

TITLE OF THE INVENTION
AUTOMATIC TRAIN CONTROL DEVICE

BACKGROUND OF THE INVENTION

The present invention is suitable in applying to an automatic train control device and an automatic train control method which control travel of a train.

In recent years, in the light of the crammed train operation diagram, increase of
5 the platform door, and so on, with the aim of reducing the load of the crew and trimming the labor cost, introduction of the automatic train control (ATO) device has been in progress. Among the ATO devices, the train automatic stop control (TASC) device in particular for stopping the train so as to precisely match the train door position with the platform door position has been vigorously introduced to many lines accompanying introduction of the platform door to
10 stations of existing lines.

In JP-A-2015-012676, a technology on an ATO device is disclosed. More specifically, an automatic train control device is disclosed which on-line processes data acquired at the time of train travel, automatically learns the train property at the time of the train travel based on the data on-line processed, and executes automatic operation of the train using the train
15 property automatically learnt.

In JP-A-2015-012676, it is mentioned that the train property can be automatically learnt on-line during travel and that automatic operation of the train can be effected using the result automatically learnt. In concrete terms, the waveform of the commanded deceleration and the waveform of the generated deceleration are generally similar, both waveforms are
20 superimposable by parallel displacement in the time axis direction and the deceleration axis direction, and the amount of the parallel displacement is learnt as the deviation from the designed value.

However, according to the technology described in JP-A-2015-012676, when the step size of the parallel displacement in the time axis direction and the deceleration axis direction
25 is small, the calculation load increases, whereas when the step size of the parallel displacement is large, the waveform of the commanded deceleration and the waveform of the generated deceleration cannot be superimposed precisely and the deviation from the designed value cannot be calculated precisely from the amount of the parallel displacement.

30 SUMMARY OF THE INVENTION

The present invention has been achieved in view of the points described above,

and proposes an automatic train control device that reduces the calculation load while precisely calculating the deviation from the designed value. By the present invention, the vehicle property learning function can be installed to the automatic train control device, and change of the vehicle property caused by aged deterioration and replacement of parts can be coped with.

5 In order to solve such problem, according to an aspect of the present invention, in an automatic train control device including a vehicle property learning unit that automatically learns the vehicle property of a train of an object of data acquisition acquired at the time of travel of the train, the vehicle property learning unit causes waveform of generated deceleration calculated from the actual motion of the train to be displaced parallel in the time axis direction
10 and the deceleration axis direction, defines the approximation function that approximates the evaluating function, the approximation function being the shift of both waveforms of the waveform of the generated deceleration and the waveform of the commanded deceleration to be outputted in design, analytically calculates the local minimum value of the approximation function, thereby determines the parallel displacement amount of the case the evaluating function
15 is minimized, and calculates the vehicle property from the parallel displacement amount.

According to the present invention, the calculation load can be reduced while precisely calculating the deviation from the designed value.

Other objects, features and advantages of the invention will become apparent from the following description of the embodiments of the invention taken in conjunction with the
20 accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a function configuration drawing of a train automatic stop control device.

25 FIG. 2 is a relation drawing of the vehicle speed, the commanded deceleration and the generated deceleration, and the elapsed time.

FIG. 3 is a function configuration drawing of a train automatic stop control device having a vehicle property learning function.

30 FIG. 4 is a relation drawing of the step size of the parallel displacement in the time axis direction and the deceleration axis direction and the evaluating function.

FIG. 5 is a function configuration drawing of an automatic train control device in the first embodiment.

FIG. 6 is a flowchart showing the vehicle property value calculating process of the first embodiment.

FIG. 7 is a function configuration drawing of an automatic train control device in the second embodiment.

FIG. 8 is a schematic drawing for a representative point determining method in the second embodiment.

5 FIG. 9 is a function configuration drawing of an automatic train control device in the third embodiment.

DESCRIPTION OF THE EMBODIMENTS

Below, an embodiment of the present invention will be explained in detail referring to the drawings. Also, FIG. 1-FIG. 3 are explanatory drawings explaining the configuration and the object of the train automatic stop control device (TASC device) included in common automatic train control device (ATO device), and FIG. 5-FIG. 9 are explanatory drawings explaining the configuration of the automatic train control device (particularly the train automatic stop control device) in the present embodiments.

15 Further, respective sections illustrated in FIG. 5-FIG. 9 are devices formed of any of a processor, storage medium, or program, or a combination thereof. For example, the processor reads the program stored in the storage medium, and achieves various functions.

(1) Summary of train automatic stop control device

FIG. 1 shows the function configuration of the train automatic stop control device (TASC device). The TASC device detects the speed signal from the tachogenerator installed on the wheel shaft and detects the position information from the pickup coil that communicates with the wayside coil by the speed/position detecting unit. Also, the TASC device calculates the braking command by a control command calculating unit based on the speed signal and the position information acquired, and outputs the calculated braking command to the train control and monitoring system and the driving/braking control device.

25 The TASC device has 2 main functions as described above, namely the speed/position detecting function for detecting the speed signal and the position information, and the control command calculating function for calculating the control command. The control command calculating unit having the control command calculating function out of them is further formed of a planning unit that has the planning function and a tracking unit that has the tracking function.

The planning function is a function of calculating the target speed with respect to the braking speed applied to the station stopping position held beforehand referring to the present vehicle position. Also, the tracking function is a function of inputting the speed deviation

between the target speed and the vehicle speed and calculating the braking force to be outputted. The TASC device outputs this calculated braking force along with the braking command to the train control and monitoring system and the driving/braking control device.

Also, the braking command includes the brake notch command, the torque
5 command, and the like. The train control and monitoring system is a device for managing on-vehicle information transmission. When the braking command from the TASC device is inputted, the train control and monitoring system outputs the inputted braking command to the driving/braking control device. The driving/braking control device controls travel of the train based on the inputted braking command.

10 In the meantime, a little lag normally occurs between the time when the braking command is outputted from the TASC device and the time the motion based on the braking command is actually reflected to the train. Further, it is known that a little difference is also generated between the braking force included in the braking command from the TASC device and the braking force actually applied to the train.

15 FIG. 2 shows the relation of the vehicle speed, the commanded deceleration and the generated deceleration, and the elapsed time. The vehicle speed is shown in a dotted line, the commanded deceleration is shown in a solid line, and the generated deceleration is shown in a single dot chain line. As shown in FIG. 2, a little gap is generated between the time the braking command that instructs deceleration is outputted from the TASC device and the time the
20 commanded deceleration included in this braking command is actually reflected to the train. This is called a loss time.

Further, a little difference is generated also between the commanded deceleration and the generated deceleration actually applied to the train. This is called a deceleration deviation. As these loss time and deceleration deviation become larger, the tracking
25 performance of tracking the target speed deteriorates. Therefore, in introducing the TASC device, it is necessary that the adjusting work of various parameters is executed by the worker sufficiently and the adverse effect of these loss time and deceleration deviation on the stopping position accuracy is reduced as much as possible.

On the other hand, in recent years, in order to reduce the man-hours of the
30 adjusting work by the worker, development of the function of automatically learning the vehicle property (loss time and deceleration deviation) based on the travel result obtained when the train actually travels and reflecting the learnt result in control is in progress. This function is called a vehicle property learning function.

FIG. 3 shows a function configuration of the TASC device provided with the

vehicle property learning unit. The vehicle property learning unit has a function of being inputted with the braking command and the present speed, estimating the loss time and the deceleration deviation with respect to deceleration, and outputting the adjusting parameter including the vehicle property value to a control command calculating unit.

5 With respect to the position and speed of the vehicle, the control command calculating unit calculates the predicted position and the predicted speed of the time after the loss time elapses, and executes prediction control considering the delay of the loss time portion. Also, considering the deceleration deviation, the control command calculation unit corrects the command value of the braking force.

10 Here, as shown in FIG. 2, the waveform of the commanded deceleration and the waveform of the generated deceleration are approximately similar and are displaced parallel in the time axis direction and the deceleration axis direction, the shift of both waveform is made an evaluating function, and the parallel displacement amount of the case the evaluating function is minimized is learnt as the deviation from the designed value.

15 However, when the step size of the parallel displacement in the time axis direction and the deceleration axis direction is small, the calculation load increases, whereas when the step size is large, the waveform of the commanded deceleration and the waveform of the generated deceleration cannot be superimposed precisely and the deviation from the designed value cannot be calculated precisely from the amount of the parallel displacement.

20 In FIG. 4, an example of the step size of the parallel displacement amount in the time axis direction and the deceleration axis direction is shown. In FIG. 4, the evaluation range was made 0-2 (sec) in the time axis direction and -1 to +1 (km/h/s) in the deceleration axis direction in terms of the deceleration deviation from the designed value, and the step size was made 0.1 (sec) in the time axis direction and 0.1 (km/h/s) in the deceleration axis direction. In
25 this case, it is necessary to evaluate the shift of the waveform of the commanded deceleration and the waveform of the generated deceleration at 441 points in total of 21 points in the time axis direction and 21 points in the deceleration axis direction.

With respect to learning of the vehicle property, it is preferable to finish learning of the vehicle property using the data of the time of entering a certain station until the time of
30 entering the next station from the viewpoint of quickly accumulating the learnt vehicle property value. However, when the combination of the loss time and the deceleration deviation shown in the previous paragraph is to be calculated by a current automatic train control device, it is difficult to finish leaning of the vehicle property using the data of the time of entering a certain station until the time of entering the next station.

(1) First embodiment

In the first embodiment, an automatic train control device will be explained in which the shift of both waveforms of the commanded deceleration waveform and the generated deceleration waveform is made the evaluating function, the evaluating function is approximated
5 by a secondary multiple variable function, the local minimum value of the multiple variable function is analytically calculated, and thereby the number of the point for evaluating the shift of both waveforms of the commanded deceleration waveform and the generated deceleration waveform is reduced.

(1-1) Configuration of automatic train control device

10 FIG. 5 shows a function configuration of an automatic train control device 501 in the first embodiment. The automatic train control device 501 calculates the braking command, outputs the calculated braking command to an actuator 503 through a driving/braking control device 502, and thereby controls travel of the train.

The automatic train control device 501 acquires the position and the speed of the
15 own train by a speed/position detecting unit 504, and acquires the vehicle property value by a vehicle property learning unit 505. Also, the automatic train control device 501 is inputted with the position and the speed from the speed/position detecting unit 504 and the vehicle property value from the vehicle property learning unit 505 by a control command calculating unit 506, and calculates the braking command.

20 Also, with respect to the detection method of the speed of the own train by the speed/position detecting unit 504, there are a method of detection by multiplying the rotation speed of the wheel shaft and the wheel periphery length using the speed signal from the tachogenerator installed on the wheel shaft, a method of measuring the speed difference against the ground using a Doppler radar, and so on for example.

25 Next, the vehicle property learning unit 505 will be explained. The vehicle property learning unit 505 is formed of a vehicle property estimating unit 507 and a vehicle property reflecting unit 508.

The vehicle property estimating unit 507 is inputted with the position and speed of the own train from the speed/position detecting unit 504 and the braking command of the own
30 train from the control command calculating unit 506, and estimates the vehicle property of the own train.

The vehicle property reflecting unit 508 executes accumulation and statistical processing of the vehicle property value calculated by the vehicle property estimating unit 507, and outputs the result to the control command calculating unit 506.

Next, the detail of the vehicle property estimating unit 507 will be explained.

The vehicle property estimating unit 507 is formed of a travel result data accumulating unit 509, a commanded deceleration waveform calculating unit 510, a generated deceleration waveform calculating unit 511, and a waveform shift amount calculating unit 512.

5 The travel result data accumulating unit 509 accumulates the position and speed of the own train from the speed/position detecting unit 504 and the braking command of the own train from the control command calculating unit 506 as the data that show the travel result.

 The commanded deceleration waveform calculating unit 510 calculates the time series data of the deceleration instructed at the time of braking (commanded deceleration
10 waveform) based on the braking command accumulated by the travel result data accumulating unit 509. Also, the generated deceleration waveform calculating unit 511 calculates the time series data of the deceleration generated at the time of braking (generated deceleration waveform) based on the position and speed accumulated by the travel result data accumulating unit 509.

15 Also, in the process of calculating the waveform of the deceleration generated at the time of braking, by referring to the route slope information not illustrated using the position data of the own vehicle, the effect of the slope resistance on the generated deceleration can be eliminated, and the deceleration actually generated in the train can be calculated more precisely.

 The waveform shift amount calculating unit 512 is inputted with the commanded
20 deceleration waveform calculated by the commanded deceleration waveform calculating unit 510 and the generated deceleration waveform calculated by the generated deceleration waveform calculating unit 511.

 Also, the waveform shift amount calculating unit 512 calculates the waveform shift amount that shows how much both waveforms are shifted from each other (difference) in
25 the time axis direction and the deceleration axis direction. This waveform shift amount is the vehicle property value estimated by the vehicle property estimating unit 507.

Next, the detail of the vehicle property reflecting unit 508 will be explained.

 The vehicle property reflecting unit 508 is formed of a vehicle property data accumulating unit 513 and a vehicle property statistical processing unit 514. The vehicle property data
30 accumulating unit 513 accumulates the waveform shift amount from the vehicle property estimating unit 507 in the data base as the vehicle property value.

 The vehicle property statistical processing unit 514 refers to a set of the vehicle property value accumulated in the vehicle property data accumulating unit 513, executes statistical processing, thereby determines a representative value from the set of the vehicle

property value, and updates the adjusting parameter held in the control command calculating unit 506 with the representative value.

The control command calculating unit 506 calculates the braking command using the updated adjusting parameter, outputs the calculated braking command to the actuator 503 through the driving/braking control device 502, and thereby comes to control travel of the train.

(1-2) Flowchart

FIG. 6 shows a processing procedure of vehicle property value calculation executed by the waveform shift amount calculating unit 512.

(Step 601)

10 The commanded deceleration waveform is acquired from the commanded deceleration waveform calculating unit. The process proceeds to Step 602.

(Step 602)

The generated deceleration waveform is acquired from the generated deceleration waveform calculating unit. The process proceeds to Step 603.

15 (Step 603)

6 representative points for executing waveform shift are determined, and the shift of both waveforms of the commanded deceleration waveform and the generated deceleration waveform at the representative point is calculated as the evaluating function J. The process proceeds to Step 604.

20 (Step 604)

An approximation function Z that defines a secondary multiple variable function Z as a function that approximates the evaluating function J is expressed by the expression (1).

[Math. 1]

$$Z=ax^2+by^2+cx+dy+exy+f \quad \cdots(1)$$

25 (a, b, c, d, e, and f are coefficients)

When the evaluating function J at the representative point calculated in Step 603 is substituted to the expression (1), the equation (2) is obtained. By solving the equation (2), the approximation function Z is calculated. The process proceeds to Step 605.

[Math. 2]

$$\left. \begin{array}{l} ax_1^2+by_1^2+cx_1+dy_1+ex_1y_1+f=J(x_1, y_1)=Z_1 \\ ax_2^2+by_2^2+cx_2+dy_2+ex_2y_2+f=J(x_2, y_2)=Z_2 \\ ax_3^2+by_3^2+cx_3+dy_3+ex_3y_3+f=J(x_3, y_3)=Z_3 \\ ax_4^2+by_4^2+cx_4+dy_4+ex_4y_4+f=J(x_4, y_4)=Z_4 \\ ax_5^2+by_5^2+cx_5+dy_5+ex_5y_5+f=J(x_5, y_5)=Z_5 \\ ax_6^2+by_6^2+cx_6+dy_6+ex_6y_6+f=J(x_6, y_6)=Z_6 \end{array} \right\} \quad \cdots(2)$$

30

(Step 605)

Because the point minimizing the approximation function Z (local minimum value) means the shift amount that minimizes the shift of both waveforms of the commanded deceleration waveform and the generated deceleration waveform, the point where the

5 approximation function Z becomes the local minimum value is calculated from the expression (3). The process proceeds to Step 606.

[Math. 3]

$$\left. \begin{array}{l} \frac{\partial Z}{\partial x} = 0 \\ \frac{\partial Z}{\partial y} = 0 \end{array} \right\} \cdots (3)$$

(Step 606)

10 From the combination of the shift amount that minimizes the shift of both waveforms of the commanded deceleration waveform and the generated deceleration waveform obtained from the local minimum value of the approximation function Z, the vehicle property value (loss time and deceleration deviation) is calculated. The calculated vehicle property value is transmitted to the vehicle property reflecting unit 508, and the present process is
15 finished.

Further, although the expression (1) includes a term of zero order of x and y, because the term of zero order of x and y is not required for calculation of the local minimum value, there is not any problem in defining the approximation function Z as the expression (4).

[Math. 4]

20 $Z = ax^2 + by^2 + cx + dy + exy \quad \cdots (4)$

(a, b, c, d, and e are coefficients)

When the expression (4) is employed, because the number of the coefficients to be obtained becomes 5, the number of the representative points for calculating the approximation function Z only has to be 5, and the calculation load can be further reduced.

25 Further, it is also possible to calculate the evaluating function in all step sizes in the time axis direction and the deceleration axis direction at an optional gap, and to calculate the waveform shift amount that minimizes the evaluating function. With this method, the result using the approximation function can be examined at regular intervals, and the accuracy of the adjusting parameter calculated by the vehicle property learning unit can be improved.

30 (1-3) Effect of the first embodiment

As described above, according to the first embodiment, because the points for

comparing the commanded deceleration waveform and the generated deceleration waveform with each other substantially reduce, the vehicle property value can be calculated within the automatic train control device at all times, and the change of the vehicle property value caused by aged deterioration can be also coped with.

5 (2) Second embodiment

In the second embodiment, an automatic train control device will be explained which improves the estimation accuracy of the vehicle property value by dynamically changing the representative point for calculating the evaluating function. Also, the configurations same to those of the first embodiment will be marked with same reference signs, and explanation

10 thereof will be omitted.

(2-1) Configuration of automatic train control device

FIG. 7 shows a function configuration of an automatic train control device 701 in the second embodiment. A vehicle property learning unit 702 is formed of the vehicle property estimating unit 507, the vehicle property reflecting unit 508, and a representative point

15 determining unit 703. Here, explanation of the vehicle property estimating unit 507 and the vehicle property reflecting unit 508 will be omitted, and the representative point determining unit 703 will be explained.

Based on the adjusting parameter calculated by the vehicle property reflecting unit 508, the representative point determining unit 703 determines the point where the
20 commanded deceleration waveform and the generated deceleration waveform should be compared with each other, and notifies the waveform shift amount calculating unit 512 of the result.

Next, the detail of the representative point determining unit 703 will be explained using FIG. 8.

25 When the vehicle property of the object train is unknown in such case of the time of the first travel after a new vehicle has been manufactured, the representative point determining unit 703 determines the maximum value of the error against the designed value which can be employed by the train in general as the representative point (which is made a representative point group 1).

30 One obtained by converting the local minimum value of the approximation function approximated by the representative point group 1 to the waveform shift amount based on the calculated adjusting parameter is made the waveform shift amount 1. The representative point determining unit 703 sets the representative point to be used at the time of next waveform shift amount calculation (which is made a representative point group 2) to a value obtained by

bringing the representative point group 1 close to the waveform shift amount 1 by a predetermined rate.

Thus, the representative point is gradually brought close to the waveform shift amount that is based on the adjusting parameter calculated by the vehicle property learning unit

5 702.

Also, because it is highly unlikely in general that the vehicle property sharply changes, a method of setting several points in the vicinity of the waveform shift amount 1 as the representative point may be employed. It is also possible to calculate the evaluating function by the representative point in the vicinity of the waveform shift amount 1 and to make the waveform shift amount minimizing the evaluating function the vehicle property.

10

(2-2) Effect of the second embodiment

According to the second embodiment, the adjusting parameter calculated by the vehicle property learning unit 702 can finish learning quickly irrespective of the initial vehicle property of the train, and the accuracy of the calculated adjusting parameter can be improved.

15

(3) Third embodiment

Although the vehicle property learning unit 505 determined the reflection timing of the adjusting parameter to the control command in the first and second embodiments, in the third embodiment, the reflection timing of the adjusting parameter to the control command is allowed to be set optionally. Also, the configurations same to those of the first embodiment will be marked with same reference signs, and explanation thereof will be omitted.

20

(3-1) Configuration of automatic train control device

FIG. 9 shows a function configuration of an automatic train control device 901 in the third embodiment. A vehicle property learning unit 902 is formed of the vehicle property estimating unit 507, the vehicle property reflecting unit 508, and a vehicle property value control reflecting timing determining unit 903. Here, explanation of the vehicle property estimating unit 507 and the vehicle property reflecting unit 508 will be omitted, and the vehicle property value control reflecting timing determining unit 903 will be explained.

25

The vehicle property value control reflecting timing determining unit 903 receives a notification of change of the adjusting parameter and receives the adjusting parameter from the vehicle property reflecting unit 508. Upon receiving the notification of change of the adjusting parameter from the vehicle property reflecting unit 508, the vehicle property value control reflecting timing determining unit 903 notifies the crew and the maintenance staff of the same through a train control and monitoring system 904. The crew and the maintenance staff notify the train control and monitoring system 904 of approval/non-approval with respect to the

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adjusting parameter. Upon receiving approval/non-approval from the crew and the maintenance staff, the train control and monitoring system 904 notifies the vehicle property value control reflecting timing determining unit 903 of the same. The vehicle property value control reflecting timing determining unit 903 issues a command to the vehicle property reflecting unit 508 to notify the control command calculating unit 506 of the new adjusting parameter in the case of approval, and issues a command to the vehicle property reflecting unit 508 not to notify the control command calculating unit 506 of the new adjusting parameter in the case of non-approval.

(3-3) Effect of the third embodiment

As described above, according to the third embodiment, the adjusting parameter can be reflected optionally, and manual final confirmation becomes possible.

(4) Other embodiments

The adjusting parameter calculated by the vehicle property learning unit 505 can be also utilized for other than control of the automatic train control device 501. For example, it is also possible to compare the adjusting parameters of respective organizations with each other, and to doubt the defect of the vehicle state with respect to an organization whose adjusting parameter is different from that of the other organizations to serve the maintenance.

Also, when a connection occurs, the vehicle property as the total organization possibly changes. When a connection is effected, by transmitting and receiving the vehicle property of each organization, the automatic train control device can quickly grasp the vehicle property of the connected organization. Because the vehicle property in effecting the connection may possibly differ from the vehicle property of the single organization, it is preferable to hold an adjusting parameter for exclusive use of the time of effecting a connection separately from that of the time of the single organization.

Although the vehicle property learning unit 505 effected reflection to the control command at the timing when the adjusting parameter changed in the first and second embodiments, it is also possible to monitor the stopping accuracy continuously, and, if the stopping accuracy does not deteriorate when the adjusting parameter changes, not to reflect the adjusting parameter to the control command.

It should be further understood by those skilled in the art that although the foregoing description has been made on embodiments of the invention, the invention is not limited thereto and various changes and modifications may be made without departing from the spirit of the invention and the scope of the appended claims.

CLAIMS:

1. An automatic train control device (501, 701, 901) comprising:
a vehicle property learning unit (505, 702, 902) that learns vehicle property based on speed of own train and braking command for controlling travel of the own train, wherein
the vehicle property learning unit (505, 702, 902) includes a vehicle property estimating unit (507) that estimates the vehicle property and a vehicle property reflecting unit (508) that reflects the vehicle property in a braking command to be newly calculated, and
the vehicle property estimating unit (507) calculates generated deceleration that has been actually generated in the own train, calculates commanded deceleration that has been commanded to the own train based on the braking command, makes an evaluating function using difference of waveform obtained when the generated deceleration having been calculated is displaced in the time axis direction and the deceleration axis direction and waveform of the commanded deceleration, and calculates a displacement amount, as a vehicle property value, in the time axis direction and the deceleration axis direction that minimizes the evaluating function.
2. The automatic train control device (501, 701, 901) according to claim 1, wherein
the vehicle property estimating unit (507) approximates the evaluating function that is the difference of the waveform obtained when the generated deceleration is displaced in the time axis direction and the deceleration axis direction and the waveform of the commanded deceleration by a bivariate secondary function.
3. The automatic train control device (501, 701, 901) according to claim 1, wherein
the vehicle property estimating unit (507) calculates the displacement amount in the time axis direction and the deceleration axis direction which minimizes the evaluating function as the vehicle property value by analytically solving a local minimum value of an approximation function of the evaluating function that is the difference of the waveform obtained when the generated deceleration is displaced in the time axis direction and the deceleration axis direction and the waveform of the commanded deceleration.
4. The automatic train control device (501, 701, 901) according to claim 1, wherein
the vehicle property estimating unit (507) includes a representative point determining unit (703) that determines points for calculating a plurality of evaluating functions required for calculating the approximation function, and
the representative point determining unit (703) sets the points for calculating the evaluating functions in the vicinity of the vehicle property value calculated by the vehicle property learning unit (505, 702, 902).
5. The automatic train control device (501, 701, 901) according to claim 1, wherein

the vehicle property estimating unit (507) includes a vehicle property value control reflecting timing determining unit (903) that determines timing at which a control command calculating unit (506) is notified of the vehicle property value, and

the vehicle property value control reflecting timing determining unit (903) notifies a crew or a maintenance staff of an event the vehicle property value has changed when the vehicle property value recognized by the vehicle property reflecting unit (508) has changed.