METHOD AND APPARATUS FOR AUTOMATICALLY CONTROLLING CONTACT LENGTH OF SIDE BRUSH ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Chinese patent application No. 202411438008.6, filed with the China National Intellectual Property Administration on October 15, 2024, and entitled "Method and Apparatus for Automatically Controlling Contact Length of Side Brush Assembly", the entire contents of the above-identified application are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present application relates to the technical field of train cleaning machines, particularly to a method and an apparatus for automatically controlling a contact length of a side brush assembly.

DESCRIPTION OF RELATED ART

[0003] Trains need to be cleaned almost every day when entering or exiting from a depot according to backhaul inspection and servicing protocols of the trains. A brush assembly used for cleaning the trains has an extremely high usage rate. However, there are many differences in the trains entering the depot, and widths of bodies of the trains are quite different. The existing brush assembly generally adopts a pneumatic drive mode with a block limitation, and a contact length is determined according to a position of the block. When the contract length is too large, a reaction force of the brush assembly increases, and a pneumatic cylinder retracts to provide safety protection. In such drive mode, the brush assembly only has two positions, i.e., an initial position and a limit position, and thus a put-out position of the brush assembly cannot be precisely adjusted. Therefore, when side cleaning of the train is performed, the contact lengths may vary at different positions on the body of the train, resulting in problems of incomplete cleaning of the train body or excessive contact length on the train body and scratches on the train body.

SUMMARY

[0004] In accordance with various embodiments of the present application, a method and an apparatus for automatically controlling a contact length of a side brush assembly are provided.

[0005] In accordance with the first aspect of the present application, a method for automatically controlling a contact length of a side brush assembly is provided. The method includes following steps:

determining a push-out angle of a first brush assembly, and pushing out the first brush assembly

based on the push-out angle of the first brush assembly; and

determining, at any moment when a to-be-cleaned train passes through the first brush assembly, a target expected adjustment strategy corresponding to the moment according to an expected adjustment strategy sequence corresponding to the first brush assembly, and adjusting the push-out angle of the first brush assembly according to the target expected adjustment strategy;

where, the expected adjustment strategy sequence includes a plurality of expected adjustment strategies, each of the plurality of expected adjustment strategies is determined according to a v pressure value applied on a second brush assembly in a process that the to-be-cleaned train passes through the second brush assembly, and the second brush assembly is located behind the first brush assembly in a forward direction of the to-be-cleaned train.

[0006] In an embodiment, the method further includes following steps:

detecting the pressure value applied on the second brush assembly at any moment when the to-be-cleaned train passes through the second brush assembly, and determining a real-time adjustment strategy of the second brush assembly corresponding to the moment based on the pressure value;

adjusting a push-out angle of the second brush assembly according to the real-time adjustment strategy; and

updating the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly.

[0007] In an embodiment, the step of determining the real-time adjustment strategy of the second brush assembly based on the pressure value includes:

determining a decrease of the push-out angle as the real-time adjustment strategy of the second brush assembly when the pressure value is greater than a first preset pressure threshold; or

determining an increase of the push-out angle as the real-time adjustment strategy when the pressure value is less than a second preset pressure threshold;

where, the first preset pressure threshold is greater than the second preset pressure threshold.

[0008] In an embodiment, the step of updating the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly includes:

determining an expected execution moment of the real-time adjustment strategy corresponding to the first brush assembly according to a distance between the second brush assembly and the first brush assembly, and a forward speed of the to-be-cleaned train; and

updating the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly according to the expected execution moment.

[0009] In an embodiment, the method further includes following steps:

detecting a target pressure value applied on the first brush assembly in a process of adjusting the

push-out angle according to the target expected adjustment strategy;

advancing expected execution moments corresponding to the plurality of expected adjustment strategies respectively when the target expected adjustment strategy indicates a decrease of the push-out angle and the value of the target pressure is greater than the first preset pressure threshold, or when the target expected adjustment strategy indicates an increase of the push-out angle and the target pressure value is less than the second preset pressure threshold; or

delaying the expected execution moments corresponding to the plurality of expected adjustment strategies respectively when the target expected adjustment strategy indicates the decrease of the push-out angle and the value of the target pressure is less than the second preset pressure threshold, or when the target expected adjustment strategy indicates the increase of the push-out angle and the target pressure value is greater than the first preset pressure threshold.

[0010] In an embodiment, the step of determining the push-out angle of the first brush assembly includes following steps:

determining a target push-out distance of the first brush assembly according to a width of the to-be-cleaned train, positions of train tracks, an initial position of the first brush assembly, and a preset contact length of the first brush assembly for the to-be-cleaned train; and

determining the push-out angle of the first brush assembly according to the target push-out distance of the first brush assembly and a length of a mounting rod.

[0011] In an embodiment, the step of determining the target push-out distance of the first brush assembly according to the width of the to-be-cleaned train, the positions of the train tracks, the initial position of the first brush assembly, and the preset contact length of the first brush assembly for the to-be-cleaned train includes:

determining a position of a center axis of the tracks according to the positions of the train tracks; and

summing the position of the center axis of the train tracks and half of the width of the to-be-cleaned train, and obtaining a side position of the to-be-cleaned train;

summing the initial position of the first brush assembly and the preset contact length of the first brush assembly for the to-be-cleaned train, and obtaining a target position of the first brush assembly; and

calculating a difference between the side position of the to-be-cleaned train and the target position of the first brush assembly, and obtaining the target push-out distance of the first brush assembly.

[0012] In an embodiment, the step of determining the push-out angle of the first brush assembly includes:

detecting a train model of the to-be-cleaned train;

determining the push-out angle of the first brush assembly according to a corresponding relationship between the train model and the push-out angle of the first brush assembly, when the train model is successfully detected; and

determining a train model corresponding to a widest train body among a plurality of train models as the train model of the to-be-cleaned train, when the detection of the train model fails.

[0013] In an embodiment, a top end of the side brush assembly is fixed on a transverse mounting rod, the mounting rod is connected to a stand column, and a push rod is disposed between the mounting rod and the stand column, the side brush assembly is pushed out by pushing the mounting rod through the push rod.

[0014] In an embodiment, the push rod is driven by a DC motor with an encoder, and the step of pushing out the first brush assembly based on the push-out angle of the first brush assembly includes:

driving the push rod to be pushed out through the DC motor until a code value of the encoder reaches a code value corresponding to the push-out angle of the first brush assembly.

[0015] In an embodiment, a pressure sensor is mounted on the first brush assembly, and the method further includes:

detecting a pressure value of the pressure sensor in real time in a process of driving the push rod to be pushed out through the DC motor; and

stopping the process of pushing out the first brush assembly when the pressure value exceeds a pressure threshold or the code value has an abnormality.

[0016] In accordance with the second aspect of the present application, an apparatus for automatically controlling a contact length of a side brush assembly is provided. The apparatus includes:

a determination module configured to determine a push-out angle of a first brush assembly, and push out the first brush assembly based on the push-out angle of the first brush assembly; and

a first adjustment module configured to determine, at any moment when a to-be-cleaned train passes through the first brush assembly, a target expected adjustment strategy corresponding to the moment according to an expected adjustment strategy sequence corresponding to the first brush assembly, and adjust the push-out angle according to the target expected adjustment strategy;

where the expected adjustment strategy sequence includes a plurality of expected adjustment strategies, and each of the plurality of expected adjustment strategies is determined according to a pressure value applied on a second brush assembly in a process that the to-be-cleaned train passes through the second brush assembly, and the second brush assembly is located behind the first brush assembly in a forward direction of the to-be-cleaned train.

[0017] In an embodiment, the apparatus further includes:

a first detection module configured to detect the pressure value applied on the second brush assembly at any moment when the to-be-cleaned train passes through the second brush assembly, and determine a real-time adjustment strategy of the second brush assembly corresponding to the moment based on the pressure value;

a second adjustment module configured to adjust a push-out angle of the second brush assembly according to the real-time adjustment strategy; and

an updating module configured to update the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly.

[0018] In an embodiment, the first detection module is further configured to:

determine a decrease of the push-out angle as the real-time adjustment strategy of the second brush assembly when the pressure value is greater than a first preset pressure threshold; or alternatively,

determine an increase of the push-out angle as the real-time adjustment strategy when the pressure value is less than a second preset pressure threshold;

where the first preset pressure threshold is greater than the second preset pressure threshold.

[0019] In an embodiment, the updating module is further configured to:

determine an expected execution moment of the real-time adjustment strategy corresponding to the first brush assembly according to a distance between the second brush assembly and the first brush assembly, and a forward speed of the to-be-cleaned train; and

update the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly according to the expected execution moment.

[0020] In an embodiment, the apparatus further includes:

a second detection module configured to detect a target pressure value applied on the first brush assembly in a process of adjusting the push-out angle according to the target expected adjustment strategy;

an execution moment adjustment module configured to: advance expected execution moments corresponding to the plurality of expected adjustment strategies respectively when the target expected adjustment strategy indicates the decrease of the push-out angle and the value of the target pressure is greater than the first preset pressure threshold, or when the target expected adjustment strategy indicates the increase of the push-out angle and the value of the target pressure is less than the second preset pressure threshold; or delay the expected execution moments corresponding to the plurality of expected adjustment strategies respectively, when the target expected adjustment strategy indicates the decrease of the push-out angle and the value of the target pressure is less than the second preset

pressure threshold, or when the target expected adjustment strategy indicates the increase of the push-out angle and the target pressure value is greater than the first preset pressure threshold.

[0021] In an embodiment, the determination module is further configured to:

determine a target push-out distance of the first brush assembly according to a width of the to-be-cleaned train, positions of train tracks, an initial position of the first brush assembly, and a preset contact length of the first brush assembly for the to-be-cleaned train; and

determine the push-out angle of the first brush assembly according to the target push-out distance of the first brush assembly and a length of a mounting rod.

[0022] In an embodiment, the determination module is further configured to:

determine a position of a center axis of the tracks according to the positions of the train tracks;

sum the position of the center axis of the tracks and half of the width of the to-be-cleaned train, and obtain a side position of the to-be-cleaned train;

sum the initial position of the first brush assembly and the preset contact length of the first brush assembly for the to-be-cleaned train, and obtain a target position of the first brush assembly; and

calculate a difference between the side position of the to-be-cleaned train and the target position of the first brush assembly, and obtain the target push-out distance of the first brush assembly.

[0023] In an embodiment, the determination module is further configured to:

detect a train model of the to-be-cleaned train; and

determine the push-out angle of the first brush assembly according to a corresponding relationship between the train model and the push-out angle of the first brush assembly when the train model is successfully detected; and

determine a train model corresponding to a widest train body among a plurality of train models as the train model of the to-be-cleaned train when the detection of the train model fails.

[0024] In an embodiment, a top end of the side brush assembly is fixed on a transverse mounting rod, the mounting rod is connected to a stand column, and a push rod is provided between the mounting rod and the stand column, the side brush assembly is pushed out by pushing the mounting rod through the push rod.

[0025] In an embodiment, the push rod is driven by a DC motor with an encoder, and the determination module is further configured to:

drive the push rod to be pushed out through the DC motor until a code value of the encoder reaches a code value corresponding to the push-out angle of the first brush assembly.

[0026] In an embodiment, a pressure sensor is mounted on the first brush assembly, and the apparatus further includes:

a detection module configured to detect a pressure value of the pressure sensor in real time in

the process of driving the push rod to be pushed out through the DC motor; and

a stop module configured to stop pushing out the first brush assembly when the pressure value exceeds a pressure threshold or the code value has an abnormality.

[0027] In accordance with the third aspect of the present application, a computer device is further provided. The computer device includes a processor and a memory storing a computer program. The processor, when executing the computer program, implements the method in any of the above-mentioned embodiments.

[0028] In accordance with the fourth aspect of the present application, a computer-readable storage medium is provided, on which a computer program is stored. The computer program, when executed by a processor, causes the processor to implement the method in any of the above-mentioned embodiments.

[0029] In accordance with the fifth aspect of the present application, a computer program product is further provided, which includes a computer program. The computer program, when executed by a processor, causes the processor to implement the method in any of the above-mentioned embodiments.

[0030] The details of one or more embodiments of the present invention are set forth in the accompanying drawings and the description below. Other features, purposes, and advantages of the present application will become obvious from the specification, the accompanying drawings and the claims.

DESCRIPTION OF THE DRAWINGS

[0031] In order to better describe and illustrate the embodiments and/or examples of the invention disclosed herein, one or more accompanying drawings are provided for reference. Additional details or examples for describing the drawings should not be considered as limitations to the scope of any one of the disclosed invention, the currently described embodiments and/or examples, and the optimal modes of the invention as currently understood.

[0032] FIG. 1 is a flow chart showing a method for automatically controlling a contact length of a side brush assembly according to an embodiment.

[0033] FIG. 2 is a side view of a brush assembly according to an embodiment.

[0034] FIG. 3 is a flow chart of determining an initial put-out position of a brush assembly according to an embodiment.

[0035] FIG. 4 is a flow chart of acquiring an expected adjustment strategy sequence according to an embodiment.

[0036] FIG. 5 is a schematic diagram illustrating a mounting position of a pressure sensor

according to an embodiment.

[0037] FIG. 6 is a flow chart of a step S406 according to an embodiment.

[0038] FIG. 7 is a flow chart of adjusting an execution moment of an expected adjustment strategy according to an embodiment.

[0039] FIG. 8 is a schematic structure diagram of an apparatus for automatically controlling a contact length of a side brush assembly according to an embodiment.

[0040] FIG. 9 is an internal structure diagram of a computer device according to an embodiment.

DETAILED DESCRIPTIONS OF EMBODIMENTS

[0041] In order to make the purpose, technical solution and advantages of the present application clearer and more understandable, the present application will be further described in detail below with reference to the accompanying drawings and embodiments. It should be appreciated that the embodiments elaborated herein are merely intended to explain the present application, rather than being construed as limitations to the present application.

[0042] In an embodiment, as shown in FIG. 1, a method for automatically controlling a contact length of a side brush assembly is provided. In the embodiment, the method is applied to a control device of a train cleaning machine as an example for illustration. The method includes following steps.

[0043] Step S102: a push-out angle of a first brush assembly is determined, and the first brush assembly is pushed out based on the push-out angle of the first brush assembly.

[0044] In the embodiment of the present invention, a plurality of brush assemblies are mounted on the train cleaning machine. The plurality of brush assemblies may be divided into a first brush assembly and a second brush assembly. The second brush assembly is configured to adjust a push-out angle thereof according to a pressure value detected in real time, and the first brush assembly is configured to adjust the push-out angle thereof according to a strategy for adjusting the push-out angle of the second brush assembly. Since a to-be-cleaned train is cleaned by slowly moving on a track and passing through various brush assemblies in sequence, a position on the train currently cleaned by a rear brush assembly in a forward direction of the train may pass through a front brush assembly after a period of time. Thus, the first brush assembly is enabled to adjust the push-out angle thereof in advance with reference to the strategy for adjusting the push-out angle of the second brush assembly.

[0045] The plurality of brush assemblies on each side of the to-be-cleaned train may include at least one second brush assembly and a plurality of first brush assemblies. The plurality of first brush assemblies may correspond to the same second brush assembly, in this case, all second brush assemblies need to be located behind all first brush assemblies in the forward direction of the to-be-

cleaned train. Each first brush assembly may also correspond to a different second brush assembly, in this case, a second brush assembly corresponding to a first brush assembly need to be located behind the first brush assembly.

[0046] The push-out angle refers to an included angle between a mounting rod and a stand column for a brush assembly in a horizontal direction, as shown in FIG. 2. A top end of the brush assembly is fixed on the horizontal mounting rod connected to the stand column. A push rod may be provided between the mounting rod and the stand column, and may drive the mounting rod to rotate around the stand column to change the push-out angle of the brush assembly. Alternatively, a vertical support rod parallel to the brush assembly may be provided on the mounting rod, and a push rod may be provided between the support rod and the stand column, so that the push rod can change the push-out angle of the brush assembly. The embodiments of the present application are not specifically limited thereto. A threaded screw and nut structure with a locking device may further be mounted on the push rod, such that the brush assembly can be locked after being pushed out according to the push-out angle, thereby preventing the push rod from retracting due to a pressure during a train cleaning process. The push rod may be driven by a DC motor with an encoder or a potentiometer. There may exist a corresponding relationship between push-out angles and encoded values of the encoder. When the brush assembly needs to be pushed out to a specific push-out angle, the DC motor drives the push rod to push out until the encoded value reaches an encoded value corresponding to the push-out angle.

[0047] In an embodiment, the push-out angle of the first brush assembly may be determined according to a model of the to-be-cleaned train. Specifically, the train model of the to-be-cleaned train is detected, and the push-out angle of the first brush assembly is determined according to the corresponding relationship between train models and push-out angles of the first brush assembly. For example, an appropriate push-out angle corresponding to each type of train may be obtained through experiments in advance, so that the contact length of the train is within a reasonable range. When the to-be-cleaned train needs to be cleaned, the control device may identify the model of the to-be-cleaned train (alternatively, a working staff may manually enter the model of the to-be-cleaned train through the control device), and look up a data table that records the corresponding relationship between various train models and push-out angles, obtain the push-out angle corresponding to the model of the to-be-cleaned train from the data table, and push out the first brush assembly according to the push-out angle corresponding to the model of the to-be-cleaned train. When the identification of train model fails, a train model corresponding to the widest train body may serve as the train model of the to-be-cleaned train, thereby avoiding a problem that the distance between brush assemblies is too narrow, and the train collides with the brush assemblies, causing damage to the brush assemblies.

[0048] In another embodiment, the push-out angle of the brush assembly may also be determined

in real time according to a width of the to-be-cleaned train. A target push-out distance of the first brush assembly may be determined according to the width of the to-be-cleaned train, positions of train tracks, an initial position of the first brush assembly, and a preset contact length of the first brush assembly for the to-be-cleaned train, and the push-out angle of the first brush assembly is determined respectively according to the target push-out distance of the first brush assembly and a length of the mounting rod. The position of the side surface of the to-be-cleaned train in the train cleaning process may be determined according to the width of the to-be-cleaned train and the position of the track for the to-be-cleaned train. Since a train generally has an axisymmetric structure, a position of a center axis of the tracks may be determined according to the positions of the tracks, the width of the to-be-cleaned train is divided by 2, and then the position of the center axis of the tracks plus the result obtained by dividing the width of the to-be-cleaned train by 2 gives the position of the side surface of the to-be-cleaned train in the cleaning process of the train. Furthermore, a sum of the initial position of the first brush assembly (referring to a position where a center axis of the brush assembly is located) and the preset contact length may be calculated, a difference between the position of the side surface of the to-be-cleaned train and the sum is calculated, and a distance that the first brush assembly needs to be pushed forward in a direction perpendicular to the side surface of the train is obtained, that is, the target push-out distance. The contact length refers to a length over which the bristles of the brush assembly come into contact with the side surface of the train, which may generally be represented in millimeters. For example, when the contact length is 150 millimeters, it indicates that the length over which the bristles come into contact with the train during the cleaning process of the train is equal to 150 millimeters.

[0049] An angle by which the first brush assembly needs to rotate, that is, the push-out angle, may be calculated according to the target push-out distance and the length of the mounting rod. A ratio of the target push-out distance to the length of the mounting rod may be calculated, and an arc tangent value of the ratio may be calculated to obtain the push-out angle required for the first brush assembly to advance the target push-out distance in the direction perpendicular to the side surface of the train.

[0050] In the above-mentioned parameters, the positions of the train tracks and the initial positions of the brush assemblies are fixed, the width of the to-be-cleaned train may be determined by the control device through a mode such as collecting an image of the to-be-cleaned train to perform an image identification, performing a measurement with a radar, or the like. Alternatively, the width of the to-be-cleaned train may be manually entered by a working staff through the control device.

[0051] Referring to FIG. 3, a pressure sensor may further be mounted on the first brush assembly. In the process of obtaining the push-out angle by automatically identifying the train model, or by identifying the width of the train, and pushing out the first brush assembly according to the push-out

angle, the pressure value of the pressure sensor may also be detected in real time. If the pressure value exceeds a pressure threshold, or a coded value of a motor has an abnormality, pushing-out of the first brush assembly and a train cleaning operation are stopped. If both the pressure value and the coded value are normal, the motor may be started to perform the train cleaning operation after the brush assembly is pushed out according to the push-out angle, and the train is allowed to start to slowly pass through each brush assembly along the tracks.

[0052] Step S104: at any moment when the to-be-cleaned train passes through the first brush assembly, a target expected adjustment strategy corresponding to the moment is determined according to the expected adjustment strategy sequence corresponding to the first brush assembly, and the push-out angle is adjusted according to the target expected adjustment strategy. The expected adjustment strategy sequence includes a plurality of expected adjustment strategies, and each expected adjustment strategy is determined according to a pressure value applied on a second brush assembly in a process during which the to-be-cleaned train passes through the second brush assembly. The second brush assembly is located behind the first brush assembly in the forward direction of the to-be-cleaned train.

[0053] In the embodiment of the present invention, when the to-be-cleaned train passes through the second brush assembly, the control device detects the pressure value applied on the second brush assembly, and may determine, according to the pressure value applied on the second brush assembly, an expected adjustment strategy that the first brush assembly needs to execute when the partial train body currently cleaned by the second brush assembly passes through the first brush assembly. The expected adjustment strategy may include decrease of the push-out angle or increase of the push-out angle.

[0054] The control device may further determine a moment at which the partial train body currently cleaned by the second brush assembly passes through the first brush assembly according to a distance between the second brush assembly and the first brush assembly and a forward speed of the to-be-cleaned train, and the moment serves as an expected execution moment at which the first brush assembly needs to execute the expected adjustment strategy. In a case where the current moment does not correspond to an expected execution moment of any expected adjustment strategy in the expected adjustment strategy sequence, the target expected adjustment strategy corresponding to the current moment is determined as maintaining the current push-out angle of the first brush assembly without adjusting the push-out angle. In a case where the current moment corresponds to an expected execution moment of an expected adjustment strategy in the expected adjustment strategy sequence, the target expected adjustment strategy corresponding to the current moment is determined as the expected adjustment strategy, and the push-out angle is adjusted according to the expected adjustment

strategy.

[0055] In accordance with the method for automatically controlling the contact length of the side brush assembly in the embodiment of the present invention, when the to-be-cleaned train passes through the second brush assembly behind the first brush assembly, the pressure value applied on the second brush assembly is detected, and the expected adjustment strategy for adjusting the push-out angle of the first brush assembly is determined according to the pressure value when the same position on the to-be-cleaned train passes through the first brush assembly, so that the first brush assembly may adjust the push-out angle in advance according to the expected adjustment strategy, without needing to perform a delayed adjustment on the push-out angle of the first brush assembly when the pressure value applied on the first brush assembly is too large or too small. It is possible to allow the pressure value applied on the first brush assembly to be maintained within a reasonable range during the process that the to-be-cleaned train passes through the first brush assembly, so that the contact length may also be maintained within a reasonable range, thereby avoiding the problem of incomplete cleaning of the train body or scratches on the train body.

[0056] In an embodiment, as shown in FIG. 4, the above-mentioned method further includes following steps.

[0057] Step S402: a pressure value applied on the second brush assembly at any moment when the to-be-cleaned train passes through the second brush assembly is detected, and a real-time adjustment strategy of the second brush assembly for the moment is determined based on the pressure value.

[0058] Step S404: a push-out angle of the second brush assembly is adjusted according to the real-time adjustment strategy.

[0059] Step S406: the real-time adjustment strategy is updated into the expected adjustment strategy sequence of the first brush assembly.

[0060] In the embodiment of the present invention, when the to-be-cleaned train passes through the second brush assembly, the control device may detect the pressure value applied on the second brush assembly, determine the real-time adjustment strategy of the second brush assembly according to the pressure value, adjust the push-out angle of the second brush assembly according to the real-time adjustment strategy, and synchronize the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly.

[0061] The pressure value applied on the second brush assembly may be detected by a pressure sensor, and the pressure sensor may be mounted on an electric push rod, as shown in FIG. 5. When the pressure value applied on the second brush assembly is too large, decrease of the push-out angle of the brush assembly may serve as the real-time adjustment strategy of the second brush assembly. In addition, when the pressure value applied on the second brush assembly is too small, increase of

the push-out angle of the brush assembly may serve as the real-time adjustment strategy of the second brush assembly. If the pressure value applied on the second brush assembly is within a reasonable range, the real-time adjustment strategy may not be generated, that is, the push-out angle of the second brush assembly is not adjusted.

[0062] In an embodiment, a first preset pressure threshold and a second preset pressure threshold may be set in advance. When the pressure value is greater than the first preset pressure threshold, decrease of the push-out angle serves as the real-time adjustment strategy of the second brush assembly. Alternatively, when the pressure value is less than the second preset pressure threshold, increase of the push-out angle serves as the real-time adjustment strategy. The first preset pressure threshold is greater than the second preset pressure threshold. In the embodiment of the present invention, the first preset pressure threshold and the second preset pressure threshold may be obtained through experiments. A maximum contact length that does not scratch the train and a minimum contact length that can effectively clean the train may be predetermined, a pressure value applied on the brush assembly when the contact length reaches the maximum contact length is determined through experiments, and the pressure value serves as the first preset pressure threshold. A pressure value applied on the brush assembly when the contact length reaches the minimum contact length is determined through experiments, and the pressure value serves as the second preset pressure threshold.

[0063] In an embodiment, as shown in FIG. 6, the step S406 of updating the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly includes following steps.

[0064] Step S602: an expected execution moment of the real-time adjustment strategy corresponding to the first brush assembly is determined according to the distance between the second brush assembly and the first brush assembly and the forward speed of the to-be-cleaned train.

[0065] Step S604: the real-time adjustment strategy is updated into the expected adjustment strategy sequence of the first brush assembly according to the expected execution moment.

[0066] In the embodiment of the present invention, travel time required for a certain position on the to-be-cleaned train when the certain position moves from the position where the second brush assembly is located to the position where the first brush assembly is located may be determined according to the distance between the second brush assembly and the first brush assembly and the forward speed of the to-be-cleaned train. Since the push-out angle of second brush assembly may be adjusted only after the pressure value is greater than the first preset pressure threshold or less than the second preset pressure threshold, the real-time adjustment strategy of the second brush assembly has hysteresis. In order to enable the adjustment of the push-out angle of the first brush assembly in advance before the position on the to-be-cleaned train that needs to be cleaned reaches the first brush

assembly, a shorter duration may also be set as preset lead time, after the current moment and the travel time are summed, a difference between the obtained sum result and the preset lead time is calculated to obtain the expected execution moment. In such a manner, the time when the first brush assembly executes the adjustment strategy is earlier than the time when the second brush assembly executes the same adjustment strategy. Accordingly, the push-out angle of the first brush assembly may be adjusted in advance before the position on the train that needs be cleaned reaches the first brush assembly.

[0067] After the expected execution moment is determined, the real-time adjustment strategy is updated into the expected adjustment strategy sequence of the first brush assembly according to the expected execution moment, so that when the expected execution moment arrives, the first brush assembly determines the real-time adjustment strategy as the target expected adjustment strategy and executes the target expected adjustment strategy.

[0068] In an embodiment, as shown in FIG. 7, the method further includes following steps.

[0069] Step S702: a target pressure value applied on the first brush assembly is detected in the process of adjusting the push-out angle according to the target expected adjustment strategy.

[0070] Step S704: expected execution moments respectively corresponding to the plurality of expected adjustment strategies are advanced when the target expected adjustment strategy indicates decrease of the push-out angle and the target pressure value is greater than the first preset pressure threshold, or the target expected adjustment strategy indicates increase of the push-out angle and the target pressure value is less than the second preset pressure threshold. Alternatively,

[0071] step 706: the expected execution moments respectively corresponding to the plurality of expected adjustment strategies are delayed when the target expected adjustment strategy indicates decrease of the push-out angle and the target pressure value is less than the second preset pressure threshold, or the target expected adjustment strategy indicates increase of the push-out angle and the target pressure value is greater than the first preset pressure threshold.

[0072] In the embodiment of the present invention, a pressure sensor may also be mounted on the first brush assembly, and the expected execution moment is adjusted according to feedback of the pressure sensor on the first brush assembly in the process of adjusting the push-out angle of the first brush assembly according to the target expected adjustment strategy. When the target expected adjustment strategy indicates decrease of the push-out angle, but the target pressure value detected by the pressure sensor is greater than the first preset pressure threshold, it indicates that the process of decreasing the push-out angle is delayed, the decrease of the push-out angle should be started earlier so that the pressure value can remain below the first preset pressure threshold. Since the reason for the delay in the execution of the adjustment strategy is most likely that the previously determined

expected execution moment is inaccurate. Accordingly, in a case where the execution of a target expected adjustment strategy is delayed, the expected execution moments corresponding to other expected adjustment strategies are also likely to be delayed. Therefore, the expected execution moments corresponding to the plurality of expected adjustment strategies may be advanced accordingly. The preset lead time may be a preset fixed value, or may be determined according to the number of adjustments of the expected execution moment. For example, the preset lead time may be inversely proportional to the number of adjustments of the expected execution moment, so that the expected execution moment may eventually converge to an optimal value.

[0073] When the target expected adjustment strategy indicates increase of the push-out angle, but the target pressure value is less than the second preset pressure threshold, it also indicates that the execution of the target expected adjustment strategy is delayed. Accordingly, the expected execution moments of other expected adjustment strategies also need to be advanced.

[0074] Conversely, when the target expected adjustment strategy indicates decrease of the push-out angle, but the target pressure value is less than the second preset pressure threshold, or when the target expected adjustment strategy indicates increase of the push-out angle, but the target pressure value is greater than the first preset pressure threshold, it indicates that the push-out angle is decreased or increase at an excessively rapid rate, and the execution of the target expected adjustment strategy is advanced. Therefore, the expected execution moments corresponding to the plurality of expected adjustment strategies may be correspondingly delayed to avoid a situation where the pressure value applied on the first brush assembly exceeds the range defined by the first preset pressure threshold and the second preset pressure threshold.

[0075] According to the method for automatically controlling the contact length of the side brush assembly, the target pressure value applied on the first brush assembly is detected, whether the execution of the target expected adjustment strategy is delayed or advanced is determined according to the currently executed target expected adjustment strategy and whether the target pressure value is greater than the first preset pressure threshold or less than the second preset pressure threshold, and the expected execution moments of other expected adjustment strategies are correspondingly adjusted according to the determination result, thereby reducing the situation where the target pressure value applied on the first brush assembly is greater than the first preset pressure threshold or less than the second preset pressure threshold, and avoiding the problems such as incomplete cleaning of the train body or scratches on the train body.

[0076] It should be appreciated that, although the steps in the flow charts relating to the various embodiments are displayed sequentially according to the indication of the arrows, these steps are not necessarily performed in the order indicated by the arrows. The execution of these steps is not strictly

limited unless being explicitly stipulated herein, and these steps can be performed in other order. Moreover, at least a part of the steps in the flow charts relating to the various embodiments may include a plurality of steps or phases, and these steps or phases are not necessarily performed at the same time. Instead, these steps or phases may be performed at different moments. The order of execution of these steps or phases is not necessarily performed in sequence, instead, the execution of these steps or phases may be performed in turn or alternately with other steps or at least a part of steps or phases in other steps.

[0077] Based on the same inventive concept, an apparatus for automatically controlling a contact length of a side brush assembly for implementing the above-mentioned method for automatically controlling the contact length of the side brush assembly is further provided in an embodiment of the present invention. An implementation solution for solving the problem provided by the apparatus is similar to the implementation solution described in the above-mentioned method. Accordingly, as for the specific limitations in one or more embodiments of the apparatus for automatically controlling the contact length of the side brush assembly described below, reference can be made to the limitations on the method for automatically controlling the contact length of the side brush assembly described above, which will not be repeated herein.

[0078] In an embodiment, as shown in FIG. 8, an apparatus 800 for automatically controlling a contact length of a side brush assembly is provided, which includes a determination module 802 and a first adjustment module 804.

[0079] The determination module 802 is configured to determine a push-out angle of a first brush assembly, and push out the first brush assembly based on the push-out angle of the first brush assembly.

[0080] The first adjustment module 804 is configured to determine, at any moment when a to-be-cleaned train passes through a first brush assembly, a target expected adjustment strategy corresponding to the moment according to an expected adjustment strategy sequence corresponding to the first brush assembly, and adjust the push-out angle according to the target expected adjustment strategy.

[0081] The expected adjustment strategy sequence includes a plurality of expected adjustment strategies, and each of the plurality of expected adjustment strategies is determined according to a pressure value applied on a second brush assembly in a process that the to-be-cleaned train passes through the second brush assembly. The second brush assembly is located behind the first brush assembly in a forward direction of the to-be-cleaned train.

[0082] In accordance with the apparatus for automatically controlling the contact length of the side brush assembly in the embodiment of the present invention, when the to-be-cleaned train passes

through the second brush assembly behind the first brush assembly, the pressure value applied on the second brush assembly is detected, and the expected adjustment strategy for adjusting the push-out angle of the first brush assembly is determined according to the pressure value when the same position on the to-be-cleaned train passes through the first brush assembly,, so that the first brush assembly may adjust the push-out angle in advance according to the expected adjustment strategy, without needing to perform a delayed adjustment on the push-out angle of the first brush assembly when the pressure value applied on the first brush assembly is too large or too small. In the process during which the to-be-cleaned train passes through the first brush assembly, the pressure value applied on the first brush assembly is maintained within a reasonable range, so that the contact length may also be maintained within a reasonable range, thereby avoiding the problem of incomplete cleaning of the train body or scratches on the train body.

[0083] In an embodiment, the apparatus further includes:

a first detection module configured to detect a pressure value applied on the second brush assembly at any moment when the to-be-cleaned train passes through the second brush assembly, and determine a real-time adjustment strategy of the second brush assembly at the moment based on the pressure value;

a second adjustment module configured to adjust a push-out angle of the second brush assembly according to the real-time adjustment strategy; and

an updating module configured to update the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly.

[0084] In an embodiment, the first detection module is further configured to:

determine a decrease of the push-out angle as the real-time adjustment strategy of the second brush assembly when the pressure value is greater than a first preset pressure threshold; or,

determine an increase of the push-out angle as the real-time adjustment strategy when the pressure value is less than a second preset pressure threshold;

where the first preset pressure threshold is greater than the second preset pressure threshold.

[0085] In an embodiment, the updating module is further configured to:

determine an expected execution moment of the real-time adjustment strategy corresponding to the first brush assembly according to a distance between the second brush assembly and the first brush assembly and a forward speed of the to-be-cleaned train; and

update the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly according to the expected execution moment.

[0086] In an embodiment, the apparatus further includes:

a second detection module configured to detect a target pressure value applied on the first brush

assembly in a process of adjusting the push-out angle according to the target expected adjustment strategy; and

an execution moment adjustment module configured to: advance an expected execution moment corresponding to each expected adjustment strategy when the target expected adjustment strategy indicates the decrease of the push-out angle and the target pressure value is greater than the first preset pressure threshold, or when the target expected adjustment strategy indicates the increase of the push-out angle and the target pressure value is less than the second preset pressure threshold; or delay the expected execution moment corresponding to each expected adjustment strategy when the target expected adjustment strategy indicates the decrease of the push-out angle and the target pressure value is less than the second preset pressure threshold, or when the target expected adjustment strategy indicates the increase of the push-out angle and the target pressure value is greater than the first preset pressure threshold.

[0087] In an embodiment, the determination module 802 is further configured to:

determine a target push-out distance of the first brush assembly according to a width of the to-be-cleaned train, positions of train tracks, an initial position of the first brush assembly, and a preset contact length of the first brush assembly for the to-be-cleaned train; and

determine a push-out angle of the first brush assembly according to the target push-out distance of the first brush assembly and a length of a mounting rod.

[0088] In an embodiment, the determination module 802 is further configured to:

determine a position of a center axis of the tracks according to the positions of the train tracks; and

sum the position of the center axis of the tracks and half of the width of the to-be-cleaned train, and obtain a side position of the to-be-cleaned train;

sum the initial position of the first brush assembly and the preset contact length of the first brush assembly for the to-be-cleaned train, and obtain a target position of the first brush assembly; and

calculate a difference between the side position and the target position of the first brush assembly, and obtain the target push-out distance of the first brush assembly.

[0089] In an embodiment, the determination module 802 is further configured to:

detect a train model of the to-be-cleaned train;

determine the push-out angle of the first brush assembly according to a corresponding relationship between train models and push-out angles of the first brush assembly when the train model is successfully detected; and

determine a train model corresponding to a widest train body among the train models as the train model of the to-be-cleaned train when detection of the train model fails.

[0090] In an embodiment, a top end of the brush assembly is fixed on a transverse mounting rod, the mounting rod is connected to a stand column, and a push rod is provided between the mounting rod and the stand column, the brush assembly is pushed out by pushing the mounting rod through the push rod.

[0091] In an embodiment, the push rod is driven by a DC motor with an encoder, and the determination module 802 is further configured to:

drive the push rod to be pushed out by the DC motor until a code value of the encoder reaches a code value corresponding to the push-out angle.

[0092] In an embodiment, a pressure sensor is mounted on the first brush assembly, and the apparatus further includes:

a detection module configured to detect a pressure value of the pressure sensor in real time in the process of driving the push rod to be pushed out through the DC motor; and

a stop module configured to stop pushing-out the first brush assembly when the pressure value exceeds a pressure threshold, or the code value has an abnormality.

[0093] All or some of the modules in the aforementioned apparatus may be implemented by using software, hardware, and a combination thereof. The modules may be embedded in or independent of a processor in a computer device in a hardware form. Alternatively, the modules may be stored in a memory in the computer device in a software form, so that the processor invokes and executes operations corresponding to the modules.

[0094] In an embodiment, a computer device is provided. The computer device may be a server, and an internal structure diagram of the computer device may be shown in FIG. 9. The computer device includes a processor, a memory, and a network interface which are interconnected through a system bus. The processor of the computer device is configured to provide computing and control capabilities. The memory of the computer device includes a non-transitory storage medium and an internal storage. The non-transitory storage medium stores an operating system and a computer program. The internal storage provides an environment for operations of the operating system and the computer program in the non-transitory storage medium. The network interface of the computer device is configured to communicate with an external terminal through a network connection. The computer program is configured to, when executed by the processor, implement a method for automatically controlling a contact length of a side brush assembly.

[0095] A person of ordinary skill in the art may understand that the structure shown in FIG. 9 is merely a block diagram of a partial structure related to the solution of the present application, and thus shouldn’t be regarded as limitations to the computer device to which the solution of the present application is applied. The specific computer device may include more or fewer components than

those shown in the figure, or combine some components, or have different component arrangements.

[0096] In an embodiment, a computer device is provided, which includes a processor and a memory storing a computer program, the processor, when executing the computer program, implement the steps in the aforementioned method embodiments.

[0097] In an embodiment, a computer-readable storage medium is provided, on which a computer program is stored. The computer program, when executed by a processor, implement the steps in the aforementioned method embodiments.

[0098] In an embodiment, a computer program product is provided, which includes a computer program. The computer program, when executed by a processor, implement the steps in the aforementioned method embodiments.

[0099] It should be noted that the user information (including, but is not limited to, user equipment information, user personal information, etc.) and data (including, but not limited to, data for analysis, stored data, displayed data, etc.) involved in the present application are information and data authorized by the user or fully authorized by all parties.

[0100] A person of ordinary skill in the art may understand that all or some of the processes in the method in the aforementioned embodiments may be implemented by instructing relevant hardware through a computer program. The computer program may be stored in a non-transitory computer-readable storage medium, when the computer program is executed, the procedures of the various method embodiments may be included. Any references to a memory, a database, or other media used in the embodiments provided in the present application may include at least one of a non-transitory memory and a transitory memory. The non-transitory memory may include a Read-Only Memory (ROM), a magnetic tape, a floppy disk, a flash memory, an optical memory, a high-density embedded non-volatile memory, a resistive random access memory (ReRAM), a Magnetoresistive Random Access Memory (MRAM), a Ferroelectric Random Access Memory (FRAM), a Phase Change Memory (PCM), a graphene memory, and the like. The transitory memory may include a Random Access Memory (RAM) or an external cache. By way of illustration, rather than limitation, the RAM may be in various forms, such as a Static Random Access Memory (SRAM) or a Dynamic Random Access Memory (DRAM), etc. The databases involved in the embodiments provided in the present application may include at least one of a relational database and a non-relational database. The non-relational database may include a blockchain-based distributed database or the like, but is not limited thereto. The processor in the embodiments provided in the present application may be a general-purpose processor, a central processing unit, a graphics processor, a digital signal processor, a programmable logic device, a quantum computing-based data processing logic device, and the like, but is not limited thereto.

[0101] The technical features in the above embodiments may be combined in any manner. For conciseness purpose, all possible combinations of the technical features in the above embodiments are not described. However, the combinations of these technical features should be considered as the scope of the present application, as long as the combinations of these technical features are not contradictory.

[0102] The embodiments described above merely illustrate several implementation modes of the present application, and are described in relatively specific and detailed manner. However, these implementations should not be regarded as limitations to the scope of the present application. It should be noted that a person of ordinary skill in the art may also make some transformations and improvements without departing from the concept of the present application, which all fall within the protection scope of the present application. Therefore, the protection scope of the present application shall be subject to the appended claims.

CLAIMS

1. A method for automatically controlling a contact length of a side brush assembly, characterized by comprising:

determining a push-out angle of a first brush assembly, and pushing out the first brush assembly based on the push-out angle of the first brush assembly; and

determining, at any moment when a to-be-cleaned train passes through the first brush assembly, a target expected adjustment strategy corresponding to the moment according to an expected adjustment strategy sequence corresponding to the first brush assembly, and adjusting the push-out angle according to the target expected adjustment strategy;

wherein the expected adjustment strategy sequence comprises a plurality of expected adjustment strategies, each of the plurality of expected adjustment strategies is determined according to a pressure value applied on a second brush assembly in a process that the to-be-cleaned train passes through the second brush assembly, and the second brush assembly is located behind the first brush assembly in a forward direction of the to-be-cleaned train.

2. The method according to claim 1, further comprising:

detecting the pressure value applied on the second brush assembly at any moment when the to-be-cleaned train passes through the second brush assembly, and determining a real-time adjustment strategy of the second brush assembly corresponding to the moment based on the pressure value;

adjusting a push-out angle of the second brush assembly according to the real-time adjustment strategy; and

updating the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly.

3. The method according to claim 2, wherein determining the real-time adjustment strategy of the second brush assembly based on the pressure value comprises:

determining a decrease of the push-out angle as the real-time adjustment strategy of the second brush assembly when the pressure value is greater than a first preset pressure threshold; or

determining an increase of the push-out angle as the real-time adjustment strategy when the pressure value is less than a second preset pressure threshold;

wherein the first preset pressure threshold is greater than the second preset pressure threshold.

4. The method according to claim 2, wherein updating the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly comprises:

determining an expected execution moment of the real-time adjustment strategy corresponding to the first brush assembly according to a distance between the second brush assembly and the first

brush assembly and a forward speed of the to-be-cleaned train; and

updating the real-time adjustment strategy into the expected adjustment strategy sequence of the first brush assembly according to the expected execution moment.

5. The method according to claim 1, further comprising:

detecting a target pressure value applied on the first brush assembly in a process of adjusting the push-out angle according to the target expected adjustment strategy;

advancing expected execution moments corresponding to the plurality of expected adjustment strategies respectively when the target expected adjustment strategy indicates a decrease of the push-out angle and the target pressure value is greater than the first preset pressure threshold, or when the target expected adjustment strategy indicates an increase of the push-out angle and the target pressure value is less than the second preset pressure threshold; or

delaying the expected execution moments corresponding to the plurality of expected adjustment strategies respectively when the target expected adjustment strategy indicates the decrease of the push-out angle and the value of the target pressure is less than the second preset pressure threshold, or when the target expected adjustment strategy indicates the increase of the push-out angle and the target pressure value is greater than the first preset pressure threshold.

6. The method according to claim 1, wherein determining the push-out angle of the first brush assembly comprises:

determining a target push-out distance of the first brush assembly according to a width of the to-be-cleaned train, positions of train tracks, an initial position of the first brush assembly, and a preset contact length of the first brush assembly for the to-be-cleaned train; and

determining the push-out angle of the first brush assembly according to the target push-out distance of the first brush assembly and a length of a mounting rod.

7. The method according to claim 6, wherein determining the target push-out distance of the first brush assembly according to the width of the to-be-cleaned train, the positions of the train tracks, the initial position of the first brush assembly, and the preset contact length of the first brush assembly for the to-be-cleaned train comprises:

determining a position of a center axis of the tracks according to the positions of the train tracks;

summing the position of the center axis of the tracks and half of the width of the to-be-cleaned train, and obtaining a side position of the to-be-cleaned train;

summing the initial position of the first brush assembly and the preset contact length of the first brush assembly for the to-be-cleaned train, and obtaining the first target position of a brush assembly; and

calculating a difference between the side position and the target position of the first brush

assembly, and obtaining the target push-out distance of the first brush assembly.

8. The method according to claim 1, wherein determining the push-out angle of the first brush assembly comprises:

detecting a train model of the to-be-cleaned train;

determining the push-out angle of the first brush assembly according to a corresponding relationship between the train model and the push-out angle of the first brush assembly when the train model is successfully detected; and

determining a train model corresponding to a widest train body among a plurality of train models as the train model of the to-be-cleaned train when the detection of the train model fails.

9. The method according to claim 1, wherein a top end of the side brush assembly is fixed on a transverse mounting rod, the mounting rod is connected to a stand column, and a push rod is provided between the mounting rod and the stand column, the side brush assembly is pushed out by pushing the mounting rod through the push rod.

10. The method according to claim 9, wherein the push rod is driven by a DC motor with an encoder, and pushing out the first brush assembly based on the push-out angle of the first brush assembly comprises:

driving the push rod to be pushed out through the DC motor until a code value of the encoder reaches a code value corresponding to the push-out angle.

11. The method according to claim 10, wherein a pressure sensor is mounted on the first brush assembly, and the method further comprises:

detecting a pressure value of the pressure sensor in real time in a process of driving the push rod to be pushed out through the DC motor; and

stopping the process of pushing out the first brush assembly when the pressure value exceeds a pressure threshold or the code value has an abnormality.

12. An apparatus for automatically controlling a contact length of a side brush assembly, comprising:

a determination module configured to determine a push-out angle of a first brush assembly, and push out the first brush assembly based on the push-out angle of the first brush assembly; and

a first adjustment module configured to determine, at any moment when a to-be-cleaned train passes through the first brush assembly, a target expected adjustment strategy corresponding to the moment according to an expected adjustment strategy sequence corresponding to the first brush assembly, and adjust the push-out angle according to the target expected adjustment strategy;

wherein the expected adjustment strategy sequence comprises a plurality of expected adjustment strategies, and each of the plurality of expected adjustment strategies is determined according to a

pressure value applied on a second brush assembly in a process that the to-be-cleaned train passes through the second brush assembly, and the second brush assembly is located behind the first brush assembly in a forward direction of the to-be-cleaned train.

13. A computer device, comprising a processor and a memory storing a computer program, wherein the processor, when executing the computer program, implements steps of the method according to any one of claims 1 to 11.

14. A computer-readable storage medium, on which a computer program is stored, wherein the computer program, when executed by a processor, causes the processor to implement steps of the method according to any one of claims 1 to 11.

15. A computer program product, comprising a computer program, wherein the computer program, when executed by a processor, causes the processor to implement steps of the method according to any one of claims 1 to 11.