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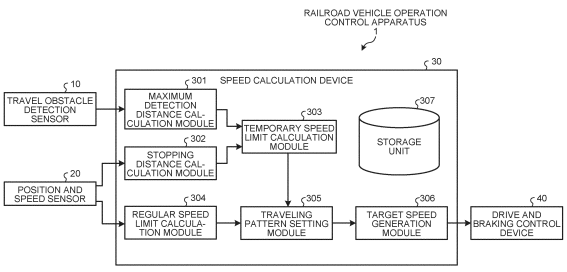
(54) RAILROAD CAR OPERATION CONTROL APPARATUS

(57) A railroad vehicle operation control apparatus according to an embodiment includes a sensor configured to detect an obstacle in a traveling direction of a railroad vehicle in traveling, a maximum detection distance calculation module configured to calculate a maximum detection distance within which the sensor is able to detect the obstacle, a stopping distance calculation module configured to calculate a stopping distance when an emergency brake of the railroad vehicle is applied, a temporary speed limit calculation module configured to calculate a temporary speed limit that is a vehicle speed at which the railroad vehicle is able to stop by the emergency brake at the smaller distance of the maximum detection distance and the stopping distance, a regular speed limit calculation module configured to calculate a regular speed limit corresponding to a position of the railroad vehicle during normal traveling, a traveling pattern setting module configured to calculate and set a traveling pattern representing relationship between the position and a target speed of the railroad vehicle based on the temporary speed limit and the regular speed limit, and a target speed generation module configured to generate the target speed based on the traveling pattern and transmit the target speed to a control device of the railroad vehicle.

FIG.2



EP 4 324 719 A1

Description

FIELD

[0001] Embodiments of the present invention relate to a railroad vehicle operation control apparatus.

BACKGROUND

[0002] Conventionally, railroad managers need to check for obstacles in the path of railroad vehicles, such as railroad trains and electric trains, in order to ensure the safety of the railroad vehicles in operation of the railroad vehicles. For this purpose, for example, there are techniques using sensors (e.g., cameras) to detect obstacles existing in front of a railroad vehicle in traveling.

CITATION LIST

Patent Literature

[0003]

[Patent Literature 1] Japanese Patent No. 3244870
[Patent Literature 2] Japanese Patent Application Laid-open No. 2019-84881
[Patent Literature 3] Japanese Patent Application Laid-open No. 2004-357399
[Patent Literature 4] Japanese Patent No. 3160793
[Patent Literature 5] Japanese Patent Application Laid-open No. 2020-62899
[Patent Literature 6] Japanese Translation of PCT International Application Publication No. 2019-537534
[Patent Literature 7] Japanese Patent Application Laid-open No. 2000-264209

SUMMARY OF THE INVENTION

Problem to be Solved by the Invention

[0004] In the method described above, the maximum detection distance of the sensor to an obstacle differs according to geographical and environmental conditions (weather conditions, etc.). Therefore, for example, when the maximum detection distance of the sensor to an obstacle is short, if the traveling speed is not slowed down, a collision between the railroad vehicle and the obstacle may not be avoided if braking is started after the obstacle is detected. However, conventional technology fails to take measures against this point.

[0005] Therefore, an object of the present embodiment is to provide a railroad vehicle operation control apparatus capable of adjusting the traveling speed of a railroad vehicle according to the maximum detection distance of a sensor to an obstacle.

Means for Solving Problem

[0006] A railroad vehicle operation control apparatus according to one embodiment includes: a sensor configured to detect an obstacle in a traveling direction of a railroad vehicle in traveling; a maximum detection distance calculation module configured to calculate a maximum detection distance within which the sensor is able to detect the obstacle; a stopping distance calculation module configured to calculate a stopping distance when an emergency brake of the railroad vehicle is applied; a temporary speed limit calculation module configured to calculate a temporary speed limit that is a vehicle speed at which the railroad vehicle is able to stop by the emergency brake at a smaller distance of the maximum detection distance and the stopping distance; a regular speed limit calculation module configured to calculate a regular speed limit corresponding to a position of the railroad vehicle during normal traveling; a traveling pattern setting module configured to calculate and set a traveling pattern representing relationship between the position and a target speed of the railroad vehicle based on the temporary speed limit and the regular speed limit; and a target speed generation module configured to generate the target speed based on the traveling pattern and transmit the target speed to a control device of the railroad vehicle.

BRIEF DESCRIPTION OF DRAWINGS

[0007]

FIG. 1 is a diagram illustrating a schematic configuration of a railroad vehicle according to an embodiment.
FIG. 2 is a block diagram illustrating a functional configuration of a speed calculation device according to the embodiment.
FIG. 3 is a diagram schematically illustrating an example of an image taken by a travel obstacle detection sensor according to the embodiment.
FIG. 4 is a flowchart illustrating processing executed by the railroad vehicle operation control apparatus according to the embodiment.

DETAILED DESCRIPTION

[0008] A railroad vehicle operation control apparatus according to an embodiment will be explained below with reference to the accompanying drawings. To facilitate understanding of the railroad vehicle operation control apparatus according to the embodiment, the conventional technology is first explained again.

(Conventional Technology)

[0009] Railroad managers need to check for obstacles in the path of railroad vehicles, such as railroad trains

and electric trains, in order to ensure the safety of the railroad vehicles in operation of the railroad vehicles. For example, the following may be installed in sections where obstacles to the path of railroad vehicles are likely to occur due to fall of passengers or luggage from station platforms and/or automobiles or bicycles stalled at railroad crossings, or the like.

- Station platform fences and railroad crossing gates to prevent the entry of obstacles
- Station platform fall detection devices, such as pressure-sensitive mats that detect the presence of obstacles and/or image recognition devices that recognize images of obstacles
- Optical, loop coil, and other types of railroad crossing obstacle detection devices that detect the presence of obstacles at railroad crossings

[0010] In addition, emergency stop warning buttons may be installed in sections where obstacles are likely to occur in the path of railroad vehicles, to give notice of an emergency situation of railroad trains and/or stations, etc.

[0011] However, these facilities are only installed in areas of the railroad vehicle path where obstacles are likely to occur, and it is difficult to cover the entire railroad vehicle path. In addition, since these facilities require ground equipment and on-board equipment to work together to detect obstacles, there is concern that this will lead to increased system complexity and a bloated system. For this reason, a system has been developed to detect obstacles existing in front of a railroad vehicle in traveling using sensors (e.g., cameras) mounted on the railroad vehicle.

[0012] By the way, there is a high possibility that a railroad vehicle cannot avoid a collision with an obstacle, if it does not detect the obstacle at a distance shorter than the stopping distance. The stopping distance is the sum of the idle running distance by which the railroad vehicle travels until the driver or the above equipment detects the obstacle and takes action to slow down the railroad vehicle, and the braking distance from when the railroad vehicle starts to slow down to a stop.

[0013] In addition, railroad vehicles are different from automobile collision avoidance systems in that the railroad vehicles have longer braking distances and cannot avoid obstacles by steering due to the constraints of traveling on rails. Therefore, railroad vehicles are required to detect obstacles existing in their path from a distance with high accuracy.

[0014] However, the size of the detectable area (distance) of a sensor (e.g., camera) changes from time to time depending on the traveling conditions due to geographical and environmental conditions (e.g., weather conditions). Under the condition that the detectable distance is shorter than the stopping distance, it is likely that a collision with an obstacle cannot be avoided. In the conventional technology, the only restriction is simply to travel at or below a preset speed limit for each section, so even if an obstacle is actually detected, there is a possibility that the vehicle may not be traveling at a speed at which a collision can be avoided.

[0015] Therefore, the following explanation illustrates a technology that can adjust the traveling speed of railroad vehicles according to the maximum detection distance of the sensor to an obstacle.

Embodiment

[0016] FIG. 1 is a diagram illustrating a schematic configuration of a railroad vehicle RV according to an embodiment. As illustrated in FIG. 1, a railroad vehicle RV according to the present embodiment includes a travel obstacle detection sensor 10, a position and speed sensor 20, a speed calculation device 30, and a drive and braking control device 40.

[0017] The travel obstacle detection sensor 10 is an example of a device that detects obstacles in a traveling direction of the railroad vehicle RV in traveling. The range in which the travel obstacle detection sensor 10 detects obstacles may be limited to a track.

[0018] The position and speed sensor 20 is an example of a device that measures the position and the traveling speed of the railroad vehicle RV.

[0019] The speed calculation device 30 is an example of a device that calculates a target speed based on detection results of obstacles and/or the detectable distance to obstacles by the travel obstacle detection sensor 10 and the position and the traveling speed of the railroad vehicle RV obtained by the position and speed sensor 20 and the like.

[0020] The drive and braking control device 40 is an example of a device that controls the traveling speed and other aspects of the railroad vehicle RV by powering, coasting, and braking based on the target speed and other factors.

[0021] FIG. 2 is a block diagram illustrating a functional configuration of the speed calculation device 30 according to the embodiment. As illustrated in FIG. 2, the speed calculation device 30 includes a maximum detection distance calculation module 301, a stopping distance calculation module 302, a temporary speed limit calculation module 303, a regular speed limit calculation module 304, a traveling pattern setting module 305, a target speed generation module 306, and a storage unit 307. Some or all of the units 301 to 306 are achieved by a processor included in the railroad vehicle RV, such as a central processing unit (CPU), executing software stored in the storage unit 307.

[0022] In addition, some or all of the units 301 to 306 may be achieved by hardware being a circuit board, such as a large scale integration (LSI), an application specific integrated circuit (ASIC), and a field programmable gate array (FPGA), etc. The units 301 to 306 may be achieved by cooperation of software executed by the processor and hardware.

[0023] The storage unit 307 includes a non-volatile storage medium, such as a read-only memory (ROM), a flash memory, a hard disk drive (HDD), and a secure digital (SD) card, and a volatile storage medium, such as a random-access memory (RAM) and a register. The storage unit 307 stores therein various information items, such as computer programs executed by the processor included in the railroad vehicle RV.

[0024] The maximum detection distance calculation module 301 timely calculates the maximum detection distance at which obstacles can be detected by the travel obstacle detection sensor 10 for the traveling direction of the railroad vehicle RV. The travel obstacle detection sensor 10 can be any type of sensor, including a camera image recognition sensor (imaging device), a stereo camera sensor, a millimeter wave radar sensor, a 3D light detection and ranging (LiDAR) sensor, and others. Herein, FIG. 3 is a diagram schematically illustrating an example of an image taken by the travel obstacle detection sensor 10 according to the embodiment. When the travel obstacle detection sensor 10 is a camera image recognition sensor, image data as illustrated in FIG. 3 can be obtained.

[0025] When the travel obstacle detection sensor 10 is a sensor using visible light camera images, the detection performance may deteriorate due to the sunlight environment. For example, when the sun is included within the camera's angle of view, halation (overexposure) occurs in the camera image, or black clipping occurs in areas other than the sun to adjust the brightness level of the entire image. In addition, in low-illuminance environments, such as at night or in tunnels, accurate detection may only be possible in a range as far as the front lights of the railroad vehicle RV can reach. Regardless of the type of the travel obstacle detection sensor 10, detection performance may deteriorate due to weather conditions, such as clouds, rain, snow, fog, temperature, humidity, wind, and tornadoes.

[0026] Based on these circumstances, the maximum detection distance calculation module 301 calculates the maximum detection distance of the travel obstacle detection sensor 10 in a timely manner based on predetermined weather information obtained from outside. Examples of the calculation method include a method of calculating the maximum detection distance by analyzing the actual measurement data of the travel obstacle detection sensor 10, and a method of performing measurement for the sunlight and/or environmental conditions and storing the relationship between those conditions and the maximum detection distance of the travel obstacle detection sensor 10 as a database in the storage unit 307 in advance. For example, with the video image analysis technology of a visible light camera, as disclosed in Japanese Patent Application Laid-open No. 2019-84881, the continuity of the rail area is analyzed from the video image of the rail track, to determine the distance at which a distant place cannot be visualized due to rain or fog and use it as the maximum detection distance.

[0027] In addition, the vegetation growing on the inside part of the curve may reduce visibility due to temporary concealment. While it does not obstruct traveling in itself, poor visibility reduces the distance at which an obstacle can be detected by the travel obstacle detection sensor 10. Also in this case, a distance up to the divided position can be calculated as the maximum detection distance by analyzing the continuity of the rail area on the image, as in the case of video analysis of a visible light camera, as in the technique in Japanese Patent Application Laid-open No. 2019-84881 described above.

[0028] On the other hand, the detection performance may deteriorate due to a defect in the travel obstacle detection sensor 10 itself. In the case of using an active sensor, a self-diagnostic function may be provided to check for degradation of output signals, sensitivity degradation due to sensor contamination, etc., or performance degradation due to external noise. In such a case, the maximum detection distance calculation module 301 calculates the maximum detection distance based on the self-diagnosis results acquired by the travel obstacle detection sensor 10.

[0029] The stopping distance calculation module 302 calculates the stopping distance at the time when the emergency brakes are applied based on the vehicle's own speed and other data obtained from the position and speed sensor 20. A stationary distance at which the railroad vehicle RV can securely stop is calculated in a timely manner in consideration of the idle running distance until an emergency brake command is issued and the brakes are applied, as well as the actual vehicle body weight, brake characteristics, and the braking distance with the rail surface condition taken into account.

[0030] The temporary speed limit calculation module 303 calculates an upper limit value of the traveling speed, i.e., the temporary speed limit that is the vehicle speed at which the railroad vehicle RV can stop by emergency braking, from a maximum detection distance value Ld calculated by the maximum detection distance calculation module 301 and a stopping distance value Ls calculated by the stopping distance calculation module 302. During normal traveling, "Ld > Ls" is satisfied, and the railroad vehicle RV is traveling in a state in which a distant place farther than the distance at which the railroad vehicle RV can stop is detectable.

[0031] On the other hand, if "Ld < Ls" is satisfied, the railroad vehicle RV cannot necessarily stop at all distances at which the travel obstacle detection sensor 10 can detect an obstacle. Therefore, the vehicle speed at which contact with an obstacle can be avoided or damage can be reduced is calculated. For example, to avoid contact with an obstacle, the speed should be limited to speed at which "Ld > Ls" is satisfied. The speed is calculated as the temporary speed limit in a timely manner.

[0032] However, if an obstacle approaches the railroad vehicle RV, contact with the obstacle may be unavoidable even if the railroad vehicle RV is able to stop at the distance with the stopping distance value Ls. If the travel

obstacle detection sensor 10 can also measure the moving speed of the detected obstacle, it can also take the relative speed (relative approach speed) of the obstacle into account to reduce contact damage by setting the temporary speed limit smaller than normal.

[0033] If the obstacle is moving away from the railroad vehicle RV, the temporary speed limit may be set greater than normal, also in consideration of the relative speed (relative leaving speed) of the obstacle. It is also possible to perform control to apply no temporary speed limit, when the moving direction of the detected obstacle is the direction of exiting from the track.

[0034] If the travel obstacle detection sensor 10 can recognize the type of the detected obstacle, the temporary speed limit is calculated according to the type of the detected obstacle. If the type of the obstacle is a wild animal or the like that is likely to leave the area by a whistle, for example, no temporary speed limit may be applied. If the type of the obstacle is a fire along the line, it may be better in some situations to allow the railroad vehicle RV to run through without stopping to reduce damage, and no temporary speed limit may be applied.

[0035] The regular speed limit calculation module 304 calculates a predetermined speed limit (regular speed limit) for the section based on the position information of the own vehicle (railroad vehicle RV) during normal traveling obtained from the position and speed sensor 20.

[0036] When the travel obstacle detection sensor 10 is an imaging device that images an area on and above the track in the traveling direction of the railroad vehicle RV, the maximum detection distance calculation module 301 calculates the maximum detection distance based on the images taken by the imaging device. The detection performance by the imaging device deteriorates due to, for example, concealment by structures (station platforms, pillars, distribution boards, and other peripheral equipment) at curves and poor visibility due to uphill gradients, which occur depending on the traveling position of the own vehicle. In many cases, it is possible to recognize in advance the decline in detection performance based on the type of the own vehicle, its position, the traveling direction, etc. The regular speed limit determined in consideration of these factors may be stored as a database in the storage unit 307 and referred to, based on the own vehicle's position information.

[0037] The traveling pattern setting module 305 calculates and sets a traveling pattern that represents the relationship between the position and the target speed of the railroad vehicle RV based on the temporary speed limit and the regular speed limit. For example, the traveling pattern setting module 305 calculates and sets a traveling pattern that represents the relationship between the position and the target speed of the railroad vehicle RV as a vehicle traveling plan between the next station arrival time at which the traveling vehicle stops next and the current time. For example, in view of the temporary speed limit that changes from time to time, a traveling pattern is generated using conventional technologies, such as Japanese Patent Application Laid-open No. 2004-357399 and Japanese Patent No. 3160793.

[0038] The target speed generation module 306 generates a target speed based on the position and the traveling pattern of the railroad vehicle RV and transmits the target speed to the drive and braking control device 40.

[0039] The drive and braking control device 40 compares the target speed with the actual vehicle speed using known feedback (feedback) control techniques, performs compensation calculations to stabilize the control system, determines a thrust command, and provides it to a thrust controller. As a result, the railroad vehicle RV can travel between stations according to the traveling pattern and arrive at the next station at the target time.

[0040] FIG. 4 is a flowchart illustrating processing executed by the railroad vehicle operation control apparatus 1 according to the embodiment. First, at Step S1, the travel obstacle detection sensor 10 detects an obstacle in the traveling direction of the railroad vehicle RV in traveling.

[0041] Next, at Step S2, the maximum detection distance calculation module 301 calculates the maximum detection distance at which an obstacle can be detected by the travel obstacle detection sensor 10 for the traveling direction of the railroad vehicle RV.

[0042] Next, at Step S3, the stopping distance calculation module 302 calculates the stopping distance at the time when the emergency brakes are applied based on the own vehicle speed and other information obtained from the position and speed sensor 20.

[0043] Next, at Step S4, the temporary speed limit calculation module 303 calculates the temporary speed limit at which the railroad vehicle RV can stop by emergency braking, based on the maximum detection distance value and the stopping distance value.

[0044] Next, at Step S5, the regular speed limit calculation module 304 calculates the regular speed limit based on the position information of the railroad vehicle RV during normal traveling obtained from the position and speed sensor 20.

[0045] Next, at Step S6, the traveling pattern setting module 305 calculates and sets a traveling pattern that represents the relationship between the position and the target speed of the railroad vehicle RV based on the temporary speed limit and the regular speed limit.

[0046] Next, at Step S7, the target speed generation module 306 generates a target speed based on the position and the traveling pattern of the railroad vehicle RV.

[0047] Next, at Step S8, the drive and braking control device 40 controls the speed, etc. of the railroad vehicle RV by powering, coasting, and braking based on the target speed, etc.

[0048] As described above, with the railroad vehicle RV according to the present embodiment, the traveling speed of the railroad vehicle RV can be adjusted according to the maximum detection distance of the travel ob-

stacle detection sensor 10 to an obstacle. In other words, this enables safer automatic operation control for the railroad vehicle RV, in consideration of the timely changing detection performance of the travel obstacle detection sensor 10 mounted on the railroad vehicle RV.

[0049] In addition, the maximum detection distance can be calculated with higher accuracy based on weather information, images taken by the travel obstacle detection sensor 10, and self-diagnosis results from the travel obstacle detection sensor 10.

[0050] In addition, the temporary speed limit can be calculated with higher accuracy based on the moving speed and/or the type of the obstacle.

[0051] Although several embodiments according to the present invention have been described, these embodiments are presented for illustrative purposes only and are not intended to limit the scope of the invention. These novel embodiments can be implemented in various other forms, and various omissions, substitutions, and modifications can be made within the scope and spirit of the invention. The embodiments and modifications thereto are within the scope and spirit of the invention and are within the invention described in claims and equivalents thereof.

[0052] For example, the above embodiment illustrates a case in which the present invention is applied to speed control technology (automatic driving technology) using feedback control to cause the actual vehicle speed to follow the target speed, but the invention is not limited thereto. For example, the present invention may be applied to a guidance device that displays the target speed on the cab of a vehicle for the driver's reference.

[0053] In addition to data from the own vehicle, data from other railroad vehicles that have traveled on the same track may be used to perform various calculations, etc.

Claims

1. A railroad vehicle operation control apparatus comprising:

a sensor configured to detect an obstacle in a traveling direction of a railroad vehicle in traveling;
a maximum detection distance calculation module configured to calculate a maximum detection distance within which the sensor is able to detect the obstacle;
a stopping distance calculation module configured to calculate a stopping distance when an emergency brake of the railroad vehicle is applied;
a temporary speed limit calculation module configured to calculate a temporary speed limit that is a vehicle speed at which the railroad vehicle is able to stop by the emergency brake at a smaller distance of the maximum detection distance and the stopping distance;
a regular speed limit calculation module configured to calculate a regular speed limit corresponding to a position of the railroad vehicle during normal traveling;
a traveling pattern setting module configured to calculate and set a traveling pattern representing relationship between the position and a target speed of the railroad vehicle based on the temporary speed limit and the regular speed limit; and
a target speed generation module configured to generate the target speed based on the traveling pattern and transmit the target speed to a control device of the railroad vehicle.

2. The railroad vehicle operation control apparatus according to claim 1, wherein the maximum detection distance calculation module is configured to calculate the maximum detection distance based on predetermined weather information obtained from outside.

3. The railroad vehicle operation control apparatus according to claim 1, wherein

the sensor includes an imaging device configured to image an area on and above a track in the traveling direction of the railroad vehicle, and the maximum detection distance calculation module is configured to calculate the maximum detection distance based on an image taken by the imaging device.

4. The railroad vehicle operation control apparatus according to claim 1, wherein the maximum detection distance calculation module is configured to calculate the maximum detection distance based on a self-diagnosis result by the sensor.

5. The railroad vehicle operation control apparatus according to claim 1, wherein

the sensor is configured to measure a moving speed of the detected obstacle, and
the temporary speed limit calculation module is configured to calculate the temporary speed limit based on a relative speed between the railroad vehicle and the obstacle.

6. The railroad vehicle operation control apparatus according to claim 1, wherein

the sensor is configured to recognize a type of the detected obstacle, and
the temporary speed limit calculation module is configured to calculate the temporary speed lim-

it according to the type of the obstacle.

FIG.1

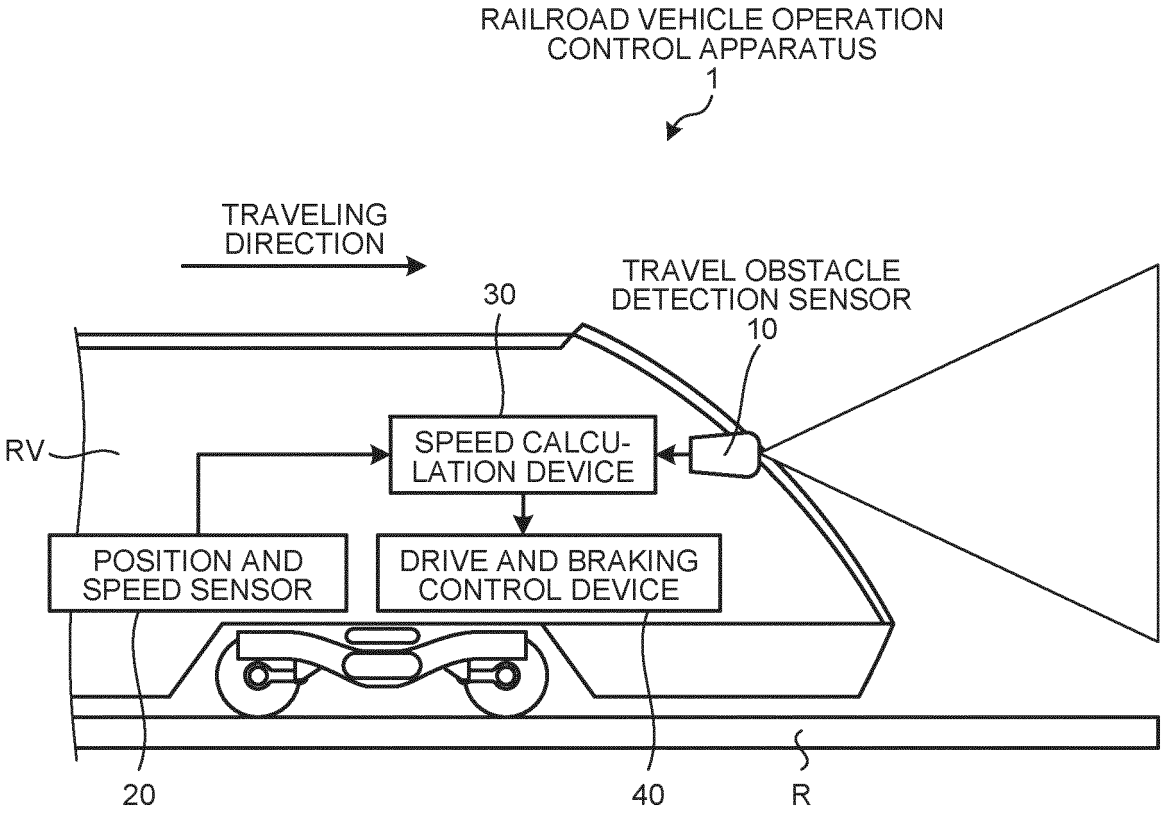

RAILROAD VEHICLE OPERATION CONTROL APPARATUS
1
TRAVELING DIRECTION
30
TRAVEL OBSTACLE DETECTION SENSOR
10
RV
SPEED CALCU-LATION DEVICE
POSITION AND SPEED SENSOR
DRIVE AND BRAKING CONTROL DEVICE
20
40
R

FIG.2

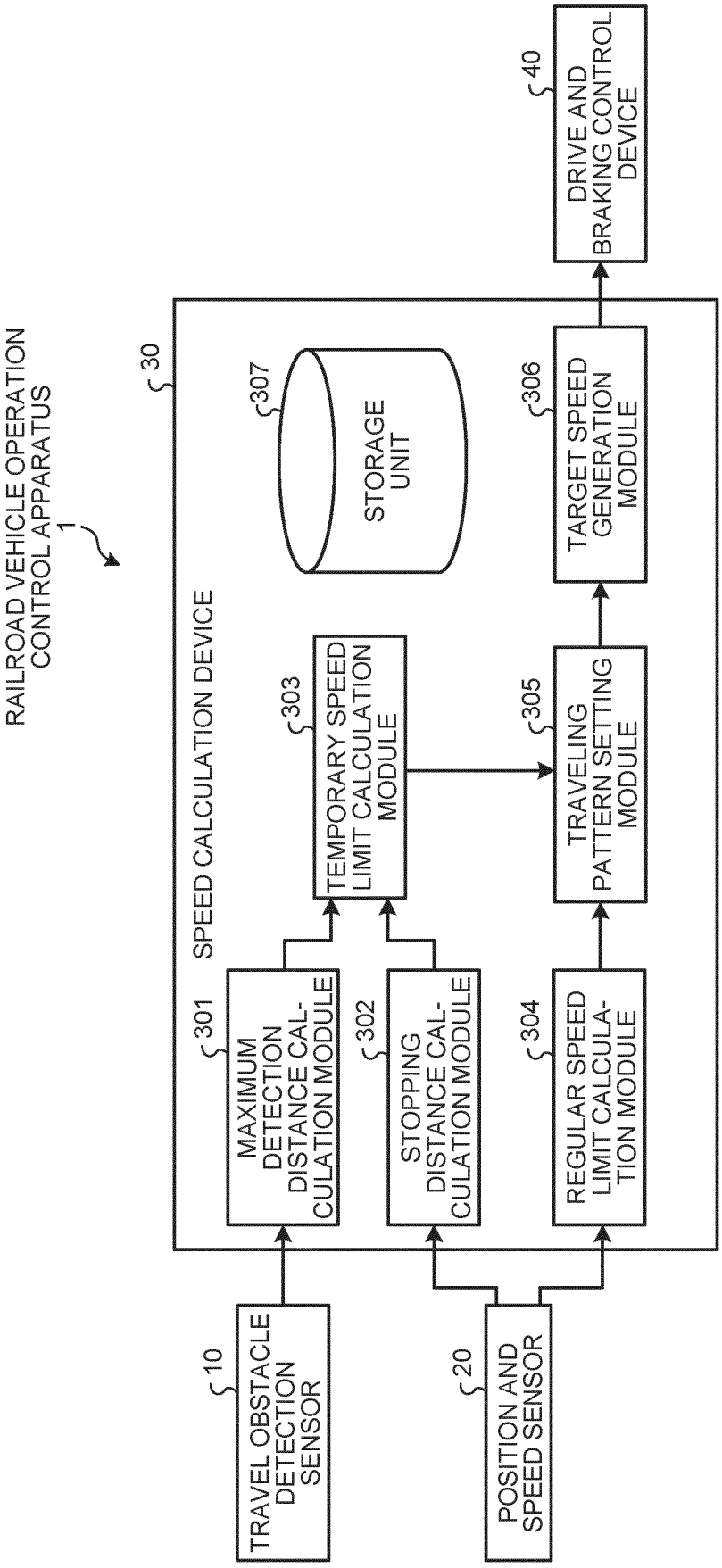

RAILROAD VEHICLE OPERATION CONTROL APPARATUS
1
30
SPEED CALCULATION DEVICE
10
TRAVEL OBSTACLE DETECTION SENSOR
20
POSITION AND SPEED SENSOR
301
MAXIMUM DETECTION DISTANCE CALCULATION MODULE
302
STOPPING DISTANCE CALCULATION MODULE
303
TEMPORARY SPEED LIMIT CALCULATION MODULE
304
REGULAR SPEED LIMIT CALCULATION MODULE
305
TRAVELING PATTERN SETTING MODULE
306
TARGET SPEED GENERATION MODULE
307
STORAGE UNIT
40
DRIVE AND BRAKING CONTROL DEVICE

FIG.3

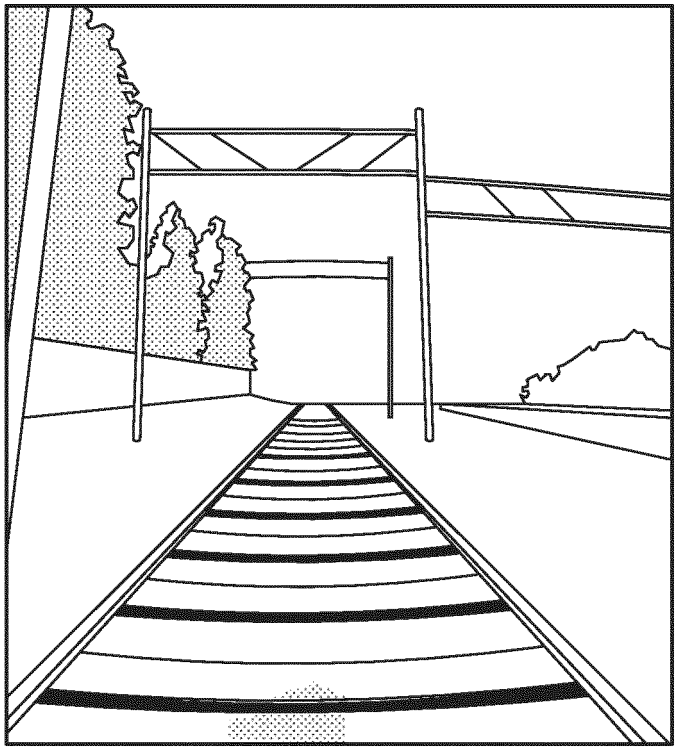
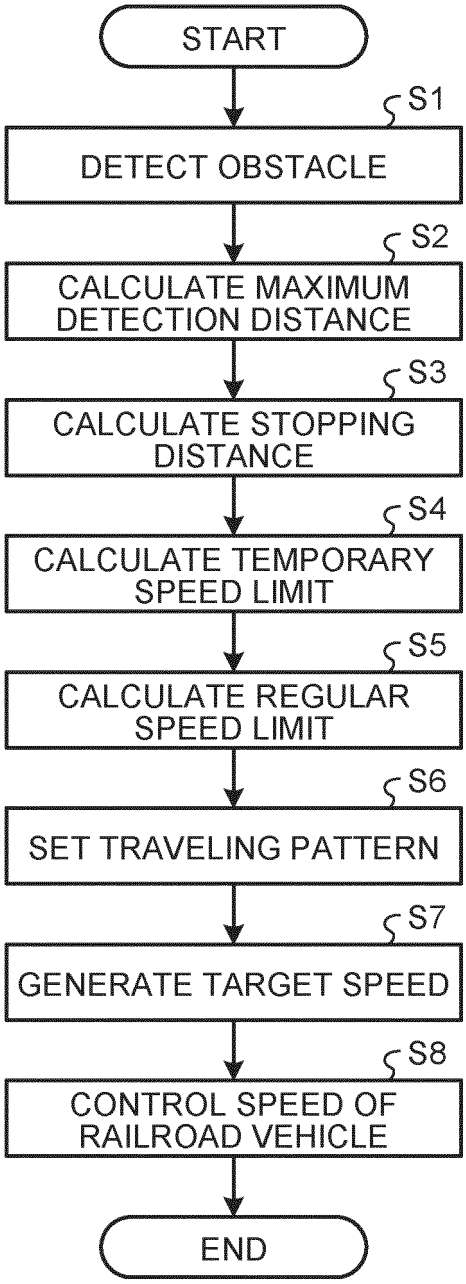


FIG.4


START
S1
DETECT OBSTACLE
S2
CALCULATE MAXIMUM DETECTION DISTANCE
S3
CALCULATE STOPPING DISTANCE
S4
CALCULATE TEMPORARY SPEED LIMIT
S5
CALCULATE REGULAR SPEED LIMIT
S6
SET TRAVELING PATTERN
S7
GENERATE TARGET SPEED
S8
CONTROL SPEED OF RAILROAD VEHICLE
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/017791

A. CLASSIFICATION OF SUBJECT MATTER

B61L 23/00(2006.01)i; ***B61C 17/12***(2006.01)i
FI: B61L23/00 A; B61C17/12 Z

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B61L23/00; B61C17/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2016-162383 A (HITACHI, LTD.) 05 September 2016 (2016-09-05) paragraphs [0009]-[0038], fig. 1-2	1-6
A	JP 2019-503302 A (RAIL VISION LTD.) 07 February 2019 (2019-02-07) paragraphs [0001]-[0002], [0022]-[0066], fig. 1-7	1-6
A	JP 2020-164013 A (HITACHI, LTD.) 08 October 2020 (2020-10-08) paragraphs [0068]-[0074]	1-6
A	JP 3160793 B2 (HITACHI, LTD.) 25 April 2001 (2001-04-25) paragraphs [0011]-[0012], fig. 5-6	1-6
P, A	WO 2022/009273 A1 (MITSUBISHI ELECTRIC CORP.) 13 January 2022 (2022-01-13) paragraphs [0032]-[0045], fig. 7-9	1-6

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 June 2022	**05 July 2022**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/017791

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JP 2016-162383 A	05 September 2016	(Family: none)	
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