

DESCRIPTION

TITLE OF THE INVENTION: DEVICE FOR HANGER DETECTION BY IMAGE PROCESSING

TECHNICAL FIELD

[0001]

The present invention relates to a device for hanger detection by image processing that detects hangers by image processing to detect the travel position of a train vehicle and abnormality in hanger angles.

BACKGROUND ART

[0002]

First, the necessity of hanger detection is described.

A railway business operator records images of railway tracks while a train is travelling and identifies the travel position of the train based on the recorded images. Conventional techniques for identifying the travel position of a train include GPS and ATC techniques. While these techniques are accurate enough not to impede the operation of a train, the travel position of a train needs to be obtained more accurately in a case where the travel position is to be identified in an image.

[0003]

It is also important to obtain the angles of hangers because hangers, which are normally suspended vertically, become slanted with respect to the vertical direction with changes in temperature, and the like, and such slanted hangers lower the power collection performance of a train. Patent Documents 1 and 2 below are publicly known as conventional hanger detection techniques. Patent Document 1 is a patent for detecting hangers in a captured image by performing template

matching processing or vertical edge detection processing. Patent Document 2 is a patent for detecting hangers in a captured image by performing Hough transform or luminance histogram processing or by detecting an intersection between two straight lines.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0004]

Patent Document 1: Japanese Patent No. 5402096

Patent Document 2: Japanese Patent No. 5402272

Patent Document 3: Japanese Patent Application Publication No. 2013-015336

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005]

The inventions disclosed in Patent Documents 1 and 2 above can detect hangers for simple line arrangements. However, it is difficult to detect hangers 6 at locations having a crossover or an overlap, where a plurality of lines 4 and 5 intersect as illustrated in Fig. 8.

Patent Document 1 detects hangers using vertical edge detection. In typical edge detection, a location with a large differential value between two pixels is detected as an edge. Such local two-pixel detection is problematic because erroneous detection often occurs.

Patent Document 2 is a patent for hanger detection using Hough transform. Hough transform finds hangers using the relative number of votes between features in the entire image and hanger features, and therefore it is difficult to detect a hanger 6 which appears small in the captured image relative

to the entire image as shown in Fig. 8.

[0006]

Patent Document 3 above is a related patent. Patent Document 3 is an invention that measures wear of an overhead line, and is a patent for robustly detecting a worn location in an overhead line by performing background elimination using GSTH processing (see Figs. 4 and 5). The GSTH processing in Patent Document 3 is characterized by utilization of the fact that light illuminated upon the lower surface of an overhead line is reflected as white. Since there is no location that causes white reflection in hangers, to which the present application refers, it is difficult to detect hangers using Patent Document 3.

[0007]

In view of the above, the present invention aims to provide a device for hanger detection by image processing, capable of detecting a hanger with higher accuracy.

MEANS FOR SOLVING THE PROBLEMS

[0008]

A device for hanger detection by image processing according to a first aspect of the present invention to solve the problem above is a device for hanger detection by image processing that includes a line sensor camera that captures an image of hangers from a roof of a vehicle, the hangers being installed with equal spacing and supporting an overhead line, and an image processing unit that is installed inside the vehicle and analyzes the image captured by the line sensor, the device being configured to detect hangers in the image, in which the image processing unit includes a GSTH processing unit that sequentially performs GSTH processing on a line sensor image

inputted from the line sensor camera in a direction of an imaging line of the line sensor camera and in a direction of time to acquire a GSTH image in which the hangers in the image are highlighted, and a hanger detection unit that detects the hangers in the GSTH image.

[0009]

In the first aspect, a device for hanger detection by image processing according to a second aspect of the present invention is the device for hanger detection by image processing in which the GSTH processing performed by the GSTH processing unit includes acquiring a first GSTH image by performing erosion processing and then dilation processing on the line sensor image in the direction of the imaging line of the line sensor camera, acquiring a difference image that is a difference between the first GSTH image and the line sensor image, and acquiring a second GSTH image in which the hangers in the line sensor image are highlighted, by performing erosion processing and then dilation processing on the difference image in the direction of time, and the hanger detection unit detects the hangers in the second GSTH image.

[0010]

In the first aspect, a device for hanger detection by image processing according to a third aspect of the present invention is the device for hanger detection by image processing in which the GSTH processing performed by the GSTH processing unit includes acquiring a gsth image by performing only erosion processing on the line sensor image in the direction of the imaging line of the line sensor camera and acquiring the GSTH image in which the hangers in the line sensor image are highlighted, by performing erosion processing and then dilation

processing on the gsth image in the direction of time, and the hanger detection unit detects the hangers in the GSTH image.

[0011]

In the first aspect, a device for hanger detection by image processing according to a fourth aspect of the present invention is the device for hanger detection by image processing in which the GSTH processing unit performs the GSTH processing after performing luminance inversion processing on the line sensor image one line at a time in the direction of the imaging line of the line sensor camera, the luminance inversion processing inverting luminance values on a line if luminance values of principal components on the line in the direction of the imaging line of the line sensor camera represent light colors, and not inverting the luminance values on the line if the luminance values of the principal components represent dark colors.

EFFECT OF THE INVENTION

[0012]

The present invention can extract only the hangers that appear in an image as straight lines extending in a predetermined direction and being thinner than a predetermined thickness, and therefore can detect with high accuracy only normal hangers having an installation angle within a management value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

[Fig. 1] Fig. 1 is a diagram illustrating an example of how a device for hanger detection by image processing according to Embodiment 1 of the present invention is installed.

[Fig. 2] Fig. 2 is a block diagram illustrating the device configuration of the device for hanger detection by image

processing according to the present invention.

[Fig. 3] Fig. 3 is a diagram illustrating an example of an original image to illustrate GSTH processing.

[Fig. 4] Fig. 4 is a diagram illustrating an example of erosion processing in the GSTH processing.

[Fig. 5] Fig. 5 is a diagram illustrating an example of dilation processing in the GSTH processing.

[Fig. 6] Fig. 6 is a diagram illustrating a transformed image obtained by the GSTH processing performed on the original image shown in Fig. 3.

[Fig. 7] Fig. 7 is a flowchart of a procedure of hanger detection according to Embodiment 1 of the present invention.

[Fig. 8] Fig. 8 is a schematic diagram illustrating an example of a line sensor image.

[Fig. 9] Fig. 9 is a schematic diagram illustrating a luminance-inverted image of the line sensor image shown in Fig. 8.

[Fig. 10] Fig. 10 is a schematic diagram illustrating an example of an image obtained by the GSTH processing performed on the image shown in Fig. 9 using a region long in the x direction.

[Fig. 11] Fig. 11 is a schematic diagram illustrating an image which is a difference between the image shown in Fig. 9 and the image shown in Fig. 10.

[Fig. 12] Fig. 12 is a schematic diagram illustrating an example of an image obtained by the GSTH processing performed on the image shown in Fig. 11 using a region long in the y direction.

[Fig. 13] Fig. 13 is a flowchart of a procedure of hanger detection according to Embodiment 2 of the present invention.

MODE FOR CARRYING OUT THE INVENTION

[0014]

A device for hanger detection by image processing according to the present invention is described below with reference to the drawings; however, the present invention is not limited to the embodiments given below.

In the following description, GSTH processing refers to processing in which erosion processing illustrated in Fig. 4 is followed by dilation processing illustrated in Fig. 5, and gsth processing is a simplified version of the GSTH processing and refers to processing in which only the erosion processing illustrated in Fig. 4 is performed, without the dilation processing illustrated in Fig. 5.

EMBODIMENT 1

[0015]

[Device for Hanger Detection using the GSTH Processing: GSTH (A-GSTH(A))]

A device for hanger detection by image processing according to Embodiment 1 of the present invention is described in detail using Figs. 1 to 12.

[0016]

As illustrated in Fig. 1, the device for hanger detection by image processing according to the present embodiment includes a line sensor camera 2 installed on the roof of a train vehicle 1, and an image processing unit 3 installed inside the vehicle 1.

An overhead line 4 is supported by a plurality of hangers 6 which are installed on a messenger wire 5 with almost equal spacing.

[0017]

The line sensor camera 2 is installed on one side of the roof of the vehicle 1 and set to have an installation angle and an elevation angle such that its optical axis is orthogonal to the travel direction of the vehicle 1 and that one of the hangers 6 is covered by its field of view. The alternate long and short dash line in Fig. 1 indicates an imaging line. Fig. 8 illustrates an example of an image captured by the line sensor camera 2 (hereinafter referred to as a line sensor image I). The line sensor image I is inputted to the image processing unit 3.

The line sensor image I in the example illustrated in Fig. 8 contains the overhead line 4, the messenger wire 5, and four hangers 6.

[0018]

The image processing unit 3 is configured to detect the hangers 6 by analyzing the line sensor image I, and includes an arithmetic device 31 and a recording device 32.

[0019]

As illustrated in Fig. 2, the arithmetic device 31 includes a GSTH processing unit 31a, a hanger detection unit 31b, and a memory 31c.

[0020]

Based on parameters inputted from the recording device 32 via the memory 31c and the line sensor image I inputted from the line sensor camera 2 via the memory 31c, the GSTH processing unit 31a performs image luminance inversion processing and GSTH processing on the line sensor image I.

The image luminance inversion processing is processing to invert the luminance values of the line sensor image I one line in the x direction at a time. If the luminance values of

principal components in the x direction represent dark colors, the luminance inversion processing is not performed on that line on the assumption that it is nighttime or the vehicle 1 is traveling inside a tunnel.

The GSTH processing is gray-scale top-hat processing, which, as its name suggests, performs top-hat processing on a gray-scale image. Top-hat processing is processing to subtract an opened image (an image having undergone erosion processing and then dilation processing the same number of times) from an original image.

[0021]

Using Figs. 3 to 6, a brief description is given below of the GSTH processing performed by the GSTH processing unit 31a. The GSTH processing is carried out by the following procedure:

(1) Erosion processing is performed on an original image 11 illustrated in Fig. 3 to create an erosion processing image 12 (12-M) as illustrated in Fig. 4, the erosion processing including finding the darkest pixel in an N (three in Fig. 3) pixel range (hereinafter referred to as a search range) S_{D-m} ($m=1$ to M), writing the luminance value of the darkest pixel to another buffer (erosion processing buffer) 12-m, and repeating the finding and the writing while shifting the search range.

(2) Next, dilation processing is performed on the erosion processing image 12 to create an opened image 13 (13-M) as illustrated in Fig. 5, the dilation processing including finding the brightest pixel in an N (three in the present embodiment) pixel range (hereinafter referred to as a search range) S_{L-m} , writing the luminance value of the brightest pixel

to another buffer (dilation processing buffer) 13-m, and repeating the finding and the writing while shifting the search range.

(3) Next, the opened image 13 (13-M) created in (2) is subtracted from the original image 11.

The above processing produces a GSTH image 14 as illustrated in Fig. 6, in which bright pixels surrounded by a dark area in the image are highlighted.

[0022]

A GSTH image (transformed image) I_D having undergone the image luminance inversion processing and then the GSTH processing by the GSTH processing unit 31a looks like the image illustrated in Fig. 12, and is inputted into the hanger detection unit 31b to via the memory 31c.

[0023]

Based on parameters inputted from the recording device 32 via the memory 31c and the transformed image inputted from the GSTH processing unit 31a via the memory 31c, the hanger detection unit 31b detects hangers 6 using binarization processing or the like.

Since the hangers 6 are suspended with predetermined equal spacing (distances), counting the number of the detected hangers 6 enables determination of the positions in the image.

In the present embodiment, as shown in Fig. 12, only the vertically-installed hangers 6 are detected, and the slanted hangers 6 are not detected. The number of hangers 6 between adjacent power poles is managed as facility data in advance acquired in advance and managed as facility data. Thus, when it is found out, in conjunction with power-pole detection signals, that the number of hangers 6 for each power pole is

less than what it is supposed to be, the missing hanger 6 can be detected as being abnormally angled.

Information on the hangers 6 detected by the hanger detection unit 31b is outputted to the memory 31c as a hanger detection result.

[0024]

The memory 31c temporarily stores various kinds of data. The recording device 32 stores various kinds of data. The parameters described above include the number of pixels N for setting a search range, the number of pixels w and the number of pixels h necessary in the GSTH processing, a binarization threshold, and the like.

[0025]

A procedure of the processing performed by the device for hanger detection by image processing according to the present embodiment is described based on Fig. 7.

[0026]

As illustrated in Fig.7, in the device for hanger detection by image processing according to the present embodiment, first, the line sensor camera 2 inputs the line sensor image I , like the one shown in the example in Fig. 8 (Step S1). Note that the x direction shown in Fig. 8 corresponds to the imaging line of the line sensor camera 2 in Fig. 1, and the y direction shown in Fig. 8 corresponds to the time passing while the line sensor camera 2 captures an image one line at a time. Fig. 8 shows an image captured from the vehicle 1 travelling at a constant speed.

[0027]

Next, the GSTH processing unit 31a performs luminance inversion processing on the line sensor image I (Step S2). This

step produces a luminance-inverted image I_A , like the one shown in Fig. 9. As described above, the luminance inversion processing is performed on the line sensor image I one line in the x direction at a time, and when the luminance values of principal components in the x direction indicate dark colors, the luminance values on that line are not inverted on the assumption that it is nighttime or the vehicle 1 is travelling inside a tunnel. Thus, the tunnel area in a dark color in the background at the upper part in Fig. 8 can be merged with a section with light colors in the background such as the sky.

[0028]

Next, the GSTH processing unit 31a performs the GSTH processing on the luminance-inverted image I_A shown in Fig. 8 in the x direction (Step S3). More specifically, the GSTH processing unit 31a first performs the erosion processing illustrated in Fig. 4 for acquiring the darkest pixel in each $w \times 1$ [pixel] region long in the x direction, and then performs the dilation processing illustrated in Fig. 5 for acquiring the brightest pixel in each $w \times 1$ [pixel] region long in the x direction. This step produces a first GSTH image I_B as shown in Fig. 10, in which the white areas' portions whose width in the x direction is equal to or below a width w are extracted. The width w corresponds to the width of a line such as the overhead line 4, and is calculated by experiment. In the example shown in Fig. 10, the first GSTH image I_B is the luminance-inverted image I_A minus the hangers 6 and a structure (hereinafter referred to as a disturbance) 7, such as a power pole or a building.

[0029]

Next, the GSTH processing unit 31a subtracts the first

GSTH image I_B from the luminance-inverted image I_A to obtain a difference image I_C like the one shown in Fig. 11 (Step S4). In the example shown in Fig. 11, the difference image I_C is an image in which the hangers 6 and the disturbance 7, such as a power pole or a building, are extracted. If the subtraction processing produces a negative area, such an area is rounded up to zero.

[0030]

Next, the GSTH processing unit 31a performs the GSTH processing on the difference image I_C in the y direction (Step S5). More specifically, the GSTH processing unit 31a first performs the erosion processing illustrated in Fig. 4 for acquiring the darkest pixel in each $1 \times h$ [pixel] region long in the y direction, and then performs the dilation processing illustrated in Fig. 5 for acquiring the brightest pixel in each $1 \times h$ [pixel] region long in the y direction. This step produces an image I_D as shown in Fig. 12, in which the white areas' portions whose length in the y direction is equal to or below h are extracted (hereinafter referred to as a second GSTH image I_D). Note that h corresponds to the diameter of the hanger 6, and is calculated by experiment. In the example shown in Fig. 12, the second GSTH image I_D is an image in which only the hangers 6 are extracted from the difference image I_C .

As a transformed image, the second GSTH image I_D is inputted to the hanger detection unit 31b via the memory 31c.

[0031]

Next, the hanger detection unit 31b detects the hangers 6 in the second GSTH image I_D shown in Fig. 12 using binarization processing or the like (Step S6). Since the hangers 6 are suspended with predetermined equal spacing (distances),

counting the number of the detected hangers 6 enables determination of the positions in the image.

[0032]

Steps P1 to P6 are iterated until the last one of all the line sensor images I is inputted.

[0033]

The thus-configured device for hanger detection by image processing according to the present embodiment uses, as the GSTH processing, a combination of the erosion processing illustrated in Fig. 4 and the dilation processing illustrated in Fig. 5, and obtains straight lines using the $w \times 1$ [pixel] region and the $1 \times h$ [pixel] region. Thus, among the straight lines appearing in the luminance-inverted image I_A , only the ones extending in a predetermined direction and being thinner than a predetermined thickness can be extracted.

The device for hanger detection by image processing according to the present embodiment thus has the following advantages that utilize the characteristics of GSTH:

- Only the hangers 6 appearing as extending in the predetermined direction and having the predetermined thickness can be detected.

- The disturbance 7 having a feature different from the hangers 6, such as a tunnel entrance/exit or a power pole 7, are eliminated so that only the hangers 6 can be detected.

- In the present embodiment, only the normal hangers 6 installed vertically are detected, leaving undetected the slanted, abnormal hangers 6 with an installation angle beyond the management value. Thus, it is also possible to detect an abnormal hanger 6 based on a comparison between the number of hangers 6 detected in the present embodiment and the normal

number of hangers 6 for each power pole or the like, which is managed as facility data in advance.

EMBODIMENT 2

[0034]

[Device for Hanger Detection using Simplified GSTH Processing:
GSTH (gsth(A))]

Using Figs. 1 to 6 and 8 to 13, as description is given below of a device for hanger detection by image processing according to a second embodiment of the present invention. The device for hanger detection by image processing according to the present embodiment is different from that of Embodiment 1 in that the processing performed by the GSTH processing unit 31a is simplified. The device configuration is the same as the device for hanger detection by image processing according to Embodiment 1, and overlapping descriptions are omitted below, focusing on the processing performed by the image processing unit 3.

[0035]

Based on Fig. 13, a description is given of a procedure of the processing performed by the device for hanger detection by image processing according to the present embodiment.

In the device for hanger detection by image processing according to the present embodiment, as illustrated in Fig. 13, the line sensor camera 2 inputs the line sensor image I like the one shown in Fig. 8 (Step S11), and then the GSTH processing unit 31a performs luminance inversion processing on the line sensor image I for each imaging line on which the luminance values of principal components in the x direction represent light colors (Step S12). Thereby, the luminance-inverted image I_A as shown in Fig. 9 is obtained.

[0036]

Next, the GSTH processing unit 31a performs gsth processing on the luminance-inverted image I_A shown in Fig. 8 in the x direction (Step S13). Specifically, the GSTH processing unit 31a performs the erosion processing illustrated in Fig. 4 for acquiring the darkest pixel in each $w \times 1$ [pixel] region long in the x direction, but omits the dilation processing illustrated in Fig. 5 for acquiring the brightest pixel in each $w \times 1$ [pixel] region long in the x direction. This step produces a gsth image I_C as shown in Fig. 11, in which the white areas' portions whose width in the x direction is equal to or below the width w are extracted. Note that w corresponds to the width of a line such as the overhead line 4 and is calculated by experiment.

[0037]

Next, the GSTH processing unit 31a performs the GSTH processing on the gsth image I_C in the y direction (Step S14). Specifically, the GSTH processing unit 31a performs the erosion processing illustrated in Fig. 4 for acquiring the darkest pixel in each $1 \times h$ [pixel] region long in the y direction, and then performs the dilation processing illustrated in Fig. 5 for acquiring the brightest pixel in each $1 \times h$ [pixel] region long in the y direction. This produces a GSTH image I_D as shown in Fig. 12, in which the white areas' portions whose length in the y direction is equal to or below h are extracted. Note that h corresponds to the diameter of the hanger 6, and is calculated by experiment.

As a transformed image, the GSTH image I_D is inputted to the hanger detection unit 31b via the memory 31c.

[0038]

Next, the hanger detection unit 31b detects the hangers 6 in the GSTH image I_D shown in Fig. 12 using binarization processing or the like (Step S15). Since the hangers 6 are installed with predetermined spacing (distances), counting the number of the detected hangers 6 enables determination of the current position of the vehicle 1. Also, using the management value for the installation angle of the hangers 6, it is checked whether the hangers 6 have a predetermined installation angle.

[0039]

Steps S11 to S15 are iterated until the last one of all the line sensor images I is inputted.

[0040]

The thus-configured device for hanger detection by image processing according to the present embodiment simplifies the processing by performing the gsth processing on the luminance-inverted image I_A in the x direction (performing only the erosion processing illustrated in Fig. 4), and therefore advantageously speeds up the hanger detection processing, compared to that of Embodiment 1. Although the gsth processing shortens the hangers 6 detected on the image, it is not problematic because the objective of the present embodiment is to determine the presence or absence of the hangers 6.

INDUSTRIAL APPLICABILITY

[0041]

The present invention is advantageously applicable to a device for hanger detection by image processing.

REFERENCE SIGNS LIST

[0042]

- 1 vehicle
- 2 line sensor camera

3	image processing unit
4	overhead line
5	messenger wire
6	hanger
7	structure
31	arithmetic device
31a	GSTH processing unit
31b	hanger detection unit
31c	memory
32	recording device
I	line sensor image
I _A	luminance-inverted image
I _B	first GSTH image
I _C	difference image, gsth image
I _D	second GSTH image, GSTH image

CLAIMS

[Claim 1]

A device for hanger detection by image processing that includes a line sensor camera that captures an image of hangers from a roof of a vehicle, the hangers being installed with equal spacing and supporting an overhead line, and an image processing unit that is installed inside the vehicle and analyzes the image captured by the line sensor, the device being configured to detect hangers in the image, wherein

the image processing unit comprises

a GSTH processing unit that sequentially performs GSTH processing on a line sensor image inputted from the line sensor camera in a direction of an imaging line of the line sensor camera and in a direction of time to acquire a GSTH image in which the hangers in the image are highlighted, and

a hanger detection unit that detects the hangers in the GSTH image.

[Claim 2]

The device for hanger detection by image processing according to claim 1, wherein

the GSTH processing performed by the GSTH processing unit includes acquiring a first GSTH image by performing erosion processing and then dilation processing on the line sensor image in the direction of the imaging line of the line sensor camera, acquiring a difference image that is a difference between the first GSTH image and the line sensor image, and acquiring a second GSTH image in which the hangers in the line sensor image are highlighted, by performing erosion processing and then dilation processing on the difference image in the direction of time, and

the hanger detection unit detects the hangers in the second GSTH image.

[Claim 3]

The device for hanger detection by image processing according to claim 1, wherein

the GSTH processing performed by the GSTH processing unit includes acquiring a gsth image by performing only erosion processing on the line sensor image in the direction of the imaging line of the line sensor camera and acquiring the GSTH image in which the hangers in the line sensor image are highlighted, by performing erosion processing and then dilation processing on the gsth image in the direction of time, and

the hanger detection unit detects the hangers in the GSTH image.

[Claim 4]

The device for hanger detection by image processing according to any one of claims 1 to 3, wherein

the GSTH processing unit performs the GSTH processing after performing luminance inversion processing on the line sensor image one line at a time in the direction of the imaging line of the line sensor camera, the luminance inversion processing inverting luminance values on a line if luminance values of principal components on the line in the direction of the imaging line of the line sensor camera represent light colors, and not inverting the luminance values on the line if the luminance values of the principal components represent dark colors.