- 10 **[0009]** An inspection pose detection system for a rail-transportation rolling stock, comprising:

 a reference datum disposed at a side of a railway where a vehicle to be detected is parked, along an extending direction of the railway;

- a pose detection device disposed on an inspection robot for the rail-transportation rolling stock and configured to detect distance information of the inspection robot for the
15 rail-transportation rolling stock with respect to the reference datum; and

- a processing device communicatively connected to the pose detection device and configured to calculate a pose deviation of the inspection robot for the rail-transportation rolling stock with respect to a datum coordinate on basis of the distance information of the inspection robot for the
20 rail-transportation rolling stock with respect to the reference datum.

[0010] In one of embodiments, the datum coordinate contains a first datum plane and a first direction. The reference datum comprises a datum scale. The datum scale is attached to a side of the railway proximal to the inspection robot for the rail-transportation rolling stock, along the extending direction of the railway.

- 25 **[0011]** The pose detection device comprises a first distance detecting device. The first distance detecting device is disposed at a first site on a side of the inspection robot for the rail-transportation rolling stock proximal to the datum scale and communicatively connected to the processing device. The first distance detecting device is configured to detect distance information of the first site with respect to the datum scale in the first direction to obtain a first

detection distance.

[0012] The processing device is configured to calculate a pose deviation of the first site with respect to the first datum plane in the first direction on basis of the first detection distance.

[0013] In one of embodiments, the datum coordinate contains a second datum plane and a second direction. The reference datum comprises a datum ramp. The datum ramp is disposed at an end of the datum scale distal from a ground where the rail-transportation rolling stock travels. The datum ramp is oblique with respect to the datum scale.

[0014] The pose detection device further comprises a second distance detecting device disposed at a second site on the inspection robot for the rail-transportation rolling stock. The first site and the second site are located on the same face of the inspection robot for the rail-transportation rolling stock. The second distance detecting device is communicatively connected to the processing device and configured to detect distance information of the second site with respect to the datum ramp in the first direction to obtain a second detection distance.

[0015] The processing device is configured to calculate a pose deviation of inspection robot for the rail-transportation rolling stock with respect to the second datum plane in the second direction on basis of the first detection distance and the second detection distance.

[0016] In one of embodiments, the first site and the second site are located on a straight line perpendicular to the second datum plane.

[0017] In one of embodiments, the datum coordinate contains a second direction. The pose detection device further comprises a third distance detecting device. The third distance detecting device is disposed at a third site on the inspection robot for the rail-transportation rolling stock. The third site and the first site are located on the same face of the inspection robot for the rail-transportation rolling stock and located at different positions in the extending direction of the railway. The third distance detecting device is communicatively connected to the processing device and configured to detect distance information of the third site with respect to the datum scale in the first direction to obtain a third detection distance.

[0018] The processing device is configured to calculate a rotation angle of the inspection robot for the rail-transportation rolling stock with respect to the second direction on basis of the first detection distance and the third detection distance.

[0019] In one of embodiments, the datum coordinate contains a third datum plane and a third direction.

[0020] The reference datum comprises a datum scale containing scale information. The pose detection device comprises an identification device configured to identify the scale information in the datum scale and obtain position information of inspection robot for the rail-transportation rolling stock with respect to the third datum plane in the third direction.

[0021] In one of embodiments, the datum coordinate further contains a first datum plane and a first direction.

[0022] The datum scale is a two-dimensional code band.

[0023] The identification device is an image acquisition device configured to acquire information in the two-dimensional code band to obtain image information.

[0024] The pose detection device further comprises a first processing mechanism communicatively connected to the image acquisition device and configured to obtain position information of the inspection robot for the rail-transportation rolling stock with respect to the first datum plane in the first direction and position information of the inspection robot for the rail-transportation rolling stock with respect to the third datum plane in the third direction on basis of the image information.

[0025] In one of embodiments, the datum scale is a two-dimensional code band or a bar code band.

[0026] The identification device is a code reader configured to identify information in the two-dimensional code band or the bar code band.

[0027] The pose detection device further comprises a second processing mechanism communicatively connected to the code reader and configured to obtain position information of the inspection robot for the rail-transportation rolling stock with respect to the third datum plane in the third direction on basis of the information in the two-dimensional code band or the bar code band.

[0028] In one of embodiments, the pose detection device further comprises a fourth distance detecting device disposed on a top of the inspection robot for the rail-transportation rolling stock and communicatively connected to the processing device. The fourth distance detecting device is

configured to detect distance information of a bottom of the vehicle to be detected with respect to the fourth distance detecting device to obtain a fourth detection distance.

[0029] The processing device is configured to calculate a pose deviation of the vehicle to be detected on basis of the fourth detection distance.

5 **[0030]** The inspection pose detection system for the rail-transportation rolling stock provided in embodiments of the present application detects the distance information of the inspection robot with respect to the reference datum under the cooperation between the reference datum and the pose detection device, and then completes the detection of the pose of the inspection robot by means of the processing device. In the present application, the reference
10 datum provides a stable and accurate reference datum for the distance detection, increasing the accuracy of the pose detection and thus the accuracy of the subsequent locating of the inspection robot.

[0031] An inspection pose detection method for a rail-transportation rolling stock, comprising:

15 acquiring a pose deviation of a vehicle to be detected with respect to a datum coordinate, thereby obtaining a vehicle pose deviation;

acquiring a pose deviation of an inspection robot for the rail-transportation rolling stock with respect to the datum coordinate, thereby obtaining a robot pose deviation; and

obtaining a rail-transportation rolling stock inspection pose deviation on basis of the vehicle
20 pose deviation and the robot pose deviation.

[0032] In one of embodiments, the datum coordinate contains a first datum plane and a first direction. The acquiring the pose deviation of the inspection robot for the rail-transportation rolling stock with respect to the datum coordinate thereby obtaining the robot pose deviation comprises:

25 acquiring distance information of a first site on the inspection robot for the rail-transportation rolling stock with respect to the first datum plane in the first direction, thereby obtaining first distance information;

acquiring recorded information of the first site with respect to the first datum plane in the first direction, thereby obtaining first recorded information;

calculating a pose deviation of the first site with respect to the first datum plane in the first direction on basis of the first distance information and the first recorded information.

[0033] In one of embodiments, the datum coordinate contains a second datum plane and a second direction. The acquiring the pose deviation of the inspection robot for the rail-transportation rolling stock with respect to the datum coordinate thereby obtaining the robot pose deviation further comprises:

acquiring distance information of a second site on the inspection robot for the rail-transportation rolling stock with respect to a datum ramp in the first direction, thereby obtaining second distance information, wherein the datum ramp is oblique with respect to the second datum plane, and the first site and the second site are located on the same face of the inspection robot for the rail-transportation rolling stock and on a straight line perpendicular to the second datum plane;

obtaining a pose deviation of the inspection robot for the rail-transportation rolling stock with respect to the second datum plane in the second direction on basis of the first distance information and the second distance information.

[0034] In one of embodiments, the datum coordinate contains a second direction. The acquiring the pose deviation of the inspection robot for the rail-transportation rolling stock with respect to the datum coordinate thereby obtaining the robot pose deviation further comprises:

acquiring distance information of a third site on the inspection robot for the rail-transportation rolling stock with respect to the first datum plane in the first direction, thereby obtaining third distance information, wherein the third site and the first site are located on the same face of the inspection robot for the rail-transportation rolling stock and located at different positions in the extending direction of the railway;

obtaining a rotation angle of the inspection robot for the rail-transportation rolling stock with respect to the second direction on basis of the first distance information and the third distance information.

[0035] In one of embodiments, the datum coordinate contains a second datum plane, a third datum plane, a second direction, and a third direction. The acquiring the pose deviation of the vehicle to be detected with respect to the datum coordinate thereby obtaining the vehicle pose

deviation comprises:

acquiring distance information of respective sites disposed on a bottom of the vehicle along the third direction with respect to the second datum plane in the second direction and distance information of the respective sites with respect to the third datum plane in the third direction, thereby obtaining bottom height-length curve information;

acquiring standard bottom height-length curve information of the vehicle to be detected;

obtaining a pose deviation of the vehicle to be detected with respect to the second datum plane in the second direction and a pose deviation of the vehicle to be detected with respect to the third datum plane in the third direction on basis of the bottom height-length curve information and the standard height-length curve information.

[0036] In one of embodiments, the obtaining the pose deviation of the vehicle to be detected with respect to the second datum plane in the second direction and the pose deviation of the vehicle to be detected with respect to the third datum plane in the third direction on basis of the bottom height-length curve information and the standard height-length curve information comprises:

obtaining distance information of a wheelset site on the vehicle to be detected with respect to the first datum plane in the first direction on basis of the bottom height-length curve information, thereby obtaining wheelset position information;

obtaining standard distance information of the wheelset site on the vehicle to be detected with respect to the first datum plane in the first direction on basis of the standard height-length curve information, thereby obtaining standard wheelset position information;

obtaining a pose deviation of the vehicle to be detected with respect to the second datum plane in the second direction and a pose deviation of the vehicle to be detected with respect to the third datum plane in the third direction on basis of the wheelset position information and the standard wheelset position information.

[0037] In the inspection pose detection method for the rail-transportation rolling stock provided in the embodiments of the present application, the vehicle pose deviation and the robot pose deviation are acquired, and the pose deviation in the process of inspecting the rail-transportation rolling stock is obtained on basis of the vehicle pose deviation and the robot

pose deviation. Both the pose detection of the inspection robot and the pose detection of the vehicle to be detected in the inspection for the rail-transportation rolling stock are taken into account in the method provided in the embodiments of the present application, so that the locating error is eliminated in many aspects, and the locating accuracy and thus the detection effect are improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] FIG. 1 is a schematic view of an inspection apparatus for a rail-transportation rolling stock and an inspection place according to an embodiment of the present application;

[0039] FIG. 2 is a schematic view of an inspection apparatus for a rail-transportation rolling stock and an inspection place according to an embodiment of the present application;

[0040] FIG. 3 is a schematic structural view of a lift device according to an embodiment of the present application;

[0041] FIG. 4 is a schematic structural view of the inspection apparatus for the rail-transportation rolling stock according to an embodiment of the present application;

[0042] FIG. 5 is a schematic front structural view of an inspection robot according to an embodiment of the present application;

[0043] FIG. 6 is a schematic perspective structural view of the inspection robot according to an embodiment of the present application;

[0044] FIG. 7 is a schematic structural view of an auxiliary charging terminal and an auxiliary charging device according to an embodiment of the present application;

[0045] FIG. 8 is a schematic front structural view of the inspection robot and an inspection auxiliary device according to an embodiment of the present application;

[0046] FIG. 9 is a schematic perspective view of the inspection robot and the inspection auxiliary device according to an embodiment of the present application;

[0047] FIG. 10 is a schematic structural view of the inspection apparatus for the rail-transportation rolling stock according to an embodiment of the present application;

[0048] FIG. 11 is a schematic view of a datum coordinate in the detection of the inspection pose according to an embodiment of the present application;

[0049] FIG. 12 is a block diagram of a structure of a pose detection device according to an

embodiment of the present application;

[0050] FIG. 13 is a side view of the reference datum according to an embodiment of the present application;

[0051] FIG. 14 is a schematic view showing the principle of a method for calculating a pose deviation of the inspection robot with respect to a second datum plane in a second direction on basis of a first detection distance and a second detection distance according to an embodiment of the present application (in which a side view of a vehicle body of the inspection robot and the reference datum is shown).

[0052] FIG. 15 is a schematic view showing the principle of a method for calculating a rotation angle of the inspection robot with respect to the second direction on basis of the first detection distance and a third detection distance according to an embodiment of the present application (in which a top view of the vehicle body of the inspection robot and the reference datum is shown).

[0053] FIG. 16 is a flow chart showing steps of an inspection pose detection method for the rail-transportation rolling stock according to an embodiment of the present application.

[0054] FIG. 17 is a flow chart showing steps of acquiring a pose deviation of the inspection robot with respect to the datum coordinate thereby obtaining a robot pose deviation according to an embodiment of the present application.

[0055] FIG. 18 is a flow chart showing steps of acquiring a pose deviation of the inspection robot with respect to the datum coordinate thereby obtaining a robot pose deviation according to an embodiment of the present application.

[0056] FIG. 19 is a flow chart showing steps of acquiring a pose deviation of the inspection robot with respect to the datum coordinate thereby obtaining a robot pose deviation according to an embodiment of the present application.

[0057] FIG. 20 is a flow chart showing steps of acquiring a pose deviation of the vehicle to be detected with respect to the datum coordinate thereby obtaining a vehicle pose deviation according to an embodiment of the present application.

[0058] FIG. 21 is a graph comparing vehicle bottom height-length curve information with standard height-length curve information according to an embodiment of the present application.

[0059] FIG. 22 is a schematic structural view of an inspection apparatus for a rail-transportation rolling stock according to an embodiment of the present application.

[0060] FIG. 23 is a schematic view showing the inspection place position arrangement of the inspection apparatus and system for the rail-transportation rolling stock according to an embodiment of the present application.

[0061] Description of reference numerals:

1-inspection system for rail-transportation rolling stock

2-inspection apparatus for rail-transportation rolling stock

100-railway 200-insepction platform 300-inspection pit 400-inspection robot

410-operation travelling device 411-vehicle body 412-vehicel wheel

413-receiving chamber 420-mechanical arm 430-detection device

431-quick coupling device 433-mechanical arm segment 435-tool segment

440-enaging device 450-auxiliary charging terminal 460-lift equipment

500-lift device group 501-lift device 510-lift platform plate

520-driving device 530-lift control device 540-distance sensor

600-control device 700-on-site working-condition detection device

710-stagnant liquid detection mechanism

720-to-be-detected vehicle in-position detection assembly

730-intrusion detection assembly 800-auxiliary charging device

900-inspection auxiliary device 910-auxiliary travelling device

920-tool rack 930-energy supplying device 931-electric power supplying device

932-gas supplying device 940-emergency device 941-mechanical emergency device

942-electrical emergency device 20-scheduling device

30-inspection pose detection system 310-reference datum 311-datum scale

312-datum ramp 320-pose detection device 321-a first distance detecting device

322-a second distance detecting device 323-third distance detecting device

324-identification device 325-first processing mechanism

326-second processing mechanism

327-fourth distance detecting device 330-processing device

DETAILED DESCRIPTION

[0062] In order to make the objectives, technical solutions, and advantages of the present application more apparent, an inspection pose detection system and method for a rail-transportation rolling stock of the present application is described in detail hereinafter according to various embodiments in conjunction with accompanying drawings. It should be understood that the specific embodiments described herein are only used to explain the present application, and are not intended to limit the present application.

[0063] The ordinal terms assigned to various members herein, such as “first”, “second”, etc., are only used to distinguish the modified objects, and do not involve any sequence or technical meanings. The terms “connect” or “couple”, unless otherwise specified, can cover the meanings of directly and indirectly connect (or couple). In the specification of the present application, it should be understood that the orientation or position relationships indicated by the terms “upper”, “lower”, “front”, “back”, “left”, “right”, “vertical”, “horizontal”, “top”, “bottom”, “inside”, “outside”, “clockwise”, “counterclockwise”, etc., are on the basis of orientation or position relationships shown in the accompanying drawings, which are only for the convenience of describing the present application to simplify the description, rather than for indicating or implying that the devices or elements described herein must have a specific orientation or position, or be constructed and operated in the specific orientation or position, and therefore, which should not be understood as a limitation of the present application.

[0064] In the present application, unless explicitly specified or defined otherwise, the expression that a first feature is “above” or “below” a second feature may be that the first feature is in direct contact with the second feature, or that the first feature is in indirect contact with the second feature via an intermediary medium. Moreover, the expression that the first feature is “above”, “over” or “on” the second feature may be that the first feature is directly above or obliquely above the second feature, or simply means that a horizontal height of the first feature is greater than the horizontal height of the second feature. The expression that first feature is “under”, “beneath” or “below” the second feature may be that the first feature is directly below or obliquely below the second feature, or simply means that the horizontal height of the first feature is less than the horizontal height of the second feature.

[0065] The present application provides an inspection apparatus 10 for a rail-transportation rolling stock. The inspection apparatus 10 for the rail-transportation rolling stock is used for detecting the rail-transportation rolling stock such as a bullet train, a high-speed railway, a train, and a subway. The rail-transportation rolling stock to be detected is hereinafter simply referred to as a vehicle to be detected.

[0066] Referring to FIG. 1, the inspection apparatus 10 for the rail-transportation rolling stock detects the vehicle to be detected at an inspection place. The inspection place comprises an inspection platform 200, a railway 100, and an inspection pit 300. The railway 100 is located on the inspection platform 200. The vehicle to be detected is parked on the railway 100. The inspection pit 300 is correspondingly formed in the inspection platform 200 along an extending direction of the railway 100.

[0067] The inspection platform 200 can be a plane flush with the ground, or a plane higher than or lower than the ground. The inspection platform 200 is configured to dispose a required apparatus for inspection and allow the required apparatus for inspection and the staff to travel thereon. The railway 100 comprises two parallel rails which can be disposed on the inspection platform 200 directly or via spaced support columns or other means. The number of railways 100 can be one or more. Each railway 100 is correspondingly provided with the inspection pit 300. The inspection pit 300 is a pit recessed in the inspection platform 200 and having a groove structure. The inspection pit 300 is formed between the railway 100 and extends in the extending direction of the railway 100. A size and recessed size of the inspection pit 300 can be set according to actual requirements and are not specifically limited in the present application. The vehicle to be detected is parked on the railway 100. The detection for sides of the vehicle to be detected can be performed on the inspection platform 200. The detection for a bottom of the vehicle to be detected can be performed in the inspection pit 300.

[0068] In an embodiment, the inspection apparatus 10 for the rail-transportation rolling stock comprises an inspection robot 400, a lift device group 500, and a control device 600.

[0069] The inspection robot 400 is a robot for inspecting the rail-transportation rolling stock, and is hereinafter referred to as the inspection robot 400. The inspection robot 400 is configured to detect relevant parameters of the vehicle to be detected, such as appearance, size, position and

pose, temperature, air leakage, and others. A specific structure and function of the inspection robot 400 are not limited in the present application, and can be selected according to actual requirements.

[0070] The lift device group 500 comprises at least one lift device 501 disposed at a side of the extending direction of the railway 100. The lift device 501 has a liftable structure, that is, the lift device 501 is capable of ascending and descending. Specifically, a lifting pit can be formed in the inspection platform 200 located at a side of the railway 100. The lift device 501 is disposed in the lifting pit and capable of ascending and descending in the lifting pit. The lift device 501 can be engaged with the inspection pit 300 and be flush with a surface of the inspection platform 200 by ascending and descending. The lift device 501 can be a rail lift, a crank lift, a scissor lift, a chain lift, or others. The specific selection can be made according to actual requirements and is not limited in the present application. The lift device 501 can be, but not exclusively, used to lower the inspection robot 400 or an operator into the inspection pit 300, or raise the inspection robot 400 or an operator to the inspection platform 200. The number of the lift devices 501 can be one or more. A plurality of lift devices 501 can be disposed at one side of the railway 100 and spaced along the railway 100, or can be distributed at both sides of the railway 100.

[0071] The control device 600 is communicatively connected to the inspection robot 400 to control an operation of the inspection robot 400. The control device 600 can be configured to control the inspection robot 400 to travel, perform detection, etc. The control device 600 can be, but is not limited to, a computer apparatus, a programmable logic controller (PLC), or other apparatus containing a processor. A specific structure, model, and the like of the control device 600 are not limited in the present application, as long as the function thereof can be realized.

[0072] An operation process of the inspection apparatus 10 for the rail-transportation rolling stock can comprise, but is not limited to, the following processes:

[0073] The control device 600 acquires an inspection task including the number of the vehicles to be detected, positions of the vehicles to be detected, items to be detected, etc. The control device 600 transmits the inspection task to the inspection robot 400 and issues an inspection instruction. The inspection robot 400 receives the inspection instruction, and autonomously travels to the position of the vehicle to be detected and detects the vehicle to be

detected according to the inspection task. When the item to be detected included in the inspection task lies in the sides of the vehicle to be detected, the inspection robot 400 travels on the inspection platform 200 along the extending direction of the railway 100 and performs the detection. To this end, the lift device 501 can keep flush with the surface of the inspection platform 200, so that the inspection robot 400 can travels along the inspection platform 200 without being obstructed. When the item to be detected included in the inspection task lies in the bottom of the vehicle to be detected, the inspection robot 400 needs to travel in the inspection pit 300 to perform operation. The inspection robot 400 firstly travels to the lift device 501 according to the inspection task. The lift device 501 is controlled to descend to be engaged with the inspection pit 300, and then the inspection robot 400 travels to the inspection pit 300 and performs the inspection operation. When the inspection is completed, the inspection robot 400 travels to the lift device 501, and the lift device 501 carrying the inspection robot 400 ascends, exits the inspection pit 300, and returns back to the inspection platform 200, thereby finishing the detection.

[0074] As compared to traditional technology in which a walking ladder or ramp is provided on the inspection platform 200 at one side of the railway 100 to be engage and communicated with the inspection pit 300, in the inspection apparatus 10 for the rail-transportation rolling stock according to embodiments of the present application, firstly, the lift device 501 automatically ascends and descends to be engaged with the inspection pit 300 and to be engaged with and communicated with the inspection platform 200, increasing the degree of automation, secondly, the lift device 501 can be flush with a surface of the inspection platform 200, so that the inspection platform 200 is flat without travelling obstacle, thirdly, the lift device 501 allows the inspection robot 400 to enter and exit the inspection pit 300 without manual intervention, thus realizing fully-automatic travelling, thereby increasing the intelligence of the inspection robot 400 and thus of the inspection apparatus 10 for the rail-transportation rolling stock.

[0075] Referring to FIG. 2, in an embodiment, the lift device group 500 comprises at least two lift devices 501. The at least two lift devices 501 are disposed at two sides of the railway 100, respectively. The at least two lift devices 501 can be engaged and communicated with the inspection pit 300 to form at least one passage.

[0076] Taken the lift device group 500 comprising two lift devices 501 as an example, the two lift devices 501 distributed at two sides of the railway 100. A connection line of the two lift devices 501 forms an angle with the railway 100. For example, the connection line of the two lift devices 501 is perpendicular to the railway 100. After the two lift devices 501 both ascend to the inspection pit 300, the two lift devices 501 are engaged and communicated with the inspection pit 300 to form one passage. An angle is formed between the passage and the inspection pit 300.

[0077] In an embodiment, the number of railways 100 is at least 2. The number of the inspection pits 300 is at least 2. The number of lift device groups 500 is at least 2. Each of the inspection pits 300 is corresponding to one railway 100. Each of the railways 100 is corresponding to one lift device group 500. That is to say, each of the railways 100 is provided with at least two lift devices 501 at two sides thereof. The plurality of lift devices 501 of the at least two lift device groups 500 can be engaged and communicated with at least two inspection pits 300 to form at least one passage across railways. That is to say, the lift devices 501 at two adjacent railways 100 can be in communication with each other, so that the passages for respective railways 100 can be in communication with each other to form at least one passage across railways. The cross-railway passage allows a plurality of inspection pits 300 to be in communication with each other. Therefore, when a plurality of vehicles is to be detected, the inspection robot 400 can perform cross-railway detection, so as to detect the plurality of vehicles to be detected at one time, thereby improving the detection efficiency.

[0078] The lift device 501 in the present application will be described hereinafter.

[0079] Referring to FIG. 3, in an embodiment, the lift device 501 comprises a lift platform plate 510, a driving device 520, and a lift control device 530. The driving device 520 is drivingly connected to the lift platform plate 510 to drive the lift platform plate 510 to ascend or descend. The lift control device 530 is electrically connected to the driving device 520. The lift control device 530 is configured to control the operation of the driving device 520.

[0080] The lift platform plate 510 is disposed in the lifting pit at the side of the railway 100. When the lift platform plate 510 is in an ascended state, the lift platform plate 510 is flush with a plane where the inspection platform 100 is located. When the lift platform plate 510 is in a descended state, the lift platform plate 510 is flush with and in communication with a plane

where the inspection pit 300 is located. The lift platform plate 510 can be an insulating plate, and the material of the insulating plate can be an inorganic insulating material, an organic insulating material, or a mixed insulating material, which can be specifically selected according to actual requirements and is not limited in the present application. A shape of the lift platform plate 510 can be a rectangle, a trapezoid, a polygon, or others which can be selected according to actual requirements and is not specifically limited in the present application. When the inspection place comprises a plurality of railways 100, and each railway 100 is provided with the lift device 501. The lift platform plates 510 of two adjacent lift devices 501 are in contact with each other, so that a passage across the railways 100 is formed when the lift platform plates 510 has been descended to the inspection pit 300.

[0081] The driving device 520 can be disposed in the lifting pit at the side of the railway 100. The driving device 520 is drivingly connected to the lift platform plate 510 to drive the lift platform plate 510 to ascend or descend. The specific structure, installation position, and installation manner of the driving device 520 can be selected according to actual requirements and are not specifically limited in this application. The number of driving devices 520 can also be selected according to actual requirements. The driving device 520 can be a hydraulic driving device, a pneumatic driving device, an electrical driving device, a chain driving device, or other types of driving device, as long as the lift platform plate 510 can be driven to ascend or descend. In a particular embodiment, the driving device 520 is a hydraulic driving device. The hydraulic driving device and the lift platform plate 510 together form a hydraulic scissor lifting platform. The hydraulic scissor lifting platform is a fixed type hydraulic scissor lifting platform. A table top such as a roller, a ball, a turntable, and the like of the fixed type hydraulic scissor lifting platform can be arbitrarily configured to meet actual use requirements. Therefore, in practical use, the fixed type hydraulic scissor lifting platform is more convenient for a maintainer or a user to perform adjustment according to actual requirements, and the use of the lift device 501 is facilitated.

[0082] The lift control device 530 is electrically connected to the driving device 520 to control startup, shutdown, and operation modes of the driving device 520. The lift control device 530 acquires a lifting instruction, and controls the startup, shutdown, and operation modes of the

driving device 520 in accordance with the lifting instruction, so as to control the lift platform plate 510 to ascend or descend.

[0083] The lifting instruction for the lift device 501 can be input manually, acquired from the control device 600, or acquired from the detection. In an embodiment, the lift device 501 further comprises a distance sensor 540. The distance sensor 540 is communicatively connected to the lift control device 530. The distance sensor 540 is configured to detect a distance thereof to an object in front, so as to determine whether there is a person or a stooped object on the surface of the lift platform plate 510. If the distance detected by the distance sensor 540 meets a preset distance threshold, it is indicated that a person or an object is resting on the surface of the lift platform plate 510 and is to be ascended and descended. For example, assuming that the distance detected by the distance sensor is 1 m when no person or object is resting on the surface of the lift platform plate 510, if the distance detected by the distance sensor 540 becomes smaller than 0.98m and larger than 0.05m, then it is judged by the lift control device 530 that there is a person or a stopped object on the lift platform plate, and the lift control device 530 controls the driving device 520 to start up. The distance sensor can be a capacitive proximity sensor, a laser distance sensor, or an ultrasonic sensor, which can be selected according to actual requirement and is not limited in the present application. The number of the distance sensors 540 can be one or more. In this embodiment, the lift platform plate 510 can be automatically ascended and descended under the cooperation of the distance sensor 540 and the lift control device 530. The lift device 501 provided in this embodiment is highly intelligent, thereby improving the intelligence of the inspection apparatus 10 for the rail-transportation rolling stock.

[0084] In an embodiment, the lift device 501 further comprises a lifting safety alarm device 550. The lifting safety alarm device 550 is electrically connected to the lift control device 530. The lifting alarm device 550 is configured to send an alarm when the distance sensor 540 detects abnormal data or when the lift device 501 breaks down. A specific structure of the lifting safety alarm device 550 is not limited in the present application, and can be selected according to actual requirements. By means of the lifting safety alarm device 550, the safety and intelligence of the lift device 501 can be improved, and thus the safety and intelligence of the inspection apparatus 10 for the rail-transportation rolling stock can be improved.

[0085] Referring to FIG. 4, in an embodiment, the inspection apparatus 10 for the rail-transportation rolling stock further comprises an on-site working-condition detection device 700 disposed at the inspection place. Specifically, the on-site working-condition detection device 700 can be disposed at the railway 100, the inspection platform, and/or the inspection pit 300.

5 The on-site working-condition detection device 700 is communicatively connected to the control device 600. The on-site working-condition detection device 700 is configured to detect the working condition in the inspection place. By providing the on-site working-condition detection device 700, the condition of the inspection place can be timely acquired before and during the inspection, so that the control for the inspection robot 400 can be regulated according to the condition, thus improving the reliability, safety and intelligence of the inspection.

[0086] The on-site working-condition detection device 700 may have different configurations depending upon different requirements and different conditions. The configuration of the on-site working-condition detection device 700 will be described hereafter in combination with the embodiments.

15 **[0087]** In an embodiment, the on-site working-condition detection device 700 comprises a stagnant liquid detection mechanism 710. The stagnant liquid detection mechanism 710 is disposed in the inspection pit 300. The stagnant liquid detection mechanism 710 is communicatively connected to the control device 600. The stagnant liquid detection mechanism 710 is configured to detect the stagnant liquid condition in the inspection pit 300.

20 **[0088]** The stagnant liquid detection mechanism 710 can be a liquid detection sensor. The number of the stagnant liquid detection mechanisms 710 is not limited. The specific location of the stagnant liquid detection mechanism 710 in the inspection pit 300 is also not limited, and can be set according to actual situations. For example, the stagnant liquid detection mechanism 710 can be disposed at a relatively deep position in the inspection pit 300 where the stagnant liquid
25 tends to occur. The stagnant liquid detection mechanism 710 detects the stagnant liquid condition at the current position and transmits it to the control device 600. The control device 600 determines whether or not to start the inspection operation in combination with the stagnant liquid condition. When the stagnant liquid exceeds the preset stagnant liquid threshold, the operation condition is not satisfied, and no enable signal is sent to the inspection robot 400. In

this embodiment, due to the stagnant liquid detection mechanism 710, it is prevented that the inspection operation is started when a relatively large amount of stagnant liquid is in the inspection pit 300, improving the safety and the intelligence of the inspection apparatus 10 for the rail-transportation rolling stock.

5 **[0089]** In an embodiment, the on-site working-condition detection device 700 comprises a to-be-detected vehicle in-position detection assembly 720. The to-be-detected vehicle in-position detection assembly 720 is disposed at the railway 100. The to-be-detected vehicle in-position detection assembly 720 is communicatively connected to the control device 600. The to-be-detected vehicle in-position detection assembly 720 is configured to detect whether the
10 vehicle to be detected is parked in position.

[0090] The to-be-detected vehicle in-position detection assembly 720 can be disposed at a side of the railway 100, or on the support column supporting the railway 100. A number of the to-be-detected vehicle in-position detection assemblies 720 can be one or more. The to-be-detected vehicle in-position detection assembly 720 can comprise, but is not limited to, a
15 speed sensor and a presence sensor. In a specific embodiment, a plurality of presence sensors and a plurality of speed sensors are arranged in sequence at an inner side of the rail along the extending direction of the railway 100. When the vehicle to be detected drives in along the railway 100 to be parked on the railway 100, if the presence sensor detects the presence of a wheel and a vehicle body on the railway 100, and the plurality of speed detection devices
20 arranged in sequence detect that the speed of the vehicle body gradually decreases to 0, it is suggested that the vehicle to be detected has arrived the railway 100 and stopped at the position where the sensors are located. The control device 600 determines whether or not to start the inspection operation based on the detection result of the to-be-detected vehicle in-position detection assembly 720, and controls the startup of the inspection robot 400. In this embodiment,
25 due to the to-be-detected vehicle in-position detection assembly 720, the intelligence and the automaticity of the inspection apparatus 10 for the rail-transportation rolling stock is further improved, and the accuracy of the inspection of the inspection apparatus 10 for the rail-transportation rolling stock is improved.

[0091] In an embodiment, the on-site working-condition detection device 700 comprises an

intrusion detection assembly 730 disposed at the inspection place. Specifically, the intrusion detection assembly 730 can be disposed at the railway 100, the inspection platform 200, and/or the inspection pit 300. The intrusion detection assembly 730 is communicatively connected to the control device 600. The intrusion detection assembly 730 is configured to detect whether there is an intrusion at the inspection place.

[0092] The intrusion detection assembly 730 can comprise an image acquisition device and an image processing device communicatively connected to the image acquisition device. The image acquisition device can be a webcam, a camera, or the like. The image acquisition device acquires image information of the inspection place and transmits it to the image processing device. The image processing device can be a computer apparatus or the like. The image processing device can also be a module or processing software or the like of the control apparatus 600. The image processing device processes the image information, and determines whether or not a person or an object invades the inspection place to further determine whether or not the operation condition is met and whether or not the inspection operation can be started. In this embodiment, due to the intrusion detection assembly 730, the intelligence of the inspection apparatus for the rail-transportation rolling stock is improved, and the safety of the operation of the inspection apparatus 10 for the rail-transportation rolling stock is further improved.

[0093] In an embodiment, the on-site working-condition detection device 700 can further comprise an assembly for detecting an attachment state between the inspection robot 400 and associated device, so as to ensure the security of the attachment of the inspection robot 400.

[0094] It should be understood that the control device 600 comprises a corresponding module for processing the data from the on-site working-condition detection device 700 in the above embodiment and configured to receive and process the related data transmitted from the on-site working-condition detection device 700 and to judge and determine whether the current inspection place satisfies the inspection operation condition and further determine whether an inspection enable signal is to be issued.

[0095] The inspection robot 400 performs the inspection operation according to the inspection enable signal. The inspection robot 400 will be described hereafter in combination with embodiments.

[0096] Referring to FIGS. 5 and 6, in an embodiment, the inspection robot 400 comprises an operation travelling device 410 and a mechanical arm 420. The operation travelling device 410 comprises a vehicle body 411 and vehicle wheels 412. The vehicle wheels 412 are disposed at the bottom of the vehicle body 411. The vehicle body 411 comprises a receiving chamber 413.

5 The mechanical arm 420 is disposed on the vehicle body 411. The mechanical arm 420 has a foldable structure. The mechanical arm 420 can be received in the receiving chamber 413.

[0097] The operation travelling device 410 can be specifically an automated guided vehicle (AGV), or can be other trolleys capable of automatically travelling. The vehicle body 411 can have a cubic structure, or other shaped structures. Taken the vehicle body 411 having a cubic
10 structure as an example, the vehicle body 411 has a cavity structure, and the receiving chamber 413 is surrounded by six faces. The mechanical arm 420 is mounted on the top of the vehicle body 411. Moreover, the vehicle body 411 is provided with an opening. The folded mechanical arm 420 is received in the receiving chamber 413 through the opening. The operation travelling device 410 can be communicatively connected to the control device 600. The control device 600
15 is configured to issue an operation instruction and an operation travelling task to the operation travelling device 410. The operation travelling device 410 can comprise its own control system. The travelling of the operation travelling device 410 can be controlled by its own control system or by an external control system, for example, by the control device 600.

[0098] The vehicle wheels 412 are mounted at the bottom of the vehicle body 411. A
20 number of the vehicle wheels 412 can be four. The vehicle wheel 412 can have a variety of structures, for example, the vehicle wheel 412 can have a universal wheel structure. In a particular embodiment, the vehicle wheel 412 has a two-wheel differential drive structure. The vehicle wheel 412 having the two-wheel differential drive structure can effectively reduce the volume of the inspection robot 400. Moreover, when the vehicle wheel 412 adopts the two-wheel
25 differential drive structure, the complex calculation in the traditional planning based on the midpoint of the wheel pitch is avoided, the control is simple, the trajectory tracking effect is good, and the real-time performance of the motion control is effectively improved.

[0099] The mechanical arm 420 can comprise a plurality of movable joints. In a particular embodiment, the mechanical arm 420 comprises six movable joints, and each of the movable

joints is rotatable about an axis, so that the mechanical arm 420 can be flexibly moved and positioned along the six axes. The mechanical arm 420 is in signal connection with the control device 600. The control device 600 is configured to control the action such as the movement, the folding, and the like of the mechanical arm 420.

5 **[00100]** The mechanical arm 420 in operation is located outside the vehicle body 411. When the operation of the mechanical arm 420 is finished, the control device 600 controls the mechanical arm 420 to be folded and received in the receiving chamber 413, thereby achieving effects of dust-proof, collision-proof, and volume reduction.

10 **[00101]** In this embodiment, the inspection robot 400 comprises the operation travelling device 410 and the mechanical arm 420. The vehicle body 411 of the operation travelling device 410 comprises the receiving chamber 413. The mechanical arm 420 has a foldable structure, and can be received in the receiving cavity 413, so that the size of the inspection robot 400 can be reduced, and it is dust-proof, collision-proof, and convenient for storage.

15 **[00102]** In an embodiment, the shape and size of the folded mechanical arm 420 is matched with the shape and size of the opening of the receiving chamber 413.

20 **[00103]** The vehicle body 411 can be formed with an opening along a top end and a side face thereof. The opening of the vehicle body 411 is exactly the opening of the receiving chamber 413. The shape and size of the opening are the same as the shape and size of the folded mechanical arm 420, so that the folded mechanical arm 420 can be sealed at the opening. For example, the mechanical arm 420 comprises six movable joints. After the mechanical arm 420 is folded, one segment has three movable joints. The shape, length, and width of the opening are the same as the shape, the length, and the width of the segment having the three movable joints. When the mechanical arm 420 is received in the receiving chamber 413, three movable joints are received in the receiving chamber 413, and the other three movable joints are fitted into the opening to seal the opening of the receiving chamber 413, thereby further preventing the dust. In this way, the space in the receiving chamber 413 can be saved so that other apparatuses and devices can be placed in the receiving chamber 413. This embodiment improves the practicality of the inspection robot 400.

25 **[00104]** In an embodiment, the inspection robot 400 further comprises a lift equipment

460. The lift equipment 460 is disposed in the receiving chamber 413. The lift equipment 460 is mechanically connected to the mechanical arm 420. The lift equipment 460 is configured to enable the mechanical arm 420 to ascend or descend.

[00105] The lift equipment 460 can specifically comprise an additional lifting shaft.

5 One end of the additional lifting shaft is disposed in the receiving chamber 413, and the other end of the additional lifting shaft is mechanically connected to the bottom of the mechanical arm 420. The driving manner of the lifting of the additional lifting shaft comprises, but is not limited to, hydraulic driving, cylinder driving, etc., which is not specifically limited in the present application and can be selected according to actual requirements. The driving of the lift
10 equipment 460 can be automatic or manual. In a particular embodiment, the lift equipment 460 is communicatively connected to the control device 600. The control device 600 is further configured to control the operation of the lift equipment 460. The lift equipment 460 can drive the mechanical arm 420 to ascend or descend, so that the mechanical arm 420 not only can ascend until being protruded, but also can descend until being received. Moreover, when the
15 mechanical arm 420 performs the inspection and the detection, the height of the mechanical arm 420 can be further adjusted by the lift equipment 460 to compensate the position of the end of the mechanical arm 420. Therefore, the inspection robot 400 provided in this embodiment is highly practical, besides, the flexibility of the inspection can be increased, and the accuracy of the inspection can be improved.

20 **[00106]** In an embodiment, the inspection robot 400 comprises a detection device 430. The detection device 430 is disposed at the end of the mechanical arm 420. The detection device 430 is configured to detect the vehicle to be detected. The type of the detection device 430 can be selected according to actual requirements. The detection device 430 can be electrically connected to the end of the mechanical arm 420 directly or indirectly via other devices. The mechanical arm
25 420 is moved to move the detection device 430 to a region of the inspection item of the detection device, so that the inspection item can be detected. The detection device 430 is communicatively connected to the control device 600. The control device 600 controls the detection device 430 to perform detection, and processes and analyzes the detection data acquired by the detection device 430.

[00107] In an embodiment, the detection device 430 comprises at least one of an image acquisition device, a leakage detection device, a temperature detection device, and a size detection device. It should be understood that the detection device 430 can also comprise other detection device in order to achieve other functions as desired, which is not limited in this application.

[00108] The image acquisition device may comprise a 2D image collector and/or a 3D image collector. In a specific embodiment, the 2D image collector mainly comprises an area-array camera. The area-array camera is configured to acquire a surface image of a workpiece to be detected, and can be used in the presence detection, the shape detection, the position and attitude detection, the appearance detection, the size detection, and others of the components of the vehicle to be detected. The 2D image collector can further comprise a light source. The light source is used to supply lights for the workpiece to be detected, so as to achieve a better image acquisition effect.

[00109] In a specific embodiment, the 3D image collector mainly comprises a linear laser source, a linear array camera, and a linear movement unit. In the operation of the 3D image collector, the linear laser source emits a linear laser which is projected onto a surface of the workpiece to be detected. The linear array camera acquires an image. The linear array camera continuously acquires images with the movement of the linear movement unit. By stitching multiple images, a complete image containing depth information can be obtained. The 3D image collector can be used in the bolt fastening detection, the crack detection, the wheelset tread quality detection, and the like of the vehicle to be detected.

[00110] The leakage detection device is configured to detect the air duct at the bottom and/or side of the vehicle to be detected. In a particular embodiment, the leakage detection device comprises a microphone array. The microphone array is configured to acquire and detect the sound data of the air leakage. The sound data of the air leakage acquired by the microphone array is transmitted to the control device 600. The control device 600 processes and judges the sound of the air leakage to determine whether the air leakage occurs in the air duct and further determine the specific position of the air leakage. In an embodiment, the microphone array comprises three cardioid microphones and one omnidirectional microphone. In another

embodiment, the microphone array comprises one cardioid microphone, and a plurality of the cardioid microphones is disposed on the mechanical arm 420.

[00111] In an embodiment, the control device 600 processes the sound data of the air leakage and determine whether the air leakage occurs in the air duct and further determine the specific location of the air leakage by the following method comprising steps of:

S1110, modeling the vehicle to be detected to form a model of the vehicle to be detected;

S1120, identifying a sound of air leakage in the region of the inspection item of the vehicle to be detected;

S1130, determining a source location of the sound of the air leakage; and

S1140, judging whether the air leakage occurs in the vehicle to be detected according to the source position and the model of the vehicle to be detected; and

S1150, identifying the source position in the model of the vehicle to be detected.

[00112] In the method provided by in this embodiment, by matching the model of the vehicle to be detected with the source position of the sound of the air leakage sound in the inspection item region of the vehicle to be detected, the possibility that the air leakage sound around the item to be detected is judged as the air leakage of the vehicle to be detected can be effectively avoided, and the accuracy of the detection is improved, thereby providing a reliable basis for vehicle inspection and maintenance. Meanwhile, the vehicle to be detected is modeled, and the air leakage sound is matched with the model of the vehicle to be detected, so that the vehicle airtightness detection process and the detection result are more intuitive.

[00113] The temperature detection device is configured to detect the temperature of the workpiece to be detected of the vehicle to be detected. The specific structure of the temperature detection device can be selected without limitation. In a particular embodiment, the temperature detection device comprises a thermal imager. The thermal imager is configured to detect a temperature distribution of the workpiece to be detected and form a corresponding temperature distribution image. The temperature distribution image detected by the thermal imager is transmitted to the control device 600. The control device 600 further processes the temperature distribution image. In yet another embodiment, the temperature detection device further comprises a non-contact infrared temperature sensor. The non-contact infrared temperature

sensor is configured to detect the temperature on the surface of the workpiece to be detected. Before performing the detection, the control device 600 can optionally create a 3D model of the vehicle to be detected. The positions of the item to be detected and the points to be measured are labeled on the 3D model. One item to be detected comprises a plurality of points to be measured.

5 The mechanical arm 420 clamping the non-contact infrared temperature sensor moves to the item to be detected, and allows the lights of the non-contact infrared temperature sensor to direct to the outer surface of the item to be detected. The mechanical arm 420 changes its pose to sequentially measure the temperature of the points to be measured. After the temperatures of the points to be measured are measured, the data measured by the non-contact infrared temperature
10 sensor is transmitted to the control device 600. The control device 600 can process the data by taking an intermediate value, taking an expected value, and the like, and match the data with the 3D model, thereby obtaining a model image reflecting the temperature of the item to be detected.

[00114] It should be understood the points to be measured are determined based upon the detection result of the thermal imager. The interested regions or points are set as the points to
15 be measured. A further detection is performed at the points to be measured to obtain the specific temperature in the interested regions.

[00115] The size detection device is configured to detect distance information associated with the vehicle to be detected. The size detection device can comprises a wheel rim measurement tool and/or a wheelset spacing measurement tool. The wheel rim measurement tool
20 is configured to measure the dimensions associated with the wheel rim of the vehicle to be detected. The wheelset spacing measurement tool is configured to measure the wheelset spacing of the vehicle to be detected.

[00116] In an embodiment, the wheelset spacing measurement tool comprises two laser distance sensors and one measuring rod. The distance information measured by the wheelset
25 spacing measurement tool is transmitted to the control device 600. The control device 600 processes the distance information to obtain the dimensions of the wheelset. Specific process comprises, but is not limited to, the steps of:

[00117] S2210, modeling the standard contour size of the detection item points of the wheelset to be detected to form a wheelset model.

[00118] First, a wheelset coordinate system with the symmetrical center of the wheelset as the origin is established and a 3D model describing the wheelset profile is established by the control device 600 on basis of dimension and position relationships of the cross-section of the standard wheelset flange and rim with respect to the axis. Next, the relative position of the base coordinate system of the operation travelling device 410 of the inspection robot 400 with respect to the wheelset center coordinate system and the relative position of sampling points on the end of the mechanical arm, when the inspection robot performs the measurement and sampling, are determined, and a 3D model database of detection points is established.

[00119] S2220, accurately calibrating the position of the wheelset to be detected and the position of the inspection robot 400.

[00120] Before the detection of the inspection robot 400, the locating is performed by means of the wheel axis visual feature or wheelset auxiliary locating mark points to acquire actual pose information of the inspection robot 400 in the wheelset coordinate system. The inspection robot 400 compensates the actual pose by adjusting the pose of the end of the mechanical arm 420, to allow the actual pose to be consistent the 3D model database at the measurement points.

[00121] S2230, the inspection robot 400 performing sampling and measurement.

[00122] The laser distance-measuring sensor is clamped at the end of the inspection robot 400, samples the points to measure the distance dimension of the profile of the detection item wheelset, and transmits the data to the control device.

[00123] S2240, calculating the dimension value of the target.

[00124] The inspection robot 400 draws the actual profile of the detection item wheelset on basis of the sampled dimension points of the profile in combination with the positions of the running track points of the inspection robot 400, and compares the detected actual profile with the standard profile to obtain the actual dimension value of the detection item wheelset.

[00125] Each of the detection devices 430 as described above can be separately disposed at the end of the mechanical arm 420, or a combination of a plurality of detection devices 430 can be disposed at the end of the mechanical arm 420. In an embodiment, the 2D

image collector, the air leakage detection device, and the temperature detection device are disposed at the end of the mechanical arm 420 in combination to simultaneously detect a plurality of items such as the presence of the vehicle to be detected, the shape, the pose, the air leakage, and the temperature.

5 **[00126]** In yet another embodiment, the 3D image collector, the air leakage detection device, and the temperature detection device are disposed at the end of the mechanical arm 420 in combination to simultaneously detect a plurality of items such as the fastness of the bolt of the vehicle to be detected, the crack, the wheelset tread quality, the air leakage, and the temperature.

10 **[00127]** In the above embodiments, by providing the detection device 430 at the end of the mechanical arm 420, various items of the vehicle to be detected are inspected, so that the inspection robot 400 has a plurality of inspection functions, increasing the comprehensiveness of the functions and intelligence of the inspection robot 400.

15 **[00128]** In an embodiment, the inspection robot 400 further comprises an engaging device 440. The engaging device 440 is disposed on the vehicle body 411. The engaging device 440 is configured to be engaged with other devices. The engaging device 440 is configured to be mechanically or electrically engaged with other devices. The configuration of the engaging device 440 can be varied depending on different requirements. Taken the engaging device 440 to be mechanically engaged with a rescue equipment or an inspection auxiliary device as an example, the engaging device 440 can be disposed at a leading end and/or a trailing end the vehicle body 411. The engaging device 440 can have an annular or square engaging port or the like, so that the rescue equipment or the inspection auxiliary device can be engaged therewith to pull or drag the inspection robot 400. In this embodiment, by means of the engaging device 440, the function of the inspection robot 400 is further improved, and the practicality of the inspection apparatus 10 for the rail-transportation rolling stock is improved.

25 **[00129]** In an embodiment, the inspection robot 400 further comprises a quick-coupling device 431. The quick-coupling device 431 is connected between the end of the mechanical arm 420 and the detection device 430. That is, the detection device 430 is connected to the end of the mechanical arm 420 by means of the quick-coupling device 431. The detection device 430 can be electrically and mechanically connected to the mechanical arm 420 by means of the

quick-coupling device 431.

[00130] Referring to FIG. 7, in an embodiment, the inspection robot 400 further comprises an auxiliary charging terminal 450. The auxiliary charging terminal 450 is provided on the vehicle body 411. The auxiliary charging terminal 450 can be a charging plug or socket, a charging brush, a charging conductor rail, or any device capable of forming a conductive circuit. The auxiliary charging terminal 450 is connected to a power supply apparatus of the inspection robot 400, and is configured to be connected to an external charging device to charge the inspection robot 400. In this embodiment, by means of the auxiliary charging terminal 450, the electric power can be timely supplied to the inspection robot 400, thereby improving the inspection capability of the inspection robot 400.

[00131] In an embodiment, the inspection apparatus 10 for the rail-transportation rolling stock further comprises an auxiliary charging device 800. The auxiliary charging device 800 is disposed at the railway 100. The auxiliary charging device 100 is matched with the auxiliary charging terminal 450 for supplying power to the auxiliary charging terminal 450 and in turn charging the inspection robot 400. The specific configuration, structure, and the like of the auxiliary charging device 800 are not limited, as long as the auxiliary charging device 800 can cooperate with the auxiliary charging terminal to realize the charging. Two embodiments of the auxiliary charging device 800 and the auxiliary charging terminal 450 are provided below.

[00132] In an embodiment, the auxiliary charging terminal 450 is a conductive brush. The auxiliary charging device 800 is a conductive rail. The conductive brush is of a brush structure. The conductive brush can be disposed at one side of the vehicle body 411 via an extendable cantilever structure. The extendable cantilever can be a corner contact structure. A spring or other elastic devices can be disposed between the extendable cantilever and the vehicle body 411 to improve the mobility and flexibility of the conductive brush, and to facilitate the retraction of the conductive brush to the vehicle body 411 when not in use, thereby saving space. A number of the conductive brushes may be one disposed at one side of the vehicle body 411 or two disposed at both sides of the vehicle body 411, respectively. Of course, the number of the conductive brushes can be two or more, and each of the conductive brushes can be disposed at a position required by the vehicle body 411.

[00133] The conductive rail is disposed adjacent to a side of the railway 100 where the inspection robot 400 travels on. The conductive rail is in the shape of a long strip. The conductive rail can be powered with a ground-to-ground safety voltage. The conductive rail can adopt a PVC profile, an aluminum profile, a copper strip composite structure, or the like. A number of conductive rails can be plural. A plurality of conductive rails are spaced along the railway 100. When the conductive brushes are disposed on both sides of the vehicle body 411, the plurality of conductive rails can be disposed at the inner sides of the two rails of the railway 100, respectively. The plurality of conductive rails can be controlled to be turned on and off separately.

[00134] In the entire operation of the inspection robot 400, when the inspection robot 400 stops at the target position and performs the detection, the mechanical arm 420 has a heavy workload for a long work time, therefore, the power consumption is maximum in the detection process. Consequently, the inspection robot 400 often needs to be charged in the detection process. In this embodiment, when the inspection robot 400 travels and stops at the target position to perform the detection, the conductive brush of the inspection robot 400 is extended by means of the extendable cantilever to be in contact with the conductive rail. When the conductive rail is powered, the inspection robot 400 can be charged via the conductive rail. When the detection task of the inspection robot 400 is to be completed and the inspection robot 400 is to move towards next detection position, the conductive rail is de-energized, the charging of the conductive brush is stopped, and the conductive brush is retracted by means of the extendable cantilever. Then the inspection robot 400 travels to the next detection position.

[00135] In another embodiment, the auxiliary charging terminal 450 is a conductive brush and the auxiliary charging device 800 is a conductive brush. The arrangement of the conductive brush and the conductive rail is just opposite to that of the previous embodiment. The implementation methods, principles, and arrangements are similar. Details will not described again herein.

[00136] In the above two embodiments, the auxiliary charging of the inspection robot 400 is realized by the cooperation of the conductive brush and the conductive rail, so that the working electric quantity of the inspection robot 400 is ensured, and the reliability and stability

of the inspection apparatus 10 for the rail-transportation rolling stock are improved. Moreover, the conductive rail is in the shape of a long strip, and thus when the inspection robot 400 or the vehicle to be detected stops with a position deviation, it is still possible to cooperate with the conductive brush to complete charging of the inspection auxiliary device 900, thereby reducing a charging error.

[00137] Referring to FIGS. 8 and 9, in an embodiment, the quick-coupling device 431 comprises two parts: a mechanical arm segment 433 and a tool segment 435. The mechanical arm segment 433 is corresponding to and matched with the tool segment 435. The mechanical arm segment 433 is electrically and mechanically connected to the mechanical arm 420. The tool segment 435 is electrically and mechanically connected to the detection device 430. The electrical and mechanical connection between the mechanical arm segment 433 and the tool segment 435 and thus between the mechanical arm 420 and the detection device 430 can be achieved in a plug-in connection manner.

[00138] In the above two embodiments, the detection device 430 is electrically and mechanically connected to the end of the mechanical arm 420 by means of the quick-coupling device 431, which is simple, convenient, and versatile.

[00139] In an embodiment, the inspection apparatus 10 for the rail-transportation rolling stock further comprises an inspection auxiliary device for the rail-transportation rolling stock which is hereinafter referred to as the inspection auxiliary device 900. The inspection auxiliary device 900 is configured to assist the inspection robot 400 to complete the replacement of the detection device 430, and the functions of energy supply, maintenance, and emergency rescue. The inspection auxiliary device 900 will be further described hereafter in combination with the embodiments.

[00140] Referring to FIG. 9, in an embodiment, the inspection auxiliary device 900 comprises an auxiliary travelling device 910 and a tool rack 920. The tool rack 920 is disposed on the auxiliary travelling device 910. The tool rack 920 is configured to place the detection device to be replaced thereon.

[00141] In the inspection process of the inspection robot 400 of the inspection apparatus 10 for the rail-transportation rolling stock, the detection device 430 disposed at the end

of the mechanical arm 420 sometimes needs to be replaced in order to complete detection items. For convenience of explanation, the alternative detection device is named as the replacing detection device. The replaced detection device is named as the original detection device.

[00142] The auxiliary travelling device 910 is configured to travel to carry the devices thereon to move. The configuration, implementation principle, and control method of the auxiliary travelling device 910 are similar to those of the operation travelling device 410, and will not be described again herein.

[00143] The tool rack 920 can be disposed on top of the vehicle body of the auxiliary travelling device 910. The specific structure of the tool rack 920 is not limited and can be designed according to the structure, the size, and others of the tool to be placed thereon. The replacing detection device is placed on the tool rack 920. When the original detection device needs to be replaced, the auxiliary travelling device 910 is controlled to travel to the inspection robot 400, and then the original detection device is replaced with the replacing detection device placed on the tool rack 920. The replacement method can be automatic or manual, and is not limited herein.

[00144] In this embodiment, the inspection apparatus 10 for the rail-transportation rolling stock comprises the inspection auxiliary device 900. The inspection auxiliary device 900 is provided with the tool rack 920, so that the replacing detection device can be transported to the inspection robot 400, thereby realizing the replacement of the detection device 430. The inspection auxiliary device 900 provided in this embodiment improves the comprehensiveness of the function of the inspection apparatus 10 for the rail-transportation rolling stock, and improves the intelligence thereof.

[00145] In an embodiment, the tool rack 920 has a shape and size which is matched with the shape and size of the replacing detection device. That is, the tool rack 920 mimics the shape design of the replacing detection device, so that the replacing detection device can be more securely and more fitly placed on the tool rack 920.

[00146] In an embodiment, the replacing detection device is disposed on the tool rack 920 of the inspection auxiliary device 900. One end of the replacing detection device is connected with the tool segment 435. The replacing detection device is electrically and

mechanically connected to the tool segment 435. The tool segment 435 is configured to be connected to the mechanical arm segment 433, so that the replacing detection device is connected to the end of the mechanical arm 420. In the replacement of the detection device 430, the original detection device 430 and the tool segment 435 connected thereto are removed, the tool segment 435 of the replacing detection device is connected to the mechanical arm segment 433 at the end of the mechanical arm 420, so that the replacing detection device is electrically and mechanically connected to the mechanical arm 420. In this embodiment, by providing the tool segment 435 on the replacing detection device, the quick replacement of the detection device is achieved, thereby improving the working efficiency.

[00147] In an embodiment, the inspection auxiliary device 900 further comprises an energy supply device 930. The energy supply device 930 is disposed on the auxiliary travelling device. The energy supply device is configured to supply energy to the inspection apparatus for the rail-transportation rolling stock. The inspection apparatus for the rail-transportation rolling stock comprises, but is not limited to, the inspection robot 400. The energy supply device 930 can comprise an electric power supply device 931, or a gas supply device 932, or any other device for supplying energy required for the inspection robot 400. In this example, the energy supply device 930 can supply and replenish energy to the inspection robot 400, thereby ensuring the energy supply of the inspection robot 400, and improving the stability and reliability of the operation of the inspection robot 400 and thus of the inspection apparatus 10 for the rail-transportation rolling stock.

[00148] In an embodiment, the energy supply device 930 comprises an electric power supply device 931. The electric power supply device 931 comprises an electric power source and a source interface. The electric power source is provided on the auxiliary travelling device 910. The source interface is electrically connected to the electric power source to electrically connect the electric power source and the inspection robot 400. That is, the electric power source supplies the electric power to the inspection robot 400 through the source interface. The specific structure, installation mode, and the like of the electric power source and the source interface are not limited as long as their functions can be realized. When the electric power of the inspection robot 400 is exhausted, the inspection auxiliary device 900 carrying the power supply device travels to

the inspection robot 400 to supply the electric power to the inspection robot 400. In this embodiment, the function of supplying power to the inspection robot 400 is realized by the electric power source and the source interface, so that the function of the inspection auxiliary device 900 is improved, thereby improving the practicality.

5 **[00149]** In an embodiment, the inspection auxiliary device 900 further comprises an emergency device 940. The emergency device 940 is disposed on the auxiliary travelling device 910. The emergency device is configured to provide emergency rescue to the inspection robot 400.

10 **[00150]** The inspection robot 400 may encounter a sudden fault during the inspection operation, causing emergency circumstances where the operation travelling device 410 is unable to travel, the mechanical arm 420 cannot be operated, the mechanical arm 420 is stuck, etc. In this case, the inspection auxiliary device 900 carrying the emergency device 940 is controlled to travel to the vicinity of the inspection robot 400 and provide emergency rescue to the inspection robot 400. In this embodiment, the function of the inspection auxiliary device 900 is further
15 improved by the emergency device 940, thereby ensuring safety and stability of the inspection robot 400.

20 **[00151]** In an embodiment, the emergency device 940 can comprise a mechanical emergency device 941. The mechanical emergency device 941 is disposed on the auxiliary travelling device 910. The mechanical emergency device 941 is configured to be mechanically engaged with the inspection robot 400. A specific structure of the mechanical emergency device 941 is not limited, as long as its function can be realized. In an embodiment, the structure of the mechanical emergency device 941 is matched with the structure of the engaging device 440, so as to be mechanically engaged with the inspection robot 400, so that the inspection robot 400 can be dragged and moved by the inspection auxiliary device 900. The inspection auxiliary device
25 900 provided in this embodiment can drag the inspection robot 400 away from the inspection place when the inspection robot 400 breaks down, and thus improves the automation level and intelligence of the inspection apparatus 10 for the rail-transportation rolling stock.

30 **[00152]** In an embodiment, the emergency device 940 further comprises an electrical emergency device 942. The electrical emergency device 942 is disposed on the auxiliary

travelling device 910. Specifically, the electrical emergency device 942 can be disposed on the mechanical emergency device 941. The electrical emergency device 942 is configured to be electrically engaged with the inspection robot 400 to perform an electrical emergency rescue for the inspection robot 400. Further, the emergency device 940 can also comprise a
5 communicational emergency device. The communicational emergency device is configured to perform a communicational emergency rescue for the inspection robot 400.

[00153] In an embodiment, the inspection auxiliary device 900 further comprises a maintenance device (not shown). The maintenance device is disposed on the auxiliary travelling device 910. The maintenance device is configured to check fault information of the inspection
10 robot 400 and perform repairs. For example, when the mechanical arm 420 of the inspection robot 400 is unable to move, the maintenance device can be connected to the electrical communication control line of the inspection robot 400, debug the inspection robot 400, and further repair the inspection robot 400 according to the debugging result. In this embodiment, the function of the inspection auxiliary device 900 is further improved by the maintenance device,
15 improving the safety and reliability of the inspection robot 400.

[00154] In the inspection operation of the inspection apparatus 10 for the rail-transportation rolling stock as described above, the inspection robot 400 needs to locate the vehicle to be detected in order to achieve accurate detection and measurement. However, the locating deviation may be caused due to various errors in determining the position of the vehicle
20 to be detected by the inspection robot 400. Firstly, the inspection robot 400 may not be able to accurately arrive at the predetermined position due to its own locating error caused by errors in its own navigation system, unevenness of the travelling ground, wheel slip, wheel wear, and others. Secondly, the deviation of the actual parking position of the vehicle to be detected from the predetermined parking position may be caused due to wheel wear, navigation error, and
25 others of the vehicle to be detected. The errors in both aspects result in the deviation of the relative position between the inspection robot 400 and the vehicle to be detected, which finally causes the inaccurate detection in the inspection operation of the inspection robot 400 performed on the vehicle to be detected. There is a need to detect an error in the process of inspecting the rail-transportation rolling stock, so that a location calibration can be further performed according

to the error.

[00155] Referring to FIG. 10, in an embodiment, the inspection apparatus 10 for the rail-transportation rolling stock further comprises an inspection pose detection system for the rail-transportation rolling stock, which is hereinafter referred to as the inspection pose detection system 30. The inspection pose detection system 30 will be further described hereafter in combination with embodiments.

[00156] Referring to FIG. 10, in an embodiment, the inspection pose detection system 30 comprises a reference datum 310, a pose detection device 320, and a processing device 330.

[00157] The reference datum 310 is disposed at one side of a railway 100, where the vehicle to be detected is parked, along the extending direction of the railway 100. A length of the reference datum 310 is matched with a length of a working surface on which the inspection robot 400 travels. The reference datum 310 can be a reference object made of a profile. The reference datum 310 contains information of an absolute position in the extending direction of the railway 100, information of a datum plane, and others. The reference datum 310 can present the information of the absolute position and the information of the datum plane and other information as scale information, image information, or other forms.

[00158] The pose detection device 320 is configured to detect information of a distance of the inspection robot 400 with respect to the reference datum 310. The pose detection device 320 is disposed on the inspection robot 400 and thus can be moved with the inspection robot 400 to detect in real time the information of the distance of the inspection robot 400 with respect to the reference datum 310 to further obtain a pose deviation of the inspection robot 400. The pose detection device 320 can be disposed at different sites on the vehicle body 411 of the inspection robot 400 according to different parameters required to be detected. The pose detection device 320 comprises, but is not limited to, a distance detecting device.

[00159] The processing device 330 is communicatively connected to the pose detection device 320. The information of the distance of the inspection robot 400 with respect to the reference datum 310 detected by the pose detection device 320 is transmitted to the processing device 330. The processing device 330 calculates the pose deviation of the inspection robot 400 with respect to a datum coordinate according to the information of the distance of the inspection

robot 400 with respect to the reference datum 310.

[00160] Referring to FIG. 11, the datum coordinate can contain one or more datum planes and datum directions in a coordinate system of a first coordinate axis, a second coordinate axis, and a third coordinate axis. In an embodiment, the first coordinate axis is the y-axis shown in FIG. 11, i.e., an axis perpendicular to the travelling direction of the inspection robot 400 and parallel or substantially parallel to the ground on which the inspection robot 400 travels. The second coordinate axis is the z-axis shown in FIG. 11, i.e., an axis perpendicular to the travelling direction of the inspection robot 400 and to the second coordinate axis. The third coordinate axis is the x-axis shown in FIG. 11, i.e., an axis parallel to the travelling direction of the inspection robot 400.

[00161] In an embodiment, the datum coordinate used to calculate the pose deviation contains a first datum plane, a second datum plane, a third datum plane, a first direction, a second direction, and a third direction. The first datum plane is a plane parallel to a plane formed by the x-axis and the z-axis. The first direction is a direction parallel to the y-axis. The specific position of the first datum plane along the y-axis can be set according to actual requirements. For example, the first datum plane can be a plane with respect to which the inspection pit 300 is laterally symmetrical, i.e., a plane which is parallel to the plane formed by the x-axis and the z-axis and where a center of the inspection pit 300 in a direction perpendicular to the extending direction of the railway 100 is located at. The second datum plane is a plane parallel to a plane formed by the x-axis and the y-axis. The second direction is a direction parallel to the z-axis. The specific position of the second datum plane along the z-axis can be set according to actual requirements. For example, if the ground on which the inspection robot 400 travels is parallel to a plane formed by the x-axis and the y-axis, then the second datum plane can be the ground on which the inspection robot 400 travels. The third datum plane is a plane parallel to a plane formed by the y-axis and the z-axis. The third direction is a direction parallel to the x-axis. The specific position of the third datum plane along the x-axis can be set according to actual requirements. For example, the third datum plane can be located at a position from which the inspection pit 300 starts to extend in the extending direction of the railway 100.

[00162] The pose deviation of the inspection robot 400 with respect to the datum

coordinate can comprise, but is not limited to, a deviation of the inspection robot 400 in the first direction with respect to the first datum plane, a deviation of the inspection robot 400 in the second direction with respect to the second datum plane, and a deviation of the inspection robot 400 in the third direction with respect to the third datum plane, as well as a rotation angle of the inspection robot 400 with respect to the first direction, a rotation angle of the inspection robot 400 with respect to the second direction, and a rotation angle of the inspection robot 400 with respect to the third direction.

[00163] In this embodiment, the information of the distance of the inspection robot 400 with respect to the reference datum 310 is detected under the cooperation of the reference datum 310 with the pose detection device 320, and then processed by the processing device 330, thereby achieving the detection of the pose of the inspection robot 400. The reference datum 310 provides a stable and accurate reference for distance detection, thereby improving the accuracy of the pose detection and thus the accuracy of subsequent locating to the inspection robot 400.

[00164] Based on the above-described embodiment, referring to FIGS. 12 and 13, in an embodiment, the datum coordinate contains the first datum plane and the first direction. The reference datum 310 comprises a datum scale 311. The datum scale 311 is attached to the side of the railway 100, where the inspection robot 400 travels, along the extending direction of the railway 100.

[00165] Also referring to FIG. 14, the pose detection device 320 comprises a first distance detecting device 321. The first distance detecting device 321 comprises, but is not limited to, a laser diastimeter. The first distance detecting device 321 is disposed at a first site on a side of the vehicle body 411 of the inspection robot 400 proximal to the datum scale 311. The first site can be selected according to actual requirements. The first distance detecting device 321 is configured to detect information of a distance of the first site with respect to the datum scale 311 in the first direction to obtain a first detection distance. The first distance detecting device 321 is communicatively connected to the processing device 330. The first detection distance obtained by the first distance detecting device 321 is transmitted to the processing device 330.

[00166] The processing device 330 calculates a pose deviation of the first site with respect to the first datum plane in the first direction according to the first detection distance. The

method for calculating the pose deviation of the first site with respect to the first datum plane in the first direction adopted by the processing device 330 can be various. In an embodiment, the processing device 330 acquires the first detection distance and information of a distance of the datum scale 311 with respect to the first datum plane in the first direction to calculate the information of the distance of the inspection robot 400 with respect to the first datum plane in the first direction to obtain the first distance information. The processing device 330 further acquires first recorded information of the inspection robot 400, and calculates the pose deviation of the inspection robot 400 with respect to the first datum plane in the first direction based on the first recorded information and the first distance information. The first recorded information may be acquired from a position acquisition module such as an encoder of the vehicle body 411 of the inspection robot 400.

[00167] In this embodiment, the information of the distance of the inspection robot 400 with respect to the datum scale 311 is detected by the first distance detecting device 321, and the pose deviation of the inspection robot 400 with respect to the first datum plane in the first direction is calculated by the processing device 330. In this embodiment, the detection of the deviation of the inspection robot 400 along the y-axis is achieved, which provides a basis for subsequent calibration and locating along the y-axis, thus eliminating the y-axis deviation of the inspection robot 400 caused by factors such as unevenness of the travelling floor, wheel wear, and errors in navigation system, and achieving the accurate locating in the inspection.

[00168] In an embodiment, the datum coordinate contains the second datum plane and the second direction. The reference datum 310 further comprises a datum ramp 312. The datum ramp 312 is disposed at an end of the datum scale 311 distal from the ground on which the inspection robot 400 travels, along the extending direction of the railway 100. That is, the datum ramp 312 is disposed on the top of the datum scale 311. The datum ramp 312 is disposed obliquely with respect to the datum scale 311. The angle between the datum ramp 312 and the datum scale 311 can be set according to needs. In a particular embodiment, the angle between the datum ramp 312 and the datum scale 311 is 45°.

[00169] The pose detection device 320 further comprises a second distance detecting device 322. The second distance detecting device 322 is disposed at a second site on the vehicle

body 411 of the inspection robot 400. The second site and the first site are on the same face of the vehicle body 411 of the inspection robot 400. That is, the second site is also on the side of vehicle body 411 proximal to the datum scale. The second distance detecting device 322 comprises, but is not limited to, a laser diastimeter. The second distance detecting device 322 is configured to detect information of a distance of second site with respect to the datum ramp 312 in the first direction to obtain a second detection distance. The second site can be specifically selected according to the location of the datum ramp 312, to ensure that the information of the distance of the second site with respect to the datum ramp 312 in the first direction can be detected by the second distance detecting device 322. For example, the second site is above the first site, and the second site is higher than the lowest point of the datum ramp 312, so that the information of the distance of the second site with respect to the datum ramp can be detected by the second distance detecting device 322.

[00170] The second distance detecting device 322 is communicatively connected to the processing device 330. The processing device 330 calculates a pose deviation of the inspection robot 400 with respect to the second datum plane in the second direction according to the first detection distance and the second detection distance.

[00171] Taken the angle between the datum ramp 312 and the datum scale 311 being 45° , the first detection distance being y_1 , and the second detection distance being y_2 as an example, assuming that when no deviation of the inspection robot 400 with respect to the second datum plane in the second direction occurs, the second detection distance $y_2=y_1$, then the pose deviation of the inspection robot 400 with respect to second datum plane in the z-axis direction is equal to y_1-y_2 .

[00172] The inspection pose detection system 30 provided in this embodiment detects the second detection distance by means of the second distance detecting device 322 and the datum ramp 312, so as to calculate the pose deviation of the inspection robot 400 with respect to the second datum plane in the second direction. The system provided in this embodiment is simple and efficient, and can accurately detect and calculate the deviation of the inspection robot 400 in the z-axis direction, thereby eliminating errors in the z-axis direction caused by the wheel wear of the inspection robot 400, unevenness of the travelling floor, and others.

[00173] In an embodiment, the first site and the second site are on a straight line perpendicular to the second datum plane, that is, the first site and the second site are on a straight line parallel to the second direction, so that the deviation between the first site and the second site in the third direction is zero. Therefore, when the pose deviation in the y-axis direction is calculated, the influence caused by the inclination of the vehicle body of the inspection robot 400 is avoided, improving the accuracy of the detection and the calculation of the pose deviation in the z-axis direction.

[00174] [177] In an embodiment, the datum coordinate contains the second direction. The pose detection device 320 further comprises a third distance detecting device 323. The third distance detecting device 323 is disposed at a third site on the inspection robot. The third distance detecting device 323 comprises, but is not limited to, a laser diastimeter. The third distance detecting device 323 is configured to detect information of a distance of the third site with respect to the datum scale 311 in the first direction to obtain a third detection distance. The third site is on the same plane as the first site and the second site. The third site and the first site are respectively at different positions in the extending direction of the railway 100. That is, the third site and the first site have different coordinate values on the third coordinate axis. The third site and the first site are on a side face of the vehicle body 411 of the inspection robot 400 and one is in front of another.

[00175] The third distance detecting device 323 is communicatively connected to the processing device 330. The processing device 330 calculates a rotation angle of the inspection robot 400 with respect to the second direction according to the first detection distance and the third detection distance. The rotation angle of the inspection robot 400 with respect to the second direction is the inclination angle of the vehicle body 411 of the inspection robot 400.

[00176] Referring to FIG. 15, if the first detection distance is y_1 , the third detection distance is y_3 , and the distance between the first site and the third site is d , then the degree of $\angle 1$, i.e., the degree of the rotation angle of the inspection robot 400 with respect to the second direction can be calculated from d and $y_3 - y_1$.

[00177] In this embodiment, the third detection distance is detected by the third distance detecting device 323, and the rotation angle of the inspection robot 400 with respect to

the second direction is calculated based on the first detection distance and the third detection distance, so that the inclination of the vehicle body of the inspection robot 400 caused by uneven travel floor, wheel wear, wheel slip, and others can be eliminated, improving the locating accuracy.

5 **[00178]** Referring to FIG. 12, in an embodiment, the datum coordinate contains the third datum plane and the third direction. The reference datum 310 comprises the datum scale 311. The datum scale 311 contains scale information. The pose detection device 320 further comprises an identification device 324. The identification device is configured to identify the scale information of the datum scale to obtain position information of the inspection robot in the
10 third direction with respect to the third datum plane. That is, the identification device 324 identifies the scale information of the datum scale 311, obtains the position information of the inspection robot 400 in the travelling direction, and further obtains the position information of the inspection robot 400 in the third direction with respect to the third datum plane. The system in this embodiment can further detect the deviation between the actual travelling position and the
15 target position of the inspection robot 400 in the third direction caused by the wheel slip and errors in the navigation system, thereby improving the accuracy of subsequent locating and improving the quality and efficiency of the inspection operation.

[00179] The display form of the scale information on the datum scale 311, and the specific structure of the identification device 324 are not limited, as long as the position
20 information can be acquired under their cooperation. In an embodiment, the datum scale 311 is a two-dimensional code band. The two-dimensional code band contains y-axis information and x-axis information. The identification device 324 is an image acquisition device. The image acquisition device comprises, but is not limited to, a camera and others. The image acquisition device is disposed on the vehicle body 411 of the inspection robot 400, and is configured to
25 acquire information of the two-dimensional code band to obtain image information. The pose detection device 320 further comprises a first processing mechanism 325. The first processing mechanism 325 is communicatively connected to the image acquisition device. The first processing mechanism 325 acquires the image information, and obtains position information of the inspection robot 400 in the first direction with respect to the first datum plane and position

information of the inspection robot 400 in the third direction with respect to the third datum plane according to the image information. That is, the first processing mechanism 325 acquires the current position of the inspection robot 400 in the y-axis direction and the current position of the inspection robot 400 in the x-axis based on the information of the two-dimensional code band
5 acquired by the image acquisition device 324. It should be understood that the first distance detecting device 321 can be not provided when information acquisition is performed by the two-dimensional code band and the image acquisition device.

[00180] In this embodiment, the position of the inspection robot 400 in the x-axis direction and in the y-axis direction is detected under the cooperation of the two-dimensional
10 code band and the image acquisition device, so that the pose deviations of the inspection robot 400 in the x-axis direction and in the y-axis direction can be obtained. This detection method is simple and accurate.

[00181] In an embodiment, the datum scale 311 is a two-dimensional code band or a bar code band. The identification device 324 is a code reader. The code reader is configured to
15 identify information of the two-dimensional code band or the bar code band. The bar code band contains x-axis information. The pose detection device 320 further comprises a second processing mechanism 326. The second processing mechanism 326 is communicatively connected to the code reader. The second processing mechanism 326 is configured to acquire position information of the inspection robot 400 in the third direction with respect to the third
20 datum plane according to the information of the two-dimensional code band or the bar code band. That is, the x-axis information of the two-dimensional code band or the bar code band is read by the code reader to obtain the position information of the inspection robot 400 in the x-axis direction.

[00182] In this embodiment, the position of the inspection robot 400 in the x-axis
25 direction is detected under the cooperation of the two-dimensional code band or the bar code band with the code reader, so that the pose deviations of the inspection robot 400 in the x-axis direction can be obtained. This detection method is simple and accurate.

[00183] In an embodiment, the pose detection device 320 further comprises a fourth distance detecting device 327. The fourth distance detecting device 327 is disposed on the top of

the inspection robot 400. The fourth distance detecting device 327 comprises, but is not limited to, a laser diastimeter. The fourth distance detecting device 327 is configured to detect information of a distance of the bottom of the vehicle to be detected with respect to the fourth distance detecting device 327 to obtain a fourth detection distance. The fourth distance detecting device 327 is communicatively connected to the processing device 330. The processing device 330 is configured to calculate the pose deviation of the vehicle to be detected according to the fourth detection distance.

[00184] The fourth detection distance is information of a height of the bottom of the vehicle to be detected. The fourth distance detecting device 327 continuously moves in the inspection pit 300 to acquire of height curve information of the bottom of the vehicle to be detected. Moreover, during the movement of the inspection robot 400, the identification device 324 can indentifies the information of the datum scale 311 to acquire the position information in the x-axis direction corresponding to the height information, thereby obtaining bottom height-length curve information of the vehicle to be detected. The processing device 330 is configured to calculate the pose deviation of the vehicle to be detected according to the height-length curve information. The pose deviation of the vehicle to be detected comprises, but is not limited to, a pose deviation of the vehicle to be detected in the second direction with respect to the second datum plane and a pose deviation of the vehicle to be detected in the third direction with respect to the third datum plane, i.e., a deviation of the vehicle to be detected in the z-axis direction and a deviation of the vehicle to be detected in the x-axis direction. The processing and calculating process of the processing device 330 can be referred to the embodiments of the following methods.

[00185] In this embodiment, the pose deviation of the vehicle to be detected is detected by the fourth distance detecting device 327, so that the parking deviation of the vehicle to be detected in the x-axis direction caused by navigation errors and others and the pose deviation in the z-axis direction caused by the wheel wear of the vehicle to be detected can be eliminated, thereby obtaining the accurate locating.

[00186] Referring to FIG. 16, an embodiment of the present application provides a method for detecting an inspection pose of the rail-transportation rolling stock. The inspection

pose detection system 30 as described above is used to perform the pose detection. The execution body of the method is a computer apparatus. The computer apparatus can be the processing device 330 in the inspection pose detection system 30 for the rail-transportation rolling stock, the control device 600, or any other computer apparatus including a memory and a processor capable of processing a computer program.

[00187] The method comprises steps of:

[00188] S10, acquiring a pose deviation of the vehicle to be detected with respect to the datum coordinate, thereby obtaining a vehicle pose deviation;

[00189] S20, acquiring a pose deviation of the inspection robot 400 with respect to the datum coordinate, thereby obtaining a robot pose deviation;

[00190] S30, obtaining an inspection pose deviation of the rail-transportation rolling stock based on the vehicle pose deviation and the robot pose deviation.

[00191] The datum coordinate is defined as that described in the above embodiments. The pose deviation of the vehicle to be detected with respect to the datum coordinate can be detected and obtained by the fourth distance detecting device 327, the processing device 330, the identification device 324, the first processing mechanism 325, and the second processing mechanism 326 as described above. The pose deviation of the inspection robot 400 with respect to the datum coordinate can be detected and obtained by the first distance detecting device 321, the second distance detecting device 322, and/or the third distance detecting device 324, as well as the processing device 330, the identification device 324, the first processing mechanism 325, and the second processing mechanism 326, as described above. The vehicle pose deviation can be acquired after the vehicle to be detected is parked in position and stored in a memory of the computer apparatus. The robot pose deviation can be acquired in real time during the inspection operation of the inspection robot 400.

[00192] After obtaining the vehicle pose deviation and the robot pose deviation respectively, the computer apparatus processes the vehicle pose deviation and the robot deviation and calculates an overall pose deviation in the inspection operation, i.e., the inspection pose deviation of the rail-transportation rolling stock, according to a preset method. The calculation method comprises, but is not limited to, summation or weighted summation of the pose

deviations in the same coordinate axis and of other related parameters, and the like. The specific calculation method can be set according to actual requirements.

[00193] The inspection pose deviation of the rail-transportation rolling stock is transmitted to the control device 600. The control device 600 calibrates and regulates the travelling direction of the inspection robot 400 in real time according to the pose deviation, so as to accurately locate and detect the vehicle to be detected.

[00194] In this embodiment, the vehicle pose deviation and the robot pose deviation are acquired, and the overall pose deviation in the inspection operation for the rail-transportation rolling stock is obtained according to the vehicle pose deviation and the robot pose deviation.

Both the pose deviation of the inspection robot 400 and the pose deviation of vehicle to be detected in the inspection operation for the rail-transportation rolling stock are taken account into the method provided in this embodiment to eliminate locating errors in various aspects, improving the locating accuracy and thus the inspection effects.

[00195] In an embodiment, the datum coordinate contains the first datum plane and the first direction, and the step S20 comprises:

[00196] S210, acquiring information of the distance of the first site on the inspection robot 400 with respect to the first datum plane in the first direction, thereby obtaining the first distance information.

[00197] The obtaining of the first distance information can comprise, but is not limited to, detecting the distance between the first site and the datum scale 311 by the first distance detecting device 321 in the above-described embodiment to obtain the first detection distance, and then calculating the first distance information based on the distance of the datum scale 311 with respect to the first datum plane in the first direction and the first detection distance. Of course, the first datum plane can be set as the datum scale, if so, the first distance information is exactly the first detection distance.

[00198] The first distance information represents actual distance information of the first site on the inspection robot 400 with respect to the first datum plane in the first direction. Continuing with the above-described embodiment, the first distance is the distance information of the first site on the inspection robot 400 with respect to the first datum plane along the y-axis.

[00199] S220, acquiring recorded information of first site with respect to the first datum plane in the first direction, thereby obtain first recorded information.

[00200] The first recorded information represents an ideal position or a target position of the first site on the inspection robot 400 with respect to the first datum plane in the first direction. The first recorded information can be acquired from the navigation module such as the encoder of the inspection robot 400.

[00201] S230, calculating the pose deviation of the first site with respect to the first datum plane in the first direction according to the first distance information and the first recorded information. The calculation method comprises, but is not limited to, subtraction of the first distance information and the first recorded information with or without being multiplied by a proportionality coefficient.

[00202] In this embodiment, the first distance information and the first recorded information are acquired, and the pose deviation of the inspection robot 400 with respect to the first datum plane in the first direction, i.e., the pose deviation of the inspection robot 400 in the x-axis, is obtained based on the first distance information and the first recorded information.

[00203] Referring to FIG. 18, in an embodiment, the datum coordinate contains the second datum plane and the second direction, and the step S20 comprises:

[00204] S240, acquiring information of the distance of the second site of the inspection robot 400 with respect to the datum ramp in the first direction, thereby obtaining second distance information. The datum ramp is disposed obliquely with respect to the second datum plane. The first site and the second site are on the same face of the inspection robot 400. The first site and the second site are on a straight line perpendicular to the second datum plane.

[00205] S250, obtaining the pose deviation of the inspection robot 400 with respect to the second datum plane in the second direction according to the first distance information and the second distance information.

[00206] The acquisition of the second distance information and the calculation and acquisition of the pose deviation of the inspection robot 400 with respect to the second datum plane in the second direction are as described in the above-described embodiments and shown in FIG. 14 and will not be repeated herein.

[00207] Referring to FIG. 19, in an embodiment, the datum coordinate contains the second direction. The step S20 comprises:

[00208] S260, acquiring information of the distance of the third site on the inspection robot 400 with respect to the first datum plane in the first direction, thereby obtaining third distance information. The third site and the first site are on the same face of the inspection robot 400. The first site and the third site are located at different locations on the inspection robot 400 in the extending direction of the railway 100.

[00209] S270, obtaining the rotation angle of the inspection robot 400 with respect to the second direction according to the first distance information and the third distance information.

[00210] The acquisition of the third distance information is similar to the acquisition of the first distance information. The calculation and acquisition of the rotation angle of the inspection robot 400 with respect to the second direction are as described in the above-described embodiment and shown in FIG. 15. Details will not be repeated herein.

[00211] Referring to FIG. 20, in an embodiment, the datum coordinate contains the second datum plane, the third datum plane, the second direction, and the third direction. The step S10 comprises:

[00212] S110, acquiring distance information of respective sites on the bottom of the vehicle to be detected and arranged in the third direction with respect to the second datum plane in the second direction and distance information of the bottom of vehicle to be detected with respect to the third datum plane in the third direction, thereby obtaining height-length curve information of the vehicle bottom.

[00213] S120, acquiring standard height-length curve information of the bottom of the vehicle to be detected.

[00214] S130, obtaining the pose deviation of the vehicle to be detected with respect to the second datum plane in the second direction and the pose deviation of the vehicle to be detected in the third direction according to the bottom height-length curve information and the standard height-length curve information.

[00215] The height-length curve information indicates the positions of respective parts

of the vehicle bottom on the z-axis in the x-axis direction and the corresponding relationship of positions on the z-axis and on the x-axis when the vehicle to be detected is parked at the actual parking position. The standard height-length curve information indicates the positions of respective parts of the vehicle bottom on the z-axis in the x-axis direction and the corresponding relationship of positions on the z-axis and on the x-axis when the vehicle to be detected is parked at the target parking position.

[00216] Referring to FIG. 21, the inspection robot 400 carrying the fourth distance detecting device moves along the bottom of the vehicle to be detected to acquire the height information of the bottom of the vehicle to be detected, while the identification device 324 identifies the information of the datum scale 311 to acquire position information of respective sites on the bottom of the vehicle to be detected with respect to the third datum plane in the third direction, thereby obtaining the height-length curve information.

[00217] The deviation of the vehicle to be detected in the z-axis direction and the parking deviation of the vehicle to be detected in the x-axis direction can be quickly obtained by comparing the bottom height-length curve information and the standard height-length curve information.

[00218] For example, in FIG. 21, it can be seen from figures a and b that the z-axis deviation is equal to $z1a-z1b$ and the x-axis deviation is equal to $x1a-0=x1a$.

[00219] In the method provided in this embodiment, the pose deviation of the vehicle to be detected in the z-axis direction and the parking deviation of the vehicle to be detected in the x-axis direction can be quickly and accurately obtained by acquiring the height-length curve information of the bottom of the vehicle to be detected and the standard height-length curve information.

[00220] In an embodiment, the step S130 comprises:

[00221] S131, acquiring distance information of the position of the wheelset of the vehicle to be detected with respect to the first datum plane in the first direction according to the bottom height-length curve information, thereby obtaining wheelset position information;

[00222] S132, acquiring standard distance information of the position of the wheelset of the vehicle to be detected with respect to the first datum plane in the first direction according to

the standard height-length curve information, thereby obtaining standard wheelset position information;

[00223] S133, obtaining a pose deviation of the vehicle to be detected with respect to the second datum plane in the second direction and a pose deviation of the vehicle to be detected with respect to the third datum plane in the third direction according to the wheelset position information and the standard wheelset position information.

[00224] With continued reference to FIG. 21, from figure a, it can be seen that the actual parking position of the wheelset is the point $x1a$ on the x-axis and the height is $z2a$. From figure b, it can be seen that the ideal parking position of the wheelset is the point $x2b$ on the x-axis and the height is $z2b$. Therefore, it can be obtained that the vehicle to be detected has a z-axis deviation of $z2a-z2b$ and an x-axis deviation of $x2a-x2b$.

[00225] In this embodiment, by identifying the position of the wheelset, the pose deviation of the vehicle to be detected with respect to the second datum plane in the second direction and the pose deviation of the vehicle to be detected with respect to the third datum plane in the third direction can be quickly and accurately acquired, thereby increasing the calculation speed of the pose deviation.

[00226] In an embodiment, the control device 600 of inspection apparatus 10 for the rail-transportation rolling stock is communicatively connected to the processing device 330. The pose deviation of the inspection robot 400 with respect to the datum coordinate, the pose deviation of the vehicle to be detected with respect to the datum coordinate, and/or the rail-transportation rolling stock inspection pose deviation calculated by the processing device 330 are transmitted to the control device 600. The control device 600 controls the travelling of the inspection robot 400 according to the above deviations, thereby achieving accurate locating and accurate inspection.

[00227] Referring to FIG. 22, an embodiment of the present application provides inspection system 1 for the rail-transportation rolling stock. The inspection system 1 for the rail-transportation rolling stock comprises the inspection apparatus 10 or the rail-transportation rolling stock as described above and a scheduling device 20. The number of the inspection robots 400 is at least 2. The scheduling device 20 is communicatively connected to the inspection robots

400. The scheduling device 20 is configured to schedule the inspection robots 400.

[00228] The inspection system 1 for the rail-transportation rolling stock comprises a plurality of the inspection robots 400. The control device 600 of each of the apparatus 10 for the rail-transportation rolling stock can be separately configured to control the corresponding inspection robot 400. Alternatively, one control device 600 can be configured to control a plurality of the inspection robots.

[00229] Similarly, the scheduling device 20 can be a separate device, or can be a module of the control device 600. The scheduling device 20 is configured to plan the operation sequence and the travelling routes of respective inspection robots 400 according to contents and requirements in the inspection task and the statuses of the inspection robots 400. The scheduling device 20 can also be configured to control the lift devices 501 to ascend or descend according to the operation requirements and the operation statuses of the inspection robots 400. In addition, the scheduling device 20 can further control the operation of the inspection auxiliary device 900 according to the operation requirements and the operation statuses of the inspection robots 400.

[00230] In this embodiment, the operations of the plurality of inspection robots 400 can be controlled by means of the scheduling device 20, so that the plurality of inspection robots 400 can perform the inspection operations simultaneously, greatly reducing the time period of the inspection operations and improving the efficiency of the inspection operations.

[00231] The scheduling device 20 can control the plurality of inspection robots 400 in various manners. In an embodiment, each of the inspection robots 400 can be provided with different type of detecting devices 430 according to needs. The scheduling device 20 is configured to control each of the inspection robots 400 to detect a plurality of items for one vehicle to be detected. That is, the scheduling device 20 controls each of the inspection robots 400 to detect a plurality of items required for one vehicle to be detected. The plurality of the inspection robots 400 detects the plurality of vehicles to be detected simultaneously. In this embodiment, no cross-railway detection is required to be performed by the inspection robot 400, saving the travelling time of the inspection robot 400 and increasing the detection efficiency.

[00232] In another embodiment, the inspection robots 400 are provided with different types of detection devices 430, respectively. The scheduling device 20 is configured to separately

control each of the inspection robots 400 to detect one item for a plurality of vehicles to be detected. That is, the inspection robots 400 are provided with different types of detection devices 430 detecting different items, respectively. The plurality of inspection robots 400 perform inspection operations at the same time, and each of the inspection robots 400 performs detection
5 for the plurality of vehicles to be detected across the railways, so that the plurality of vehicles to be detected can be detected simultaneously. In this embodiment, there is no need to replace the detection device 430 for each of the inspection robots 400, saving time and resources for replacing the detecting device 400 for the inspection robot 400, and increasing the inspection efficiency.

10 **[00233]** The operation process of the inspection apparatus 10 and the inspection system 1 for the rail-transportation rolling stock will be described hereafter with reference to the embodiments.

[00234] Referring to FIG. 23, the inspection system 1 for the rail-transportation rolling stock comprises in total six inspection robots 400, M5 (1) -M5 (6), stopped at positions
15 P001-P006, respectively. The inspection system 1 for the rail-transportation rolling stock further comprises in total two inspection auxiliary devices 900, M6 (1) and M6 (2), stopped at positions P007 and P008, respectively. In the drawing, Pxxx denotes the position. J1-J6 shown with dashed lines denotes different carriages of the vehicle to be detected. M7 (1) and M7 (2) denote lift devices 501. It is assumed that the lift device 501 is communicatively connected to the
20 scheduling device 20, and the scheduling device 20 controls the lift device 501 to ascend or descend.

[00235] The positions P001-P186 in the drawing will be described as follows.

[00236] P001-P006: standby positions of the inspection robots M5 (1) -M5 (6) arranged at a side L of the vehicle to be detected.

25 **[00237]** P007-P008: standby positions of the inspection auxiliary device M6 (1) -M6 (2) arranged at the side L of the vehicle to be detected.

[00238] P120: a point (a datum point at a center of the side L) on the lifting platform of the lift device M7 (1), which is moved between a plane in which the inspection platform 200 is located, at the vehicle side L of the vehicle to be detected and a plane in which the inspection pit

300 is located.

[00239] P110 and P130: datum points at two ends of the side L of the vehicle to be detected.

[00240] P114-P119, P121-P126: typical detection stopping points at the side L, corresponding to respective carriages of the vehicle to be detected.

[00241] P150: a datum point at a center of the inspection pit 300.

[00242] P140 and P160: datum points at two ends of the inspection pit 300.

[00243] P144-P149, P151-P156: typical detection stopping points in the inspection pit, at the vehicle bottom, corresponding to respective carriages of the vehicle to be detected.

[00244] P180: a point (a datum point at a center of a side R of the vehicle) on the lifting platform of the lift device M7 (2), which is moved between a plane in which the inspection platform 200 is located, at the side of the vehicle to be detected and a plane in which the inspection pit 300 is located.

[00245] P170 and P190: datum points at two ends of the side R of the vehicle to be detected.

[00246] P174-P179, P181-P186: typical detection stopping points at the side R, corresponding to respective carriages of the vehicle to be detected.

[00247] In an embodiment, the inspection system 1 for the rail-transportation rolling stock comprises one inspection robot 400, and the inspection operation is as follows.

[00248] S101, operation modules of the inspection apparatus 10 for the rail-transportation rolling stock are normally self-checked, and the functions of respective parts are ready.

[00249] S102, the on-site working-condition detection device 700 acquires the working condition parameters of the inspection place.

[00250] Specifically, the stagnant liquid detection mechanism 710 detects the stagnant liquid condition in the inspection pit 300, and the intrusion detection assembly 730 detects the presence of the intrusion in the inspection place. If it is abnormal, the on-site working-condition detection device 700 or the control device 600 sends an alarm.

[00251] At the same time, the to-be-detected vehicle in-position detection assembly 720

detects whether the vehicle to be detected is parked in position. If the vehicle to be detected is parked in position, it can be used as a start enable signal.

[00252] S103, the control device 600 determines whether or not the operation can be started based on the detection of the on-site working-condition detection device 700, and if yes,
5 sends a start signal.

[00253] S104, the scheduling device 20 acquires information of the inspection robot 400 that is activated and on standby, allocates an inspection task to the inspection robot M5 (1), and issues an operation control instruction. It is assumed that the inspection task is to complete a certain inspection item at P150 in the figure.

10 **[00254]** S105, the inspection robot M5 (1) operates according to the following four steps:

[00255] 1) The scheduling device 20 controls the inspection robot M5 (1) to travel from the P001 to the P120, and when ready, the inspection robot M5 (1) feeds back the status to the scheduling device 20.

15 **[00256]** 2) The scheduling device 20 sends an instruction “descending” to the lift device M7 (1), which performs a descending action and feeds back to the scheduling device 20 after it is in position.

[00257] 3) The scheduling device 20 sends an instruction “P120->P150” to the inspection robot M5 (1). When the inspection robot M5 (1) travels to P150, the inspection robot
20 M5 (1) enters the inspection pit 300 and feeds back the status to the scheduling device 20.

[00258] 4) The scheduling device 20 issues an instruction “ascending” to the lifting device M7 (1) which then performs an ascending action.

[00259] S106, the control device 600 sends an instruction “detecting the location of the vehicle to be detected” to the inspection robot M5 (1), which then travels and performs a
25 measurement along the direction “J4->J5->J6->J3->J2->J1” to obtain a parking deviation ΔX of the vehicle to be detected and the height deviation ΔY_n of the parts.

[00260] S107, the control device 600 sends an instruction “detecting the bottom of the vehicle to be detected” to the inspection robot M5(1), which then travels along the direction “P140->P150->P160” and detects the item at the bottom of the vehicle to be detected.

[00261] S108, the detection of the item at the bottom of the vehicle to be detected is performed as follows:

[00262] 1) The inspection robot M5 (1) stops at P144, and the control device 600 controls the end of the mechanical arm 420 of the inspection robot M5 (1) to arrive at a predetermined detection position.

[00263] 2) The detection device 430 installed at the end of the mechanical arm 420 starts to operate to acquire information related to the detection item and transmit the information related to the detection item to the control device 600.

[00264] 3) The control device 600 processes the related information and determines whether there is a fault.

[00265] 4) The inspection robot M5 (1) travels to the next detection stopping position and repeats steps 1) to 3) until the detection operations corresponding to all positions in P140 to P160 which need to be detected are completed.

[00266] S109, after the inspection robot M5 (1) completes the detection operation at the bottom of the vehicle to be detected, it travels back to P150, and then feeds back the status to the control device 600.

[00267] S110, it is assumed that the inspection robot M5 (1) is currently located at the P150 position, and the control device 600 sends an instruction “completing the detection of an item at P110” to the inspection robot M5 (1), the steps are as follows:

[00268] 1) The scheduling device 20 sends an instruction “descending” to the lift device M7 (1), which then performs a descending action and feeds back to the scheduling device 20 after it is in position.

[00269] 2) The scheduling device 20 sends an instruction “P150->P120” to the inspection robot M5 (1). When the inspection robot M5 (1) travels to P120, the inspection robot M5 (1) exits the inspection pit 300 and feeds back the status to the control device 600.

[00270] 3) The control device 600 sends an instruction “ascending” to the lift device M7 (1), which then performs an ascending action and feeds back to the scheduling device 20 after it is in position.

[00271] 4) The scheduling device 20 sends an instruction “P120->P110” to the

inspection robot M5 (1). When the inspection robot M5 (1) travels to P110, the operation is completed.

[00272] S111, the inspection robot M5 (1) performs a detection operation at the side L of the vehicle to be detected from P110 to P130. The process is similar to that in S108, and details are not described herein. After the inspection robot M5 (1) completes the detection, it arrives at P130.

[00273] S112, the scheduling device 20 sends an instruction “executing P130->P170 action” to the inspection robot M5 (1), and performs the following steps:

[00274] 1) The scheduling device 20 controls the inspection robot M5 (1) to travel from the P130 to the P120. The inspection robot M5 (1) feeds back the status to the scheduling device 20 when it is in position.

[00275] 2) The scheduling device 20 sends a “descending” instruction to the lift devices M7 (1), M7 (2), which then perform the descending action and feeds back to the scheduling device 20 after they are in position.

[00276] 3) The scheduling device 20 sends an instruction “P120->P180” to the inspection robot M5 (1). When the inspection robot M5 (1) travels to P180, the inspection robot M5 (1) comes out of the groove and feeds back the status to the scheduling device 20.

[00277] 4) The scheduling device 20 issues an instruction “ascending” to the lift device M7 (1) and the lift device M7 (2), and the lift device M7 (1) and the lift device M7 (2) perform the ascending operation. The lift device M7 (1) and the lift device M7 (2) feed back information to the scheduling device 20 when they are in position.

[00278] 5) The scheduling device 20 sends an instruction “P180->P170” to the inspection robot M5 (1). When the inspection robot M5 (1) travels to P110, the operation is completed.

[00279] S113, the inspection robot M5 (1) performs a detection operation at the vehicle side R from P170 to P190. The process is similar to that in S108, and details are not described herein.

[00280] S114, during or after the above inspection and detection operation, the detection device 430 transmits the acquired information to the control device 600 for processing.

The control device 600 feeds back the fault information to the maintenance personnel for confirmation via the client platform. If it is confirmed that there is the component failed, a reminder is given to the maintenance personnel to perform maintenance. If it cannot be confirmed, the re-inspection can be performed to confirm again. The process of the re-inspection is similar to that described above.

[00281] S115, after the manual maintenance is completed, the scheduling device 20 controls the inspection robot M5 (1) to travel to the position where the maintenance has been performed, and the controlling device 600 controls the inspection robot M5 (1) to acquire and record information again for the detection item undergone the maintenance.

[00282] It will be appreciated that when the inspection system 1 for the rail-transportation rolling stock comprises one inspection robot 400, the travelling route and inspection operation of the inspection robot 400 can also be controlled by the control device 600. The lift operation of the lift device 501 can also be controlled by the control device 600.

[00283] In yet another embodiment, the scheduling device 20 schedules three inspection robots 400 to perform inspection operations at the same time. The inspection operations are as follows:

[00284] S201, the check before the inspection operation and the acquisition of the task comprises the steps of:

[00285] S2011, each of the operation modules of the inspection system 1 for the rail-transportation rolling stock are normally self-checked, and the functions of various parts are ready.

[00286] S2012, the on-site working-condition detection device 700 acquires the working condition parameters of the inspection place. The details are the same as those in step S102.

[00287] S2013, the control device 600 determines whether or not the operation can be started based on the detection of the on-site working-condition detection device 700, and if yes, a start signal is sent.

[00288] S2014, the scheduling device 20 acquires information of the inspection robots 400 which are activated and on standby, allocates inspection tasks to the inspection robots M5

(1), M5 (2), M5 (3), and issues an operation control instruction. It is assumed that the inspection task is allocated such that the inspection robot M5 (1) completes the first inspection item at P150 in the figure; the inspection robot M5 (2) completes the second inspection item at P110 in the figure; and the inspection robot M5 (3) completes the third inspection item at P170 in the figure.

5 **[00289]** S2015, the inspection robots M5 (1), M5 (2), and M5 (3) respectively travel to P150, P110, and P170 according to the instructions of the scheduling device 20 and the control device 600.

10 **[00290]** S2016, the control device 600 sends an instruction “detecting position of the vehicle to be detected” to the inspection robot M5 (1) or M5 (2) or M5 (3), which then travels and performs a measurement along the direction “J4->J5->J6->J3->J2->J1” to obtain the parking deviation ΔX of the vehicle to be detected and the height deviation ΔY_n of the components.

15 **[00291]** S202, the inspection robots M5 (1), M5 (2), and M5 (3) feed back information to the control device 600 after being in position.

15 **[00292]** S203, the control device 600 sends an instruction “detecting the bottom of the vehicle to be detected” to the inspection robot M5(1), which then travels along the direction “P140->P150->P160” and detect the item at the vehicle bottom.

20 **[00293]** S204, the control device 600 sends an instruction “detecting the side L of the vehicle to be detected” to the inspection robot M5(2), which then travels along the direction “P110->P120->P130” to detect the item at the vehicle side L.

20 **[00294]** S205, the control device 600 sends an instruction “detecting the vehicle side R of the vehicle to be detected” to the inspection robot M5(3), which then travels along the direction “P170->P180->P190” to detect the item at the vehicle side R.

25 **[00295]** S206, the same as steps S114 to S115.

25 **[00296]** In an embodiment, the scheduling device 20 schedules six inspection robots M5 to perform inspection operations at the side L of the vehicle to be detected at the same time, the steps are as follows:

25 **[00297]** S211, the same as the step S201.

25 **[00298]** S212, in the above S2014, the scheduling device 20 sends "P001->P110" to the inspection robot M5(1); the scheduling device 20 sends “P002->P114” to the inspection robot

M5(2); the scheduling device 20 sends "P003->P116" to the inspection robot M5(3); the scheduling device 20 sends "P004->P118" to the inspection robot M5(4); the scheduling device 20 sends "P005->P123" to the inspection robot M5(5); the scheduling device 20 sends "P006->P125" to the inspection robot M5(6); and the scheduling device 20 sends "P144->P125" to the inspection robot M5 (6). The travelling process of the inspection robots is similar to that of S110. The inspection robots feed back information to the control device 600 when they are in position.

[00299] S213, the control device 600 sends an instruction "detecting the vehicle side L-J1" to the inspection robot M5(2), which then travels along the direction "the vehicle to be detected P114->P115" to detect the item at the vehicle side L-J1.

[00300] S214, the control device 600 sends an instruction "detecting the vehicle side L-J2 of the vehicle to be detected" to the inspection robot M5(3), which then travels along the direction "P116->P117" to detect the item at the vehicle side L-J2.

[00301] S215, the control device 600 sends an instruction "detecting the vehicle side L-J3 of the vehicle to be detected" to the inspection robot M5(4), which then travels along the direction "P118->P119" to detect the item at the vehicle side L-J3.

[00302] S216, the control device 600 sends an instruction "detecting the vehicle side L-J4 of the vehicle to be detected" to the inspection robot M5(1), which then travels along the direction "P121->P122" to detect the item at the vehicle side L-J4.

[00303] S217, the control device 600 sends an instruction "detecting the vehicle side L-J5 of the vehicle to be detected" to the inspection robot M5(5), which then travels along the direction "P123->P124" to detect the item at the vehicle side L-J5.

[00304] S218, the control device 600 sends an instruction "detecting the vehicle side L-J6 of the vehicle to be detected" to the inspection robot M5(6), which then travels along the direction "P125->P126" to detect the item at the vehicle side L-J6.

[00305] S219, the same as steps S114 to S115.

[00306] In an embodiment, the inspection robots M5 (1) and M5 (2) are engaged with each other by means of the engaging device 440 and cooperatively operated at the P122 and P123 positions as follows:

[00307] S301, the inspection robot M5 (1) arrives at the detection point P123.

[00308] S302, the inspection robot M5 (2) arrives at the detection point P122 and is mechanically connected with M5 (1) by the real time engaging device 440.

[00309] S303, according to the process requirements, the inspection robots M5 (1) and M5 (2) cooperate with each other in such a manner that the relative positions are kept stationary.

[00310] S304, after the inspection robots M5 (1) and M5 (2) complete the operation, they are disconnected by the engaging device 440.

[00311] In an embodiment, the inspection auxiliary device M6 (1) performs an auxiliary operation for the inspection robot M5 (1) as follows:

[00312] S401, the inspection robot M5 (1) controls the end of the mechanical arm 420 to arrive at a predetermined inspection position during the inspection operation in step S108 (assuming the stopping position is P121). The detection device 430 starts the detection operation. After the acquisition and the detection are completed, the detection device 430 needs to be replaced in order to perform another detection.

[00313] S402, the scheduling device 20 sends an instruction “replacing the detection device disposed at the end of the mechanical arm at position P121” to the inspection auxiliary device M6 (1). The inspection auxiliary device M6 (1) performs a “P007->P121” action and travels from the P007 to the position P121. When it is in position, it is engaged with and mechanically connected to the inspection robot M5 (1) by the engaging device 440. After that, the status is fed back to the control device 600.

[00314] S403, the control device 600 sends instruction to replace the detection device. The inspection robot M5 (1) replaces the detection device at the end of the mechanical arm 420 with the detection device on the tool rack 920 of the inspection auxiliary device M6 (1). After that, the inspection robot M5 (1) is disconnected from the inspection auxiliary device M6 (1), and the inspection auxiliary device M6 (1) returns back.

[00315] In an embodiment, the inspection auxiliary device M6 (1) performs an auxiliary emergency rescue for the inspection robot M5 (1) as follows:

[00316] S501, the inspection robot M5 (1) encounters a fault at the position P121 during the inspection operation and cannot work normally. After obtaining the abnormal

information, the scheduling device 20 sends an instruction "rescue at position P121" to the inspection robot M6 (1).

[00317] S502, the inspection robot M6 (1) travels to the P121 and is engaged with inspection robot M5 (1) which has a fault, thereby achieving mechanical and electrical connection.

[00318] S503, the inspection robot M5 (1) is diagnosed by the inspection auxiliary device M6 (1), and if it is a software failure, the software of the inspection robot M5 (1) is repaired and restarted. A determination is then made as to whether or not the fault condition is still present.

[00319] S504, if the software repair is not successful, an electrical connection check is performed for the inspection robot M5 (1) by the inspection auxiliary device M6 (1), and if it is an electrical fault, try to switch the driving control mode of the travelling parts of the inspection robot M5(1) to enable the inspection robot M5 (1) to automatically travel to a maintenance area.

[00320] S505, if the switching of the driving control mode of the inspection robot M5 (1) is not successful, the inspection robot M5 (1) is directly pushed to the maintenance area.

[00321] S506, the inspection auxiliary device M6 (1) is disconnected from the engaging device 440 of the inspection robot M5 (1), and the inspection auxiliary device M6 (1) returns back.

[00322] The foregoing embodiments are merely some embodiments of the present application, and descriptions thereof are relatively specific and detailed. However, it should not be understood as a limitation to the patent scope of the present application. It should be noted that, a person of ordinary skill in the art may further make some variations and improvements without departing from the concept of the present application, and the variations and improvements belong to the protection scope of the present application. Therefore, the protection scope of the present application shall be subject to the protection scope of the appended claims.

CLAIMS

What is claimed is:

1. An inspection pose detection system for a rail-transportation rolling stock, characterized by comprising:

5 a reference datum disposed at a side of a railway where a vehicle to be detected is parked, along an extending direction of the railway;

a pose detection device disposed on an inspection robot for the rail-transportation rolling stock and configured to detect distance information of the inspection robot for the rail-transportation rolling stock with respect to the reference datum; and

10 a processing device communicatively connected to the pose detection device and configured to calculate a pose deviation of the inspection robot for the rail-transportation rolling stock with respect to a datum coordinate on basis of the distance information of the inspection robot for the rail-transportation rolling stock with respect to the reference datum.

15 2. The inspection pose detection system for the rail-transportation rolling stock of claim 1, characterized in that the datum coordinate contains a first datum plane and a first direction; the reference datum comprises a datum scale; the datum scale is attached to a side of the railway proximal to the inspection robot for the rail-transportation rolling stock, along the extending direction of the railway;

20 the pose detection device comprises a first distance detecting device, the first distance detecting device is disposed at a first site on a side of the inspection robot for the rail-transportation rolling stock proximal to the datum scale and communicatively connected to the processing device, and the first distance detecting device is configured to detect distance information of the first site with respect to the datum scale in the first direction to obtain a first
25 detection distance;

the processing device is configured to calculate a pose deviation of the first site with respect to the first datum plane in the first direction on basis of the first detection distance.

3. The inspection pose detection system for the rail-transportation rolling stock of claim 2,

characterized in that the datum coordinate contains a second datum plane and a second direction; the reference datum comprises a datum ramp, the datum ramp is disposed at an end of the datum scale distal from a ground where the rail-transportation rolling stock travels, and the datum ramp is oblique with respect to the datum scale;

5 the pose detection device further comprises a second distance detecting device disposed at a second site on the inspection robot for the rail-transportation rolling stock, the first site and the second site are located on the same face of the inspection robot for the rail-transportation rolling stock, the second distance detecting device is communicatively connected to the processing device and configured to detect distance information of the second site with respect to the datum
10 ramp in the first direction to obtain a second detection distance; and

 the processing device is configured to calculate a pose deviation of inspection robot for the rail-transportation rolling stock with respect to the second datum plane in the second direction on basis of the first detection distance and the second detection distance.

15 4. The inspection pose detection system for the rail-transportation rolling stock of claim 3, characterized in that the first site and the second site are located on a straight line perpendicular to the second datum plane.

5. The inspection pose detection system for the rail-transportation rolling stock of claim 2,
20 characterized in that the datum coordinate contains a second direction, the pose detection device further comprises a third distance detecting device, the third distance detecting device is disposed at a third site on the inspection robot for the rail-transportation rolling stock, the third site and the first site are located on the same face of the inspection robot for the rail-transportation rolling stock and located at different positions in the extending direction of the railway, the third
25 distance detecting device is communicatively connected to the processing device and configured to detect distance information of the third site with respect to the datum scale in the first direction to obtain a third detection distance;

 the processing device is configured to calculate a rotation angle of the inspection robot for the rail-transportation rolling stock with respect to the second direction on basis of the first

detection distance and the third detection distance.

6. The inspection pose detection system for the rail-transportation rolling stock of any one of claims 1-5, characterized in that the datum coordinate contains a third datum plane and a third direction;

the reference datum comprises a datum scale containing scale information, the pose detection device comprises an identification device configured to identify the scale information in the datum scale and obtain position information of inspection robot for the rail-transportation rolling stock with respect to the third datum plane in the third direction.

7. The inspection pose detection system for the rail-transportation rolling stock of claim 6, characterized in that the datum coordinate further contains a first datum plane and a first direction;

the datum scale is a two-dimensional code band;

the identification device is an image acquisition device configured to acquire information in the two-dimensional code band to obtain image information;

the pose detection device further comprises a first processing mechanism communicatively connected to the image acquisition device and configured to obtain position information of the inspection robot for the rail-transportation rolling stock with respect to the first datum plane in the first direction and position information of the inspection robot for the rail-transportation rolling stock with respect to the third datum plane in the third direction on basis of the image information.

8. The inspection pose detection system for the rail-transportation rolling stock of claim 6, characterized in that the datum scale is a two-dimensional code band or a bar code band;

the identification device is a code reader configured to identify information in the two-dimensional code band or the bar code band; and

the pose detection device further comprises a second processing mechanism communicatively connected to the code reader and configured to obtain position information of

the inspection robot for the rail-transportation rolling stock with respect to the third datum plane in the third direction on basis of the information in the two-dimensional code band or the bar code band.

- 5 9. The inspection pose detection system for the rail-transportation rolling stock of claim 1, characterized in that the pose detection device further comprises a fourth distance detecting device disposed on a top of the inspection robot for the rail-transportation rolling stock and communicatively connected to the processing device, the fourth distance detecting device is configured to detect distance information of a bottom of the vehicle to be detected with respect to
10 the fourth distance detecting device to obtain a fourth detection distance;

the processing device is configured to calculate a pose deviation of the vehicle to be detected on basis of the fourth detection distance.

10. An inspection pose detection method for a rail-transportation rolling stock, characterized by
15 comprising:

acquiring a pose deviation of a vehicle to be detected with respect to a datum coordinate, thereby obtaining a vehicle pose deviation;

acquiring a pose deviation of an inspection robot for the rail-transportation rolling stock with respect to the datum coordinate, thereby obtaining a robot pose deviation; and

- 20 obtaining a rail-transportation rolling stock inspection pose deviation on basis of the vehicle pose deviation and the robot pose deviation.

11. The method of claim 10, characterized in that the datum coordinate contains a first datum plane and a first direction, the acquiring the pose deviation of the inspection robot for the
25 rail-transportation rolling stock with respect to the datum coordinate thereby obtaining the robot pose deviation comprises:

acquiring distance information of a first site on the inspection robot for the rail-transportation rolling stock with respect to the first datum plane in the first direction, thereby obtaining first distance information;

acquiring recorded information of the first site with respect to the first datum plane in the first direction, thereby obtaining first recorded information;

calculating a pose deviation of the first site with respect to the first datum plane in the first direction on basis of the first distance information and the first recorded information.

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12. The method of claim 11, characterized in that the datum coordinate contains a second datum plane and a second direction, the acquiring the pose deviation of the inspection robot for the rail-transportation rolling stock with respect to the datum coordinate thereby obtaining the robot pose deviation further comprises:

10 acquiring distance information of a second site on the inspection robot for the rail-transportation rolling stock with respect to a datum ramp in the first direction, thereby obtaining second distance information, wherein the datum ramp is oblique with respect to the second datum plane, and the first site and the second site are located on the same face of the inspection robot for the rail-transportation rolling stock and on a straight line perpendicular to the
15 second datum plane;

obtaining a pose deviation of the inspection robot for the rail-transportation rolling stock with respect to the second datum plane in the second direction on basis of the first distance information and the second distance information.

20 13. The method of claim 11, characterized in that the datum coordinate contains a second direction, the acquiring the pose deviation of the inspection robot for the rail-transportation rolling stock with respect to the datum coordinate thereby obtaining the robot pose deviation further comprises:

25 acquiring distance information of a third site on the inspection robot for the rail-transportation rolling stock with respect to the first datum plane in the first direction, thereby obtaining third distance information, wherein the third site and the first site are located on the same face of the inspection robot for the rail-transportation rolling stock and located at different positions in the extending direction of the railway;

obtaining a rotation angle of the inspection robot for the rail-transportation rolling stock

with respect to the second direction on basis of the first distance information and the third distance information.

14. The method of claim 10, characterized in that the datum coordinate contains a second datum plane, a third datum plane, a second direction, and a third direction, and the acquiring the pose deviation of the vehicle to be detected with respect to the datum coordinate thereby obtaining the vehicle pose deviation comprises:

acquiring distance information of respective sites disposed on a bottom of the vehicle along the third direction with respect to the second datum plane in the second direction and distance information of the respective sites with respect to the third datum plane in the third direction, thereby obtaining bottom height-length curve information;

acquiring standard bottom height-length curve information of the vehicle to be detected;

obtaining a pose deviation of the vehicle to be detected with respect to the second datum plane in the second direction and a pose deviation of the vehicle to be detected with respect to the third datum plane in the third direction on basis of the bottom height-length curve information and the standard height-length curve information.

15. The method of claim 14, characterized in that the obtaining the pose deviation of the vehicle to be detected with respect to the second datum plane in the second direction and the pose deviation of the vehicle to be detected with respect to the third datum plane in the third direction on basis of the bottom height-length curve information and the standard height-length curve information comprises:

obtaining distance information of a wheelset site on the vehicle to be detected with respect to the first datum plane in the first direction on basis of the bottom height-length curve information, thereby obtaining wheelset position information;

obtaining standard distance information of the wheelset site on the vehicle to be detected with respect to the first datum plane in the first direction on basis of the standard height-length curve information, thereby obtaining standard wheelset position information; and

obtaining a pose deviation of the vehicle to be detected with respect to the second datum

plane in the second direction and a pose deviation of the vehicle to be detected with respect to the third datum plane in the third direction on basis of the wheelset position information and the standard wheelset position information.