

TACS DEGRADED TRAIN POSITIONING INFORMATION INITIALIZATION METHOD, DEVICE AND MEDIUM

TECHNICAL FIELD

The present invention relates to a rail transit signal system, and in particular to a train autonomous circumambulation system (TACS) degraded train positioning information initialization method, a device and a medium.

BACKGROUND

Compared with a traditional communication-based train control (CBTC) system, a train autonomous circumambulation system (TACS) based on train-to-train communication is "train-centric," with trains autonomously calculating movement authorities. The essence of the TACS system is to migrate core wayside control functions of the traditional CBTC system to the trains, optimizing the system architecture while reducing the quantity of wayside equipment, which significantly reduces the device maintenance workload.

In the traditional CBTC system, position tracking of degraded trains or non-communicating trains relies heavily on track occupancy detection. A computer interlocking system sets routes for a degraded train and opens corresponding signals according to track occupancy situations, and a driver operates the train according to signals and dispatching instructions. However, since the TACS system greatly simplifies wayside equipment and no longer relies on secondary detection devices, the TACS system lacks effective detection means to acquire the position of a TACS degraded train on a line, i.e., it lacks means to initialize and track the position of a degraded train through secondary detection equipment such as axle counters or track circuits. When a train failure or communication failure occurs, the wayside train controller (WTC) applies for or releases resources for the TACS degraded train or non-communicating train. However, when the WTC takes over train control authority, it does not have position information of the degraded train. Therefore, how to initialize the position of a degraded train after the WTC takes over train control authority is a significant challenge.

Upon retrieval, Chinese Patent Publication No. CN115782979A discloses an envelope-based train management method and apparatus, which specifically discloses calculating a safety range using a safety calculation model according to a real-time position of a communicating train, and generating a communicating train envelope according to the safety range; generating a hidden train envelope according to an axle counter section range occupied by a hidden train; generating a lost communicating train envelope by combining the communicating train envelope with corresponding axle counter section occupancy/vacancy status information when a communicating train that has completed front-end screening experiences communication interruption; and retracting the lost communicating train envelope to a maximum boundary range enclosed by occupied axle counter sections. Its function is to achieve continuous tracking of trains under different communication situations. However, this existing method requires the use of axle counter devices, resulting in high implementation costs. Therefore, how to effectively initialize the position of a TACS degraded train, and reduce the quantity of system wayside equipment, construction costs, and maintenance workload, thereby improving system competitiveness and flexibility, has become a technical problem to be solved.

SUMMARY

An objective of the present invention is to provide a TACS degraded train positioning information initialization method, a device and a medium, in order to overcome the defects of the above prior art.

The objective of the present invention can be achieved through the following technical solutions:

According to a first aspect of the present invention, a TACS degraded train positioning information initialization method is provided, including calculating a train safety envelope according to a principle of a TACS train authorization permitted running range or red light signal blocking, thereby effectively initializing a position of the TACS degraded train.

As a preferred technical solution, the method is implemented by interaction of a

wayside resource manager (WRC) with a carborne controller (CC) and a wayside train controller (WTC), respectively.

As a preferred technical solution, when controlling the train, the carborne controller (CC) calculates the train safety envelope and sends the train safety envelope to the wayside resource manager (WRC), and the WRC verifies and stores a received valid train safety envelope calculated by the CC and sends train safety envelope confirmation information to the CC.

As a preferred technical solution, when the CC fails or train-to-ground wireless communication fails, the wayside train controller (WTC) takes over the train, the WRC sends the stored train safety envelope to the WTC, and after receiving the train safety envelope, the WTC performs safety envelope initialization on the train, thereby obtaining position information of the train.

As a preferred technical solution, the method includes a TACS train degradation initialization processing process and a manual train degradation initialization processing process.

As a preferred technical solution, the TACS train degradation initialization processing process specifically includes:

step S101. controlling, by the carborne controller (CC), the train to run under automatic train protection (ATP) protection;

step S102. calculating, by the carborne controller (CC), a train position safety envelope;

step S103. sending, by the carborne controller (CC), the train position safety envelope to the WRC for storage;

step S104. determining whether a failure exists in the CC or train-to-ground communication, and if the failure exists in the CC or the train-to-ground communication, repeating the steps S101-S103, otherwise, executing step S105;

step S105. triggering an emergency brake (EB) stop by the train and prohibiting the train from moving;

step S106. sending, by the WRC, the stored train safety envelope to the WTC;

step S107. calculating, by the WTC, a wayside safety position of the train; and
step S108. taking over the train and applying for and releasing a resource by the WTC.

As a preferred technical solution, the calculating, by the carborne controller (CC), a train position safety envelope in the step S102 is specifically as follows:

continuously calculating, by the carborne controller (CC), a train safety envelope [a, b] according to a current speed, a current position, a safety reaction time, an EB guarantee rate, a line gradient, and current task information.

As a preferred technical solution, the train safety envelope [a, b] is a range that ensures normal running of the TACS train without speed reduction.

As a preferred technical solution, in the step S103, after receiving train safety envelope information, the WRC performs verification and stores the train safety envelope information after the verification is passed.

As a preferred technical solution, the manual train degradation initialization processing process specifically includes:

step S201. enabling a manual train to run under manual protection;
step S202. calculating, by the CC, a train position safety envelope to a red light signal;
step S203. sending, by the CC, the train position safety envelope to the WRC for storage;
step S204. determining whether a failure exists in the CC or train-to-ground communication, and if the failure exists in the CC or the train-to-ground communication, repeating the steps S201-S203, otherwise, executing step S205;
step S205. prohibiting the train from running past the red light signal;
step S206. sending, by the WRC, the stored train safety envelope to the WTC;
step S207. calculating, by the WTC, a safety position of the train; and
step S208. taking over the train and applying for and releasing a resource by the WTC.

As a preferred technical solution, in the step S202, the calculating is specifically as follows:

continuously calculating, by the CC, a train safety envelope [c, d] according to a current position of the manual train and status information of the nearest red light signal.

As a preferred technical solution, the train safety envelope [c, d] is from a train rear of the train to the red light signal.

As a preferred technical solution, in the step S203, after receiving train safety envelope information, the WRC performs verification and stores the train safety envelope information after the verification is passed.

As a preferred technical solution, the prohibiting the train from running past the red light signal in the step S205 causes the train safety envelope to remain within a range of the train safety envelope [c, d], and at this time, the WTC obtains train control authority, the WRC sends the stored train safety envelope [c, d] to the WTC, and the WTC utilizes the train safety envelope to perform train position initialization, thereby obtaining position information of the train, implementing control over the train, and being responsible for applying for and releasing the resource for the train.

According to a second aspect of the present invention, an electronic device is provided, including a memory and a processor, the memory having a computer program stored thereon, where the processor, when executing the program, implements the method.

According to a third aspect of the present invention, a computer-readable storage medium having a computer program stored thereon is provided, where the program, when executed by a processor, implements the method.

Compared with the prior art, the present invention has the following advantages:

1) According to the present invention, a train safety envelope is calculated according to the principle of a TACS train authorization permitted running range or red light signal blocking, thereby effectively initializing the position of the TACS degraded train and ensuring the availability and safety of resource application and release for the TACS degraded train.

2) According to the present invention, the method for performing train safety envelope initialization calculation for the TACS degraded train through an information verification method does not require complex wayside equipment such as axle counters

or track circuits to track the degraded train. This significantly reduces the quantity of system wayside equipment, construction costs, and maintenance workload, and improves system competitiveness and flexibility.

3) According to the present invention, by utilizing the TACS train authorization permitted running range or utilizing a red light signal as the safety envelope of the train, it is ensured that after a CC failure, the WTC can still safely track the position of the train. This provides a simple and safe method for TACS train position tracking, simplifies the system structure, and ensures system safety.

4) According to the present invention, when calculating the TACS train authorization permitted running range, the train safety envelope is calculated by considering not only factors such as a current speed, a current position, a safety reaction time, an EB guarantee rate, and a line gradient, but also situations such as the current task. This envelope can ensure normal running of the TACS train without speed reduction, thereby ensuring the normal running and availability of the system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic structural diagram of a TACS system;

FIG. 2 is a schematic diagram of a principle of positioning information initialization for a TACS degraded train according to the present invention;

FIG. 3 is a schematic diagram of TACS train degradation initialization processing according to the present invention;

FIG. 4 is a flowchart of TACS train degradation initialization processing according to the present invention;

FIG. 5 is a schematic diagram of manual train degradation initialization according to the present invention; and

FIG. 6 is a flowchart of manual train degradation initialization processing according to the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The technical solutions in the embodiments of the present invention are clearly and

completely described below with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the described embodiments are merely some rather than all of the embodiments of the present invention. Based on the embodiments of the present invention, all other embodiments obtained by those of ordinary skill in the art without making creative efforts shall fall within the scope of protection of the present invention.

As shown in FIG. 1, a train autonomous running system based on train-to-train communication mainly includes a wayside resource manager (WRC), a wayside train controller (WTC), an object controller (OC), an automatic train supervision system (ATS), a carborne controller (CC), an intelligent operation and maintenance system (IOM), and a beacon. The automatic train supervision system (ATS) subsystem is responsible for supervising and controlling train operations, and has functions such as train tracking running, alarm and event reporting, running adjustment, and operation control. The wayside resource manager (WRC) is responsible for functions such as line resource allocation and recovery, train safety envelope verification and storage, and train sequence management. The wayside train controller (WTC) is mainly responsible for managing and tracking failed trains, taking over failed trains for resource application and release, and interacting with adjacent trains. The object controller (OC) mainly achieves the status collection and driving of wayside equipment. The carborne controller (CC) requests and releases line resources according to a plan, actively performs train control, and achieves train safety protection functions and automatic train operation functions. The beacon, combined with a line map, is responsible for providing location information of the line where it is located.

A principle of positioning initialization for a TACS degraded train is shown in FIG. 2. When controlling the train, the carborne controller (CC) calculates a train safety envelope and sends it to the wayside resource manager (WRC) (as indicated by A in FIG. 2). The WRC verifies and stores a received valid train safety envelope calculated by the CC, and sends train safety envelope confirmation information to the CC (as indicated by B in FIG. 2), indicating that the train safety envelope has been confirmed by the WRC.

When the CC fails or train-to-ground wireless communication fails, the CC can no longer control the train to apply for and release resources. At this time, the wayside train controller (WTC) takes over the train. The WRC sends the stored train safety envelope to the WTC (as indicated by C in FIG. 2). After receiving the stored train safety envelope, the WTC performs safety envelope initialization on the train, thereby obtaining position information of the train, implementing control over the train, and being responsible for applying for and releasing the resource for the train.

TACS train degradation initialization processing is shown in FIG. 3. During running of a TACS train (CC-ATP), a train safety envelope [a, b] is continuously calculated according to situations such as a current speed, a current position, a safety reaction time, an EB guarantee rate, a line gradient, and a current task. This envelope can ensure normal running of the TACS train without speed reduction. Simultaneously, the train safety envelope information is sent to the WRC. After receiving the train safety envelope information, the WRC performs verification and stores the train safety envelope information after the verification is passed (i.e., storing verification information). When the TACS train fails or communication is lost, the CC loses control authority over the train, and at the same time, an EB stop is triggered, and the train is prohibited from moving. A position of the train will not exceed a range of the train safety envelope [a, b]. At this time, the WTC obtains the train control authority. The WRC sends the stored train safety envelope [a, b] to the WTC. The WTC utilizes this train safety envelope to perform train position initialization (i.e., a method of verification), thereby obtaining position information of the train, implementing control over the train, and being responsible for applying for and releasing the resource for the train. Since the train ensures that it will not move after stopping by means of EB application, position information initialized by the WTC is valid.

A workflow of the TACS train degradation initialization processing is shown in FIG. 4, including the following steps:

step S101. controlling, by the carborne controller (CC), the train to run under ATP protection;

step S102. calculating, by the carborne controller (CC), a train position safety envelope;

step S103. sending, by the carborne controller (CC), the train position safety envelope to the WRC for storage;

step S104. determining whether a failure exists in the CC or train-to-ground communication, and if the failure exists in the CC or the train-to-ground communication, repeating the steps S101-S103, otherwise, executing step S105;

step S105. triggering an emergency brake (EB) stop by the train and prohibiting the train from moving;

step S106. sending, by the WRC, the stored train safety envelope to the WTC;

step S107. calculating, by the WTC, a wayside safety position of the train; and

step S108. taking over the train and applying for and releasing a resource by the WTC.

Manual train degradation initialization processing is shown in FIG. 5. During running of a manual train (CC-manual), a train safety envelope [c, d] is continuously calculated according to situations such as a current position and status of signal S3, i.e., a range from a train rear of the train to the red light signal S3. The CC sends the train safety envelope information [c, d] to the WRC. After receiving the train safety envelope information, the WRC performs verification and stores the train safety envelope information after the verification is passed (i.e., storing verification information). When the manual train fails or communication is lost, the CC loses control authority over the train and cannot apply for subsequent resources or release the resources. Since a driver is prohibited from driving the train past the red light signal S3, the train safety envelope remains within the range [c, d]. At this time, the WTC obtains the train control authority. The WRC sends the stored train safety envelope [c, d] to the WTC. The WTC utilizes this train safety envelope to perform train position initialization (i.e., a method of verification), thereby obtaining position information of the train, implementing control over the train, and being responsible for applying for and releasing the resource for the train. Since the train is prohibited from running a red light, the position information [c, d] initialized by

the WTC is ensured to be valid. For the abnormal situation where the manual train runs the red light signal, the TACS system is provided with additional crossing detection means. When an abnormal red light crossing occurs, the system performs sufficient protection, ensuring that even if the driver runs a red light, corresponding protection is provided.

A workflow of the manual train degradation initialization processing is shown in FIG. 6, including the following steps:

- step S201. enabling a manual train to run under manual protection;
- step S202. calculating, by the CC, a train position safety envelope to a red light signal;
- step S203. sending, by the CC, the train position safety envelope to the WRC for storage;
- step S204. determining whether a failure exists in the CC or train-to-ground communication, and if the failure exists in the CC or the train-to-ground communication, repeating the steps S201-S203, otherwise, executing step S205;
- step S205. prohibiting the train from running past the red light signal;
- step S206. sending, by the WRC, the stored train safety envelope to the WTC;
- step S207. calculating, by the WTC, a safety position of the train; and
- step S208. taking over the train and applying for and releasing a resource by the WTC.

The above is an introduction to embodiments of the method, and the solutions of the present invention are further explained by embodiments of an electronic device and a storage medium.

An embodiment of the present invention further provides an electronic device, including a central processing unit (CPU) that can execute various appropriate actions and processes according to computer program instructions stored in a read-only memory (ROM) or loaded from a storage unit into a random access memory (RAM). In the RAM, various programs and data required for device operation can also be stored. The CPU, the ROM, and the RAM are connected to each other via a bus. An input/output (I/O) interface is also connected to the bus.

A plurality of components in the device are connected to the I/O interface, including:

input units, such as a keyboard and a mouse; output units, such as various types of displays and speakers; storage units, such as a disk and an optical disc; and communication units, such as a network card, a modem, and a wireless communication transceiver. The communication unit allows the device to exchange information/data with other devices through computer networks such as the Internet and/or various telecommunication networks.

The processing unit performs the methods and processing described above, such as the method in the present invention. For example, in some embodiments, the method in the present invention may be implemented as computer software programs that are tangibly included in a machine-readable medium, such as a storage unit. In some embodiments, part or all of the computer program may be loaded and/or installed on the device via the ROM and/or the communication unit. When the computer programs are loaded into the RAM and executed by the CPU, one or more of the steps of the method in the present invention described above can be performed. Alternatively, in other embodiments, the CPU may be configured to perform the method in the present invention in any other proper manner (for example, with the help of firmware).

The functions described above herein can be executed, at least in part, by one or more hardware logic components. For example, without limitation, demonstration types of hardware logic components that can be used include: a field programmable gate array (FPGA), an application-specific integrated circuit (ASIC), an application-specific standard product (ASSP), a system-on-chip (SOC), a complex programmable logic device (CPLD), and so on.

Program codes for implementing the method of the present invention can be written in any combination of one or more programming languages. These program codes may be provided to a processor or controller of a general-purpose computer, a special-purpose computer, or another programmable data processing device, so that the program codes, when executed by the processor or controller, implement the functions/operations specified in the flow chart and/or block diagram. The program codes may be executed entirely on a machine, partially on a machine, partially on a machine and partially on a

remote machine as a standalone software package, or entirely on a remote machine or server.

In the context of the present invention, the machine-readable medium may be a tangible medium that may contain or store a program for use by or in conjunction with an instruction executing system, apparatus, or device. The machine-readable medium may be a machine-readable signal medium or a machine-readable storage medium. The machine-readable medium may include, but is not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the above. More specific examples of the machine-readable storage medium would include an electrical connection based on one or more wires, a portable computer disk, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable ROM (EPROM or flash memory), an optical fiber, a convenient compact disk ROM (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the above.

The above descriptions are only specific implementations of the present invention, but the scope of protection of the present invention is not limited thereto. Any of those skilled in the art can easily think of various equivalent modifications or substitutions within the technical scope of the present invention, and these modifications or substitutions shall all be included within the scope of protection of the present invention. Therefore, the scope of protection of the present invention shall be determined based on the scope of protection of the claims.

CLAIMS

1. A train autonomous circumambulation system (TACS) degraded train positioning information initialization method, comprising calculating a train safety envelope according to a principle of a TACS train authorization permitted running range or red light signal blocking, thereby effectively initializing a position of the TACS degraded train.

2. The TACS degraded train positioning information initialization method according to claim 1, wherein the method is implemented by interaction of a wayside resource manager (WRC) with a carborne controller (CC) and a wayside train controller (WTC), respectively.

3. The TACS degraded train positioning information initialization method according to claim 2, wherein when controlling the train, the carborne controller (CC) calculates the train safety envelope and sends the train safety envelope to the wayside resource manager (WRC), and the WRC verifies and stores a received valid train safety envelope calculated by the CC and sends train safety envelope confirmation information to the CC.

4. The TACS degraded train positioning information initialization method according to claim 2, wherein when the CC fails or train-to-ground wireless communication fails, the wayside train controller (WTC) takes over the train, the WRC sends the stored train safety envelope to the WTC, and after receiving the train safety envelope, the WTC performs safety envelope initialization on the train, thereby obtaining position information of the train.

5. The TACS degraded train positioning information initialization method according to claim 2, comprising a TACS train degradation initialization processing process and a manual train degradation initialization processing process.

6. The TACS degraded train positioning information initialization method according to claim 5, wherein the TACS train degradation initialization processing process specifically comprises:

step S101. controlling, by the carborne controller (CC), the train to run under automatic train protection (ATP) protection;

step S102. calculating, by the carborne controller (CC), a train position safety

envelope;

step S103. sending, by the carborne controller (CC), the train position safety envelope to the WRC for storage;

step S104. determining whether a failure exists in the CC or train-to-ground communication, and if the failure exists in the CC or the train-to-ground communication, repeating the steps S101-S103, otherwise, executing step S105;

step S105. triggering an emergency brake (EB) stop by the train and prohibiting the train from moving;

step S106. sending, by the WRC, the stored train safety envelope to the WTC;

step S107. calculating, by the WTC, a wayside safety position of the train; and

step S108. taking over the train and applying for and releasing a resource by the WTC.

7. The TACS degraded train positioning information initialization method according to claim 6, wherein the calculating, by the carborne controller (CC), a train position safety envelope in the step S102 is specifically as follows:

continuously calculating, by the carborne controller (CC), a train safety envelope [a, b] according to a current speed, a current position, a safety reaction time, an EB guarantee rate, a line gradient, and current task information.

8. The TACS degraded train positioning information initialization method according to claim 7, wherein the train safety envelope [a, b] is a range that ensures normal running of the TACS train without speed reduction.

9. The TACS degraded train positioning information initialization method according to claim 6, wherein in the step S103, after receiving train safety envelope information, the WRC performs verification and stores the train safety envelope information after the verification is passed.

10. The TACS degraded train positioning information initialization method according to claim 5, wherein the manual train degradation initialization processing process specifically comprises:

step S201. enabling a manual train to run under manual protection;

step S202. calculating, by the CC, a train position safety envelope to a red light signal;
step S203. sending, by the CC, the train position safety envelope to the WRC for storage;

step S204. determining whether a failure exists in the CC or train-to-ground communication, and if the failure exists in the CC or the train-to-ground communication, repeating the steps S201-S203, otherwise, executing step S205;

step S205. prohibiting the train from running past the red light signal;

step S206. sending, by the WRC, the stored train safety envelope to the WTC;

step S207. calculating, by the WTC, a safety position of the train; and

step S208. taking over the train and applying for and releasing a resource by the WTC.

11. The TACS degraded train positioning information initialization method according to claim 10, wherein in the step S202, the calculating is specifically as follows:

continuously calculating, by the CC, a train safety envelope [c, d] according to a current position of the manual train and status information of the nearest red light signal.

12. The TACS degraded train positioning information initialization method according to claim 11, wherein the train safety envelope [c, d] is from a train rear of the train to the red light signal.

13. The TACS degraded train positioning information initialization method according to claim 10, wherein in the step S203, after receiving train safety envelope information, the WRC performs verification and stores the train safety envelope information after the verification is passed.

14. The TACS degraded train positioning information initialization method according to claim 11, wherein the prohibiting the train from running past the red light signal in the step S205 causes the train safety envelope to remain within a range of the train safety envelope [c, d], and at this time, the WTC obtains train control authority, the WRC sends the stored train safety envelope [c, d] to the WTC, and the WTC utilizes the train safety envelope to perform train position initialization, thereby obtaining position information of the train, implementing control over the train, and being responsible for

applying for and releasing the resource for the train.

15. An electronic device, comprising a memory on which a computer program is stored and a processor, wherein the processor, when executing the program, implements the method according to any one of claims 1-14.

16. A computer-readable storage medium having a computer program stored thereon, wherein the program, when executed by a processor, implements the method according to any one of claims 1-14.