

DESCRIPTION

Title of Invention

ABNORMALITY DETECTION SYSTEM, VEHICLE-
MOUNTED DEVICE, ABNORMALITY DETECTION METHOD, AND PROGRAM

[Technical Field]

[0001]

The present disclosure relates to an abnormality detection system, a vehicle-mounted device, an abnormality detection method, and a program.

[Background Art]

[0002]

As a technology for specifying a traveling position of a moving body such as a vehicle, the global navigation satellite system (hereinafter, also referred to as GNSS) is known. For example, Patent Document 1 discloses a technology in which a GNSS receiver (vehicle-mounted device) mounted on a vehicle receives a satellite signal transmitted from a GNSS satellite and estimates a position of the vehicle based on the received satellite signal.

[0003]

In addition, a GNSS charging system that specifies a traveling route of the vehicle from the time-series change of GNSS positioning data including information on the

received satellite signal, self-position information estimated from the satellite signal, and charges a toll according to the traveling route is being considered.

[Citation List]

[Patent Document]

[0004]

[Patent Document 1] Japanese Unexamined Patent Application Publication No. H9-5092

[Summary of Invention]

[Technical Subject]

[0005]

In applications used for the GNSS charging systems or the like, an abnormality check of the GNSS positioning data is necessary throughout the entire life cycle for operation verification at the development stage, detection of malfunction of the vehicle-mounted device after operation, and detection of fraud such as spoofing and jamming of the GNSS positioning data.

[0006]

However, the quality of the GNSS positioning data such as the magnitude of the positional error and the signal strength depends on various factors, such as the characteristics of each type of the vehicle-mounted device, the characteristics of the vehicle on which the vehicle-mounted device is mounted, and the usage environment of

the vehicle-mounted device (such as the presence or absence of a building around the traveling route). For this reason, it has been difficult to detect an abnormality in the GNSS positioning data by rule-based determination processing that combines simple conditional branching such as comparison with a threshold value.

[0007]

The present disclosure has been made in view of such a subject, and provides an abnormality detection system, a vehicle-mounted device, an abnormality detection method, and a program that can detect an abnormality in actually measured GNSS positioning data using pseudo GNSS positioning data generated by a trained generation model.

[Subject to be solved]

[0008]

According to an aspect of the present disclosure, an abnormality detection system includes a state observation unit that collects GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a position of a vehicle estimated from the satellite signal via a GNSS receiver mounted on the vehicle, a generation unit that generates pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data, and an abnormality determination unit that determines, in a case

where new GNSS positioning data is acquired, whether or not the newly acquired GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.

[0009]

According to another aspect of the present disclosure, a vehicle-mounted device includes a state observation unit that collects GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a position of a vehicle estimated from the satellite signal via a GNSS receiver mounted on the vehicle, a generation unit that generates pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data, and an abnormality determination unit that determines, in a case where new GNSS positioning data is acquired, whether or not the GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.

[0010]

According to still another aspect of the present disclosure, an abnormality detection method includes a step of collecting GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a position of a vehicle

estimated from the satellite signal via a GNSS receiver mounted on the vehicle, a step of generating pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data, and a step of determining, in a case where new GNSS positioning data is acquired, whether or not the GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.

[0011]

According to still another aspect of the present disclosure, a program causing a computer of a vehicle-mounted device to execute a step of collecting GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a position of a vehicle estimated from the satellite signal via a GNSS receiver mounted on the vehicle, a step of generating pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data, and a step of determining, in a case where new GNSS positioning data is acquired, whether or not the GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.

[Advantageous Effects of Invention]

[0012]

By using the abnormality detection system, the vehicle-mounted device, the abnormality detection method, and the program according to the present disclosure, it is possible to detect an abnormality in actually measured GNSS positioning data using pseudo GNSS positioning data generated by the trained generation model.

[Brief Description of Drawings]

[0013]

Fig. 1 is a diagram showing an overall configuration of an abnormality detection system according to a first embodiment of the present disclosure.

Fig. 2 is a diagram showing a functional configuration of the abnormality detection system according to the first embodiment of the present disclosure.

Fig. 3 is a diagram showing an example of a functional configuration of a training unit and training processing according to the first embodiment of the present disclosure.

Fig. 4 is a diagram showing an example of abnormality detection processing according to the first embodiment of the present disclosure.

Fig. 5 is a diagram showing an example of a functional configuration of a training unit and training

processing according to a second embodiment of the present disclosure.

Fig. 6 is a diagram showing an example of abnormality detection processing according to the second embodiment of the present disclosure.

Fig. 7 is a diagram showing a functional configuration of an abnormality detection system according to a third embodiment of the present disclosure.

Fig. 8 is a diagram showing an example of a hardware configuration of a vehicle-mounted device and a center server according to an embodiment of the present disclosure.

[Description of Embodiments]

[0014]

<First Embodiment>

Hereinafter, an abnormality detection system 1 according to the first embodiment of the present disclosure will be described with reference to Figs. 1 to 4.

[0015]

(Overall Configuration of Abnormality Detection System)

Fig. 1 is a diagram showing an overall configuration of an abnormality detection system according to the first embodiment of the present disclosure.

As shown in Fig. 1, the abnormality detection system 1 includes a plurality of vehicle-mounted devices 10 and a center server 20.

[0016]

Each of the plurality of vehicle-mounted devices 10 is mounted on a vehicle A. The vehicle-mounted device 10 receives the satellite signal transmitted by a GNSS satellite 40, and estimates a position of the vehicle A on which the vehicle-mounted device 10 is mounted based on the signal. In addition, the vehicle-mounted device 10 collects and records GNSS positioning data including information on a received satellite signal, information on the estimated position of the vehicle A, and the like.

[0017]

The center server 20 is communicably connected to the vehicle-mounted device 10 via a network N for wireless communication (cellular network or the like). The center server 20 collects GNSS positioning data from each of the plurality of vehicle-mounted devices 10, and trains a generation model that generates pseudo GNSS data simulating normal GNSS data in each vehicle-mounted device 10. In addition, the center server 20 uses the trained generation model to detect an abnormality in the GNSS positioning data actually measured in each vehicle-mounted device 10.

[0018]

(Functional Configuration of Abnormality Detection System)

Fig. 2 is a diagram showing the functional configuration of the abnormality detection system according to the first embodiment of the present disclosure.

As shown in Fig. 2, the vehicle-mounted device 10 includes a GNSS receiver 100, a sensor information acquisition unit 101, a state observation unit 102, an output unit 103, and a storage medium 104.

[0019]

The GNSS receiver 100 receives the satellite signal transmitted from the GNSS satellite 40, and estimates the position of the vehicle A. In addition, the GNSS receiver 100 generates GNSS positioning data including signal reception information on the received satellite signal and estimated position information on the position of the vehicle A, and outputs the GNSS positioning data to the state observation unit 102.

[0020]

The signal reception information includes a signal strength of the satellite signal received by the GNSS receiver 100, the number of satellites, an elevation angle, an azimuth angle, and the like. The estimated position

information includes an estimated position (latitude, longitude, and altitude), an estimated speed, and the like of the vehicle A at the time of signal reception.

[0021]

The sensor information acquisition unit 101 acquires sensor information from a vehicle-mounted sensor 30 included in the vehicle A. The vehicle-mounted sensor 30 is, for example, a receiver that receives a beacon signal capable of detecting the position of the vehicle A from a position information distribution beacon provided on the roadside. The vehicle-mounted sensor 30 may be a receiver that receives a signal capable of detecting a vehicle speed of the vehicle A at an installation position of the speed measurement device from the speed measurement device provided on the roadside. In addition, the vehicle-mounted sensor 30 may be a vehicle-mounted camera or light detection and ranging (LiDAR), capable of detecting the surrounding environment (presence or absence of a surrounding building) of the vehicle A. Furthermore, the vehicle-mounted sensor 30 may be a vehicle speed sensor, an acceleration sensor, an angular speed sensor, or the like of the vehicle A. The sensor information acquisition unit 101 outputs various sensor information acquired via the vehicle-mounted sensor 30 to the state observation unit 102.

[0022]

The state observation unit 102 collects the GNSS positioning data via the GNSS receiver 100.

[0023]

In addition, the state observation unit 102 further collects a positioning error of the GNSS positioning data. The positioning error is a difference (positional error) between an estimated position of the vehicle A based on the satellite signal and an actual position. In addition, the positioning error may include a difference (speed error) between the estimated speed of the vehicle A based on the satellite signal and an actual speed.

[0024]

For example, the state observation unit 102 specifies, based on map data stored in advance in the storage medium 104, a position on the link of the map data of the vehicle A, and obtains a distance between the estimated position of the vehicle A and the position on the link, as the positional error. The state observation unit 102 may obtain a difference between the estimated position of the vehicle A and a position of the vehicle A specified based on the beacon signal of the position information distribution beacon acquired by the sensor information acquisition unit 101, as the positional error. In addition, the state observation unit 102 obtains a

difference between the estimated speed of the vehicle A and a speed of the vehicle A obtained from the speed measurement device on the roadside or the vehicle speed sensor of the vehicle A via the sensor information acquisition unit 101, as the speed error.

[0025]

In addition, the state observation unit 102 may further collect receiver information indicating the characteristics of the GNSS receiver 100, attachment environment information indicating the attachment environment of the GNSS receiver 100, and surrounding environment information indicating the presence or absence of a shield around the vehicle A.

[0026]

The characteristics of the GNSS receiver 100 include antenna sensitivity, directivity, frequency characteristics, and the like. The receiver information includes, for example, a type of the GNSS receiver. In addition, the receiver information may include information indicating a manufacturing time of the GNSS receiver 100 and a period of attachment to the vehicle A. It is possible to detect the effects of aged deterioration of the GNSS receiver 100 from the manufacturing time and the attachment period.

[0027]

The attachment environment information includes information (type or the like) on a vehicle on which the GNSS receiver 100 is mounted, an antenna attachment position, and an antenna attachment angle.

[0028]

The surrounding environment information is information capable of detecting the presence or absence of a shield that shields the satellite signal of the GNSS satellite 40, such as a building that exists around the vehicle A. The surrounding environment information is, for example, an image of the vehicle-mounted camera acquired by the sensor information acquisition unit 101 and a measurement result of LiDAR.

[0029]

Every time the GNSS receiver 100 generates GNSS positioning data, the state observation unit 102 transmits the generated GNSS positioning data to the center server 20. In another embodiment, every predetermined period or every time a predetermined number of GNSS positioning data are accumulated in the storage medium 104, the state observation unit 102 may collectively transmit the plurality of pieces of the accumulated GNSS positioning data to the center server 20. In addition, in a case where the state observation unit 102 collects the positioning error, the receiver information, the

attachment environment information, and the surrounding environment information, the state observation unit 102 transmits these to the center server 20 together with the GNSS positioning data.

[0030]

The output unit 103 is a display device such as a liquid crystal display, and outputs (displays) abnormality detection information on an abnormality in the GNSS positioning data. The output unit 103 may further have a speaker that outputs abnormality detection information by voice or the like.

[0031]

The storage medium 104 stores various data acquired and generated by each unit of the vehicle-mounted device 10. For example, the storage medium 104 stores the sensor information acquired by the sensor information acquisition unit 101, the GNSS positioning data collected by the state observation unit 102, and the like.

[0032]

In addition, the center server 20 includes a training unit 200, a generation unit 201, an abnormality determination unit 202, and a storage medium 203.

[0033]

The training unit 200 trains a generation model that generates pseudo GNSS positioning data by using the

training data received from the vehicle-mounted device 10. The training data includes the GNSS positioning data collected by the state observation unit 102 of the vehicle-mounted device 10. In addition, the training data may further include receiver information of the vehicle-mounted device 10, attachment environment information, and information on the surrounding environment of the vehicle A on which the vehicle-mounted device 10 is mounted.

[0034]

The generation unit 201 generates pseudo GNSS positioning data by using the generation model trained by the training unit 200.

[0035]

In a case where new GNSS positioning data is acquired from the vehicle-mounted device 10, the abnormality determination unit 202 determines whether or not the GNSS positioning data is abnormal, based on comparison with the pseudo GNSS positioning data generated by the generation unit 201.

[0036]

The storage medium 203 stores various data acquired and generated by each unit of the center server 20. For example, the storage medium 203 stores the GNSS positioning data collected from each of the vehicle-

mounted devices 10, the generation model trained by the training unit 200, and the like.

[0037]

(Training Processing)

Fig. 3 is a diagram showing an example of a functional configuration of the training unit and training processing according to the first embodiment of the present disclosure.

The training unit 200 according to the present embodiment trains a generation model for generating pseudo GNSS positioning data by using a technology of generative adversarial networks. As shown in Fig. 3, the training unit 200 has a generator 2001 and a discriminator 2002.

[0038]

The generator 2001 is a generation model that generates pseudo GNSS positioning data x' simulating normal GNSS positioning data from the input latent variable z . That is, the generator 2001 maps the input latent variable z to an observation space composed of a plurality of pieces of actually measured GNSS positioning data. In the storage medium 203 of the center server 20, GNSS positioning data in a normal state actually measured in advance by the vehicle-mounted device 10 is accumulated as training data. Using this training data, the generator 2001 performs training so as to generate pseudo GNSS

positioning data that is close to the real GNSS positioning data acquired in a normal state. The normal GNSS positioning data is, for example, GNSS positioning data determined to be normal by engineers or the like. In addition, the normal GNSS positioning data may be GNSS positioning data collected by the GNSS receiver 100 that has been confirmed to be operated normally without any failure or the like.

[0039]

The discriminator 2002 discriminates whether the input GNSS positioning data is GNSS positioning data x actually measured by the vehicle-mounted device 10 or the pseudo GNSS positioning data x' generated by the generator 2001. The discriminator 2002 performs training based on the training data accumulated in the storage medium 203 so as to discriminate the GNSS positioning data, which is real data, and the pseudo GNSS positioning data, which is fake data.

[0040]

As described above, the training data may further include the positioning error. By using such training data, the generator 2001 is trained to generate pseudo GNSS positioning data including positioning errors that are closer to the real GNSS positioning data. In addition, the discriminator 2002 is trained so that the authenticity

of the data can be more accurately discriminated even in a case where the GNSS positioning data includes the positioning error.

[0041]

In addition, the training data may further include receiver information (type, manufacturing time, specification period, or the like of the GNSS receiver 100), attachment environment information (attachment position of the GNSS receiver 100 or the like), and surrounding environment information (presence or absence of a shield that shields the satellite signal). The signal reception information of the GNSS satellite 40 (signal strength, the number of satellites, or the like) and the estimated position information of the vehicle A obtained from the received satellite signal change according to conditions such as the characteristics of the receiver type, the attachment environment, or the presence or absence of a shield around the vehicle A (GNSS receiver 100). For example, the characteristics of the receiver (antenna sensitivity, directivity, and frequency characteristics) are different for each type of the GNSS receiver 100. Therefore, in a case where two vehicle-mounted devices 10 each have GNSS receivers 100 of different types, even if the satellite signals are received at the same time at the same position, the signal

reception information and the estimated position information included in the GNSS positioning data output by each vehicle-mounted device 10 may differ. Similarly, the GNSS positioning data may differ depending on the attachment environment of the GNSS receiver 100 and the surrounding environment such as the presence or absence of the shield. Therefore, the generator 2001 can generate pseudo GNSS positioning data that is closer to the real GNSS positioning data according to the information by training the generator 2001 further on the receiver information, the attachment environment information, and the surrounding environment information included in the training data. Similarly, the discriminator 2002 is trained to more accurately discriminate the authenticity of the data even in a case where the GNSS positioning data includes the effects of the receiver characteristics, the attachment environment, and the presence or absence of the shield.

[0042]

In addition, the training unit 200 performs processing of further training the generator 2001 and the discriminator 2002 by repeating training to discriminate whether the pseudo GNSS positioning data generated by the generator 2001 is real or fake with the discriminator 2002.

Hereinafter, the flow of this training processing will be described with reference to Fig. 3.

[0043]

First, the generator 2001 generates pseudo GNSS positioning data x' based on the input latent variable z (step S101). Here, a random number, for example, is used as the latent variable z .

[0044]

Next, the pseudo GNSS positioning data x' generated by the generator 2001 or GNSS positioning data x accumulated in the storage medium 203 is input to the discriminator 2002 (step S102).

[0045]

The discriminator 2002 discriminates whether the input data is the GNSS positioning data x (real) or the pseudo GNSS positioning data x' (fake), and outputs a discrimination result P (step S103).

[0046]

In the phase of performing training of the discriminator 2002, training (parameter adjustment or the like) is performed such that the discriminator 2002 can more accurately discriminate between fake and real based on the correctness of the discrimination result P (step S104). At this time, the generator 2001 remains unchanged and fixed.

[0047]

In addition, in the phase of performing training of the generator 2001, training is performed such that the generator 2001 can generate pseudo GNSS positioning data that is closer to the real thing (such that the discriminator 2002 mistakenly discriminates it as the real thing) based on the discrimination result P (step S105). At this time, the discriminator 2002 remains unchanged and fixed.

[0048]

The training unit 200 alternately trains the generator 2001 and the discriminator 2002 by repeatedly executing each of the above steps. Accordingly, the training unit 200 can train a generation model capable of generating pseudo GNSS positioning data x' that is closer to the real thing. The trained generator 2001 (generation model) is stored in the storage medium 203, and is used by the generation unit 201 in a case where the center server 20 performs abnormality detection processing which will be described later.

[0049]

(Abnormality Detection Processing)

Fig. 4 is a diagram showing an example of the abnormality detection processing according to the first embodiment of the present disclosure.

Hereinafter, a flow of the abnormality detection processing of GNSS positioning data in the abnormality detection system 1 will be described with reference to Fig. 4. The abnormality detection processing is performed after the above-described training processing (Fig. 3) is completed.

[0050]

First, the state observation unit 102 of the vehicle-mounted device 10 acquires GNSS positioning data via the GNSS receiver 100 (step S111). In addition, the state observation unit 102 acquires sensor information via the sensor information acquisition unit 101 (step S112).

[0051]

In addition, the state observation unit 102 transmits evaluation data for detecting an abnormality in the GNSS positioning data to the center server 20 (step S113). The GNSS positioning data is included in the evaluation data. In addition, at least one of the positioning error, the receiver information, the attachment environment information, and the surrounding environment information collected by the state observation unit 102 may be included in the evaluation data.

[0052]

Next, the generation unit 201 of the center server 20 uses the generation model that is trained by the

training unit 200 to generate pseudo GNSS positioning data x' (step S114). The latent variable z corresponding to the normal GNSS positioning data is unknown in the present embodiment. Therefore, the generation unit 201 inputs all possible values of the latent variable z in order, for example, and generates a plurality of pieces of pseudo GNSS positioning data x' based on each value. Then, any one of the plurality of pieces of generated pseudo GNSS positioning data becomes close to the real GNSS positioning data.

[0053]

Next, the abnormality determination unit 202 of the center server 20 compares the GNSS positioning data x , which is the actually measured data acquired from the vehicle-mounted device 10, with the pseudo GNSS positioning data x' , which is generated by the generation unit 201, and determines whether or not there is an abnormality in the GNSS positioning data x (step S115).

[0054]

The pseudo GNSS positioning data x' is a simulated GNSS positioning data that is estimated to be acquired when the state of the vehicle-mounted device 10 is normal. Therefore, if the state of the vehicle-mounted device 10 is normal, the GNSS positioning data x actually measured by the vehicle-mounted device 10 should be data close to

any one of the plurality of pieces of pseudo GNSS positioning data x' generated by the generation unit 201. For this reason, the abnormality determination unit 202 calculates, for example, a degree of coincidence between the GNSS positioning data x and each of the plurality of pieces of pseudo GNSS positioning data x' , and determines that the GNSS positioning data x is normal in a case where there is pseudo GNSS positioning data x' whose degree of coincidence is equal to or larger than a predetermined value. On the other hand, the abnormality determination unit 202 determines that the GNSS positioning data x is abnormal in a case where there is no pseudo GNSS positioning data x' whose degree of coincidence is equal to or larger than the predetermined value.

[0055]

In a case where the determination is completed, the abnormality determination unit 202 transmits abnormality detection information including the determination result indicating the presence or absence of the abnormality to the vehicle-mounted device 10 (step S116). The abnormality detection information may include the degree of coincidence calculated by the abnormality determination unit 202.

[0056]

In addition, the output unit 103 of the vehicle-mounted device 10 outputs the abnormality detection information received from the center server 20 and presents the abnormality detection information to a passenger of the vehicle A (step S117). The output unit 103 may output the abnormality detection information as a warning only in a case where the abnormality detection information includes information indicating that the GNSS positioning data x is abnormal.

[0057]

The abnormality detection system 1 executes a series of processing shown in Fig. 4 every time the state observation unit 102 acquires the GNSS positioning data or every predetermined time, and determines whether or not there is an abnormality in the GNSS positioning data.

[0058]

(Actions and Effects)

As described above, the abnormality detection system 1 according to the present embodiment determines whether or not the acquired GNSS positioning data x is abnormal based on the comparison between the GNSS positioning data x acquired by the state observation unit 102 and the pseudo GNSS positioning data x' created by using the generation model that is trained by the generation unit 201.

In this way, the abnormality detection system 1 can detect that the GNSS positioning data x is abnormal in a case where the GNSS positioning data x actually measured by the GNSS receiver 100 deviates from the pseudo GNSS positioning data x' .

[0059]

In addition, the center server 20 of the abnormality detection system 1 further includes the training unit 200 that trains the generation model that generates pseudo GNSS positioning data by using the normal GNSS positioning data collected by the state observation unit 102.

In this way, the abnormality detection system 1 can train a generation model capable of generating pseudo GNSS positioning data which simulates data that is estimated to be acquired in a case where the state of the GNSS receiver 100 is normal. Therefore, by using the generation model trained in this manner, the abnormality detection system 1 can accurately determine that the GNSS positioning data x is abnormal in a case where the actually measured GNSS positioning data x deviates from the pseudo GNSS positioning data x' which simulates the data in a normal state.

[0060]

In addition, the state observation unit 102 further collects the positioning error of the GNSS positioning

data, and the training unit 200 further trains the generation model using the positioning error.

The actually measured GNSS positioning data may include the positioning error. Therefore, the abnormality detection system 1 according to the present embodiment performs training of the generation model including the positioning error. Accordingly, the abnormality detection system 1 can also simulate a positioning error that occurs in the actual vehicle-mounted device 10 (GNSS receiver 100), and thus it is possible to generate pseudo GNSS positioning data including such a positioning error. Then, the abnormality detection system 1 can generate pseudo GNSS positioning data that is closer to the real thing, thereby improving the accuracy of abnormality detection.

[0061]

In addition, the state observation unit 102 further collects receiver information capable of detecting the characteristics of the GNSS receiver 100, and the training unit 200 further uses the receiver information to train the generation model.

The receiver characteristics (antenna sensitivity, directivity, frequency characteristics, and the like) may differ depending on the type of the GNSS receiver 100. That is, in a case where different GNSS receivers 100 are used, positioning results (contents of GNSS positioning

data) may be different even at the same place at the same time. Therefore, the abnormality detection system 1 according to the present embodiment performs training of the generation model including the receiver information (type) of the GNSS receiver 100. Accordingly, the abnormality detection system 1 can generate the pseudo GNSS positioning data that is closer to the real thing according to the characteristics of the GNSS receiver 100. As a result, the abnormality detection in consideration of the difference in the characteristics of each of the GNSS receivers 100 becomes possible, and the accuracy of the abnormality detection can be improved.

[0062]

In addition, the receiver information may include information capable of specifying the manufacturing time and the usage period of the GNSS receiver 100.

Accordingly, the abnormality detection system 1 can further train the change in the characteristics of the GNSS receiver 100 due to the aged deterioration. As a result, the abnormality detection in consideration of the aged deterioration of each of the GNSS receivers 100 becomes possible, and the accuracy of the abnormality detection can be improved.

[0063]

In addition, the state observation unit 102 further collects the attachment environment information indicating the attachment environment of the GNSS receiver 100, and the training unit 200 further trains the generation model by using the attachment environment information.

For example, in a case where the vehicle on which the GNSS receiver 100 is mounted, the attachment position, or the like in the vehicle A changes, the signal strength of the satellite signal received by the GNSS receiver 100 may be affected. Then, even with the same type of GNSS receivers 100, there is a possibility that the positioning results may differ. For this reason, the abnormality detection system 1 according to the present embodiment performs training of the generation model including the attachment environment information of the GNSS receiver 100. Accordingly, the abnormality detection system 1 can generate the pseudo GNSS positioning data that is closer to the real thing according to the attachment environment of the GNSS receiver 100. As a result, the abnormality detection in consideration of the attachment environment of the GNSS receivers 100 becomes possible, and the accuracy of the abnormality detection can be improved.

[0064]

In addition, the state observation unit 102 further collects the surrounding environment information on the

surrounding environment of the vehicle A, and the training unit 200 further trains the generation model by using the surrounding environment information.

In a case where there is a building around the vehicle A, which shields the satellite signal, the signal strength of the satellite signal received by the GNSS receiver 100 may be affected. Then, even if the state of the vehicle-mounted device 10 (GNSS receiver 100) is normal, there is a possibility that the positioning error or the like may greatly vary depending on the traveling position of the vehicle A. For this reason, the abnormality detection system 1 according to the present embodiment performs training of the generation model including the surrounding environment information of the vehicle A. Accordingly, the abnormality detection system 1 can generate the pseudo GNSS positioning data that is closer to the real thing according to the presence or absence of the shield around the vehicle A. As a result, the abnormality detection in consideration of the shielding state around the vehicle A becomes possible, and the accuracy of the abnormality detection can be improved.

[0065]

<Second Embodiment>

Hereinafter, an abnormality detection system 1 according to the second embodiment of the present

disclosure will be described with reference to Figs. 5 and 6.

The same reference numerals are given to the components common to those in the first embodiment, and the detailed description thereof will be omitted.

[0066]

(Training Processing)

Fig. 5 is a diagram showing an example of a functional configuration of a training unit and training processing according to the second embodiment of the present disclosure.

As shown in Fig. 5, the training unit 200 according to the present embodiment further has an encoder 2003.

[0067]

The encoder 2003 is a model (latent variable model) for obtaining an optimum latent variable z' to be input to the generator 2001. The encoder 2003 maps the GNSS positioning data accumulated in the storage medium 203 to the latent space, and trains so that when the GNSS positioning data is input, the latent variable z' corresponding to the input data can be output.

[0068]

In addition, the training unit 200 performs processing of further training the generator 2001, the discriminator 2002, and the encoder 2003. Hereinafter,

the flow of this training processing will be described with reference to Fig. 5.

[0069]

First, the generator 2001 generates pseudo GNSS positioning data x' based on the input latent variable z , as in the first embodiment (step S201).

[0070]

In addition, the encoder 2003 obtains, from the input GNSS positioning data x , a latent variable z' corresponding to the data (step S202).

[0071]

Next, the data composed of a combination of the GNSS positioning data and the latent variable is input to the discriminator 2002 (step S202). The data input here is either a set (x', z) composed of the pseudo GNSS positioning data x' generated by the generator 2001 and the latent variable z used for its generation or a set (x, z') composed of the GNSS positioning data x input to the encoder 2003 and a latent variable z' corresponding to it.

[0072]

The discriminator 2002 discriminates whether the input data is the GNSS positioning data x (real) or the pseudo GNSS positioning data x' , and outputs a discrimination result P (step S204).

[0073]

Similar to the first embodiment, the discriminator 2002 and the generator 2001 perform training based on the discrimination result P in each training phase (step S205 and step S206).

[0074]

In addition, in the training phase of the encoder 2003, the encoder 2003 maps the GNSS positioning data x to the latent space to discriminate the GNSS positioning data x as real data by the discriminator 2002, and performs training so that an appropriate latent variable z' can be output.

[0075]

The training unit 200 alternately trains the generator 2001, the discriminator 2002, and the encoder 2003 by repeatedly executing each of the above steps. Accordingly, the training unit 200 can train a generation model capable of generating pseudo GNSS positioning data x' that is closer to the real thing and can train a latent variable model capable of outputting a more appropriate latent variable z' . The trained generator 2001 (generation model) and the encoder 2003 (latent variable model) are stored in the storage medium 203, and are used by the generation unit 201 in a case where the center server 20 performs abnormality detection processing which will be described later.

[0076]

(Abnormality Detection Processing)

Fig. 6 is a diagram showing an example of the abnormality detection processing according to the second embodiment of the present disclosure.

Hereinafter, a flow of the abnormality detection processing of GNSS positioning data in the abnormality detection system 1 will be described with reference to Fig. 6. The abnormality detection processing is performed after the above-described training processing (Fig. 5) is completed.

[0077]

First, the state observation unit 102 of the vehicle-mounted device 10 acquires GNSS positioning data (step S211) and also acquires sensor information (step S212). In addition, the state observation unit 102 transmits for detecting an abnormality in the GNSS positioning data to the center server 20 (step S213). These processes are the same as steps S111 to S113 of the first embodiment (Fig. 4).

[0078]

Next, the generation unit 201 of the center server 20 inputs the GNSS positioning data acquired from the vehicle-mounted device 10 to the latent variable model trained by the training unit 200, and obtains the latent

variable z' corresponding to the GNSS positioning data (step S214).

[0079]

In addition, the generation unit 201 inputs the latent variable z' output from the latent variable model to the generation model and generates pseudo GNSS positioning data x' from the latent variable z' (step S215).

[0080]

Next, the abnormality determination unit 202 of the center server 20 compares the GNSS positioning data x , which is the actually measured data acquired from the vehicle-mounted device 10, with the pseudo GNSS positioning data x' , which is generated by the generation unit 201, and determines whether or not there is an abnormality in the GNSS positioning data x (step S216). The generation unit 201 generates only one pseudo GNSS positioning data based on the latent variable z' in the present embodiment. Therefore, the abnormality determination unit 202 may only need to compare the GNSS positioning data x with one generated pseudo GNSS positioning data x' . In a case where the determination is completed, the abnormality determination unit 202 transmits abnormality detection information including the determination result indicating the presence or absence of

the abnormality to the vehicle-mounted device 10 (step S217). In a case where the output unit 103 of the vehicle-mounted device 10 receives the abnormality detection information from the center server 20, the output unit 103 outputs this information and presents the information to a passenger of the vehicle A (step S218). These specific processes are the same as in steps S115 to S117 of the first embodiment (Fig. 4).

[0081]

The abnormality detection system 1 executes a series of processing shown in Fig. 6 every time the state observation unit 102 acquires the GNSS positioning data or every predetermined time, and determines whether or not there is an abnormality in the GNSS positioning data.

[0082]

(Actions and Effects)

As described above, in the abnormality detection system 1 according to the present embodiment, the training unit 200 further trains the latent variable model using the GNSS positioning data. In addition, the generation unit 201 inputs the latent variable z' output from the latent variable model to the generation model and generates pseudo GNSS positioning data x' .

The abnormality detection system 1 according to the present embodiment can specify the latent variable z' from

the GNSS positioning data using the trained latent variable model. Therefore, as in the first embodiment, it is not necessary to generate a plurality of pieces of the pseudo GNSS positioning data based on each of a plurality of latent variables and compare all the pseudo GNSS positioning data with the GNSS positioning data. Therefore, the abnormality detection system 1 can greatly reduce the processing load in the generation unit 201 and the abnormality determination unit 202.

[0083]

<Third Embodiment>

Hereinafter, an abnormality detection system 1 according to the third embodiment of the present disclosure will be described with reference to Fig. 7.

The same reference numerals are given to the components common to those in the first and second embodiments, and the detailed description thereof will be omitted.

[0084]

In the abnormality detection system 1 according to the first and second embodiments, the center server 20 determines whether or not there is an abnormality in the collected GNSS positioning data in each of the plurality of vehicle-mounted devices 10. On the other hand, in the abnormality detection system 1 according to the present

embodiment, each of the plurality of vehicle-mounted devices 10 determines whether or not there is an abnormality in the GNSS positioning data acquired by each of the plurality of vehicle-mounted devices 10.

[0085]

In addition, the training unit 200 of the center server 20 according to the present embodiment has the same functional configuration as the training unit 200 according to the first or second embodiment. In a case where the training unit 200 completes training of the generation model and the latent variable model, the trained models are distributed to each vehicle-mounted device 10 and stored in the storage medium 104 of the vehicle-mounted device 10.

[0086]

(Functional Configuration of Abnormality Detection System)

Fig. 7 is a diagram showing a functional configuration of an abnormality detection system according to the third embodiment of the present disclosure.

As shown in Fig. 7, the vehicle-mounted device 10 according to the present embodiment further includes a generation unit 111 and an abnormality determination unit 112.

[0087]

The generation unit 111 and the abnormality determination unit 112 have the same functions same as the generation unit 201 and the abnormality determination unit 202 of the center server 20 according to the first or second embodiment.

[0088]

That is, in a case where only the generation model is distributed from the center server 20, the generation unit 111 performs the same processing as in step S114 of the first embodiment (Fig. 4) and generates a plurality of pieces of pseudo GNSS positioning data x' . In addition, the abnormality determination unit 112 performs the same processing as in step S115 of the first embodiment (Fig. 4), and compares the GNSS positioning data x acquired by the state observation unit 102 with each of the plurality of pieces of pseudo GNSS positioning data x' to determine the presence or absence of the abnormality.

[0089]

In addition, in a case where the generation model and the latent variable model are distributed from the center server 20, the generation unit 111 performs the same processing as in step S214 of the second embodiment (Fig. 6), and obtains the latent variable z' by inputting the GNSS positioning data to the latent variable model. In addition, the generation unit 111 inputs the latent

variable z' to the generation model and generates one pseudo GNSS positioning data x' . The abnormality determination unit 112 performs the same processing as in step S216 of the second embodiment (Fig. 6), and compares the GNSS positioning data x acquired by the state observation unit 102 with the pseudo GNSS positioning data x' to determine the presence or absence of the abnormality.

[0090]

(Actions and Effects)

As described above, the vehicle-mounted device 10 according to the present embodiment includes the state observation unit 102 that collects the GNSS positioning data, the generation unit 111 that generates the pseudo GNSS positioning data using the trained generation model, and the abnormality determination unit 112 that determines, based on the comparison between the newly acquired GNSS positioning data x and the pseudo GNSS positioning data x' , whether or not the GNSS positioning data x is abnormal.

In this way, the vehicle-mounted device 10 mounted on each vehicle A can detect an abnormality in GNSS positioning data collected by the vehicle-mounted device 10. As a result, the abnormality detection system 1 does not need to frequently transmit and receive evaluation data (GNSS positioning data) between the vehicle-mounted device 10 and the center server 20, so that the amount of

communication can be greatly reduced. In addition, compared with a mode in which the center server 20 performs the abnormality detection processing of the plurality of vehicle-mounted devices 10, the load of the abnormality detection processing can be distributed to each vehicle-mounted device 10, so that the processing load of the center server 20 can be greatly reduced.

[0091]

<Hardware Configuration>

Fig. 8 is a diagram showing an example of a hardware configuration of a vehicle-mounted device and a center server according to an embodiment of the present disclosure.

As shown in Fig. 8, a computer 900 includes a CPU 901, a main storage device 902, an auxiliary storage device 903, and an interface 904.

[0092]

The vehicle-mounted device 10 and the center server 20 according to each of the above-described embodiments are implemented in the computer 900, respectively. Then, the operation of each of the above-described processing units is stored in the auxiliary storage device 903 in a form of a program. The CPU 901 reads out a program from the auxiliary storage device 903, expands the program into the main storage device 902, and executes the above

processing according to the program. In addition, the CPU 901 secures storage areas corresponding to each of the above-described storage units in the main storage device 902 according to the program.

[0093]

The program may be for realizing some of the functions exerted by the computer 900. For example, the program may exert its function in combination with another program already stored in the auxiliary storage device 903 or in combination with another program implemented in another device. In another embodiment, the computer 900 may include a custom large scale integrated circuit (LSI) such as a programmable logic device (PLD) in addition to the above configuration or in place of the above configuration. Examples of the PLDs include programmable array logic (PAL), generic array logic (GAL), complex programmable logic device (CPLD), and field programmable gate array (FPGA). In this case, some or all of the functions realized by the CPU 901 may be realized by the integrated circuit.

[0094]

Examples of the auxiliary storage device 903 include a magnetic disk, a magneto-optical disk, an optical disk, a semiconductor memory, and the like. The auxiliary storage device 903 may be an internal medium directly

connected to a bus of the computer 900, or may be an external storage device 910 connected to the computer 900 via the interface 904 or a communication line. In addition, in a case where this program is distributed to the computer 900 via the communication line, the computer 900 receiving the distribution may expand the program to the main storage device 902 and execute the above processing. In at least one embodiment, the auxiliary storage device 903 is a tangible storage medium that is not temporary.

[0095]

In addition, the program may be for realizing some of the above-described functions.

Furthermore, the program may be a so-called difference file (difference program) that realizes the above-described functions in combination with another program already stored in the auxiliary storage device 903.

[0096]

As described above, although some embodiments according to the present invention have been described, all of these embodiments are presented as examples and are not intended to limit the scope of the invention. The embodiments can be executed in a variety of other forms, and various omissions, replacements, and changes can be made without departing from the concept of the invention.

These embodiments and modification examples thereof are included in the concept and technical scope of the invention.

[0097]

For example, in each of the above-described embodiments, an example in which the training unit 200 uses the GNSS positioning data in a normal state as the training data has been described, but the present invention is not limited to this. For example, the state observation unit 102 may further collect GNSS positioning data in an abnormal state. A label indicating "abnormal" is added to the GNSS positioning data in an abnormal state. In addition, the training unit 200 gives a penalty in a case where the generator 2001 generates pseudo GNSS positioning data that is close to the GNSS positioning data labeled as "abnormal". As a result, the generator 2001 (generation model) can be trained to generate only pseudo GNSS positioning data that is close to the GNSS positioning data in a normal state.

[0098]

In addition, in each of the above-described embodiments, although an example in which the abnormality determination units 202 and 112 determine the presence or absence of the abnormality based on the degree of coincidence between the GNSS positioning data x and the

pseudo GNSS positioning data x' has been described, the present invention is not limited to this. In another embodiment, the abnormality determination units 202 and 112 may determine the presence or absence of the abnormality by using a discriminator (discriminator 2002) trained by the training unit 200. For example, a discriminator (discriminator 2002) outputs a probability of discriminating that the input data is real, as the discrimination result P . At this time, the abnormality determination units 202 and 112 determine that the GNSS positioning data x is abnormal in a case where a probability $P1$ that the GNSS positioning data x is real is lower than a probability $P2$ that the pseudo GNSS positioning data x' is real. In addition, the abnormality determination units 202 and 112 may determine that the GNSS positioning data x is abnormal in a case where the probability $P1$ is lower than the probability $P2$ by a predetermined value or more in order to allow some errors.

[0099]

<Additional Notes>

The abnormality detection system, the vehicle-mounted device, the abnormality detection method, and the program described in the above-described embodiment are grasped, for example, as follows.

[0100]

According to a first aspect of the present disclosure, an abnormality detection system 1 includes a state observation unit 102 that collects GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a position of a vehicle estimated from the satellite signal via a GNSS receiver 100 mounted on the vehicle, a generation unit 111 or 201 that generates pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data, and an abnormality determination unit 112 or 202 that determines, in a case where new GNSS positioning data is acquired, whether or not the newly acquired GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.

[0101]

In this way, the abnormality detection system can detect that the GNSS positioning data is abnormal in a case where the GNSS positioning data actually measured by the GNSS receiver deviates from the pseudo GNSS positioning data.

[0102]

According to a second aspect of the present disclosure, the abnormality detection system 1 according to the first aspect further includes a training unit 200 that uses the normal GNSS positioning data collected by

the state observation unit 102 to train the generation model.

[0103]

In this way, the abnormality detection system can train a generation model capable of generating pseudo GNSS positioning data which simulates data that is estimated to be acquired in a case where the state of the GNSS receiver is normal. Therefore, by using the generation model trained in this manner, the abnormality detection system can accurately determine that the GNSS positioning data is abnormal in a case where the actually measured GNSS positioning data deviates from the pseudo GNSS positioning data which simulates the data in a normal state.

[0104]

According to a third aspect of the present disclosure, in the abnormality detection system 1 according to the second aspect, the state observation unit 102 further collects a positioning error of the GNSS positioning data, and the training unit 200 further uses the positioning error to train the generation model.

[0105]

In this way, the abnormality detection system can also accurately simulate the positioning error of the actual GNSS receiver. Then, the abnormality detection system can generate pseudo GNSS positioning data that is

closer to the real thing, thereby improving the accuracy of abnormality detection.

[0106]

According to a fourth aspect of the present disclosure, in the abnormality detection system 1 according to the second or third aspect, the state observation unit 102 further collects receiver information capable of detecting characteristics of the GNSS receiver 100, and the training unit 200 further uses the receiver information to train the generation model.

[0107]

In this way, the abnormality detection system can generate the pseudo GNSS positioning data that is closer to the real thing according to the characteristics of the GNSS receiver. As a result, the abnormality detection in consideration of the difference in the characteristics of each of the GNSS receivers becomes possible, and the accuracy of the abnormality detection can be improved.

[0108]

According to a fifth aspect of the present disclosure, in the abnormality detection system 1 according to any one of the second to fourth aspects, the state observation unit 102 further collects attachment environment information indicating an attachment environment of the GNSS receiver 100, and the training

unit 200 further uses the attachment environment information to train the generation model.

[0109]

In this way, the abnormality detection system can generate the pseudo GNSS positioning data that is closer to the real thing according to the attachment environment of the GNSS receiver. As a result, the abnormality detection in consideration of the attachment environment of the GNSS receivers becomes possible, and the accuracy of the abnormality detection can be improved.

[0110]

According to a sixth aspect of the present disclosure, in the abnormality detection system 1 according to any one of the second to fifth aspects, the state observation unit 102 further collects surrounding environment information on a surrounding environment of the vehicle, and the training unit 200 further uses the surrounding environment information to train the generation model.

[0111]

In this way, the abnormality detection system can generate the pseudo GNSS positioning data that is closer to the real thing according to the surrounding environment of the vehicle. As a result, the abnormality detection in consideration of the shielding state around the vehicle

becomes possible, and the accuracy of the abnormality detection can be improved.

[0112]

According to a seventh aspect of the present disclosure, in the abnormality detection system 1 according to any one of the second to sixth aspects, the training unit 200 further trains a latent variable model that outputs a latent variable for generating the pseudo GNSS positioning data by using the GNSS positioning data, and the generation unit 111 or 201 inputs the latent variable output from the latent variable model to the generation model and generates the pseudo GNSS positioning data.

[0113]

In a case where the latent variable cannot be specified, the generation unit needs to change the latent variable one by one, generate a plurality of pieces of pseudo GNSS positioning data based on each latent variable, and individually compare the GNSS positioning data with each of the plurality of pieces of pseudo GNSS positioning data. However, in the abnormality detection system according to the above-described aspect, since the latent variable can be specified by using the trained latent variable model, the processing load in the generation unit

and the abnormality determination unit can be greatly reduced.

[0114]

According to an eighth aspect of the present disclosure, a vehicle-mounted device 10 includes a state observation unit 102 that collects GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a position of a vehicle estimated from the satellite signal via a GNSS receiver 100 mounted on the vehicle, a generation unit 111 that generates pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data, and an abnormality determination unit 112 that determines, in a case where new GNSS positioning data is acquired, whether or not the GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.

[0115]

In this way, the vehicle-mounted device 10 mounted on each vehicle can detect an abnormality in GNSS positioning data collected by the vehicle-mounted device. As a result, the abnormality detection system does not need to frequently transmit and receive evaluation data (GNSS positioning data) between the vehicle-mounted device and the center server, so that the amount of communication

can be greatly reduced. In addition, the load of the abnormality detection processing can be distributed to each vehicle-mounted device.

[0116]

According to a ninth aspect of the present disclosure, an abnormality detection method includes a step of collecting GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a position of a vehicle estimated from the satellite signal via a GNSS receiver 100 mounted on the vehicle, a step of generating pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data, and a step of determining, in a case where new GNSS positioning data is acquired, whether or not the GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.

[0117]

According to a tenth aspect of the present disclosure, a program causing a computer 900 of a vehicle-mounted device 10 to execute a step of collecting GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a position of a vehicle estimated from the satellite signal via a GNSS receiver 100 mounted on the vehicle, a step of

generating pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data, and a step of determining, in a case where new GNSS positioning data is acquired, whether or not the GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.

[Industrial Applicability]

[0118]

By using the abnormality detection system, the vehicle-mounted device, the abnormality detection method, and the program according to the present disclosure, it is possible to detect an abnormality in actually measured GNSS positioning data using pseudo GNSS positioning data generated by the trained generation model.

[Reference Signs List]

[0119]

- 1: Abnormality detection system
- 10: Vehicle-mounted device
- 100: GNSS receiver
- 101: Sensor information acquisition unit
- 102: State observation unit
- 103: Output unit
- 104: Storage medium
- 111: Generation unit
- 112: Abnormality determination unit

20: Center server
200: Training unit
2001: Generator
2002: Discriminator
2003: Encoder
201: Generation unit
202: Abnormality determination unit
203: Storage medium
30: Vehicle-mounted sensor
40: GNSS satellite
900: Computer
901: CPU
902: Main storage device
903: Auxiliary storage device
904: Interface
910: External storage device

Claims

[Claim 1]

An abnormality detection system comprising:
a state observation unit that collects GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a position of a vehicle estimated from the satellite signal via a GNSS receiver mounted on the vehicle;

a generation unit that generates pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data; and

an abnormality determination unit that determines, in a case where new GNSS positioning data is acquired, whether or not the newly acquired GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.

[Claim 2]

The abnormality detection system according to Claim 1, further comprising a training unit that uses the normal GNSS positioning data collected by the state observation unit to train the generation model.

[Claim 3]

The abnormality detection system according to Claim 2,

wherein the state observation unit further collects a positioning error of the GNSS positioning data, and

the training unit further uses the positioning error to train the generation model.

[Claim 4]

The abnormality detection system according to Claim 2 or 3,

wherein the state observation unit further collects receiver information capable of detecting characteristics of the GNSS receiver, and

the training unit further uses the receiver information to train the generation model.

[Claim 5]

The abnormality detection system according to any one of Claims 2 to 4,

wherein the state observation unit further collects attachment environment information indicating an attachment environment of the GNSS receiver, and

the training unit further uses the attachment environment information to train the generation model.

[Claim 6]

The abnormality detection system according to any one of Claims 2 to 5,

wherein the state observation unit further collects surrounding environment information on a surrounding environment of the vehicle, and

the training unit further uses the surrounding environment information to train the generation model.

[Claim 7]

The abnormality detection system according to any one of Claims 2 to 6,

wherein the training unit further trains a latent variable model that outputs a latent variable for generating the pseudo GNSS positioning data by using the GNSS positioning data, and

the generation unit inputs the latent variable output from the latent variable model to the generation model and generates the pseudo GNSS positioning data.

[Claim 8]

A vehicle-mounted device comprising:

a state observation unit that collects GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a

position of a vehicle estimated from the satellite signal via a GNSS receiver mounted on the vehicle;

a generation unit that generates pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data; and

an abnormality determination unit that determines, in a case where new GNSS positioning data is acquired, whether or not the GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.

[Claim 9]

An abnormality detection method comprising:

a step of collecting GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a position of a vehicle estimated from the satellite signal via a GNSS receiver mounted on the vehicle;

a step of generating pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data; and

a step of determining, in a case where new GNSS positioning data is acquired, whether or not the GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.

[Claim 10]

A program causing a computer of a vehicle-mounted device to execute:

a step of collecting GNSS positioning data including information on a satellite signal received from a GNSS satellite and information on a position of a vehicle estimated from the satellite signal via a GNSS receiver mounted on the vehicle;

a step of generating pseudo GNSS positioning data by a generation model that is trained by using the GNSS positioning data; and

a step of determining, in a case where new GNSS positioning data is acquired, whether or not the GNSS positioning data is abnormal, based on a comparison with the generated pseudo GNSS positioning data.