DESCRIPTION

Title of Invention

CLASSIFICATION MODEL LEARNING DEVICE, CLASSIFICATION MODEL LEARNING METHOD, CLASSIFICATION MODEL LEARNING PROGRAM, CLASSIFICATION MODEL, CLASSIFICATION DEVICE, AND SORTING DEVICE

Technical Field

[0001] One aspect of the present disclosure relates to a classification model learning device, a classification model learning method, a classification model learning program, a classification model, a classification device, and a sorting device.

Background Art

[0002] In factories of foods, industrial products, and the like, sorting of target objects such as a defective product sorting test, quality product sorting, classification of quality products, and the like are performed. Such sorting of target objects is manually performed by a person. In addition, sorting devices for automating sorting have been developed and practically used. A sorting device is mainly composed of a sensor used for detecting states of target objects and an actuator used for sorting and removing target objects. For example, in Patent Literature 1, a sorting device for sorting grains is described. In this sorting device, images of grains of quality products and defective products are formed as templates, and sorting is performed by performing template matching.

Citation List

Patent Literature

[0003] [Patent Literature 1] Japanese Unexamined Patent Publication No. 2002-312762

Summary of Invention

Technical Problem

[0004] In a sorting device that automatically sorts target objects, features of target objects to be sorted need to be defined quantitatively. However, features of target objects of defective products or quality products differ in accordance with the target objects, and thus sorting devices are individually developed in accordance with the target objects. Thus, the development cost of a sorting device becomes very high. In a case in which the development cost of a sorting device is not expected to be collected in accordance with an operation thereafter, development of the device is not performed, and sorting of the target objects remains for a process of a manual operation, and there is an obstacle for manpower saving in a factory and the like.

[0005] Thus, the present invention is in consideration of the problems described above, and an object thereof is to enable a sorting device, which sorts target objects, to be configured in a simple manner by causing learning of features of various target objects to be easily performed.

Solution to Problem

[0006] According to one aspect of the present disclosure, there is provided a classification model learning device that generates a classification model classifying sensor data acquired from target objects by a predetermined sensor, the classification model including: a

clustering model that classifies the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and a classification unit that classifies the sensor data included in an extraction target group among a plurality of groups classified using the clustering model, the classification model learning device including: a sensor data acquiring unit that acquires a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from the plurality of target objects as first sensor data using the sensor acquiring states of the target objects and acquires a plurality of pieces of sensor data acquired from the target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group as second sensor data using the sensor; a clustering model generating unit that updates parameters of the clustering model by classifying a sensor data group formed from the plurality of pieces of the first sensor data and the plurality of pieces of the second sensor data into a plurality of groups using the clustering model; a designation unit that designates a group in which the number of pieces of the second sensor data included in the group is smaller than the number of pieces of the first sensor data by a predetermined degree or more from among a plurality of groups classified using the clustering model as the extraction target group; and a learning unit that performs learning of the classification model by repeating a learning process including a process of acquisition of the first sensor data and the second sensor data using the sensor data acquiring unit, update of the parameters of the clustering model using the

clustering model generating unit, and designation of the extraction target group using the designation unit.

[0007] According to one aspect of the present disclosure, there is provided a classification model learning method for generating a classification model classifying sensor data acquired from target objects by a predetermined sensor, the classification model including: a clustering model that classifies the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and a classification unit that classifies the sensor data included in an extraction target group among a plurality of groups classified using the clustering model, the classification model learning method including: a sensor data acquiring step of acquiring a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from the plurality of target objects as first sensor data using the sensor acquiring states of the target objects and acquiring a plurality of pieces of sensor data acquired from the target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group as second sensor data using the sensor; a clustering model generating step of updating parameters of the clustering model by classifying a sensor data group formed from the plurality of pieces of the first sensor data and the plurality of pieces of the second sensor data into a plurality of groups using the clustering model; a designation step of designating a group in which the number of pieces of the second sensor data included in the group is smaller than the number of pieces of the first sensor data by a predetermined degree or more from among a plurality of

groups classified using the clustering model as the extraction target group; and a learning step of performing learning of the classification model by repeating a learning process including a process of acquisition of the first sensor data and the second sensor data in the sensor data acquiring step, update of the parameters of the clustering model in the clustering model generating step, and designation of the extraction target group in the designation step.

[0008] According to one aspect of the present disclosure, there is provided a classification model learning program causing a computer to function as a classification model learning device that generates a classification model classifying sensor data acquired from target objects by a predetermined sensor, the classification model including: a clustering model that classifies the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and a classification unit that classifies the sensor data included in an extraction target group among a plurality of groups classified using the clustering model, the classification model learning program causing the computer to implement: a sensor data acquiring function of acquiring a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from the plurality of target objects as first sensor data using the sensor acquiring states of the target objects and acquiring a plurality of pieces of sensor data acquired from the target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group as second sensor data using the sensor; a clustering model generating function of updating

parameters of the clustering model by classifying a sensor data group formed from the plurality of pieces of the first sensor data and the plurality of pieces of the second sensor data into a plurality of groups using the clustering model; a designation function of designating a group in which the number of pieces of the second sensor data included in the group is smaller than the number of pieces of the first sensor data by a predetermined degree or more from among a plurality of groups classified using the clustering model as the extraction target group; and a learning function of performing learning of the classification model by repeating a learning process including a process of acquisition of the first sensor data and the second sensor data using the sensor data acquiring function, update of the parameters of the clustering model using the clustering model generating function, and designation of the extraction target group using the designation function.

[0009] According to such an aspect, parameters of a clustering model are updated by clustering a sensor data group formed from a plurality of pieces of first sensor data and a plurality of pieces of second sensor data using the clustering model, and, by performing learning of repeating clustering and updating the parameters, a clustering model that is suitable for classification of target objects is configured. In addition, the extraction target groups are groups in which the number of pieces of second sensor data included in the group has a significant small difference from the number of pieces of first sensor data by a predetermined degree or more, and thus sensor data classified into the extraction target groups is sensor data including features of target objects excluded from the first target object group. The classification model classifies sensor data

included in the extraction target groups, and thus the classification model is configured to classify sensor data having a feature of target objects excluded from the first target object group through a learning process. Thus, in a stage of learning a classification model, the second target object group is configured by removing target objects from the first target object group using a specific means, and thus a classification model capable of classifying target objects that have been removed using the means can be acquired. For example, the second target object group is configured by manually removing target objects from the first target object group, and thus a classification model capable of classifying target objects that have been manually removed can be easily acquired. Thus, learning of a classification model for automatically sorting target objects can be performed while a conventional operation of sorting the target objects using a means such as a manual operation or the like continues.

[0010] In a classification model learning device according to another aspect, the sensor data acquiring unit may acquire a reference sensor data set formed from a plurality of pieces of sensor data prepared in advance, and the learning unit may end the learning process in a case in which a difference between a classification result of sensor data acquired by inputting the reference sensor data set to the classification model after performance of the learning process n times (here, n is an integer equal to or larger than 1) and a classification result of sensor data acquired by inputting the reference sensor data set to the classification model after performance of the learning process (n+1) times becomes less than a predetermined degree.

[0011] According to such an aspect, when a degree of update of the parameters of the clustering model becomes less than a predetermined degree in repeating the learning process, the learning process ends, and thus the clustering model that is suitable for classification of the target object can be built.

[0012] In a classification model learning device according to another aspect, the clustering model generating unit may use a sensor data group formed from the plurality of pieces of the first sensor data and the plurality of pieces of the second sensor data acquired on the basis of sensing of a predetermined one unit using the sensor as a sensor data group of one unit and perform classification of sensor data and update of the parameters using the clustering model for each sensor data group of one unit, and the designation unit designates the extraction target group every time classification of the sensor data group of one unit is performed.

[0013] According to such an aspect, every time sensor data of a target object is acquired, the parameters of the clustering model are updated, and thus the clustering model can be learned with higher accuracy.

[0014] In a classification model learning device according to another aspect, the clustering model generating unit may use a sensor data group formed from the plurality of pieces of the first sensor data and the plurality of pieces of the second sensor data acquired on the basis of sensing of a predetermined one unit using the sensor as a sensor data group of one unit and perform classification of sensor data and update of the parameters using the clustering model for the sensor data group of at least two units or more, and the designation unit may designate the

extraction target group every time classification of the sensor data group of two units or more is performed.

[0015] According to such an aspect, every time sensor data of which an amount is equal to or larger than a predetermined degree is acquired, the parameters of the clustering model are updated, and thus a processing load relating to learning is reduced.

[0016] In a classification model learning device according to another aspect, the sensor may be an optical sensor, and the sensor data may be an image representing a target object.

[0017] According to such an aspect, a classification model capable of classifying target objects using images acquired by imaging the target objects can be built.

[0018] In a classification model learning device according to another aspect, the predetermined clustering technique may be one of the k-means method and the x-means method

[0019] According to such an aspect, a clustering model included in the classification model can be easily configured.

[0020] In a classification model learning device according to another aspect, the second target object group may be a target object group acquired by manually excluding one or more target objects from the first target object group.

[0021] According to such an aspect, a classification model capable of classifying target objects that have been manually removed can be easily acquired.

[0022] According to one aspect of the present disclosure, there is provided a classification model learning device that generates a

classification model classifying sensor data acquired from target objects by a predetermined sensor, the classification model including: a clustering model that classifies the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and a classification unit that classifies the sensor data included in an i-th (here, i = 1, 2, …, m; m is an integer equal to or larger than 2) extraction target group among a plurality of groups clustered using the clustering model into an i-th group, and the classification model learning device including: a sensor data acquiring unit that acquires a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from the plurality of target objects as first sensor data using the sensor acquiring states of the target objects and acquires a plurality of pieces of sensor data acquired from the target objects included in an (i+1)-th target object group that is a target object group acquired by excluding one or more target objects from an i-th target object group as (i+1)-th sensor data using the sensor; a clustering model generating unit that updates parameters of the clustering model by classifying a sensor data group formed from the plurality of pieces of the first sensor data, the plurality of pieces of the second sensor data, …, and the plurality of pieces of (m+1)-th sensor data into a plurality of groups using the clustering model; a designation unit that designates a group in which the number of pieces of the (i+1)-th sensor data included in the group is smaller than the number of pieces of the i-th sensor data by a predetermined degree or more from among a plurality of groups classified using the clustering model as an i-th extraction target group; and a learning unit that performs learning of the

classification model by repeating a learning process including a process of acquisition of the sensor data using the sensor data acquiring unit, update of the parameters of the clustering model using the clustering model generating unit, and designation of the extraction target group using the designation unit.

[0023] According to such an aspect, the sensor data group formed from a plurality of pieces of first sensor data, a plurality of pieces of second sensor data, …, and a plurality of pieces of the (m+1)-th sensor data is clustered using the clustering model, and thus the parameters of the clustering model are updated, and through learning of repeating clustering and update of the parameters, a clustering model that is suitable for classification of target objects into a plurality of groups is configured. In addition, the extraction target group is a group in which the number of pieces of the (i+1)-th sensor data included in the group has a significant small difference from the number of pieces of the (i+1)-th sensor data by a predetermined degree or more, and thus sensor data classified into the extraction target group is sensor data including a feature of target objects excluded from the i-th target object group. The classification model classifies sensor data included in the extraction target group, and thus the classification model is configured to classify sensor data having a feature of target objects excluded from the i-th target object group through a learning process. Thus, in a stage of learning a classification model, because the (i+1)-th target object group is configured by removing target objects from the i-th target object group, whereby a classification model capable of classifying target objects that have been manually removed in each of the first to the i-th stages can be easily acquired.

[0024] According to one aspect of the present disclosure, there is provided a learned classification model causing a computer to function to classify sensor data acquired from target objects using a predetermined sensor, the classification model including: a clustering model that classifies the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and a classification unit that classifies the sensor data included in an extraction target group among a plurality of groups classified using the clustering model, and the clustering model is built by updating parameters of the clustering model by classifying a sensor data group formed from first sensor data formed from a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from a plurality of target objects using the sensor and second sensor data formed from a plurality of pieces of sensor data acquired from the target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group using the sensor into a plurality of groups using the clustering model, the classification unit classifies the sensor data using a group in which the number of pieces of the second sensor data included in the group is smaller than the number of pieces of the first sensor data by a predetermined degree or more among the plurality of groups classified using the clustering model as an extraction target group.

[0025] According to one aspect of the present disclosure, there is provided a classification device that classifies sensor data acquired from target objects using a predetermined sensor using a learned classification model, the classification model is a model for causing a computer to

function and includes: a clustering model that classifies the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and a classification unit that classifies the sensor data included in an extraction target group among a plurality of groups classified using the clustering model, and the clustering model is built by updating parameters of the clustering model by classifying a sensor data group formed from first sensor data formed from a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from a plurality of target objects using the sensor and second sensor data formed from a plurality of pieces of sensor data acquired from the target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group using the sensor into a plurality of groups using the clustering model, and the classification unit classifies the sensor data using a group in which the number of pieces of the second sensor data included in the group is smaller than the number of pieces of the first sensor data by a predetermined degree or more among the plurality of groups classified using the clustering model as an extraction target group, and the classification device includes: an acquisition unit that acquires sensor data of classification targets; and an extraction unit that extracts sensor data classified into the extraction target group by using the classification model by inputting the sensor data of the classification target to the classification model.

[0026] According to such an aspect, the classification model classifies sensor data included in the extraction target group. The extraction target

group is a group of sensor data including a feature of target objects that have been excluded from the first target object group in the learning stage. Thus, sensor data having the feature of the target objects that have been excluded from the first target object group for configuring a second target object group in the learning stage can be classified.

[0027] According to one aspect of the present disclosure, there is provided a sorting device for sorting target objects from a target object group on the basis of states of the target objects, the sorting device including: a first sensor module that includes a first sensor acquiring the states of the target objects included in a first target object group formed from a plurality of target objects; and a lower process module configured using a second sensor module that is disposed on a downstream process side of the first sensor module and includes a second sensor that is the same sensor as the first sensor and acquires the states of the target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group.

[0028] According to such an aspect, the first sensor data acquired from target objects included in the first target object group is acquired, and the second sensor data acquired from target objects included in the second target object group is acquired. In accordance with this, a sensor data group formed from the first sensor data and the second sensor data can be provided for learning of the classification model.

[0029] A sorting device according to another aspect may further include a conveyer module that is disposed between the first sensor module and

the second sensor module and includes a conveyer used for conveying a target object from the first sensor module to the second sensor module.

[0030] According to such an aspect, persons for manually removing target objects are arranged along the conveyer module, and target objects corresponding to a predetermined state are manually removed, whereby a second target object group acquired by removing the target objects corresponding to the predetermined state from the first target object group can be configured.

[0031] A sorting device according to one aspect of the present disclosure is a sorting device for sorting target objects from a target object group on the basis of states of the target objects, the sorting device including: a first sensor module that includes a first sensor acquiring the states of the target objects included in a first target object group formed from a plurality of target objects; and a lower process module disposed on a downstream process side of the first sensor module and configured using one of a second sensor module including a second sensor that is the same sensor as the first sensor and acquires the states of the target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group or an actuator module including an actuator used for removing a target object from which the sensor data classified into an extraction target originates from the first target object group in the sensor data that is acquired by the first sensor and represents the states of the target objects included in the first target object group.

[0032] According to such an aspect, the second sensor module or the actuator module can be disposed on the downstream process side of the

first sensor module. In a case in which the second sensor module is configured on the downstream process side of the first sensor module, a sensor data group for providing learning of the classification model can be easily acquired. In addition, in a case in which the actuator module is configured on the downstream process side of the first sensor module, a target object from which sensor data classified as an extraction target originates can be removed from the target object group on the basis of the sensor data acquired by the first sensor.

[0033] According to another aspect, there is provided a sorting device, a second sensor module includes a second conveyer that conveys target objects and a second sensor, the second sensor acquires the states of the target objects conveyed by the second conveyer, an actuator module includes a third conveyer that conveys target objects and an actuator, the actuator removes target objects conveyed by the third conveyer from the third conveyer, and a length of the second conveyer in a direction in which target objects are conveyed may be the same as a length of the third conveyer in a direction in which the target object is conveyed.

[0034] According to such an aspect, a length of the second conveyer from a carrying-in part into which a target object is carried to a carrying-out part from which the target object is carried out is the same as a length of the third conveyer from a carrying-in part to a carrying-output part, and thus the second sensor module and the actuator module can be easily substituted with each other in a sorting line of target objects configured by the sorting device. In accordance with this, switching between the learning process of the classification model and the process of sorting target objects can be easily performed.

Advantageous Effects of Invention

[0035] According to one aspect of the present disclosure, by causing learning of features of various target objects to be easily performed, a sorting device that sorts target objects can be configured in a simple manner.

Brief Description of Drawings

[0036] FIG. 1 is a diagram illustrating an example of a sorting device according to an embodiment.

FIG. 2 is a block diagram illustrating an example of a functional configuration of a classification model learning device according to an embodiment.

FIG. 3 is a diagram illustrating an example of a hardware configuration of a server computer configuring a classification model learning device and the like according to an embodiment.

FIG. 4 is a diagram illustrating an example of a configuration of a classification model.

FIG. 5(a) is a diagram illustrating a first example of sensor data. FIG. 5(b) is a diagram illustrating a second example of sensor data.

FIG. 6 is a diagram illustrating a concept of clustering of sensor data using a clustering model according to this embodiment.

FIG. 7 is a diagram illustrating details of the number of pieces of first sensor data and the number of pieces of second sensor data in groups of sensor data classified using a clustering model.

FIG. 8 is a diagram illustrating a configuration of a classification model in which an extraction target group is designated.

FIG. 9 is a flowchart illustrating an example of details of a classification model learning method in a classification model learning device according to an embodiment.

FIG. 10 is a diagram illustrating an example of a functional configuration of a classification device according to an embodiment.

FIG. 11 is a diagram illustrating an example of a sorting device according to an embodiment.

FIG. 12 is a diagram illustrating details of the numbers of pieces of first to fourth sensor data in each group of sensor data classified using a clustering model.

FIG. 13 is a diagram illustrating an example of a sorting device according to an embodiment.

FIG. 14(a) is a diagram illustrating an example of a conveyer module. FIG. 14(b) is a diagram illustrating an example of a sensor module and variations thereof. FIG. 14(c) is a diagram illustrating an example of an actuator module and variations thereof.

FIG. 15 is a diagram illustrating an example of a sorting device for performing a learning process and a sorting process in parallel.

Description of Embodiments

[0037] Hereinafter, an embodiment of the present invention will be described in detail with reference to the attached drawings. In description of the drawings, the same reference numerals will be assigned to the same or equivalent elements, and duplicate description will be omitted.

[0038] FIG. 1 is a diagram illustrating an example of a sorting device according to an embodiment. The sorting device is a device used for

sorting target objects from a target object group on the basis of states of the target objects. More specifically, the sorting device is a device used for sorting target objects for sorting in factories of foods, industrial products, and the like such as defective product sorting, quality product sorting, and classification of quality products.

[0039] As illustrated in FIG. 1, a sorting device L1 includes a first sensor module ms1, a conveyer module mc, and a second sensor module ms2. The first sensor module ms1 includes a conveyer cb and a first sensor se1.

[0040] The conveyer cb includes a carrying-in part and a carrying-out part of a target object and conveys a target object from the carrying-in part to the carrying-out part.

[0041] The first sensor se1 is a sensor that acquires a state (feature) of a target object. In the example illustrated in this embodiment, the sensor is an optical sensor and acquires an image of a target object as sensor data. For example, the sensor may be a CCD camera, a CMOS camera, or the like. In addition, the sensor may be a thermo-camera that acquires a temperature distribution or a 3D camera that acquires an image accompanying depth information. The type of the sensor is not particularly limited as long as it can acquire a feature of a target object.

[0042] The conveyer module mc includes a conveyer cb. Persons h for manually removing target objects may be arranged along the conveyer module mc. In accordance with this, target objects corresponding to a predetermined condition (for example, defective products) can be manually removed from a target object group conveyed on the conveyer cb.

[0043] The second sensor module ms2 includes a conveyer cb and a second sensor se2. The second sensor se2 is configured using the same sensor as the first sensor se1. The second sensor se2 acquires a state (feature) of a target object conveyed on the conveyer cb of the second sensor module ms2. In addition, the second sensor se2 may be a sensor that detects a physical quantity of the same type as that of the first sensor se1 and may be a sensor of the same type as that of the first sensor se1.

[0044] The configuration of the sorting device L1 in a learning stage of a classification model for classifying sensor data representing states of target objects is illustrated. A target object is fed from a carrying-in part of the conveyer cb of the first sensor module ms1, passes through the conveyers cb of two conveyer modules mc, and is conveyed until reach of a carrying-output part of the conveyer cb of the second sensor module ms2.

[0045] When a first target object group formed from a plurality of target objects is fed from the carrying-in part of the conveyer cb of the first sensor module ms1, the first sensor se1 acquires images of target objects conveyed on the conveyer cb, for example, at predetermined time intervals as sensor data.

[0046] The second sensor se2 acquires images of target objects included in a second target object group, which is a target object group acquired by excluding one or more target objects from the first target object group, at predetermined time intervals as sensor data. In the example illustrated in FIG. 1, the second target object group is a target object group acquired by manually removing target objects that are defective products from the first target object group using the persons h. In the following

example of this embodiment, although a case in which the second target object group is configured by manually removing some target objects from the first target object group will be described, the second target object group may be configured by removing target objects from the first target object group using any other removal means.

[0047] In this embodiment, although the sorting device L1 is illustrated as a device for sorting defective products, the purpose thereof is not limited to sorting of defective products and may be sorting of quality products, classification of quality products, or the like.

[0048] FIG. 2 is a block diagram illustrating an example of a functional configuration of a classification model learning device according to an embodiment. A classification model learning device 10 is a device that generates a classification model that classifies sensor data acquired from target objects by predetermined sensors through a learning process. As illustrated in FIG. 2, the classification model learning device 10 according to this embodiment may include functional units configured in a processor 101 and a classification model storing unit 17. The functional units will be described below.

[0049] FIG. 3 is a diagram illustrating an example of a hardware configuration of a server computer 100 configuring the classification model learning device 10 according to an embodiment. In addition, the server computer 100 may configure a classification device 20.

[0050] For example, the server computer 100 includes a processor 101, a main storage unit 102, an auxiliary storage unit 103, and a communication unit 104 as hardware constituent elements.

[0051] The processor 101 is an arithmetic operation device that executes an operating system and an application program. Examples of the processor include a central processing unit (CPU) and a graphic processing unit (GPU), and the type of the processor 101 is not limited thereto. For example, the processor 101 may be a combination of a sensor and a dedicated circuit. The dedicated circuit may be a programmable circuit such as a field programmable gate array (FPGA) or may be a circuit of another other type.

[0052] The main storage unit 102 is a device that stores programs for realizing the classification model learning device 10 and the like, an arithmetic operation result output from the processor 101, and the like. The main storage unit 102, for example, is configured using at least one of a read only memory (ROM) and a random access memory (RAM).

[0053] Generally, the auxiliary storage unit 103 is a device that can store a larger amount of data than the main storage unit 102. The auxiliary storage unit 103, for example, is configured using a nonvolatile storage medium such as a hard disk, a flash memory, or the like. The auxiliary storage unit 103 stores a server program P1 used for causing the server computer 100 to function as the classification model learning device 10 and the like and various kinds of data. In this embodiment, a classification model learning program realizing the classification model learning device 10 is implemented as the server program P1.

[0054] The communication unit 104 is a device that performs data communication with other computers via a communication network. For example, the communication unit 104 is configured using a network card or a wireless communication module.

[0055] Each functional element of the classification model learning device 10 is realizing by causing a corresponding server program P1 to be read into the processor 101 or the main storage unit 102 and causing the processor 101 to execute the program. The server program P1 includes codes used for realizing each functional element of a corresponding server. The processor 101 operates the communication unit 104 in accordance with the server program P1 and executes reading/writing of data in the main storage unit 102 and the auxiliary storage unit 103. In accordance with such a process, each functional element of a corresponding server is realized.

[0056] The server program P1 may be provided after it is fixedly recorded on a tangible recording medium such as a CD-ROM, a DVD-ROM, a semiconductor memory, or the like. Alternatively, at least one of such programs may be provided via a communication network as a data signal superimposed on a carrier wave.

[0057] Each server computer may be configured using one or a plurality of computers. In a case in which a plurality of computers are used for one server, such computers are connected together via a communication network, whereby one server is logically configured.

[0058] Referring back to FIG. 2, the classification model learning device 10 includes a sensor data acquiring unit 11, a clustering model generating unit 12, a designation unit 13, a learning unit 14, and an output unit 15. Each of such functional units 11 to 15 is realized by causing the server program P1 to be read by the processor 101 and executing the program.

[0059] Each functional unit of the classification model learning device 10 is configured to be able to access the classification model storing unit

17. The classification model storing unit 17 is a storage means for storing and managing a classification model that is during a learning process or a learned classification model and, for example, is configured in the main storage unit 102 or the auxiliary storage unit 103. In addition, in this embodiment, although the classification model storing unit 17 is configured in the classification model learning device 10, the classification model storing unit 17 may be configured in another device that can be accessed from the classification model learning device 10.

[0060] In addition, the classification model learning device 10 is configured to be able to communicate with the first sensor se1 and the second sensor se2 and, more specifically, acquires sensor data acquired by the sensors.

[0061] FIG. 4 is a diagram illustrating an example of a configuration of a classification model. The classification model md is a model that classifies sensor data representing states and features of target objects acquired by sensors. As illustrated in FIG. 4, the classification model md includes a clustering model md11 and a classification unit md12.

[0062] The clustering model md11 is a model that classifies sensor data into a plurality of groups using a predetermined clustering technique on the basis of similarity of the sensor data. For example, the clustering technique may be a k-means method, an x-means method, or the like that is well known. By using such a clustering technique, a clustering model can be easily configured.

[0063] The classification unit md12 classifies and extracts sensor data included in an extraction target group among a plurality of groups

classified using the clustering model md11. Designation of an extraction target group will be described below in detail.

[0064] The classification model md including the learned clustering model md11 learned through machine learning and the classification unit md12 may be perceived as a program that is read or referred to by a computer, causes the computer to perform a predetermined process, and causes the computer to realize a predetermined function.

[0065] In other words, the learned classification model md according to this embodiment is used in a computer including a CPU and a memory. More specifically, the CPU of the computer operates to execute an arithmetic operation for sensor data input to the classification model md in accordance with an instruction from the learned classification model md stored in the memory and output classified sensor data.

[0066] Subsequently, each functional unit of the classification model learning device 10 will be described. The sensor data acquiring unit 11 acquires a plurality of pieces of sensor data acquired from target objects included in a first target object group formed from a plurality of target objects using a sensor acquiring states of target objects as first sensor data. In this embodiment, the sensor data acquiring unit 11 acquires the first sensor data from the first sensor se1.

[0067] In addition, the sensor data acquiring unit 11 acquires a plurality of pieces of sensor data from target objects included in a second target object group, which is a target object group acquired by excluding one or more target objects from the first target object group, using a sensor as second sensor data. In this embodiment, the sensor data acquiring unit 11 acquires the second sensor data from the second sensor se2.

[0068] As described with reference to FIG. 1, the first target object group according to this embodiment is a target object group fed from the carrying-in part of the conveyer cb of the first sensor module ms1. Target objects corresponding to a predetermined condition indicating a defective product among target objects conveyed by the conveyer cb are manually removed by the person h. Thus, the second target object group is a target object group acquired by removing target objects determined to be defective products by the person h from the first target object group.

[0069] FIG. 5 is a diagram illustrating an example of sensor data. FIG. 5(a) is a diagram illustrating a first example of sensor data and illustrates an example of an image of one frame acquired in a case in which detection of each target object is unable to be performed or inappropriate due to a small size of a target object t. Each of the first sensor se1 and the second sensor se2 acquires an image F of one frame, for example, at predetermined time intervals or every time the conveyer cb advances by a distance corresponding to an imaging range.

[0070] When an image F of one frame is acquired from the first sensor se1 or the second sensor se2, the sensor data acquiring unit 11 generates grid images g by dividing the acquired image into images corresponding to a predetermined division number. In the example illustrated in FIG. 5(a), 16 grid images are generated from an image F of one frame. The sensor data acquiring unit 11 acquires each of the grid images g as first or second sensor data. In addition, the sensor data acquiring unit 11 may only extract grid images g in which the target object t is included using a known image processing technology such as object detection or the like and acquire the extracted grid images as first or second sensor data.

[0071] FIG. 5(b) is a diagram illustrating a second example of sensor data and illustrates an example of an image of one frame acquired in a case in which the target object t can be detected from the image F. When the image F of one frame is acquired from the first sensor se1 or the second sensor se2, the sensor data acquiring unit 11 extracts a target object t, for example, using a known detection algorithm. For example, the object detection algorithm may use an object detection model using a neural network. The sensor data acquiring unit 11 acquires an image defined by a frame f including the extracted target object t as first or second sensor data.

[0072] The clustering model generating unit 12 classifies a sensor data group formed from a plurality of pieces of first sensor data and a plurality of pieces of second sensor data into a plurality of groups using the clustering model md11, thereby updating parameters of the clustering model md11. The clustering model generating unit 12 generates a clustering model md11 through machine learning accompanying update of the parameters.

[0073] FIG. 6 is a diagram illustrating a concept of clustering of sensor data using the clustering model md11 according to this embodiment. As illustrated in FIG. 6, the clustering model generating unit 12 acquires sensor data group sd formed from the first sensor data sd1 and the second sensor data sd2 from the sensor data acquiring unit 11. In other words, the clustering model generating unit 12 provides sensor data acquired from the first sensor se1 and the second sensor se2 for the clustering model md11 as a group of sensor data without any distinction therebetween.

[0074] The clustering model generating unit 12 classifies the sensor data group sd into a plurality of groups gra to grx by inputting the sensor data group sd to the clustering model md11, thereby generating and updating the parameters of the clustering model md11. The clustering model md11, as described above, may be a model configured using a technique such as the k-means method, the x-means method, or the like, the technique is not limited thereto as long as clustering of a plurality of pieces of sensor data can be performed on the basis of similarities thereof.

[0075] In the k-means method as one example of the clustering technique, input sensor data is represented using a vector, each piece of sensor data is randomly allocated to one cluster, a center of each cluster is calculated on the basis of sensor data allocated to each cluster, a distance between the calculated center of each cluster and each piece of sensor data is acquired, and each piece of sensor data is allocated again to a cluster of which the center is the closest. The allocation of sensor data to a cluster and the calculation of the center of the cluster are repeated, and, in a case in which a change in the allocation of each piece of sensor data to a cluster is below a predetermined degree, the clustering process ends. The center of the cluster at this time configures at least some of parameters of the clustering model.

[0076] The designation unit 13 designates a group in which the number of pieces of second sensor data sd2 included in the group is smaller than the number of pieces of first sensor data sd1 by a predetermined degree or more from among a plurality of groups that are classified using the clustering model md11 as an extraction target group.

[0077] FIG. 7 is an example of a graph illustrating details of the number of pieces of first sensor data sd1 and the number of pieces of second sensor data sd2 in groups of sensor data classified using the clustering model md11. FIG. 8 is a diagram illustrating a configuration of a classification model md in which an extraction target group is designated.

[0078] In the example illustrated in FIG. 7, the sensor data group sd is classified into 10 groups of Groups A to J using the clustering model md11. Among such groups, for example, in Group A and Group B, the number of pieces of the first sensor data sd1 and the number of pieces of the second sensor data sd2 included in the groups are of the same degree. On the other hand, in Group C, the number of pieces of second sensor data sd2 included in the group is significantly smaller than the number of pieces of first sensor data sd1.

[0079] In this way, the designation unit 13 designates Group C in which the number of pieces of second sensor data sd2 included in the group is smaller than the number of pieces of first sensor data sd1 by a predetermined degree or more as an extraction target group g1. As a degree of a difference between the number of pieces of second sensor data sd2 and the number of pieces of first sensor data sd1, which is a condition for designating an extraction target group, a value representing a significant different as a number or a ratio may be set in the design in advance

[0080] Similarly, in Group D and Group F, the number of pieces of second sensor data sd2 included in the group is smaller than the number of pieces of first sensor data sd1 by a predetermined degree or more, and

thus, the designation unit 13 designates Group D and Group F as extraction target groups g2 and g3.

[0081] As illustrated in FIG. 8, among Groups A to J generated by classifying the sensor data group sd using the clustering model md11, Groups C, D, and F are designated as extraction target groups g1, g2, and g3, and thus the classification unit md12 of the classification model md is configured to classify sensor data included in Groups C, D, and F.

[0082] The sensor data classified into Groups C, D, and F is sensor data that is acquired by the first sensor se1 and is hardly acquired by the second sensor se2. In other words, a feature of a target object represented by sensor data classified into an extraction target group corresponds to a feature of a target object that corresponds to a difference between the first target object group and the second target object group and is excluded from the first target object group manually by the persons h. Thus, the classification model md is configured to classify sensor data representing a feature of target objects that are excluded manually by the persons h.

[0083] In addition, the clustering model generating unit 12, by using a sensor data group sd formed from a plurality of pieces of first sensor data sd1 and a plurality of pieces of second sensor data sd2 acquired on the basis of sensing of a predetermined one unit using sensors as a sensor data group sd of one unit, may perform classification of sensor data and update of parameters using the clustering model md11 for each sensor data group of one unit, and the designation unit 13 may perform designation of an extraction target group every time classification of sensor data group of one unit is performed. In such a case, every time sensor data of a target object is acquired, the parameters of the clustering

model are updated, and thus learning of a clustering model with higher accuracy can be performed. For example, in a case in which sensor data is an image, sensing of one unit may be acquisition of an image of one frame. In addition, sensing of one unit may be acquisition of images of a plurality of frames. The sensing of one unit may be acquisition of sensor data relating to a predetermined number, which is one or more, of target objects.

[0084] In addition, the clustering model generating unit 12 may perform classification of sensor data and update of the parameters using the clustering model md11 for at least two or more units of sensor data groups, and the designation unit 13 may perform designation of an extraction target group every time classification of two or more units of sensor data groups is performed. In such a case, every time sensor data of which an amount is equal to or larger than a predetermined degree is acquired, the parameters of the clustering model are updated, and thus a processing load relating to learning is reduced.

[0085] By repeating a learning process including processes of acquisition of the first sensor data sd1 and the second sensor data sd2 using the sensor data acquiring unit 11, update of the parameters of the clustering model md11 using the clustering model generating unit 12, and designation of an extraction target group using the designation unit 13, the learning unit 14 performs learning of the classification model md.

[0086] More specifically, in a case in which a difference between a classification result of sensor data acquired by inputting a reference sensor data set to the classification model md that is after performance of the learning process n times (here, n is an integer equal to or larger than

1) and a classification result of sensor data acquired by inputting the reference sensor data set to the classification model md that is after performance of the learning process (n+1) times becomes less than a predetermined degree, the learning unit 14 may end the learning process. The reference data set is formed from a plurality of sensor data sets prepared in advance and may be acquired from a predetermined storage means storing the reference data set by the sensor data acquiring unit 11.

[0087] For example, a difference between classification results as a condition for ending the learning process may be a difference between the numbers of pieces of sensor data classified in respective groups using the clustering model. In addition, a difference (or a square value of the difference) between the numbers of pieces of sensor data classified into respective groups may be calculated for each group, and a sum of calculated differences between the numbers of pieces of sensor data of respective groups that corresponds to all the groups being less than a predetermined value may be set as a condition for ending learning. Furthermore, a difference between classification results as a condition for ending the learning process may be a difference between the numbers of pieces of sensor data classified as an extraction target group.

[0088] In this way, the learning process is repeated, and when a degree of update of the parameters of the clustering model md11 becomes less than a predetermined degree in repeating the learning process, the learning process ends, and thus the clustering model md11 that is suitable for classification of the target object can be built.

[0089] The output unit 15 outputs the classification model md for which the learning process has ended. More specifically, in this embodiment,

the output unit 15 stores the classification model md for which the learning process has ended in the classification model storing unit 17.

[0090] FIG. 9 is a flowchart illustrating an example of details of a classification model learning method in the classification model learning device 10 according to an embodiment. By causing the processor 101 to read the server program P1 and execute the program, the functional units 11 to 15 are realized, whereby the classification model learning method is executed.

[0091] In Step S1, the sensor data acquiring unit 11 acquires a plurality of pieces of first sensor data sd1 acquired from target objects included in the first target object group by the first sensor se1 and second sensor data sd2 acquired from target objects included in the second target object group that is a target object group acquired by excluding one or more target objects from the first target object group by the second sensor se2.

[0092] In Step S2, the clustering model generating unit 12 inputs a sensor data group sd formed from the first sensor data sd1 and the second sensor data sd2 to the clustering model md11.

[0093] In Step S3, the clustering model generating unit 12 causes the clustering model md11 to classify sensor data included in the sensor data group and update the parameters of the clustering model md11.

[0094] In Step S4, the designation unit 13 designates a group in which the number of pieces of second sensor data sd2 included in the group is smaller than the number of pieces of first sensor data sd1 by a predetermined degree or more from among groups of a plurality of pieces of sensor data classified using the clustering model md11 as an extraction target group.

[0095] In Step S5, the learning unit 14 compares a classification result of sensor data acquired by inputting a reference sensor data set formed from a plurality of sensor data sets prepared in advance to the classification model md with a classification result of sensor data acquired by inputting the reference sensor data set to the classification model md before update of the parameters and the like this time.

[0096] In Step S6, the learning unit 14 determines whether or not a difference between the classification results compared in Step S5 is less than a predetermined degree. In a case in which the difference between the classification results is determined to be less than the predetermined degree, the process proceeds to Step S7. On the other hand, in a case in which the difference between the classification results is not determined to be less than the predetermined degree, the process returns to Step S1, and the learning process of the classification model md is repeated.

[0097] In Step S7, the output unit 15 outputs the classification model md of which the learning process has ended.

[0098] Next, a classification device according to an embodiment will be described. FIG. 10 is a block diagram illustrating an example of a functional configuration of a classification device 20 according to an embodiment. The classification device 20 is a device that classifies sensor data acquired from a target object by a predetermined sensor using the learned classification model md. As illustrated in FIG. 10, the classification device 20 according to this embodiment may include functional units configured in a processor 101 and a classification model storing unit 24.

[0099] The classification device 20 includes an acquisition unit 21, an extraction unit 22, and an identification information output unit 23. Such functional units 21 to 23 are realized by causing the processor 101 to read a predetermined program and execute the program.

[0100] Each functional unit of the classification device 20 is configured to be able to access a classification model storing unit 24. The classification model storing unit 24 is a storage means for storing and managing a learned classification model and, for example, is configured in the main storage unit 102 or the auxiliary storage unit 103. The classification model storing unit 24 may be configured to be the same as the classification model storing unit 17 of the classification model learning device 10. In this embodiment, although the classification model storing unit 24 is configured in the classification device 20, the classification model storing unit 24 may be configured in another device that can be accessed from the classification device 20.

[0101] The classification device 20 is configured to be able to communicate with a sensor se and an actuator ac. The classification device 20 acquires sensor data acquired by the sensor se. In addition, the classification device 20 transmits information for identifying a target object to be removed to the actuator ac.

[0102] The sensor se has a configuration similar to the first sensor se1 and the second sensor se2 of the classification model learning device 10 described with reference to FIG. 2 and the like and acquires a state (feature) of a target object.

[0103] The actuator ac is a device for removing target objects designated as extraction targets from a conveyed target object group and, for

example, may include a gripping part configured to be able to grip a target object and an arm part that three-dimensionally moves the position of the gripping part.

[0104] The acquisition unit 21 acquires sensor data acquired from a target object included in a target object group that is a classification target by the sensor se.

[0105] The extraction unit 22 extracts sensor data classified into an extraction target group by the classification model md by inputting sensor data that is a classification target acquired by the acquisition unit 21 to the classification model md.

[0106] The identification information output unit 23 outputs identification information used for identifying a target object corresponding to the sensor data extracted by the extraction unit 22 to the actuator ac. The identification information may be position information (coordinates) for identifying a position of a target object conveyed by the conveyer or the like in a sorting device (it will be described below in detail) for sorting target objects. The position information of a target object is acquired by the sensor se that has detected the target object and is notified to the actuator ac through the classification device 20. The identification information may include a conveyance speed of a target object in the conveyer. The actuator ac can remove a target object that is a sorting target on the basis of the notified identification information. In a case in which the actuator ac is a device configured to be able to grip a target object, the actuator ac can grip a target object that is a sorting target on the basis of the notified identification information.

[0107] FIG. 11 is a diagram illustrating an example of a sorting device according to an embodiment. A sorting device L2 illustrated in FIG. 11 has a configuration for acquiring sensor data used for learning a classification model while manually sorting a target object group. More specifically, for example, the sorting device L2 is configured to manually remove target objects corresponding to three kinds of classes from a target object group by persons h11, h12, and h13 and includes first to fourth sensors se11 to se14 such that features of removed target objects of the three types of classes can be learned. The first to fourth sensors se11 to se14 are sensors detecting physical quantities of the same type and may be sensors of the same type.

[0108] More specifically, the sorting device L2 includes a first sensor module ms11, a first conveyer module mc11, a second sensor module ms12, a second conveyer module mc12, a third sensor module ms13, a third conveyer module mc13, and a fourth sensor module ms14 that are disposed in a direction in which a target object is conveyed by the conveyor. The first to fourth sensor modules ms11 to ms14 respectively include first to fourth sensors se11 to se14.

[0109] When a first target object group formed from a plurality of target objects is fed from a carrying-in part of a conveyer of the first sensor module ms11, the first sensor se11 acquires information (for example, an image) representing a state of a target object conveyed on the conveyer as first sensor data.

[0110] When the first target object group is conveyed from the conveyer of the first sensor module ms11 to a conveyer of the first conveyer module mc11, a target object corresponding to a first class is manually removed

by a person h11. Thus, a second target object group acquired by removing target objects corresponding to the first class from the first target object group is conveyed from the first conveyer module mc11 to the second sensor module ms12.

[0111] When the second target object group is fed from a carrying-in part of a conveyer of the second sensor module ms12, the second sensor se12 acquires second sensor data representing a state of a target object conveyed on the conveyer.

[0112] When the second target object group is conveyed from the conveyer of the second sensor module ms12 to a conveyer of the second conveyer module mc12, a target object corresponding to a second class is manually removed by a person h12. Accordingly, a third target object group acquired by removing target objects corresponding to the second class from the second target object group is conveyed from the second conveyer module mc12 to the third sensor module ms13.

[0113] When the third target object group is fed from a carrying-in part of a conveyer of the third sensor module ms13, the third sensor se13 acquires third sensor data representing a state of a target object conveyed on the conveyer.

[0114] When the third target object group is conveyed from the conveyer of the third sensor module ms13 to a conveyer of the third conveyer module mc13, a target object corresponding to a third class is manually removed by a person h13. Accordingly, a fourth target object group acquired by removing target objects corresponding to the third class from the third target object group is conveyed from the third conveyer module mc13 to the fourth sensor module ms14.

[0115] When the fourth target object group is fed from a carrying-in part of a conveyer of the fourth sensor module ms14, the fourth sensor se14 acquires fourth sensor data representing a state of a target object conveyed on the conveyer.

[0116] As illustrated in FIG. 11, in order to generate the classification model md for classifying target objects into a plurality of classes, the classification unit md12 of the classification model md is configured to classify sensor data included in an i-th (here, i = 1, 2, …, m; m is an integer equal to or larger than 2) extraction target group among a plurality of groups clustered using the clustering model md11 into an i-th group. Here, a character m corresponds to the number of classes.

[0117] In the example illustrated in FIG. 11, the classification unit md12 is configured such that sensor data included in an i-th (here, i = 1, 2, 3, 4) extraction target group among a plurality of groups clustered using the clustering model md11 is classified into an i-th group.

[0118] In order to generate the classification model md for classifying target objects into a plurality of classes, the sensor data acquiring unit 11 acquires a plurality pieces of sensor data acquired from target objects included in the first target object group formed from a plurality of target objects as first sensor data. In addition, the sensor data acquiring unit 11 acquires a plurality of pieces of sensor data acquired from target objects included in an (i+1)-th target object group that is a target object group acquired by excluding one or more target objects from the i-th target object group as (i+1)-th sensor data.

[0119] In the example illustrated in FIG. 11, the sensor data acquiring unit 11 acquires first sensor data acquired from target objects included in

the first target object group by the first sensor se11. In addition, the sensor data acquiring unit 11 acquires second sensor data, third sensor data, and fourth sensor data from target objects respectively included in the second to fourth target object groups by the second to fourth sensors se12, se13, and se14.

[0120] In order to generate the classification model md for classifying target objects into a plurality of classes, the clustering model generating unit 12 updates the parameters of the clustering model by classifying sensor data formed from the plurality of pieces of first sensor data, the plurality of pieces of second sensor data, …, and the plurality of pieces of the (m+1)-th sensor data into a plurality of groups using the clustering model.

[0121] In the example illustrated in FIG. 11, the clustering model generating unit 12 classifies a sensor data group formed from the first sensor data, the second sensor data, the third sensor data, and the fourth sensor data into a plurality of groups using the clustering model, thereby updating the parameters of the clustering model.

[0122] In order to generate the classification model md for classifying target objects into a plurality of classes, the designation unit 13 designates a group in which the number of pieces of (i+1)-th sensor data included in the group is smaller than the number of pieces of i-th sensor data by a predetermined degree or more from a plurality of group classified using the clustering model md11 as an i-th extraction target group.

[0123] FIG. 12 is an example of a graph representing details of the numbers of pieces of the first to fourth sensor data in each group of sensor data classified using the clustering model md11. In the example

illustrated in FIG. 12, sensor data groups formed from the first to fourth sensor data are classified into five groups Group A to Group E using the clustering model md11. Among these groups, for example, in Group C and Group E, there is no significant difference between the numbers of pieces of the first to fourth sensor data included in the groups.

[0124] On the other hand, in Group B, the number of pieces of the second sensor data included in the group is significantly smaller than the number of pieces of the first sensor data. In such a case, the designation unit 13 designates Group B as a first extraction target group g11.

[0125] Similarly, in Group A, the number of pieces of the third sensor data included in the group is significantly smaller than the number of pieces of the second sensor data, and thus the designation unit 13 designates Group A as a second extraction target group g12. Furthermore, in Group D, the number of pieces of the fourth sensor data included in the group is significantly smaller than the number of pieces of the third sensor data, and thus the designation unit 13 designates Group D as a third extraction target group g13.

[0126] In this way, by designating the first to third extraction target groups gr11 to gr13, the classification model md is configured such that sensor data included in Group B, Group A, and Group D is classified into first to third groups corresponding to the first to third classes.

[0127] In the example described with reference to FIGS. 11 and 12, the clustering model generating unit 12 performs update of the parameters and learning of the clustering model md11 by classifying a sensor data group formed from the first sensor data, the second sensor data, the third sensor data, and the fourth sensor data into a plurality of groups using the

clustering model md11, and the designation unit 13 designates extraction target groups for classifying the sensor data.

[0128] In contrast to this, the sorting device L2 may be applied to the configuration similar to the example described with reference to FIGS. 1 and 7. In other words, the clustering model generating unit 12 may perform update of the parameters and learning of the clustering model md11 by classifying a sensor data group formed from the first sensor data acquired by the first sensor se11 and the second sensor data acquired by the second sensor se12 into a plurality of groups using the clustering model md11, and the designation unit 13 may designate one or more groups among the plurality of classified groups as extraction target groups.

[0129] Furthermore, the clustering model generating unit 12 may perform update of the parameters and learning of the clustering model md11 on the basis of a sensor data group formed from the second sensor data acquired by the second sensor se12 and the third sensor data acquired by the third sensor se13, and the designation unit 13 may designate one or more groups among the plurality of classified groups as extraction target groups. In addition, the clustering model generating unit 12 may perform update of the parameters and learning of the clustering model md11 on the basis of a sensor data group formed from the third sensor data acquired by the third sensor se13 and the fourth sensor data acquired by the fourth sensor se14, and the designation unit 13 may designate one or more groups among the plurality of classified groups as extraction target groups.

[0130] In this way, the sorting device L2 illustrated in FIG. 11 can be applied to a first example in which the classification model md is generated by classifying the sensor data group formed from the first sensor data, the second sensor data, the third sensor data, and the fourth sensor data into plurality of groups by inputting the sensor data group to one clustering model md11 and a second example in which three classification models are generated by performing model learning by inputting each of a sensor data group formed from the first sensor data and the second sensor data, a sensor data group formed from the second sensor data and the third sensor data, and a sensor data group formed from the third sensor data and the fourth sensor data to three clustering models md11. In the first example, compared with the second example, the amount of sensor data used for generating a model is large, and thus a model having higher accuracy can be generated. In addition, in order to classify target objects into a plurality of classes, although models corresponding to at least the number of classes need to be generated in the second example, in the first example, one clustering model md11 and the classification model md may be generated, and thus the amount of calculation relating to model generation is reduced.

[0131] Next, an example of the sorting device according to an embodiment will be described with reference to FIGS. 1 and 13 to 15. As illustrated in FIG. 1, the sorting device L1 according to this embodiment may include a first sensor module ms1 including a first sensor se1 that acquires states of target objects included in a first target object group formed from a plurality of target objects and a lower process module configured using a second sensor module ms2 disposed on a

downstream process side of the first sensor module ms1 and including a second sensor se2 that is the same sensor as the first sensor se1 and acquires states of target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group.

[0132] Modules according to this embodiment including the first sensor module ms1 and the second sensor module ms2 are functionally-integrated parts configuring a device, a machine, and a system. This similarly applies to various other modules described in this embodiment. As will be described below, various modules described in this embodiment may be configured to have the same length, the same width, and the same height. Thus, each of modules configuring the classification model learning device 10, the classification device 20, and the sorting device according to this embodiment can be easily replaced with other modules.

[0133] According to such a sorting device L1, first sensor data acquired from target objects included in the first target object group is acquired, and second sensor data acquired from target objects included in the second target object group is acquired. Thus, a sensor data group formed from the first sensor data and the second sensor data can be provided for learning of the classification model md.

[0134] In addition, as illustrated in FIG. 1, the sorting device L1 may further include a conveyer module mc that is disposed between the first sensor module ms1 and the second sensor module ms2 and includes a conveyer cb used for conveying a target object from the first sensor module ms1 to the second sensor module ms2.

[0135] By configuring the sorting device L1 as such, persons for manually removing target objects are arranged along the conveyer module mc, and target objects corresponding to a predetermined state are manually removed, whereby a second target object group acquired by removing the target objects corresponding to the predetermined state from the first target object group can be configured.

[0136] FIG. 13 is a diagram illustrating an example of a sorting device according to an embodiment. The sorting device according to the embodiment includes a first sensor module ms1 and a lower process module, and the lower process module may be configured in any one of a second sensor module ms2 or an actuator module ma. FIG. 13 illustrates an example of a sorting device L3 in which a lower process module is configured using an actuator module ma.

[0137] The actuator module ma includes an actuator ac that is used for removing target objects from which sensor data classified into extraction targets originates in sensor data that is acquired by the first sensor se1 and represents states of target objects included in the first target object group from the first target object group. The sensor data acquired by the first sensor se1 is acquired by the acquisition unit 21 of the classification device 20. The actuator ac removes target object from which sensor data classified into extraction targets originates from the conveyer cb on the basis of identification information output by the identification information output unit 23 of the classification device 20.

[0138] For example, as illustrated in FIG. 1, the second sensor module ms2 includes a conveyer cb that conveys target objects and a second sensor se2. As illustrated in FIG. 13, the actuator module ma includes

a conveyer cb that conveys target objects and an actuator ac. A length of the second sensor module ms2 in a conveyance direction of a target object in the conveyer cb is configured to be similar to a length of the actuator module ma in the conveyance direction of a target object in the conveyer cb. By configuring as such, the second sensor module ms2 and the actuator module ma can be easily substituted with each other in the sorting device. In accordance with this, switching between the process of learning the classification model md and the process of sorting target objects can be easily performed.

[0139] In addition, a width of the conveyer cb of the second sensor module ms2 may be configured to be the same in length as a width of the conveyer cb of the actuator module ma. In accordance with this, the second sensor module ms2 and the actuator module ma can be more easily substituted with each other. Furthermore, a height of the conveyer cb of the second sensor module ms2 may be configured to be the same as a height of the conveyer cb of the actuator module ma.

[0140] FIG. 14(a) is a diagram illustrating an example of a conveyer module. The conveyer module mc illustrated in FIG. 14(a) is formed from a conveyer cb that is used for conveying target objects.

[0141] FIG. 14(b) is a diagram illustrating an example of a sensor module and variations thereof. The sensor module ms31 includes a CCD/CMOS sensor se31 and a conveyer cb. The CCD/CMOS sensor se31 acquires an image of a target object conveyed by the conveyer cb as sensor data.

[0142] A sensor module ms32 includes a thermo-camera se32 and a conveyer cb. The thermo-camera se32 acquires a temperature distribution of a target object conveyed by the conveyer cb as sensor data.

[0143] A sensor module ms33 includes a depth sensor se33 and a conveyer cb. The depth sensor se33 acquires an image accompanying a depth of a target object conveyed by the conveyer cb as sensor data.

[0144] FIG. 14(c) is a diagram illustrating an example of an actuator module and variations thereof. The actuator module ma31 includes a pusher arm ac31 and a conveyer cb. The pusher arm ac31 removes a target object conveyed by the conveyer cb using a gripping part connected to the arm and moves the target object to a lateral side of the conveyer cb.

[0145] An actuator module ma32 includes a parallel link ac32 and a conveyer cb. The parallel link ac32 grips a target object conveyed by the conveyer cb using a gripping part and removes the target object from the conveyer cb.

[0146] An actuator module ma33 includes a robot arm ac33 and a conveyer cb. The robot arm ac33 removes a target object conveyed by the conveyer cb using a gripping part connected to the arm to be removed from the conveyer cb.

[0147] The conveyers cb included in the modules illustrated in FIGS. 14(a) to 14(c) are configured to have the same length and the same width in the conveyance direction. In accordance with this, modules configuring the sorting device can be easily substituted with each other.

[0148] FIG. 15 is a diagram illustrating an example of a sorting device according to an example of the embodiment. A sorting device L4 has a

configuration for performing learning of a classification model and sorting target objects using the classification model md in parallel.

[0149] The sorting device L4 includes a first sensor module ms1 including a first sensor se1 that acquires state of target objects included in a first target object group and a second sensor module ms2 disposed on a downstream process side of the first sensor module ms1 and includes a second sensor se2 that is the same sensor as the first sensor se1 and acquires states of target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group.

[0150] In addition, the sorting device L4 includes an actuator module ma and a conveyer module mc between the first sensor module ms1 and the second sensor module ms2. An actuator of the actuator module ma operates to remove target objects corresponding to sensor data classified using the classification model md on the basis of the sensor data acquired by the first sensor se1 of the first sensor module ms1. In addition, target objects conveyed on the conveyer are removed manually by a person h who is arranged along the conveyer module mc. Thus, the second target object group is a target object group acquired by removing target objects from the first target object group using the actuator of the actuator module ma and manually by the person h.

[0151] According to such a sorting device L4, by providing a sensor data group formed from first sensor data acquired from target objects included in the first target object group and the second sensor data acquired from target objects included in the second target object group for learning of the classification model md, the classification model md that classifies

sensor data representing features of the target objects that are removed by the actuator of the actuator module ac and manually by the person h into extraction targets can be built.

[0152] More specifically, the sensor data acquiring unit 11 acquires first sensor data and second sensor data respectively from the first sensor se1 and the second sensor se2. The clustering model generating unit 12 classifies a sensor data group formed from the first sensor data and the second sensor data into a plurality of groups using the clustering model md11, whereby performing update of the parameters and learning of the clustering model md11. The designation unit 13 designates groups in which the number of pieces of second sensor data included in the group is smaller than the number of pieces of first sensor data by a predetermined degree or more from among a plurality of groups classified using the clustering model md11 as extraction target groups. Then, the learning unit 14 generates a classification model md by performing the learning process described above. In addition, sorting using the actuator module ac and sorting of target objects according to the person h can be performed in parallel with the learning of the classification model md.

[0153] According to the classification model learning device 10, the classification model learning method, and the classification model learning program according to this embodiment, parameters of a clustering model are updated by clustering a sensor data group formed from a plurality of pieces of first sensor data and a plurality of pieces of second sensor data using the clustering model, and, by performing learning of repeating clustering and updating the parameters, a clustering model that is suitable for classification of target objects is configured.

In addition, the extraction target groups are groups in which the number of pieces of second sensor data included in the group has a significant difference from the number of pieces of first sensor data by a predetermined degree or more, and thus sensor data classified into the extraction target groups is sensor data including features of target objects excluded from the first target object group. The classification model classifies sensor data included in the extraction target groups, and thus the classification model is configured to classify sensor data having a feature of target objects excluded from the first target object group through a learning process. Thus, in a stage of learning a classification model, the second target object group is configured by manually removing target objects from the first target object group, a classification model capable of classifying target objects that have been manually removed can be easily acquired. Thus, learning of a classification model for automatically sorting target objects can be performed while a conventional operation of manually sorting the target objects is continued.

[0154] In addition, according to the classification model md and the classification device 20 of this embodiment, the classification model md classifies sensor data included in an extraction target group. The extraction target group is a group of sensor data including a feature of target objects excluded from the first target object group in a learning stage. Thus, in order to configure a second target object group in the learning stage, sensor data having a feature of target objects excluded from the first target object group can be classified.

[0155] In addition, according to the sorting device of this embodiment, the first sensor data acquired from target objects included in the first target object group is acquired, and the second sensor data acquired from target objects included in the second target object group is acquired. In accordance with this, a sensor data group formed from the first sensor data and the second sensor data can be provided for learning of the classification model.

[0156] As above, the present invention has been described in detail on the basis of the embodiment. However, the present invention is not limited to the embodiment described above. The present invention can be variously modified in a range not departing from the concept thereof.

Reference Signs List

[0157] L1, L2, L3, L4 Sorting device

P1 Server program

md Classification model

md11 Clustering model

md12 Classification model

10 Classification model learning device

11 Sensor data acquiring unit

12 Clustering model generating unit

13 Designation unit

14 Learning unit

15 Output unit

17 Classification model storing unit

20 Classification device

21 Acquisition unit

22 Extraction unit

23 Identification information output unit

24 Classification model storing unit

100 Server computer

101 Processor

102 Main storage unit

103 Auxiliary storage unit

104 Communication unit

CLAIMS

[Claim 1]

A classification model learning device that generates a classification model classifying sensor data acquired from target objects by a predetermined sensor,

the classification model including:

a clustering model configured to classify the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and

a classification unit configured to classify the sensor data included in an extraction target group among a plurality of groups classified using the clustering model,

the classification model learning device comprising:

a sensor data acquiring unit configured to acquire a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from the plurality of target objects as first sensor data using the sensor acquiring states of the target objects and acquire a plurality of pieces of sensor data acquired from the target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group as second sensor data using the sensor;

a clustering model generating unit configured to update parameters of the clustering model by classifying a sensor data group formed from the plurality of pieces of the first sensor data and the plurality of pieces of the second sensor data into a plurality of groups using the clustering model;

a designation unit configured to designate a group in which the number of pieces of the second sensor data included in the group is smaller than the number of pieces of the first sensor data by a predetermined degree or more from among a plurality of groups classified using the clustering model as the extraction target group; and

a learning unit configured to perform learning of the classification model by repeating a learning process including a process of acquisition of the first sensor data and the second sensor data using the sensor data acquiring unit, update of the parameters of the clustering model using the clustering model generating unit, and designation of the extraction target group using the designation unit.

[Claim 2]

The classification model learning device according to claim 1,

wherein the sensor data acquiring unit acquires a reference sensor data set formed from a plurality of pieces of sensor data prepared in advance, and

wherein the learning unit ends the learning process in a case in which a difference between a classification result of sensor data acquired by inputting the reference sensor data set to the classification model after performance of the learning process n times (here, n is an integer equal to or larger than 1) and a classification result of sensor data acquired by inputting the reference sensor data set to the classification model after performance of the learning process (n+1) times becomes less than a predetermined degree.

[Claim 3]

The classification model learning device according to claim 1 or 2,

wherein the clustering model generating unit uses a sensor data group formed from the plurality of pieces of the first sensor data and the plurality of pieces of the second sensor data acquired on the basis of sensing of a predetermined one unit using the sensor as a sensor data group of one unit and performs classification of sensor data and update of the parameters using the clustering model for each sensor data group of one unit, and

wherein the designation unit designates the extraction target group every time classification of the sensor data group of one unit is performed.

[Claim 4]

The classification model learning device according to claim 1 or 2,

wherein the clustering model generating unit uses a sensor data group formed from the plurality of pieces of the first sensor data and the plurality of pieces of the second sensor data acquired on the basis of sensing of a predetermined one unit using the sensor as a sensor data group of one unit and performs classification of sensor data and update of the parameters using the clustering model for the sensor data group of at least two units or more, and

wherein the designation unit designates the extraction target group every time classification of the sensor data group of two units or more is performed.

[Claim 5]

A classification model learning device that generates a classification model classifying sensor data acquired from target objects by a predetermined sensor,

the classification model including:

a clustering model configured to classify the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and

a classification unit configured to classify the sensor data included in each of i-th (here, i = 1, 2, …, m; m is an integer equal to or larger than 2) extraction target group among a plurality of groups clustered using the clustering model, for each of the extraction target groups, and

the classification model learning device comprising:

a sensor data acquiring unit configured to acquire a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from the plurality of target objects as first sensor data using the sensor acquiring states of the target objects, and acquire, as second sensor data to (m + 1) th sensor data, a plurality of pieces of sensor data acquired from target objects included in second to (m + 1) th target object groups obtained by removing one or more objects from each of the first to m-th object groups;

a clustering model generating unit configured to update parameters of the clustering model by classifying a sensor data group including the plurality of first sensor data and the plurality of second sensor data to the plurality of (m + 1) th sensor data into a plurality of groups using the clustering model;

a designation unit configured to designate, as the i-th extraction target group, a group in which the number of pieces of (i+1)-th sensor data included in the group is smaller than the number of pieces of i-th sensor data by a predetermined degree or more from among a plurality of groups classified by the clustering model; and

a learning unit configured to perform learning of the classification model by repeating a learning process including a process of acquisition of the sensor data using the sensor data acquiring unit, update of the parameters of the clustering model using the clustering model generating unit, and designation of the extraction target group using the designation unit.

[Claim 6]

A classification model learning method for generating a classification model classifying sensor data acquired from target objects by a predetermined sensor,

the classification model including:

a clustering model configured to classify the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and

a classification unit configured to classify the sensor data included in an extraction target group among a plurality of groups classified using the clustering model,

the classification model learning method comprising:

a sensor data acquiring step of acquiring a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from the plurality of target objects as first sensor

data using the sensor acquiring states of the target objects and acquiring a plurality of pieces of sensor data acquired from the target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group as second sensor data using the sensor;

a clustering model generating step of updating parameters of the clustering model by classifying a sensor data group formed from the plurality of pieces of the first sensor data and the plurality of pieces of the second sensor data into a plurality of groups using the clustering model;

a designation step of designating a group in which the number of pieces of the second sensor data included in the group is smaller than the number of pieces of the first sensor data by a predetermined degree or more from among a plurality of groups classified using the clustering model as the extraction target group; and

a learning step of performing learning of the classification model by repeating a learning process including a process of acquisition of the first sensor data and the second sensor data in the sensor data acquiring step, update of the parameters of the clustering model in the clustering model generating step, and designation of the extraction target group in the designation step.

[Claim 7]

A classification model learning program causing a computer to function as a classification model learning device that generates a classification model classifying sensor data acquired from target objects by a predetermined sensor,

the classification model including:

a clustering model configured to classify the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and

a classification unit configured to classify the sensor data included in an extraction target group among a plurality of groups classified using the clustering model,

the classification model learning program causing the computer to implement:

a sensor data acquiring function of acquiring a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from the plurality of target objects as first sensor data using the sensor acquiring states of the target objects and acquiring a plurality of pieces of sensor data acquired from the target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target object group as second sensor data using the sensor;

a clustering model generating function of updating parameters of the clustering model by classifying a sensor data group formed from the plurality of pieces of the first sensor data and the plurality of pieces of the second sensor data into a plurality of groups using the clustering model;

a designation function of designating a group in which the number of pieces of the second sensor data included in the group is smaller than the number of pieces of the first sensor data by a predetermined degree or more from among a plurality of groups classified using the clustering model as the extraction target group; and

a learning function of performing learning of the classification model by repeating a learning process including a process of acquisition of the first sensor data and the second sensor data using the sensor data acquiring function, update of the parameters of the clustering model using the clustering model generating function, and designation of the extraction target group using the designation function.

[Claim 8]

A learned classification model causing a computer to function to classify sensor data acquired from target objects using a predetermined sensor,

the classification model comprising:

a clustering model configured to classify the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and

a classification unit configured to classify the sensor data included in an extraction target group among a plurality of groups classified using the clustering model,

wherein the clustering model is built by updating parameters of the clustering model by classifying a sensor data group formed from first sensor data formed from a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from a plurality of target objects using the sensor and second sensor data formed from a plurality of pieces of sensor data acquired from the target objects included in a second target object group that is a target object group acquired by excluding one or more target objects from the first target

object group using the sensor into a plurality of groups using the clustering model, and

wherein the classification unit classifies the sensor data using a group in which the number of pieces of the second sensor data included in the group is smaller than the number of pieces of the first sensor data by a predetermined degree or more among the plurality of groups classified using the clustering model as an extraction target group.

[Claim 9]

A classification device that classifies sensor data acquired from target objects using a predetermined sensor using a learned classification model,

wherein the classification model is a model for causing a computer to function and includes:

a clustering model configured to classify the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and

a classification unit configured to classify the sensor data included in an extraction target group among a plurality of groups classified using the clustering model,

wherein the clustering model is built by updating parameters of the clustering model by classifying a sensor data group formed from first sensor data formed from a plurality of pieces of sensor data acquired from the target objects included in a first target object group formed from a plurality of target objects using the sensor and second sensor data formed from a plurality of pieces of sensor data acquired from the target objects included in a second target object group that is a target object group

acquired by excluding one or more target objects from the first target object group using the sensor into a plurality of groups using the clustering model,

wherein the classification unit classifies the sensor data using a group in which the number of pieces of the second sensor data included in the group is smaller than the number of pieces of the first sensor data by a predetermined degree or more among the plurality of groups classified using the clustering model as an extraction target group, and

wherein the classification device includes:

an acquisition unit configured to acquire sensor data of classification targets; and

an extraction unit configured to extract sensor data classified into the extraction target group by using the classification model by inputting the sensor data of the classification target to the classification model.

[Claim 10]

A sorting device for sorting target objects from a target object group on the basis of states of the target objects, the sorting device comprising:

a first sensor module configured to include a first sensor acquiring the states of the target objects included in a first target object group formed from a plurality of target objects; and

a lower process module disposed on a downstream process side of the first sensor module and configured using one of a second sensor module including a second sensor that is the same sensor as the first sensor and acquires the states of the target objects included in a second

target object group that is a target object group acquired by excluding one or more target objects from the first target object group;

wherein the first sensor acquires a plurality of pieces of sensor data acquired from the target objects included in the first target object group as first sensor data,

wherein the second sensor acquires a plurality of pieces of sensor data acquired from the target objects included in the second target object group as second sensor data,

wherein the first sensor data and the second sensor data are used to learn a classification model for classifying sensor data acquired from the target object, and

wherein the classification model includes:

a clustering model configured to classify the sensor data into a plurality of groups on the basis of a similarity of the sensor data using a predetermined clustering technique; and

a classification unit configured to classify the sensor data included in an extraction target group among a plurality of groups classified using the clustering model,

wherein the clustering model is built by updating parameters of the clustering model by classifying a sensor data group formed from the first sensor data and the second sensor data into a plurality of groups using the clustering model, and

wherein the classification unit classifies the sensor data using a group in which the number of pieces of the second sensor data included in the group is smaller than the number of pieces of the first sensor data by a predetermined degree or more among the plurality of groups

classified using the clustering model as an extraction target group.