

DESCRIPTION

IMAGE INSPECTION DEVICE, IMAGE INSPECTION METHOD, AND IMAGE INSPECTION PROGRAM

[Technical field]

[0001]

The present invention relates to an image inspection device, an image inspection method, and an image inspection program.

[Background Art]

[0002]

Conventionally, in image inspection of products, in order to suppress erroneous determination in which a defective product is mistakenly determined as a non-defective product, there has been known an image inspection method in which a final pass/fail determination of a product is made by combining a plurality of determination algorithms (for example, Patent document 1).

[0003]

However, in the conventional image inspection method, the determination score was sometimes unstable, and it was difficult to clearly distinguish between non-defective and defective products using a specific threshold. Therefore, there has been room for further improvement in the accuracy of the final pass/fail determination of products.

[Citation List]

[Patent Literature]

[0004]

PTLT1: Japanese Patent No. 6999150

[Summary of invention]

[Technical Problem]

[0005]

The present invention is directed to providing an image inspection device, an image inspection method, and an image inspection program capable of achieving high accuracy in pass/fail determination.

[Solution to Problem]

[0006]

(1) An image inspection device according to one embodiment of the present invention comprises:

a learning dataset acquisition unit that acquires a learning dataset including a plurality of learning image data;

a learning feature quantity extraction unit that derives learning feature quantities from the learning image data;

a clustering processing unit that clusters the learning image data into a plurality of clusters based on the learning feature quantities;

an index derivation unit that, for each cluster, derives a centroid and distances of a plurality of learning feature quantities belonging to the cluster, and calculates an average μ and a variance σ of the distances corresponding to the plurality of learning feature quantities;

a captured feature quantity extraction unit that extracts captured feature quantities based on imaging data captured by a camera;

a minimum distance derivation unit that calculates distances from the captured feature quantities to each of the centroids and derives a minimum distance X among the distances;

an anomaly degree calculation unit that calculates an anomaly degree α based on the minimum distance X , the average μ , and the variance σ ; and

a comparison unit that compares the anomaly degree α with a pre-set threshold.

(2) In the above (1), the image inspection device may further comprise an error processing unit configured to execute error processing when the anomaly degree α exceeds the threshold.

(3) In the above (1) or (2), the clustering processing unit may perform the clustering a plurality of times using random numbers, and the index derivation unit may, for each execution of the clustering, derive the centroid for each cluster, and designate, as a population for calculating the minimum distance X , a representative cluster in which the residual sum of squares of the distances within the cluster is minimized.

(4) In the above (1) or (2), the feature quantity extraction unit may perform a resize process, a window function process, an FFT process, or a band-pass filter process.

(5) An image inspection method according to one embodiment of the present invention comprises:

a learning dataset acquisition step of acquiring a learning dataset including a plurality of learning image data;

a learning feature quantity extraction step of deriving learning feature quantities from the learning image data;

a clustering processing step of clustering the learning image data into a plurality of clusters based on the learning feature quantities;

an index derivation step of, for each cluster, deriving a centroid and distances of a plurality of learning feature quantities belonging to the cluster, and calculating an average μ and a variance σ of the distances corresponding to the plurality of learning feature quantities;

a captured feature quantity extraction step of extracting captured feature quantities based on imaging data captured by a camera;

a minimum distance derivation step of calculating distances from the captured feature quantities to each of the centroids and deriving a minimum distance X among the distances;

an anomaly degree calculation step of calculating an anomaly degree α based on the minimum distance X , the average μ , and the variance σ ; and

a comparison step of comparing the anomaly degree α with a pre-set threshold.

(6) An image inspection program according to one embodiment of the present invention causes a computer to execute:

a learning dataset acquisition function for acquiring a learning dataset including a plurality of learning image data;

a learning feature quantity extraction function for deriving learning feature quantities from the learning image data;

a clustering processing function for clustering the learning image data into a plurality of clusters based on the learning feature quantities;

an index derivation function for, for each cluster, deriving a centroid and distances of a plurality of learning feature quantities belonging to the cluster, and calculating an average μ and a variance σ of the distances corresponding to the plurality of learning feature quantities;

a captured feature quantity extraction function for extracting captured feature quantities based on imaging data captured by a camera;
a minimum distance derivation function for calculating distances from the captured feature quantities to each of the centroids and deriving a minimum distance X among the distances;
an anomaly degree calculation function for calculating an anomaly degree α based on the minimum distance X , the average μ , and the variance σ ; and
a comparison function for comparing the anomaly degree α with a pre-set threshold.

[Advantageous Effects of Invention]

[0007]

According to the present invention, it is possible to provide an image inspection device, an image inspection method, and an image inspection program capable of achieving high accuracy in pass/fail determination.

[Brief description of drawings]

[0008]

[Fig. 1] is a diagram illustrating an overview of an image inspection device.

[Fig. 2] is a diagram illustrating an overview of an image inspection method.

[Fig. 3] is a diagram illustrating a flow of an image inspection method.

[Fig. 4] is a diagram illustrating a flow of a feature quantity extraction step.

[Description of Embodiments]

[0009]

(Example)

Hereinafter, embodiments of the present invention will be described in detail with reference to the drawings.

Fig. 1 is a diagram illustrating an overview of an image inspection device 100.

Fig. 2 is a diagram illustrating an overview of an image inspection method.

In the following description, components or portions having the same or similar functions are denoted by the same reference numerals or symbols.

[0010]

(Image Inspection Device)

An image inspection device 100 according to an embodiment is used, for example, for inspecting the appearance of products such as electronic components.

[0011]

As shown in Fig. 1, the image inspection device 100 includes a control means S. The image inspection device 100 may further include a camera C.

[0012]

The camera C appropriately captures an image of a product (component) to be inspected.

The captured imaging data (image data) is transmitted to the control means S.

It is also possible to cause the image inspection device 100 to perform inspection on imaging data captured by an external camera that is not included in the image inspection device 100, by inputting the externally captured imaging data into the control means S of the image inspection device 100.

[0013]

The control means S is a computer system including a CPU, a memory M (storage medium) such as a RAM, a ROM, and an auxiliary storage device, an external connection interface IF for input/output devices, and a bus B.

The control means S may further include a network interface.

The memory M stores an image inspection program for causing the control means S (computer system) to execute the image inspection method according to the present embodiment.

[0014]

The CPU is a processing circuit that performs overall control of the control means S.

The CPU reads a program stored in the ROM or the auxiliary storage device into the RAM.

The CPU executes various processes defined in the program read into the RAM.

The ROM stores system programs and the like used for controlling the control means S.

The auxiliary storage device stores application programs and the like for executing various processes, and may be, for example, an HDD or a SSD.

The external connection interface IF is an interface for connecting various devices to the control means S, and, for example, connects the camera C, the display D, and the keyboard K to the control means S.

The network interface functions to perform communication via a network under the control of the CPU.

The bus B communicably connects the above-described functional units constituting the control means S.

[0015]

The image inspection device 100 captures an image of a product to be inspected by the camera C, and determines, by the control means S based on the captured imaging data, whether the product to be inspected is a non-defective product or a defective product, that is, whether the product is a normal or an abnormal product.

[0016]

As shown in Fig. 2, the image inspection device 100 performs inspection based on imaging data obtained by capturing an image of a product.

The image inspection device 100 performs, in parallel, a defective product determination for determining whether imaging data of a product to be inspected corresponds to a non-defective product or a defective product, and an abnormality determination for determining whether the product corresponds to a normal product or an abnormal product.

The image inspection device 100 outputs an inspection result indicating “OK” (pass) when the product is determined to be both a non-defective product and a normal product, and “NG” (fail) (pass) when the product is determined to be a defective product or an abnormal product.

[0017]

The defective product determination is performed based on rules for distinguishing between non-defective and defective products, which are learned from non-defective product images and defective product images collected in advance.

In the defective product determination, when an unknown defective product image that was not included in the learning data is input as an inspection target image, there is a possibility that the image, which should originally be determined as a defective product, may be erroneously determined as a non-defective product.

[0018]

In order to suppress misclassification in the defective product determination, it is preferable that the abnormality determination be executed in parallel in combination with the defective product determination.

The abnormality determination includes a step of, after learning “non-defective likeness” as feature quantities using only non-defective product images, calculating an abnormality determination score for the image data of the inspection target.

The abnormality determination is made according to whether the abnormality determination score exceeds a threshold.

The abnormality determination score is normalized within a predetermined range.

As a specific method for calculating the abnormality determination score, for example, an algorithm using an autoencoder, or an algorithm combining kernel density estimation with a projection histogram, may be employed.

[0019]

In this manner, by performing the defective product determination and the abnormality determination in parallel combination, the image inspection device 100 can compensate for misclassification in the defective product determination through the abnormality determination, thereby enabling highly accurate inspection.

It should be noted that the image inspection device 100 may perform only the abnormality determination.

[0020]

Here, in the algorithm using an autoencoder, the abnormality determination score for normal images may become unstable.

In addition, when the image data of the inspection target is a color image, the abnormality determination score may not be clearly separated between normal and abnormal images, resulting in insufficient accuracy of the abnormality determination.

Furthermore, in the case of a method combining kernel density estimation and a projection histogram, it is necessary to appropriately normalize the abnormality determination score.

[0021]

Accordingly, the image inspection device 100 includes: a learning dataset acquisition unit 10 that acquires a learning dataset including a plurality of learning image data; a learning feature quantity extraction unit 20 that derives learning feature quantities from the learning image data; a clustering processing unit 30 that performs clustering of the learning image data based on the learning feature quantities; an index derivation unit 40 that, for each cluster obtained by the clustering, derives a centroid and distances between the centroid and a plurality of learning feature quantities belonging to the cluster, and calculates an average μ and a variance σ of the distances corresponding to the plurality of learning feature quantities; a captured feature quantity extraction unit 50 that extracts captured feature quantities based on imaging data captured by the camera C; a minimum distance derivation unit 60 that calculates distances between the captured feature quantities and the plurality of centroids, and derives a minimum distance X among the distances; an anomaly degree calculation unit 70 that calculates an anomaly degree α based on the minimum distance X , the average μ , and the variance σ ; and a comparison unit 80 that compares the anomaly degree α with a pre-set threshold.

With this configuration, even when the product to be inspected has multiple variations or when the degree of variation in non-defective products differs depending on the product type, the anomaly degree α , which serves as a properly normalized evaluation score, can be calculated. Accordingly, the pass/fail determination for the product to be inspected can be performed based on a clearly defined and stable evaluation score that distinguishes between a non-defective product and a defective product. Therefore, an image inspection device 100 having high accuracy in pass/fail determination can be provided.

[0022]

It should be noted that each of the above-described units in the image inspection device 100 may be referred to as a module or a unit.

[0023]

It is preferable that the anomaly degree α be calculated by the following equation:

$$\alpha = \{(X - \mu)^2 / \sigma\}.$$

In this manner, the anomaly degree α , which serves as a properly normalized evaluation score, can be calculated by taking into account the minimum distance X , the average μ , and the variance σ .

As a result, variations in the appearance of products to be inspected, which differ depending on the product type, can be compensated for, and the anomaly degree α presented to the user can always be maintained on the same scale.

[0024]

The image inspection device 100 may further include an error processing unit 90 configured to execute error processing when the anomaly degree α exceeds the threshold.

The error processing may include, for example, displaying on a display an indication that the inspection result of the product to be inspected is “NG” (abnormal or defective).

Accordingly, it is possible to notify the user that the inspection result of the product is “NG”.

[0025]

The clustering processing unit 30 may perform clustering a plurality of times using random numbers.

The index derivation unit 40 may, for each execution of the clustering, derive a centroid for each cluster, and designate, as a population for calculating the minimum distance X , a representative cluster in which the residual sum of squares of the distances within the cluster is minimized.

In this way, even when the results vary depending on each trial of clustering, the centroid that most accurately captures the characteristics of the learning dataset can be derived, thereby providing the image inspection device 100 with higher accuracy in pass/fail determination.

[0026]

(Image Inspection Method)

Next, a flow of the image inspection method will be described.

The image inspection method can be implemented using the image inspection device 100.

Each step in the image inspection method can be executed by the corresponding unit in the image inspection device 100.

Fig. 3 is a diagram illustrating a flow of the image inspection method.

[0027]

(1) As shown in Fig. 3, first, a learning dataset including a plurality of learning image data is acquired (learning dataset acquisition step).

The learning image data are images of non-defective products.

That is, the learning dataset may be composed only of non-defective product images.

The learning dataset acquisition step can be executed by the learning dataset acquisition unit 10 of the image inspection device 100.

[0028]

(2) Next, learning feature quantities of the learning image data acquired in the learning dataset acquisition step (process) are derived (learning feature quantity extraction step).

The learning feature quantities may be derived from the learning image data using an appropriate algorithm.

The algorithm for deriving the learning feature quantities may be, for example, a method that uses a set of brightness differences in an image as feature quantities (Haar-Like), a method that focuses on the distribution of gradient directions of luminance in a grayscale image (HOG), a method that extracts feature quantities in two stages—detection of feature points and description of the feature quantities (SIFT), a filter method, or a wrapper method.

The learning feature quantity extraction step can be executed by the learning feature quantity extraction unit 20 of the image inspection device 100.

[0029]

Here, the learning feature quantity extraction step may be executed according to the flow shown below.

It should be noted that the captured feature quantity extraction step, which will be described later, may also be executed according to a flow similar to the flow of the learning feature quantity extraction step described here.

Fig. 4 is a diagram illustrating a flow of the feature quantity extraction step.

[0030]

(2-1) As shown in Fig. 4, a resize process may be performed on the image data (learning image data or captured image data).

The resize process is an operation for changing the size of the image data in order to standardize the input size of a machine learning model.

[0031]

(2-2) Next, padding processing may be performed on the appropriately resized image data (learning image data or captured image data).

The padding process is a process of adding meaningless data to the beginning or end of shorter data to adjust its length, in order to handle the data as a fixed length.

[0032]

(2-3) Next, window function processing may be performed on the appropriately padded image data (learning image data or captured image data).

The window function process is a process of multiplying a window function by the image data in order to extract only information within a finite interval.

[0033]

(2-4) Next, FFT processing may be performed on the appropriately window-processed image data (learning image data or captured image data).

The FFT process is a process of performing a Fourier transform on the image data in order to obtain an amplitude spectrum distribution by converting the spatial domain into a spatial frequency domain based on the image data.

[0034]

(2-5) Next, band-pass filter processing may be performed on the appropriately FFT-processed image data (learning image data or captured image data).

The band-pass filter process is a process of compressing the image data by removing components that have little influence on the determination, by allowing only frequency components within a specific range to pass through.

[0035]

(3) Returning to Fig. 3, next, based on the learning feature quantities derived in the learning feature quantity extraction step, the learning image data are clustered into a plurality of clusters (clustering processing step).

Clustering is a machine learning technique for grouping data based on similarities between data.

The clustering may be hierarchical clustering using an algorithm such as the shortest distance method, the longest distance method, the average distance method, the centroid method, or Ward's method, or may be non-hierarchical clustering such as the k-means method.

The algorithm used for clustering may be selected using random numbers each time clustering processing is performed.

Alternatively, the algorithm used for clustering may be changed using random numbers each time clustering processing is performed.

Specifically, for example, one algorithm may be fixed, and random numbers used in the algorithm may be reseeded so that clustering is performed a plurality of times.

The clustering processing step can be executed by the clustering processing unit 30 of the image inspection device 100.

[0036]

(4) Next, for each cluster classified in the clustering processing step, a centroid of a plurality of learning feature quantities belonging to the cluster and distances between the centroid and the respective learning feature quantities are derived.

Then, an average μ and a variance σ of the plurality of distances derived for the plurality of learning feature quantities are calculated (index derivation step).

The index derivation step can be executed by the index derivation unit 40 of the image inspection device 100.

Through the above steps, it is possible, as preprocessing for inspection, to derive reference indices of non-defective products.

[0037]

(5) Next, captured feature quantities are extracted based on imaging data captured by the camera (captured feature quantity extraction step).

The imaging data are image data obtained by capturing an image of a product to be inspected with the camera.

The captured feature quantities may be derived from the imaging data using an appropriate algorithm.

The extraction of the captured feature quantities may employ the same method as that used for deriving the learning feature quantities in the learning feature quantity extraction step.

The captured feature quantity extraction step can be executed by the captured feature quantity extraction unit 50 of the image inspection device 100.

[0038]

(6) Next, distances between the captured feature quantities and the plurality of centroids are derived, and a minimum distance X , which is the smallest among the distances, is calculated (minimum distance derivation step).

The minimum distance derivation step can be executed by the minimum distance derivation unit 60 of the image inspection device 100.

(7) Next, based on the minimum distance X derived in the minimum distance derivation step and the average μ and the variance σ derived in the index derivation step, an anomaly degree α is calculated by the equation ($\alpha = \{(X - \mu)^2 / \sigma\}$) (anomaly degree calculation step).

The anomaly degree calculation step can be executed by the anomaly degree calculation unit 70 of the image inspection device 100.

[0039]

(8) Next, the anomaly degree α calculated in the anomaly degree calculation step is compared with a pre-set threshold (comparison step).

The comparison step can be executed by the comparison unit 80 of the image inspection device 100.

[0040]

As described above, the image inspection method includes the respective steps described above.

Accordingly, the determination score can be stabilized, and a non-defective product and a defective product can be clearly distinguished by a specific threshold.

Therefore, the accuracy of the final pass/fail determination for the product can be improved.

[0041]

(9) In addition, as appropriate, after the comparison step, error processing may be executed when the anomaly degree α exceeds the threshold (error processing step).

The error processing may include, for example, displaying on the display D an indication that the inspection result of the product to be inspected is “NG” (abnormal or defective).

Accordingly, it is possible to notify the user that the inspection result of the product is “NG.”

The error processing step can be executed by the error processing unit 90 of the image inspection device 100.

[0042]

(Image Inspection Program)

The image inspection program includes functions for causing a computer to execute the respective processes performed in each step of the image inspection method described above.

Specifically, the image inspection program includes, corresponding to the respective steps of the image inspection method described above, a learning dataset acquisition function, a learning feature quantity extraction function, a

clustering processing function, an index derivation function, a captured feature quantity extraction function, a minimum distance derivation function, an anomaly degree calculation function, and a comparison function. Accordingly, the determination score can be stabilized, and a non-defective product and a defective product can be clearly distinguished by a specific threshold.

Therefore, the accuracy of the final pass/fail determination for the product can be improved.

[0043]

It should be noted that the technical scope of the present invention is not limited to the embodiments described above, and various modifications may be made without departing from the spirit of the present invention.

[0044]

In addition, within a range not departing from the spirit of the present invention, the components in the above-described embodiments may appropriately be replaced with well-known components.

Furthermore, within a range not departing from the spirit of the present invention, the modified examples described above may be appropriately combined.

[0045]

As described above, the image inspection device 100 according to the embodiment includes: a learning dataset acquisition unit 10 that acquires a learning dataset including a plurality of learning image data; a learning feature quantity extraction unit 20 that derives learning feature quantities from the learning image data; a clustering processing unit 30 that performs clustering of the learning image data based on the learning feature quantities; an index derivation unit 40 that, for each cluster obtained by the clustering, derives a centroid and distances between the centroid and a plurality of learning feature quantities belonging to the cluster, and calculates an average μ and a variance σ of the distances corresponding to the plurality of learning feature quantities; a captured feature quantity extraction unit 50 that extracts captured feature quantities based on imaging data captured by the camera C; a minimum distance derivation unit 60 that calculates distances between the captured feature quantities and the plurality of centroids, and derives a minimum distance X among the distances; an anomaly degree calculation unit 70 that calculates an anomaly degree α based on the minimum distance X , the average μ , and the variance σ ; and a comparison unit 80 that compares the anomaly degree α with a pre-set threshold.

With this configuration, the anomaly degree α , which serves as a properly normalized evaluation score, can be calculated. Accordingly, the pass/fail determination for the product to be inspected can be performed based on a clearly defined and stable evaluation score that distinguishes between a non-defective product and a defective product. Therefore, the image inspection device 100 with high accuracy in pass/fail determination can be provided.

[0046]

The image inspection method according to the embodiment includes: a learning dataset acquisition step of acquiring a learning dataset including a plurality of learning image data; a learning feature quantity extraction step of deriving learning feature quantities from the learning image data; a clustering processing step of clustering the learning image data into a plurality of clusters based on the learning feature quantities; an index derivation step of, for each cluster, deriving a centroid and distances between the centroid and a plurality of learning feature quantities belonging to the cluster, and calculating an average μ and a variance σ of the distances corresponding to the plurality of learning feature quantities; a captured feature quantity extraction step of extracting captured feature

quantities based on imaging data captured by a camera; a minimum distance derivation step of calculating distances between the captured feature quantities and the plurality of centroids and deriving a minimum distance X among the distances; an anomaly degree calculation step of calculating an anomaly degree α based on the minimum distance X , the average μ , and the variance σ ; and a comparison step of comparing the anomaly degree α with a pre-set threshold.

Accordingly, since the anomaly degree α serving as a properly normalized evaluation score is calculated, the pass/fail determination for the product to be inspected can be performed based on a clearly defined and stable evaluation score that distinguishes between a non-defective product and a defective product. Therefore, an image inspection method with high accuracy in pass/fail determination can be provided.

[0047]

The image inspection program according to the embodiment causes a computer to execute: a learning dataset acquisition function for acquiring a learning dataset including a plurality of learning image data; a learning feature quantity extraction function for deriving learning feature quantities from the learning image data; a clustering processing function for clustering the learning image data into a plurality of clusters based on the learning feature quantities; an index derivation function for, for each cluster, deriving a centroid and distances between the centroid and a plurality of learning feature quantities belonging to the cluster, and calculating an average μ and a variance σ of the distances corresponding to the plurality of learning feature quantities; a captured feature quantity extraction function for extracting captured feature quantities based on imaging data captured by a camera; a minimum distance derivation function for calculating distances between the captured feature quantities and the plurality of centroids and deriving a minimum distance X among the distances; an anomaly degree calculation function for calculating an anomaly degree α based on the minimum distance X , the average μ , and the variance σ ; and a comparison function for comparing the anomaly degree α with a pre-set threshold.

Accordingly, since the anomaly degree α serving as a properly normalized evaluation score is calculated, the pass/fail determination for the product to be inspected can be performed based on a clearly defined and stable evaluation score that distinguishes between a non-defective product and a defective product. Therefore, an image inspection program with high accuracy in pass/fail determination can be provided.

[Reference Signs List]

[0048]

- 100 image inspection device
- 10 learning dataset acquisition unit
- 20 learning feature quantity extraction unit
- 30 clustering processing unit
- 40 index derivation unit
- 50 captured feature quantity extraction unit
- 60 minimum distance derivation unit
- 70 anomaly degree calculation unit
- 80 comparison unit
- 90 error processing unit

α anomaly degree

μ average

σ variance

B bus

C camera

D display

K keyboard

M memory

S control means

X minimum distance

CLAIMS

[Claim 1]

An image inspection device comprising:

a learning dataset acquisition unit that acquires a learning dataset including a plurality of learning image data;

a learning feature quantity extraction unit that derives learning feature quantities from the learning image data;

a clustering processing unit that clusters the learning image data into a plurality of clusters based on the learning feature quantities;

an index derivation unit that, for each cluster, derives a centroid and distances of a plurality of learning feature quantities belonging to the cluster, and calculates an average μ and a variance σ of the distances corresponding to the plurality of learning feature quantities;

a captured feature quantity extraction unit that extracts captured feature quantities based on imaging data captured by a camera;

a minimum distance derivation unit that calculates distances from the captured feature quantities to each of the centroids and derives a minimum distance X among the distances;

an anomaly degree calculation unit that calculates an anomaly degree α based on the minimum distance X , the average μ , and the variance σ ; and

a comparison unit that compares the anomaly degree α with a pre-set threshold.

[Claim 2]

The image inspection device according to claim 1, further comprising an error processing unit configured to execute error processing when the anomaly degree α exceeds the threshold.

[Claim 3]

The image inspection device according to claim 1 or 2,

wherein the clustering processing unit performs the clustering a plurality of times using random numbers, and

the index derivation unit derives, for each execution of the clustering, the centroid for each cluster, and designates, as a population for calculating the minimum distance X , a representative cluster in which the residual sum of squares of the distances within the cluster is minimized.

[Claim 4]

The image inspection device according to claim 1 or 2,

wherein the captured feature quantity extraction unit or the learning feature quantity extraction unit performs a resize process, a window function process, an FFT process, or a band-pass filter process.

[Claim 5]

An image inspection method comprising:

a learning dataset acquisition step of acquiring a learning dataset including a plurality of learning image data;

a learning feature quantity extraction step of deriving learning feature quantities from the learning image data;

a clustering processing step of clustering the learning image data into a plurality of clusters based on the learning feature quantities;

an index derivation step of, for each cluster, deriving a centroid and distances of a plurality of learning feature quantities belonging to the cluster, and calculating an average μ and a variance σ of the distances corresponding to the plurality of learning feature quantities;

a captured feature quantity extraction step of extracting captured feature quantities based on imaging data captured by a camera;

a minimum distance derivation step of calculating distances from the captured feature quantities to each of the centroids and deriving a minimum distance X among the distances;

an anomaly degree calculation step of calculating an anomaly degree α based on the minimum distance X , the average μ , and the variance σ ; and

a comparison step of comparing the anomaly degree α with a pre-set threshold.

[Claim 6]

An image inspection program for causing a computer to execute:

a learning dataset acquisition function for acquiring a learning dataset including a plurality of learning image data;

a learning feature quantity extraction function for deriving learning feature quantities from the learning image data;

a clustering processing function for clustering the learning image data into a plurality of clusters based on the learning feature quantities;

an index derivation function for, for each cluster, deriving a centroid and distances of a plurality of learning feature quantities belonging to the cluster, and calculating an average μ and a variance σ of the distances corresponding to the plurality of learning feature quantities;

a captured feature quantity extraction function for extracting captured feature quantities based on imaging data captured by a camera;

a minimum distance derivation function for calculating distances from the captured feature quantities to each of the centroids and deriving a minimum distance X among the distances;

an anomaly degree calculation function for calculating an anomaly degree α based on the minimum distance X , the average μ , and the variance σ ; and

a comparison function for comparing the anomaly degree α with a pre-set threshold.