

DESCRIPTION

TITLE OF INVENTION: OVERHEAD WIRE FITTING ABNORMALITY DETECTION DEVICE AND OVERHEAD WIRE FITTING ABNORMALITY DETECTION METHOD

TECHNICAL FIELD

[0001] The present invention relates to an overhead wire fitting abnormality detection device and an overhead wire fitting abnormality detection method.

BACKGROUND

[0002] Conventionally, in electric railway equipment, maintenance and inspection work is performed on overhead contact line fittings, and maintenance is performed by an inspector visually checking for abnormalities in overhead contact line fittings. Overhead contact line fittings refer to fittings for holding, at prescribed positions, overhead electric vehicle wires (contact wires, messenger wires, auxiliary messenger wires; hereinafter referred to as "overhead contact lines") for supplying electric power to vehicles in electric railway equipment, or for electrically connecting or demarcating multiple overhead contact lines. However, there are limits to visual inspection and there is a possibility that abnormalities will be overlooked. Therefore, there was a demand for automating such inspections.

[0003] Therefore, Patent Document 1 discloses technology for capturing an image of a target with a camera mounted on a moving body, using the captured image to generate an image using a generation model such as a neural network, determining the similarity between the generated image and the captured image, and determining that there is an abnormality when this similarity is small.

[0004] Patent Document 2 discloses an overhead contact line fitting abnormality detection device that performs abnormality detection by implementing learning for each part constituting an overhead contact line fitting in order to increase the accuracy of abnormality detection. With this device, overhead images from a railway vehicle are acquired by a line sensor camera mounted on the roof of the railway vehicle. Next, overhead contact line fittings learned by object detection based on machine learning are detected from the acquired images, and semantic segmentation is applied to the target equipment images to obtain one-hot expressions. As a result thereof, the images are simplified and abnormality

determinations of shape abnormalities are streamlined. Since semantic segmentation allows just the regions of respective parts of fittings to be extracted, these can be used to generate mask images of only the portions with the parts, normal data learning can be performed for each part, and abnormality determinations can be made by using reconstruction error in the mask portions.

CITATION LIST

PATENT LITERATURE

[0005] Patent Document 1: JP 2019-133306 A

Patent Document 2: JP 2022-159010 A

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0006] However, in the technology disclosed in Patent Document 1, detection is not performed over all portions in which the regions are small. Therefore, when the components to be detected are small, there is a risk that it will be difficult to increase the detection accuracy.

[0007] With the technology disclosed in Patent Document 2, semantic segmentation is required, and there is a problem in that the annotation cost and the learning cost are large. Additionally, there is a problem in that the segmentation accuracy (error) affects the abnormality determination in later stages. Additionally, although there is a need for resizing in order to allow target equipment that has been detected at the time of abnormality detection to be handled with an abnormality detection model, if the target component is small with respect to the target equipment in that case, there is a problem in that information can be lost due to the resizing, making abnormality determination difficult.

[0008] Thus, the present invention addresses the problem of providing an overhead contact line fitting abnormality detection device and an overhead contact line fitting abnormality detection method that allow the detection accuracy of abnormalities in overhead contact line fittings to be increased at a low cost, even when the components to be detected are small.

SOLUTION TO PROBLEM

[0009] An overhead contact line fitting abnormality detection device according to the present invention for solving the above-mentioned problem includes a learning processing unit that performs learning using image data generated by capturing an image of an overhead contact line fitting, and a data processing unit that performs abnormality determination using the image data, wherein the learning processing unit includes an equipment learning unit that learns to detect equipment, and a component learning unit that learns to detect a component of the equipment, and the data processing unit detects the equipment by using an equipment detection model learned by the equipment learning unit, detects the component from the detected equipment by using a component detection model learned by the component learning unit, and determines whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

[0010] In one embodiment of the present invention, the data processing unit detects the equipment based on the equipment detection model, travel position information for a vehicle, and equipment information.

[0011] In one embodiment of the present invention, the data processing unit determines whether there is an abnormality in the equipment and/or the component based on reconstruction error in the abnormality detection model.

[0012] In one embodiment of the present invention, an input/output unit is further provided, wherein a detection result of the equipment and/or the component detected by the data processing unit is displayed on the input/output unit, and a worker checks and edits the detection result from the input/output unit.

[0013] An overhead contact line fitting abnormality detection method of the present invention includes performing learning using image data generated by capturing an image of an overhead contact line fitting, and performing abnormality determination using the image data, wherein the performing learning includes learning to detect equipment, and learning to detect a component of the equipment, and the performing abnormality determination includes detecting the equipment by using an equipment detection model learned by learning to detect the equipment, detecting the component from the detected equipment by using a component detection model learned by learning to detect the component of the equipment, and determining whether there is an abnormality in the equipment and/or the component

by using an abnormality detection model learned in advance.

[0014] In one embodiment of the present invention, the performing abnormality determination includes detecting the equipment based on the equipment detection model, travel position information for a vehicle, and equipment information.

[0015] In one embodiment of the present invention, the performing abnormality determination includes determining whether there is an abnormality in the equipment and/or the component based on reconstruction error in the abnormality detection model.

[0016] In one embodiment of the present invention, the method includes displaying, on an input/output unit, a detection result of the equipment and/or the component detected at the performing abnormality determination, and a worker checking and editing the detection result from the input/output unit.

[0017] An overhead contact line fitting abnormality detection device according to one aspect of the present invention includes a learning processing unit that performs learning using image data generated by capturing an image of an overhead contact line fitting, and a data processing unit that performs abnormality determination using the image data, wherein the learning processing unit includes an equipment learning unit that learns to detect equipment, and a component learning unit that learns to detect a component of the equipment, and the data processing unit detects the equipment by using an equipment detection model learned by the equipment learning unit, detects the component from the detected equipment by using a component detection model learned by the component learning unit, retouches the image data in which the equipment or the component was detected, and determines whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

[0018] An overhead contact line fitting abnormality detection device according to another aspect of the present invention includes a learning processing unit that performs learning using image data generated by capturing an image of an overhead contact line fitting, and a data processing unit that performs abnormality determination using the image data, wherein the learning processing unit includes an equipment learning unit that learns to detect equipment, and a component learning unit that learns to detect a component of the equipment, and the data processing unit

retouches the image data, detects the equipment by using an equipment detection model learned by the equipment learning unit, detects the component from the detected equipment by using a component detection model learned by the component learning unit, and determines whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

[0019] An overhead contact line fitting abnormality detection device according to yet another aspect of the present invention includes a learning processing unit that performs learning using image data generated by capturing an image of an overhead contact line fitting, and a data processing unit that performs abnormality determination using the image data, wherein the learning processing unit includes an equipment learning unit that learns to detect equipment, and a component learning unit that learns to detect a component of the equipment, and the data processing unit detects the equipment by using an equipment detection model learned by the equipment learning unit, detects the component from the detected equipment by using a component detection model learned by the component learning unit, retouches the image data in which the equipment or the component was detected, based on an image capture time and travel position information for a vehicle, and determines whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

[0020] An overhead contact line fitting abnormality detection device according to yet another aspect of the present invention includes a learning processing unit that performs learning using image data generated by capturing an image of an overhead contact line fitting, and a data processing unit that performs abnormality determination using the image data, wherein the learning processing unit includes an equipment learning unit that learns to detect equipment, and a component learning unit that learns to detect a component of the equipment, and the data processing unit detects the equipment by using an equipment detection model learned by the equipment learning unit, detects the component from the detected equipment by using a component detection model learned by the component learning unit, retouches the image data in which the equipment or the component is detected, based on brightness information in the image data or on discriminative AI, and determines whether there is an abnormality in the equipment and/or the component

by using an abnormality detection model learned in advance.

[0021] In one aspect of the present invention, the data processing unit, before determining whether there is an abnormality in the equipment and/or the component by using the abnormality detection model learned in advance, performs a flipping process on the image data based on a position of a detection target in the image data.

[0022] An overhead contact line fitting abnormality detection method according to one aspect of the present invention includes performing learning using image data generated by capturing an image of an overhead contact line fitting, and performing abnormality determination using the image data, wherein the performing learning includes learning to detect equipment, and learning to detect a component of the equipment, and the performing abnormality determination includes detecting the equipment by using an equipment detection model learned by learning to detect the equipment, detecting the component from the detected equipment by using a component detection model learned by learning to detect the component of the equipment, retouching the image data in which the equipment or the component is detected, and determining whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

[0023] An overhead contact line fitting abnormality detection method according to another aspect of the present invention includes performing learning using image data generated by capturing an image of an overhead contact line fitting, and performing abnormality determination using the image data, wherein the performing learning includes learning to detect equipment, and learning to detect a component of the equipment, and the performing abnormality determination includes retouching the image data, detecting the equipment by using an equipment detection model learned by learning to detect the equipment, detecting the component from the detected equipment by using a component detection model learned by learning to detect the component of the equipment, and determining whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

[0024] An overhead contact line fitting abnormality detection method according to yet another aspect of the present invention includes performing learning using image

data generated by capturing an image of an overhead contact line fitting, and performing abnormality determination using the image data, wherein the performing learning includes learning to detect equipment, and learning to detect a component of the equipment, and the performing abnormality determination includes detecting the equipment by using an equipment detection model learned by learning to detect the equipment, detecting the component from the detected equipment by using a component detection model learned by learning to detect the component of the equipment, retouching the image data in which the equipment or the component is detected, based on an image capture time and travel position information for a vehicle, and determining whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

[0025] An overhead contact line fitting abnormality detection method according to yet another aspect of the present invention includes performing learning using image data generated by capturing an image of an overhead contact line fitting, and performing abnormality determination using the image data, wherein the performing learning includes learning to detect equipment, and learning to detect a component of the equipment, and the performing abnormality determination includes detecting the equipment by using an equipment detection model learned by learning to detect the equipment, detecting the component from the detected equipment by using a component detection model learned by learning to detect the component of the equipment, retouching the image data in which the equipment or the component was detected, based on brightness information in the image data or on discriminative AI, and determining whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

[0026] In one aspect of the present invention, the performing abnormality determination includes, before determining whether there is an abnormality in the equipment and/or the component by using the abnormality detection model learned in advance, performing a flipping process on the image data based on a position of a detection target in the image data.

EFFECTS OF INVENTION

[0027] The present invention can provide an overhead contact line fitting abnormality detection device and an overhead contact line fitting abnormality

detection method that allow the detection accuracy of abnormalities in overhead contact line fittings to be increased at a low cost, even when the components to be detected are small.

BRIEF DESCRIPTION OF DRAWINGS

[0028] Fig. 1 is a schematic diagram illustrating an installation example of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 2 is a block diagram illustrating a configuration of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 3 is a flow chart for explaining operations of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 4 is a flow chart for explaining operations for equipment detection learning according to an embodiment of the present invention.

Fig. 5 is a schematic diagram indicating an example of equipment detection results according to an embodiment of the present invention.

Fig. 6 is a flow chart for explaining operations for component detection learning according to an embodiment of the present invention.

Fig. 7 is a schematic diagram indicating an example of component detection results according to an embodiment of the present invention.

Fig. 8 is a schematic diagram indicating an example of image cutout and resizing results according to an embodiment of the present invention.

Fig. 9 is a flow chart for explaining operations for abnormality detection learning according to an embodiment of the present invention.

Fig. 10 is a schematic diagram indicating an example of abnormality detection results according to an embodiment of the present invention.

Fig. 11 is a flow chart for explaining operations of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 12 is a flow chart for explaining operations of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 13 is a schematic diagram indicating an example of abnormality detection by reconstruction error according to an embodiment of the present invention.

Fig. 14 is a flow chart for explaining operations of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 15 is a flow chart for explaining operations of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 16 is a flow chart for explaining operations of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 17 is a flow chart for explaining operations of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 18 is a flow chart for explaining operations of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 19 is a flow chart for explaining operations of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 20 is a schematic diagram indicating a positional relationship between cameras and an overhead contact line fitting for explaining an image flipping process in an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 21 is a schematic diagram for explaining an image flipping process in an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 22 is a schematic diagram for explaining an image flipping process in an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 23 is a schematic diagram for explaining an image flipping process in an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 24 is a schematic diagram for explaining an image flipping process in an overhead contact line fitting abnormality detection device according to an

embodiment of the present invention.

Fig. 25 is a schematic diagram indicating a relationship between railway tracks and overhead contact lines for explaining an image flipping process in an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 26 is a flow chart for explaining operations of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

Fig. 27 is a flow chart for explaining operations of an overhead contact line fitting abnormality detection device according to an embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0029] Hereinafter, embodiments of the present invention will be explained with reference to the attached drawings.

A. First embodiment

Fig. 1 is a schematic diagram illustrating an installation example of an overhead contact line fitting abnormality detection device 13 according to a first embodiment of the present invention. Fig. 1 illustrates a vehicle 1 that is a railway vehicle, a railway track 2 on which the vehicle 1 travels, and an overhead contact line fitting 3 in which an abnormality is to be detected. The vehicle 1 illustrated in Fig. 1 includes a camera 11, a storage device 12, an overhead contact line fitting abnormality detection device 13, and a user interface (input/output unit) 14.

[0030] The camera 11 is installed on the roof of the vehicle 1, captures images of overhead contact line fittings 3, and outputs image data. Examples of the camera 11 include area sensor cameras and line sensor cameras. An unillustrated lighting device may be provided, as needed, to project light onto the overhead contact line fittings 3 for the image capture by the camera 11.

[0031] The storage device 12 stores the image data output from the camera 11. The user interface 14 includes an input unit including at least one of a pointing device and a keyboard, and an output unit including a display. In this case, the storage device 12 may be implemented by means of a storage device such as a semiconductor memory or a magnetic disk.

[0032] Fig. 2 is a block diagram illustrating the configuration of an overhead contact line fitting abnormality detection device 13 according to the present embodiment.

The overhead contact line fitting abnormality detection device 13 includes a data processing unit 15 that has object detection and abnormality determination functions, and a learning processing unit 17 that performs learning of object detection and an abnormality determination model. The overhead contact line fitting abnormality detection device 13 performs abnormality detection of overhead contact line fittings 3 based on image data stored in the storage device 12. The learning processing unit 17 includes an equipment learning unit 19 that learns to detect equipment, and a component learning unit 21 that learns to detect a component of the equipment. By means of deep learning based on the image data stored in the storage device 12, the equipment learning unit 19 generates an equipment detection model, and the component learning unit 21 generates a component detection model. The data processing unit detects the equipment by using the equipment detection model learned by the equipment learning unit, detects the component from the detected equipment by using the component detection model learned by the component learning unit, and determines whether there is an abnormality in the equipment and/or the component by using an abnormality detection model that has been learned in advance. The overhead contact line fitting abnormality detection device 13 may be composed of, for example, an information processing device such as a personal computer.

[0033] Fig. 3 is a flow chart for explaining the operations of the overhead contact line fitting abnormality detection device 13 according to the present embodiment. The operations of the overhead contact line fitting abnormality detection device 13 will be explained using this flow chart.

[0034] <Image input>

Images of an overhead contact line fitting 3 are captured by means of the camera 11 mounted on the roof of the vehicle 1 (Fig. 3, S001).

<Storage in storage device>

The image data taken into the camera 11 is stored in the storage device 12 (Fig. 3,

S002).

[0035] <Equipment detection>

An equipment detection model from an equipment detection model database M01 is used to perform detection of target equipment (Fig. 3, S003). The equipment detection model has undergone deep learning in advance. Fig. 4 is a flow chart indicating the learning operations of the equipment detection model executed by the equipment learning unit 19. Fig. 5 is a schematic diagram indicating results of detection of target equipment using an equipment detection model MS. As indicated in Fig. 4, the equipment learning unit 19 first reads in image data from a traveling image data set D03 (Fig. 4, S101). Next, equipment detection learning is performed using data including two types, i.e., correct answer labels and position information for rectangular regions (the coordinates of the four vertices of the rectangular regions) surrounding target equipment in the image data, from an equipment annotation database D04 (Fig. 4, S102). The equipment detection model that has undergone deep learning is stored in the equipment detection model database M01 (Fig. 4, S103).

[0036] Fig. 5 indicates an example of operations for performing equipment detection using an equipment detection model MS that has been learned by deep learning in advance in this way. The equipment detection model MS receives an input image G1 as an input, and outputs an equipment detection result G2. As the equipment detection result, "equipment rectangle coordinate information" is obtained as the "rectangle coordinate information in the image data" indicated by the dashed lines A in the equipment detection result G2, and an "equipment label" corresponding to the type of equipment is obtained as "label information".

<Equipment detection result determination>

Next, in the case in which equipment has been detected, the procedure advances to component existence determination (Fig. 3, S004, YES). In the case in which equipment has not been detected, the procedure advances to image capture ending condition determination (Fig. 3, S004, NO).

[0037] <Component existence determination>

Based on an inspection category database D01 and the "equipment label" in the

case in which equipment has been detected by the equipment detection (Fig. 3, S003), it is determined whether a target component exists on the target equipment that has been detected (Fig. 3, S005). In this case, in the inspection category database D01, each equipment label describes whether or not a target component exists. In the case in which a target component exists, the procedure advances to a component detection process (Fig. 3, S005, YES), and in the case in which a target component does not exist, the procedure advances to an image cutout and resizing process (Fig. 3, S005, NO).

[0038] <Component detection>

In the component detection, object detection is performed, limited so as to be within the rectangular region detected by the equipment detection (Fig. 3, S003). At this time, a component detection model from the component detection model database M02 is used to perform component detection for each target equipment in which a target component exists (Fig. 3, S006). The component detection model has undergone deep learning in advance. Fig. 6 is a flow chart indicating the learning operations of the component detection model executed by the component learning unit 21. Fig. 7 is a schematic diagram indicating a result of performing target component detection using the component detection model MB. As indicated in Fig. 6, the component learning unit 21 first reads in image data from an equipment image data set D05 (Fig. 6, S201). Next, component detection learning is performed using data including two types, i.e., correct answer labels and position information for rectangular regions (the coordinates of the four vertices of the rectangular regions) surrounding target components in the image data, from a component annotation database D06 (Fig. 6, S202). The component detection model that has undergone deep learning is stored in the component detection model database M02 (Fig. 6, S203). Next, in the case in which the learning of the components has not been completed in all of the equipment (Fig. 6, S204, NO), the same flow is repeated from the image input S201. In the case in which the learning of the components has been completed in all of the equipment (Fig. 6, S204, YES), the learning operation ends at that point.

[0039] Fig. 7 indicates an example of operations for performing equipment detection using a component detection model MB that has been learned by deep

learning in advance in this way. The component detection model MB receives an input image G3 as an input, and outputs a component detection result G4. As the component detection result, multiple items of "component rectangle coordinate information", indicated by the dashed lines B in the detection result G2, are obtained as the "rectangle coordinate information in the image data", and "component labels" corresponding to the types of components are obtained as "label information". In this case, as detection results, detection results for both equipment and components, such as the "equipment rectangle coordinate information" and the "equipment label" remaining from the equipment detection, and the "component rectangle coordinate information" and the "component labels" detected by component detection, are stored.

[0040] <Image cutout and resizing>

From the image data, an image is cut out based on the "equipment rectangle coordinate information" indicated by the dashed lines A in Fig. 5 or on the "component rectangle coordinate information" indicated by the dashed lines B in Fig. 7, and the image is resized to an image size that can be handled by the abnormality detection model (Fig. 3, S007). Fig. 8 is a schematic diagram indicating an example of image cutout and resizing results. Fig. 8 indicates an example of image cutout and resizing of the rectangle coordinate region of the dashed lines A in the equipment detection results. The image that has been cut out is resized to a square shape for object detection. The "rectangle coordinate information in the image data", the "label information", and the "resized cutout image" are transmitted to a later process.

[0041] <Anomaly degree calculation>

Abnormality detection models are read out, from an abnormality detection model database M03, for respective equipment or components that were learned in advance, and applied to a resized cutout image to calculate an anomaly degree (Fig. 3, S008). The abnormality detection model has undergone deep learning in advance. Fig. 9 is a flow chart indicating the learning operations of the abnormality detection model executed by the equipment learning unit 19 and the component learning unit 21. Fig. 10 is a schematic diagram indicating a result of performing anomaly degree calculation using the abnormality detection model MK. As indicated in Fig. 9, the equipment learning unit 19 and the component learning unit 21 first read in image

data from respective abnormality detection image data sets D07 (Fig. 9, S301). Abnormality detection learning is performed with the images that have been read in (Fig. 9, S302). The abnormality detection model that has undergone deep learning is stored in the abnormality detection model database M03 (Fig. 9, S303). Next, in the case in which the abnormality detection learning has not been completed for all of the equipment and components (Fig. 9, S304, NO), the same flow is repeated from the image input S301. In the case in which the abnormality detection learning has been completed for all of the equipment and components (Fig. 6, S304, YES), the learning operation ends at that point.

[0042] Fig. 10 indicates an example of operations for performing abnormality detection using the abnormality detection model MK that has been learned by deep learning in advance in this way. The abnormality detection model MK receives input images G5, G6 as inputs, and outputs a component detection result G7. In this case, G5 is an example of normal data and G6 is an example of abnormal data. In the present embodiment, as the abnormality detection model, an example of a distance-based abnormality detection model using multi-dimensional features will be indicated. If the abnormality detection model used here outputs multi-dimensional features, the training data may be either supervised or unsupervised. However, in the case in which the training data is supervised, the training data must be annotated regarding whether the data is normal or abnormal in advance. The multi-dimensional features that have been output are plotted in latent variable space and the anomaly degree is calculated by the distance from a normal center. Abnormal data is plotted at positions relatively distant from the normal center.

[0043] <Anomaly degree determination>

The anomaly degree calculated as a distance in the latent variable space is subjected to an abnormality determination by reading out an abnormality determination threshold value set for respective target equipment and target components from an abnormality detection threshold value database D02 that has been prepared in advance, and by using that threshold value (Fig. 3, S009). In the case in which the output is a multi-dimensional feature as mentioned above, the anomaly degree is computed by the distance from the normal center, and when the anomaly degree is equal to or greater than the threshold value (Fig. 3, S009, YES),

an abnormal flag is appended (Fig. 3, S010). In the case in which the anomaly degree is not equal to or greater than the threshold value (Fig. 3, S009, NO), a normal flag is appended (Fig. 3, S011). After the flag has been appended, the abnormality detection result is stored (Fig. 3, S012). The information stored at this time is "rectangle coordinate information", "label information", and an "abnormality determination result".

<Image capture end determination>

Finally, it is determined whether the process has been completed for all images (Fig. 3, S013). In the case in which image capture has not been completed (Fig. 3, S013, NO), the flow is repeated from the image input S001. In the case in which image capture has been completed (Fig. 3, S013, YES), the process ends.

[0044] Although the method of deep learning using detection models for equipment detection (Fig. 3, S004) and component detection (Fig. 3, S006) in this processing flow is not particularly limited, an example is SSD (Single-Shot Multibox Detector), etc.

[0045] As mentioned above, in the present embodiment, equipment detection is performed by means of an equipment detection model, and component detection is further performed on the detected equipment by means of a component detection model for each equipment. An anomaly degree is calculated by means of respective abnormality detection models for the respective equipment and components that have been detected. Therefore, abnormality detection can be performed not only for equipment occupying relatively large regions, but also for components occupying small regions, thereby increasing the abnormality detection accuracy. By performing object detection step by step, i.e., equipment detection followed by component detection, the detection of relatively small regions is made possible without using semantic segmentation, and by employing object detection with low computational costs and annotation costs in target component detection, the cost of computation is reduced, allowing the detection accuracy to be increased. In this manner, it is possible to provide an overhead contact line fitting abnormality detection device and an overhead contact line fitting abnormality detection method that can improve overhead contact line fitting abnormality detection accuracy at a low cost, even in the case in which the component to be detected is small.

[0046] B. Second embodiment

Fig. 11 indicates a flow chart of the operations of an overhead contact line fitting abnormality detection device 13 of the present embodiment. The present embodiment differs from the first embodiment in that, during equipment detection, equipment installation position information (equipment information) from an equipment database F1 and vehicle travel position information F2 are added, and during component detection, equipment installation position information from an equipment database F3 and vehicle travel position information F4 are added. Aside from these features, the operations and functions are the same. Therefore, the same reference numbers are used in the drawings and the explanations thereof are omitted. Adding vehicle travel information and equipment installation position information during equipment detection and component detection means that, for example, it is possible to determine whether or not equipment has been installed from the vehicle position information for a captured image. Due to this feature, in addition to the functions and effects of the first embodiment, detection errors in which it is determined that there is equipment or a component even though there is no equipment or component can be suppressed, and detection can be reliably performed at travel positions at which equipment and components are installed, thereby increasing the detection accuracy.

[0047] C. Third embodiment

Fig. 12 indicates a flow chart of the operations of an overhead contact line fitting abnormality detection device 13 of the present embodiment. Fig. 13 illustrates a schematic diagram indicating abnormality detection operations using an abnormality detection model MA based on reconstruction error in the present embodiment. The present embodiment differs from the first embodiment in that reconstruction error calculated from an input image and an image reconstructed by an autoencoder or the like is used for anomaly degree determination (Fig. 12, S409). Aside from this feature, the operations and functions are the same. Therefore, the same reference numbers are used in the drawings and the explanations thereof are omitted. As indicated in Fig. 13, the abnormality detection model MA in the present embodiment is composed of an encoder and a decoder. Images G8, G9 are input and reconstructed images G10, G11 are output. Thereafter, the differences between the

input images G8, G9 and the reconstructed images G10, G11 are compared and the results are output. The differential comparison is performed, for example, by computing the difference between RGB values for each pixel, summing the differences, and using the sum as an indicator of the anomaly degree. Therefore, in addition to the functions and effects of the first embodiment, the anomaly degree computation method of the present embodiment can be applied to increase the detection accuracy based on the implemented detection target.

[0048] D. Fourth embodiment

Fig. 14 indicates a flow chart of the operations of an overhead contact line fitting abnormality detection device 13 of the present embodiment. The present embodiment differs from the third embodiment in that, during equipment detection, equipment installation position information (equipment information) from an equipment database F1 and vehicle travel position information F2 are added, and during component detection, equipment installation position information from an equipment database F3 and vehicle travel position information F4 are added. Aside from these features, the operations and functions are the same. Therefore, the same reference numbers are used in the drawings and the explanations thereof are omitted. Adding vehicle travel information and equipment installation position information during equipment detection and component detection means that, for example, it is possible to determine whether or not equipment has been installed from the vehicle position information for a captured image. Due to this feature, in addition to the functions and effects of the third embodiment, detection errors in which it is determined that there is equipment or a component even though there is no equipment or component can be suppressed, and detection can be reliably performed at travel positions at which equipment and components are installed, thereby increasing the detection accuracy.

[0049] E. Fifth embodiment

Fig. 15 indicates a flow chart of the operations of an overhead contact line fitting abnormality detection device 13 of the present embodiment. The present embodiment differs from the first embodiment in that, after equipment detection (Fig. 15, S003) or component detection (Fig. 15, S006), detection results are displayed and the detection result are edited by a worker. Aside from these features, the

operations and functions are the same. Therefore, the same reference numbers are used in the drawings and the explanations thereof are omitted. In the operations of the present embodiment, for example, detection results are displayed on a display of a user interface (input/output unit) 14. A worker checks the detection results displayed on the display, and if there is a detection error, corrects the rectangle position or/and the label from a pointing device or/and a keyboard of the user interface (input/output unit) 14 by manual input (Fig. 15, S501). Due to this feature, in addition to the functions and effects of the first embodiment, images to be input for abnormality determination are corrected and therefore become correct, allowing highly accurate abnormality determination to be implemented. The feature of the present embodiment in which detection results are edited by manual input by a worker is also applicable to each of the second embodiment, the third embodiment, and the fourth embodiment, as indicated in Fig. 16, Fig. 17, and Fig. 18. Similarly, in addition to the respective functions and effects thereof, images to be input for abnormality determination are corrected and therefore become correct, allowing highly accurate abnormality determination to be implemented.

[0050] F. Sixth embodiment

Fig. 19 indicates a flow chart of the operations of an overhead contact line fitting abnormality detection device 13 of the present embodiment. The device configuration is the same as that in Fig. 2 indicated for the first embodiment. The present embodiment differs from the first embodiment in that, after image cutout (Fig. 19, S007a) and image resizing (Fig. 19, S007b), an image retouching process (Fig. 19, S601) and an image flipping process (Fig. 19, S602, S603) are performed. The step indicated to be image cutout and resizing (Fig. 3, S007) in the flow chart of the first embodiment in Fig. 3, is indicated by two steps, i.e., image cutout (Fig. 19, S007a) and image resizing (Fig. 19, S007b) in Fig. 19. However, the operations are the same as those in the first embodiment. Aside from these features, the operations and functions are the same as those in the first embodiment. Therefore, the same reference numbers are used in the flow chart in Fig. 19 and the explanations thereof are omitted.

[0051] Hereinafter, the functions newly provided in the present embodiment will be explained.

<Image retouching process>

In the image retouching process, image data cut out based on the "equipment rectangle coordinate information" indicated by the dashed lines A in Fig. 5 or the "component rectangle coordinate information" indicated by the dashed lines B in Fig. 7 (Fig. 19, S0007a), and resized to an image size that can be handled by the abnormality detection model (Fig. 19, S007b) is retouched (Fig. 19, S601). As the image retouching process, for example, a brightness correction process and an edge enhancement process are implemented. At this time, the brightness correction method and the edge enhancement process may be arbitrary methods, examples of which include gamma correction, contrast correction, etc. for brightness correction, and bilateral filtering, etc. for edge enhancement. The "retouched image" that has been retouched is transmitted to the subsequent image flipping process together with the "rectangle coordinate information" and the "label information".

[0052] <Image flipping process>

In the image flipping process, horizontal (left-right) flipping target region information is read out from a horizontal flipping target region information database (Fig. 19, D20), and it is examined whether or not the position of the detection target in the retouched image data received from the preceding image retouching process (Fig. 19, S601) is located within a horizontal flipping target region (Fig. 19, S602). In the case in which the position of the detection target is within the horizontal flipping target region (Fig. 19, S601, YES), an image flipping process is performed (Fig. 19, S603) and the image-flipped image data is transmitted to the anomaly degree calculation process (Fig. 19, S008). In the case in which the detection position of the detection target is not within the horizontal flipping target region (Fig. 19, S601, NO), the image-retouched image data is transmitted directly to the anomaly degree calculation process (Fig. 19, S008).

[0053] The image flipping process will be explained in further detail. Fig. 20 is a schematic diagram for explaining a situation in which an image of an overhead contact line fitting 3 that is an inspection target in the present embodiment is captured. As illustrated in Fig. 20, the vehicle 1, which is a railway vehicle, is traveling on a railway track 2. A right camera 11a and a left camera 11b are installed on the roof of the vehicle 1. The right camera 11a and the left camera 11b are

installed so that the optical axes of the cameras are directed upwards to capture images of overhead contact line fittings 3 located above the vehicle 1. In Fig. 20, a messenger wire 3a, a hanger 3b, and a contact wire 3c are indicated as examples of features of the overhead contact line fitting 3. Fig. 21 is a plan view of the configuration including the vehicle 1, the right camera 11a, and the left camera 11b indicated in Fig. 20, seen from above. The rectangular images cut out as equipment from the images captured by the right camera 11a and the left camera 11b are indicated as the image R and the image L. The white arrow S indicates the scan direction of the right camera 11a and the left camera 11b that face upwards. In this case, the explanation will focus on the left camera. However, a similar situation occurs with the right camera as well.

[0054] Fig. 22 indicates an image L0 captured by the left camera 11b when in the positional relationship in Fig. 21, before image cutout. An image L is cut out from the image L0 by the equipment detection process. The region divided into the left and right by the line C defines the aforementioned horizontal flipping target region. This target information is recorded in the horizontal flipping target region information database (Fig. 19, D20). In Fig. 22, an image of the overhead contact line fitting 3 is captured on the right side with respect to the line C. As indicated in Fig. 20 and Fig. 21, the overhead contact line fitting 3 is positioned to the upper right, in the plane of the page in Fig. 21, as seen from the left camera 11b. Therefore, when the camera is scanned as in the arrow S, the captured image is captured, from the right in the plane of the page, in the order of the contact wire 3c, the hanger 3b, and the messenger wire 3a, as illustrated in Fig. 22.

[0055] Fig. 23 is a plan view similar to Fig. 21. However, the overhead contact line fitting 3 is indicated as being positioned to the upper left in the plane of the page in Fig. 23, as seen from the left camera 11b. Fig. 24 indicates an image L1 captured by the left camera 11b when in the positional relationship in Fig. 23, before image cutout. An image La is cut out from the image L1 by the equipment detection process. In this case, an image of the overhead contact line fitting 3 is captured on the left side with respect to the line C. As indicated in Fig. 23, the overhead contact line fitting 3 is positioned to the upper left, in the plane of the page in Fig. 23, as seen from the left camera 11b. Therefore, when the camera is scanned as in the arrow S, the captured image is captured, from the right in the plane of the page, in the order

of the messenger wire 3a, the hanger 3b, and the contact wire 3c, as illustrated in Fig. 24.

[0056] From the above analysis, the symmetry of the detection target changes depending on whether the detection target is captured in the right region or is captured in the left region with respect to the line C. When learning the abnormality detection model and during abnormality detection by the model, the detection accuracy can be increased by executing the learning and detection by aligning the symmetry. Therefore, the configurations of the detection targets should preferably be aligned. For example, when an image is arranged in the order of the contact wire 3c, the hanger 3b, and the messenger wire 3a from the right in the plane of the page, as indicated in Fig. 22, image processing is performed so that horizontal image flipping is not performed when the detection target is positioned in the region on the right side of line C, and horizontal image flipping is performed when the detection target is positioned in the region on the left side of line C. In this case, for the right camera 11a as well, horizontal image flipping is performed by determining the region in which a detection target is positioned so the features are arranged in the order of the contact wire 3c, the hanger 3b, and the messenger wire 3a from the right of the image.

[0057] Fig. 25 is a diagram illustrating the positional relationships of overhead contact lines 20 with respect to railway tracks 2. In Fig. 25, left/right pairs of railway tracks 2 and overhead contact lines 20 are indicated. The reason that the overhead contact line fittings 3 that are the detection targets move left and right in the image regions in the images captured by the right camera 11a and by the left camera 11b is that, as illustrated in Fig. 25, the overhead contact lines 20 are installed so as to be pulled to the left and to the right with respect to the railway tracks 2 by curve pulling devices 23. The reason that the overhead contact lines 20 are arranged in this way is to prevent localized wear on pantographs, which are power-receiving devices. That is, the overhead contact lines 20 are arranged in a so-called zigzag in order to even out the contact frequency between the overhead contact lines 20 and the pantographs on the contact surfaces of the pantographs. Therefore, even over a line of travel, there is a possibility that an overhead contact line 20 will cross the central axis of a camera. Additionally, in the case in which there are parallel railway tracks 2 (such as inbound and outbound lines), there are cases in which the overhead

contact line equipment of the parallel railway track 2 is detected, and it can be captured in a flipping region. In any case, the horizontal image flipping process is performed based on whether or not the detection targets are in image flipping regions, and the image flipping process is performed so that the images provided for anomaly degree calculation have shared features (the order of the messenger wire, the hanger, and the contact wire is fixed).

[0058] The processes following the image flipping process in the present embodiment are the same as those in the first embodiment. However, regarding the anomaly degree calculation, the anomaly degree calculation is performed on retouched and flipped cutout images. At this time, the advance learning model implements learning by using data that has been subjected to the image retouching process and to the image flipping process.

[0059] As mentioned above, in the present embodiment, an image retouching process and an image flipping process are performed on cut out and resized image data. Therefore, in addition to the functions and effects of the first embodiment, the abnormality detection accuracy can be increased. Specifically, with respect to the cut out and resized images after equipment detection, a brightness correction process and an edge enhancement process are performed, as image retouching processes, on all data. Due to this feature, even in cases in which the target equipment is not clearly captured, as in environments in which image capture tends to occur in low brightness, such as at night and in tunnels, highly accurate abnormality detection can be realized. Additionally, in the present embodiment, the order of detection targets in image data for which anomaly degree calculations are to be performed can be aligned, thereby increasing the accuracy of abnormality detection.

[0060] G. Seventh embodiment

Fig. 26 indicates a flow chart of the operations of an overhead contact line fitting abnormality detection device 13 of the present embodiment. The device configuration is the same as that in Fig. 2 indicated for the first embodiment. The present embodiment differs from the sixth embodiment in that the image retouching process (Fig. 26, S701) is performed with respect to all images that have been captured. Aside from this feature, the operations and functions are the same as those in the sixth embodiment. Therefore, the same reference numbers are used in

the flow chart in Fig. 26 and the explanations thereof are omitted. In the present embodiment, in addition to the functions and effects of the sixth embodiment, a brightness correction process and an edge enhancement process are added, as image retouching processes, before equipment detection. Due to this feature, even in cases in which the target equipment is not clearly captured, as in environments in which image capture tends to occur in low brightness, such as at night and in tunnels, highly accurate equipment detection and abnormality detection can be realized.

[0061] H. Eighth embodiment

Fig. 27 indicates a flow chart of the operations of an overhead contact line fitting abnormality detection device 13 of the present embodiment. The device configuration is the same as that in Fig. 2 indicated for the first embodiment. The present embodiment differs from the sixth embodiment in that, instead of the image retouching process (Fig. 19, S601) in the sixth embodiment, retouching is performed on an image that has been image-cutout and resized based on the image capture time and vehicle travel position information (Fig. 27, S801, S802). Aside from this feature, the operations and functions are the same as those in the sixth embodiment. Therefore, the same reference numbers are used in the flow chart in Fig. 27 and the explanations thereof are omitted. Specifically, whereas the image retouching process is implemented with respect to all of the cut out and resized image data in the sixth embodiment, travel intervals in which the images could be unclear, such as at night and in tunnels, are determined based on travel information (position information regarding the point currently being traveled is acquired from a vehicle) and image capture times for targets (the determination being made with reference to the current travel position information based on railway distance information for the insides of tunnels, etc., that has been acquired in advance), and the processing is applied by limiting the image data that is to be subjected to image retouching.

[0062] Hereinafter, the functions provided in the present embodiment will be explained.

<Unclear interval determination>

When an image-cutout, resized image is supplied, the data processing unit 15 references the image capture time and the travel position information, and based on

that information, if a travel interval is assessed to be such that images could be unclear due to it being nighttime or being inside a tunnel, a flag for executing an image retouching process is appended (Fig. 27, S801). In the case in which an interval has been assessed not to be an unclear interval (Fig. 27, S801, NO), the process shifts to the next horizontal image flipping process (Fig. 27, S602). In the case in which an interval has been assessed to be an unclear interval (Fig. 27, S801, YES), an image retouching process is performed (Fig. 27, S802). In this case, the image retouching process is the same as that of S601 in Fig. 19 in the sixth embodiment. After image retouching has been completed, the process shifts to assessing the next horizontal image flipping process (Fig. 27, S602).

[0063] In the present embodiment, in addition to the functions and effects of the sixth embodiment, a brightness correction process and an edge enhancement process are performed, as image retouching processes, based on the image capture time and travel information, on cut out and resized images after equipment detection. Therefore, image retouching is performed by accurately assessing cases in which target equipment will not be captured clearly, such as in environments in which image capture tends to occur in low brightness, such as at night and in tunnels, and highly accurate abnormality detection can be realized.

[0064] I. Ninth embodiment

The flow chart of the operations of an overhead contact line fitting abnormality detection device 13 of the present embodiment is the same as that in Fig. 27 indicated for the eighth embodiment. Additionally, the device configuration is also the same as that in Fig. 2 indicated for the first embodiment. The present embodiment differs from the eighth embodiment in terms of the conditional assessment for determining unclear intervals. Aside from this feature, the operations and functions are the same as those in the eighth embodiment. Therefore, the explanations thereof are omitted.

[0065] In the present embodiment, as a condition for determining unclear intervals, instead of the image capture time and the vehicle travel position information in the eighth embodiment, the determination is made based on brightness information of the image data. For example, travel intervals in which images could be unclear, such as at night and in tunnels, are determined by using an

automatic determination process. In the automatic determination process, the determination may be made by means of an algorithm using brightness information such as the average brightness of a captured image (determination by "average brightness < threshold value" for each line or for each image combining multiple lines). Alternatively, the determination may be made by using discriminative AI (AlexNet, VGG, GoogleNet, ResNet, etc.) or the like. Additionally, in the case in which an algorithm based on brightness information is used, the average value and the variance of the brightness may be used. In the case in which statistical information regarding the brightness is used, preprocessing, such as noise removal, may be performed, as needed, before calculating the statistical information.

[0066] In the present embodiment, in addition to the functions and effects of the sixth embodiment, a brightness correction process and an edge enhancement process are performed, as image retouching processes, based on image brightness information or on discriminative AI, on cut out and resized images after equipment detection. Therefore, image retouching is performed by accurately assessing cases in which target equipment will not be captured clearly, such as in environments in which image capture tends to occur in low brightness, such as at night and in tunnels, and highly accurate abnormality detection can be realized.

[0067] Aside from the above, the features mentioned in the above-mentioned embodiments may be adopted, omitted or selected, or may be changed, as appropriate, to other features, as long as the result does not depart from the spirit of the present invention.

REFERENCE SIGNS LIST

[0068]	1	Vehicle
	2	Railway track
	3	Overhead contact line fitting
	11	Camera
	12	Storage device
	13	Overhead contact line fitting abnormality detection device
	14	User interface (input/output unit)

15	Data processing unit
17	Learning processing unit
19	Equipment learning unit
21	Component learning unit

CLAIMS

1. An overhead contact line fitting abnormality detection device comprising:
a learning processing unit that performs learning using image data generated by capturing an image of an overhead contact line fitting; and
a data processing unit that performs abnormality determination using the image data, wherein
the learning processing unit comprises an equipment learning unit that learns to detect equipment, and a component learning unit that learns to detect a component of the equipment, and
the data processing unit detects the equipment by using an equipment detection model learned by the equipment learning unit, detects the component from the detected equipment by using a component detection model learned by the component learning unit, and determines whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.
2. The overhead contact line fitting abnormality detection device according to claim 1, wherein the data processing unit detects the equipment based on the equipment detection model, travel position information for a vehicle, and equipment information.
3. The overhead contact line fitting abnormality detection device according to claim 1 or 2, wherein the data processing unit determines whether there is an abnormality in the equipment and/or the component based on reconstruction error in the abnormality detection model.
4. The overhead contact line fitting abnormality detection device according to claim 1 or 2, further comprising an input/output unit, wherein a detection result of the equipment and/or the component detected by the data processing unit is displayed on the input/output unit, and a worker checks and edits the detection result from the input/output unit.
5. An overhead contact line fitting abnormality detection method comprising:
performing learning using image data generated by capturing an image of an overhead contact line fitting; and
performing abnormality determination using the image data, wherein

the performing learning comprises learning to detect equipment, and learning to detect a component of the equipment, and

the performing abnormality determination comprises detecting the equipment by using an equipment detection model learned by learning to detect the equipment, detecting the component from the detected equipment by using a component detection model learned by learning to detect the component of the equipment, and determining whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

6. The overhead contact line fitting abnormality detection method according to claim 5, wherein the performing abnormality determination comprises detecting the equipment based on the equipment detection model, travel position information for a vehicle, and equipment information.

7. The overhead contact line fitting abnormality detection method according to claim 5 or 6, wherein the performing abnormality determination comprises determining whether there is an abnormality in the equipment and/or the component based on reconstruction error in the abnormality detection model.

8. The overhead contact line fitting abnormality detection method according to claim 5 or 6, comprising displaying, on an input/output unit, a detection result of the equipment and/or the component detected at the performing abnormality determination, and a worker checking and editing the detection result from the input/output unit.

9. An overhead contact line fitting abnormality detection device comprising:

a learning processing unit that performs learning using image data generated by capturing an image of an overhead contact line fitting; and

a data processing unit that performs abnormality determination using the image data, wherein

the learning processing unit comprises an equipment learning unit that learns to detect equipment, and a component learning unit that learns to detect a component of the equipment, and

the data processing unit

detects the equipment by using an equipment detection model learned by the equipment learning unit,

detects the component from the detected equipment by using a component detection model learned by the component learning unit,

retouches the image data in which the equipment or the component was detected, and

determines whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

10. An overhead contact line fitting abnormality detection device comprising:

a learning processing unit that performs learning using image data generated by capturing an image of an overhead contact line fitting; and

a data processing unit that performs abnormality determination using the image data, wherein

the learning processing unit comprises an equipment learning unit that learns to detect equipment, and a component learning unit that learns to detect a component of the equipment, and

the data processing unit

retouches the image data,

detects the equipment by using an equipment detection model learned by the equipment learning unit,

detects the component from the detected equipment by using a component detection model learned by the component learning unit, and

determines whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

11. An overhead contact line fitting abnormality detection device comprising:

a learning processing unit that performs learning using image data generated by capturing an image of an overhead contact line fitting; and

a data processing unit that performs abnormality determination using the image data, wherein

the learning processing unit comprises an equipment learning unit that learns to detect equipment, and a component learning unit that learns to detect a component of the equipment, and

the data processing unit

detects the equipment by using an equipment detection model learned by

the equipment learning unit,

detects the component from the detected equipment by using a component detection model learned by the component learning unit,

retouches the image data in which the equipment or the component is detected, based on an image capture time and travel position information for a vehicle, and

determines whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

12. An overhead contact line fitting abnormality detection device comprising:

a learning processing unit that performs learning using image data generated by capturing an image of an overhead contact line fitting; and

a data processing unit that performs abnormality determination using the image data, wherein

the learning processing unit comprises an equipment learning unit that learns to detect equipment, and a component learning unit that learns to detect a component of the equipment, and

the data processing unit

detects the equipment by using an equipment detection model learned by the equipment learning unit,

detects the component from the detected equipment by using a component detection model learned by the component learning unit,

retouches the image data in which the equipment or the component is detected, based on brightness information in the image data or on discriminative AI, and

determines whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

13. The overhead contact line fitting abnormality detection device according to any one of claims 9 to 12, wherein

the data processing unit,

before determining whether there is an abnormality in the equipment and/or the component by using the abnormality detection model learned in advance, performs a flipping process on the image data based on a position of a detection

target in the image data.

14. An overhead contact line fitting abnormality detection method comprising:
performing learning using image data generated by capturing an image of an overhead contact line fitting; and
performing abnormality determination using the image data, wherein
the performing learning comprises learning to detect equipment, and learning to detect a component of the equipment, and
the performing abnormality determination comprises
detecting the equipment by using an equipment detection model learned by learning to detect the equipment,
detecting the component from the detected equipment by using a component detection model learned by learning to detect the component of the equipment,
retouching the image data in which the equipment or the component is detected, and
determining whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

15. An overhead contact line fitting abnormality detection method comprising:
performing learning using image data generated by capturing an image of an overhead contact line fitting; and
performing abnormality determination using the image data, wherein
the performing learning comprises learning to detect equipment, and learning to detect a component of the equipment, and
the performing abnormality determination comprises
retouching the image data,
detecting the equipment by using an equipment detection model learned by learning to detect the equipment,
detecting the component from the detected equipment by using a component detection model learned by learning to detect the component of the equipment, and
determining whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

16. An overhead contact line fitting abnormality detection method comprising:

performing learning using image data generated by capturing an image of an overhead contact line fitting; and

performing abnormality determination using the image data, wherein the performing learning comprises learning to detect equipment, and learning to detect a component of the equipment, and

the performing abnormality determination comprises detecting the equipment by using an equipment detection model learned by learning to detect the equipment,

detecting the component from the detected equipment by using a component detection model learned by learning to detect the component of the equipment,

retouching the image data in which the equipment or the component is detected, based on an image capture time and travel position information for a vehicle, and

determining whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

17. An overhead contact line fitting abnormality detection method comprising:

performing learning using image data generated by capturing an image of an overhead contact line fitting; and

performing abnormality determination using the image data, wherein the performing learning comprises learning to detect equipment, and learning to detect a component of the equipment, and

the performing abnormality determination comprises detecting the equipment by using an equipment detection model learned by learning to detect the equipment,

detecting the component from the detected equipment by using a component detection model learned by learning to detect the component of the equipment,

retouching the image data in which the equipment or the component is detected, based on brightness information in the image data or on discriminative AI, and

determining whether there is an abnormality in the equipment and/or the component by using an abnormality detection model learned in advance.

18. The overhead contact line fitting abnormality detection method according to

any one of claims 14 to 17, wherein

the performing abnormality determination comprises,

before determining whether there is an abnormality in the equipment and/or the component by using the abnormality detection model learned in advance, performing a flipping process on the image data based on a position of a detection target in the image data.