

[TITLE OF THE DOCUMENT] SPECIFICATION

[TITLE OF THE INVENTION] LEARNING DEVICE, LEARNING METHOD, AND
LEARNING PROGRAM

[Technical Field]

[0001]

The present invention relates to a learning device, a learning method, and a learning program.

[Background Art]

[0002]

Heretofore, in order to determine whether a product is good or defective using an image processing technique, learning results based on deep learning using a neural network have been utilized. Further, in order to make the learning by deep learning efficient, Patent Document 1 proposes a learning support device, and a learning device that performs learning of models appropriately.

[0003]

According to the learning support device of Patent Document 1, based on a model that has performed learning using a teacher data to classify a target data as either a first label or a second label, and a teacher data including a first data to which the first label is assigned and a second data to which the second label is assigned, a feature quantity of the teacher data is derived for each teacher data.

[0004]

Further, the above-mentioned device is equipped with a deriving unit for deriving, for each teacher candidate data, the feature quantity of a teacher candidate data based on at least one teacher candidate data to which either the first label or the second label is assigned and the model, a calculating unit that calculates, for each teacher candidate data, at least either one of a distance between the teacher candidate data and the first data and a distance between the teacher candidate data and the second data, and a selecting unit for selecting a data to be added as the teacher data from among the teacher candidate data based on the distance.

[0005]

According to the learning support device of Patent Document 1, among the plurality of teacher candidate data classified as the first label, the teacher candidate data having the distance close to the teacher data of the second label is selected, and among the plurality of teacher candidate data classified as the second label, the candidate data having the distance close to the teacher data of the first label is selected.

[0006]

Based on the above-described processing, the teacher candidate data classified as the first label which is close to the second label, that is, the teacher candidate data which is difficult to distinguish whether to be classified as the first label or the second label is selected. The same applies to the teacher candidate data of the second label. According to the learning support device of Patent Document 1, such teacher candidate data that is difficult to distinguish is used as the teacher data, so that the quality of the teacher data may be improved and the model may be enabled to learn efficiently.

[Citation List]

[Patent Document]

[0007]

[Patent Document 1] Japanese Patent Application Laid-Open Publication No. 2021-103344

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0008]

According to the learning support device disclosed in Patent Document 1, efficient learning is enabled. According to a general learning method, it is generally known that learning effects may be enhanced by performing an incrementation processing of incrementing the teacher data according to a predetermined method. Therefore, according to the learning support device disclosed in Patent Document 1, it is expected that the learning effects may be enhanced by incrementing the teacher data.

[0009]

However, by performing incrementation processing to the selected teacher data in the learning support device disclosed in Patent Document 1, it has been discovered that there were cases where conditions for completing learning may not be satisfied even when a maximum number of epochs has been reached, or there were cases where the learning time become excessive.

[0010]

In consideration of the problems mentioned above, the present invention aims at providing a learning device, a learning method, and a learning program, which may perform learning of models appropriately.

[Means of Solving the Problems]

[0011]

In order to achieve the objects described above, a learning device according to the present invention relates to a learning device configured to calculate an evaluation value based on a target data, and to cause learning to be performed by a model that performs learning using a teacher data to compare the evaluation value with a predetermined threshold value and classify the target data as at least one of labels of a first label and a second label, the learning device including a data acquisition unit configured to acquire a teacher candidate data classified as at least either the first label or the second label, an incrementation processing unit configured to modify a portion of a content of the teacher candidate data and generate one or a plurality of modified teacher candidate data, an extraction unit configured to perform an extraction processing of calculating, by adopting the teacher candidate data and the modified teacher candidate data as a population, an evaluation value using the model regarding the population, and extracting data the evaluation value of which is within a predetermined extraction range including the threshold value, a learning unit configured to cause the model to perform a learning processing by a predetermined learning rate, and a control unit configured to control the extraction unit and the learning unit, wherein, in a state where a number of extraction data having been extracted as a result of performing the extraction processing by the extraction unit exceeds a predetermined stop number, the control unit is configured to add the extraction data to the teacher data to perform the learning processing,

perform the extraction processing, and execute the learning processing and the extraction processing until a new number of extraction data reaches the stop number.

[0012]

The learning device according to the present invention is equipped with an incrementation processing unit of modifying a portion of a content of the teacher candidate data and generating one or a plurality of modified teacher candidate data, wherein not only the teacher candidate data but also the modified teacher candidate data are adopted as a population for extracting the teacher candidate data. The incrementation of data by the incrementation processing unit is performed before executing the learning processing and the extraction processing, such that by repeating the learning processing and the extraction processing, finally the number of extraction data reaches a predetermined stop number, and the learning is completed. Therefore, according to the learning device of the present invention, a large population may be used to cause a model to learn more efficiently compared to a conventional learning device.

[0013]

According to the learning device of the present invention, in a state where the extraction processing is performed using an already learned model, the control unit may create a new population having extruded the extraction data from the population, and cause the extraction unit to perform the extraction processing to the new population. According to this configuration, the number of data of the population data reduces as the learning processing and the extraction processing are performed repeatedly, such that the load of the processing performed by the control unit may be reduced.

[0014]

The learning device according to the present invention may be configured such that, in the extraction processing, if there are a plurality of the modified teacher candidate data having a common teacher candidate data that serves as a basis of modification, a limitation processing of extracting only a predetermined limited extraction number of the teacher candidate data or the modified teacher candidate data may be performed in the extraction processing performed once. According to this configuration, the number of teacher candidate data or the modified teacher candidate data when performing the learning processing may be suppressed, such that the learning processing may be performed promptly.

[0015]

The learning device according to the present invention may further include a display unit of displaying the extraction data, and a label modification unit capable of modifying the label of the extraction data displayed on the display unit, wherein modification of the label by the label modification unit may be enabled before adding the extraction data to the teacher data. According to this configuration, the user may confirm the determination result of the label by the extraction unit through the label modification unit and the input unit, and if there is an error in the determination result, the user may modify the result through the label modification unit, such that the determination accuracy of the extraction unit may be improved.

[0016]

According to the learning device of the present invention, in a state where a number of the extraction data has exceeded the stop number and is less than a predetermined reference number of data, the control unit may perform the extraction processing by performing an expansion processing of expanding a width of the extraction range, and in a case where the number of the extraction data has become equal to or greater than the reference number of data, the control unit may perform the learning processing.

[0017]

If the user modifies the label through the label modification unit in a state where the extraction data is smaller than the reference number of data, the frequency of modification of the label will be increased and much load is applied on the user. In the present invention, the learning processing and the extraction processing are performed after the number of extraction data has become equal to or greater than the reference number of data, such that the frequency of the user selecting a label through the selecting unit may be reduced.

[0018]

According further to the learning device of the present invention, the control unit may expand the width of the extraction range and lower the learning rate as the expansion processing. As described, by expanding the extraction range, the number of extraction data may be incremented. Further, the learning rate is an adjustment value of the amount of updating weight and bias within a neural network by learning processing performed once. In the present invention, the learning rate is lowered when the extraction range is widened in the expansion processing, by which fine-tuning of the number of extraction data may be performed.

[0019]

Further, the learning device according to the present invention is configured to calculate an evaluation value based on a target data, and to cause learning to be performed by a model that performs learning using a teacher data to compare the evaluation value with a predetermined threshold value and classify the target data as at least one of labels of a first label and a second label, the learning device including a data acquisition unit configured to acquire a teacher candidate data classified as at least either the first label or the second label, an extraction unit configured to perform an extraction processing of calculating, by adopting the teacher candidate data as a population, an evaluation value using the model regarding the population, and extracting data the evaluation value of which is within a predetermined extraction range including the threshold value, a learning unit configured to cause the model to perform a learning processing by a predetermined learning rate, and a control unit configured to control the extraction unit and the learning unit, wherein the control unit is configured to, in a state where a number of extraction data extracted by the extraction unit exceeds a predetermined stop number and is less than a predetermined reference number of data, perform an expansion processing of expanding a width of the extraction range to execute the extraction processing, and in a state where the number of the extraction data has become equal to or greater than the reference number of data, perform the learning processing by adding the extraction data to the teacher data, and perform the extraction processing, to thereby execute the learning processing and the extraction processing until a new number of extraction data reaches the stop number.

[0020]

According to the learning device configured as above, if the number of extraction by the extraction unit is smaller than the predetermined reference number of data, the width of the extraction range is widened to increase the number of extraction, such that the number of extraction is increased, and the learning processing may be performed efficiently.

[0021]

A learning method according to the present invention relates to a learning method of calculating an evaluation value based on a target data, and causing learning to be performed by a model that performs learning using a teacher data to compare the evaluation value with a predetermined threshold value and classify the target data as at least one of labels of a first label and a second label, the learning method including a data acquisition step of acquiring a teacher candidate data classified as at least either the first label or the second label, an incrementation processing step of modifying a portion of a content of the teacher candidate data and generating one or a plurality of modified teacher candidate data, an extraction step of calculating, by adopting the teacher candidate data and the modified teacher candidate data as a population, an evaluation value using the model regarding the population, and extracting data whose evaluation value is within a predetermined extraction range including the threshold value, and a learning step of causing the model to perform a learning processing by a predetermined learning rate, wherein, in a state where a number of extraction data having been extracted by the extraction step exceeds a predetermined stop number, the extraction data is added to the teacher data to execute the learning step, a new population having removed the extraction data from the population is created, the extraction step is executed to the new population, and the learning step and the extraction step are executed until a new number of extraction data reaches the stop number.

[0022]

A learning program according to the present invention is a program that causes a computer to function as the learning devices described above.

[Brief Description of the Drawings]

[0023]

FIG. 1 is an explanatory view illustrating a functional configuration of a learning device according to one example of an embodiment of the present invention.

FIG. 2 is a flowchart illustrating a learning method of the learning device according to the present embodiment.

FIG. 3 is an explanatory view illustrating an image of an extraction processing by an extraction unit of the learning device according to the present embodiment.

FIG. 4 is an explanatory view illustrating a display screen displayed by a display unit of the learning device according to the present embodiment, wherein (A) illustrates a case of a good product, and (B) illustrates a case of a defective product.

FIG. 5 is an explanatory view illustrating an incrementation processing by an incrementation processing unit of the learning device according to the present embodiment, wherein (A) illustrates a flip processing, (B) illustrates a shift processing, (C) illustrates a minute rotation processing, and (D) illustrates a filter processing.

FIG. 6 is a graph illustrating a relationship between learning time and number of data of the learning device according to the present embodiment.

[Mode for Carrying out the Invention]

[0024]

Next, a learning device, a learning method, and a learning program according to an embodiment of the present invention will be described with reference to FIGs. 1 to 6. FIG. 1 is an explanatory view illustrating a functional configuration of a learning device 1 according to the present embodiment.

[0025]

The learning device 1 according to the present embodiment is a device that causes a model M to perform learning so as to enable appropriate determination by the model M by calculating an evaluation data for a target data and at least determining and classifying whether the target data is a first label or a second label. In the present description, a model refers to a system that receives an input value of some kind that may be discriminated by a computer and that performs some kind of evaluation or determination to output an output value.

[0026]

The model M has a structure including a neural network and a parameter. The neural network has a structure in which a plurality of neurons are connected. As an example, the neural network may be a hierarchical multilayered neural network in which layers of multiple neurons formed into groups are layered.

[0027]

The neural network is defined by the number of neurons and connection relationships thereof. A connection strength between neurons or between layers is defined using parameters, such as weighting factors. In the neural network, a target data is entered, and based on a calculation result of a plurality of neurons and parameters, the evaluation of the target data and assigning of a label are performed.

[0028]

The model M recognizes the content of the target data, and at least determines whether the target data is a first label or a second label. For example, if the target data is an image data, the labels may be a type of image object, such as a person, a vehicle, or an animal, or a quality of the object, such as a good product or a defective product. The label is associated with the target data and stored. The structure of the model M is similar to Patent Document 1, such that detailed descriptions thereof are omitted.

[0029]

Next, with reference to FIG. 1, the functional configuration of the learning device 1 according to the present embodiment will be described. The learning device 1 according to the present embodiment includes, as functional configurations, a data acquisition unit 2, an incrementation processing unit 3, a control unit 4, an extraction unit 5, a learning unit 6, a display unit 7, and a label modification unit 8.

[0030]

The target data handled by the learning device 1 according to the present embodiment is a teacher data 11 to which either a first label or a second label is assigned, a teacher candidate data 12 which is a candidate of the teacher data 11, and a modified teacher candidate data 13 which has been subjected to incrementation processing by the incrementation processing unit 3. The teacher candidate data 12 and the modified teacher candidate data 13 also have either the first label or the second label assigned thereto, similar to the teacher data 11.

[0031]

The teacher data refers to a data indicating examples and answers provided to the model M. Further, the teacher candidate data is data that may be a candidate of a new teacher data to be provided to the model M.

[0032]

The data acquisition unit 2 is a function unit that performs a data acquisition process of acquiring the teacher candidate data 12 to have the learning device 1 perform learning of the model M.

[0033]

The incrementation processing unit 3 is a function unit that generates one or a plurality of modified teacher candidate data 13 by modifying a portion of a content of the teacher candidate data 12. As the incrementation processing, if the teacher candidate data 12 is an image data, the following processes may be performed, for example.

[0034]

For example, the processes may be a flip processing of creating a horizontal inversion data, a vertical inversion data, and a 180°-rotated data of an original image data, a shift processing of creating data in which the original image data is subjected to gradual coordinate deviation in the X-Y direction, a minute rotation processing in which data is created by rotating the original image data in minute rotation angles in the right and left directions, and a filter processing in which a filter such as a median filter or a Gaussian filter is applied to the original image data.

[0035]

The control unit 4 is a function unit that controls the extraction unit 5 and the learning unit 6 to have the model M perform effective learning processing. The extraction unit 5 is a function unit that sets the teacher candidate data 12 and the modified teacher candidate data 13 as a population 14, calculates an evaluation value regarding the population 14 using the model M, and performs an extraction processing of extracting data whose evaluation value is in a predetermined extraction range including a threshold value of the first label and the second label. The learning unit 6 is a function unit that causes the model M to perform the learning processing with a predetermined learning rate. The learning processing is a processing that adjusts the parameter of the model M to approximate an optimum value.

[0036]

The display unit 7 is a function unit that causes a display device such as a display to display data such that a user that performs determination of the target data may confirm an extraction data 15 extracted by the extraction unit 5. The label modification unit 8 is a function unit that may modify the label assigned to the extraction data 15 when the user performs confirmation,

regarding the label which is the first label or the second label assigned to the extraction data 15, and when there is a need to modify the label.

[0037]

The learning device 1 of the present embodiment includes a computer (not shown) as a major hardware. The computer includes a processor such as a CPU or a GPU, a storage device such as a RAM, a ROM, a hard disk, or an SSD (Solid State Drive), and a communication unit for connecting to a network such as the Internet. Further, the storage device of a computer stores a learning program for enabling the computer to operate as the learning device 1 of the present embodiment. Further, the computer includes a cloud computing system. The respective function units described above are realized by the computer as hardware and the learning program as software.

[0038]

Next, with reference to FIG. 2, a learning method which is an operation of the learning device 1 of the present embodiment will be described, taking as an example a case where a target data is an image. At first, an acquisition processing in which the data acquisition unit 2 acquires the teacher candidate data 12 is performed (STEP 1). Either the first label or the second label is assigned in advance to the teacher candidate data 12. A number of teacher candidate data 12 required for the learning of the model M is prepared in advance.

[0039]

Next, the incrementation processing unit 3 performs an incrementation processing step of performing an incrementation processing of the teacher candidate data 12 and generating the modified teacher candidate data 13 (STEP 2). The incrementation processing is performed by carrying out either one of the aforementioned flip processing, shift processing, minute rotation processing, and filter processing, or a combination thereof. Which processing to be carried out may be selected arbitrarily according to the property of target data, the aim of learning of the model M, or the contents of determination by the model M.

[0040]

Next, the control unit 4 confirms whether the processing is performed for a first time (STEP 3). In a case where the processing is performed for the first time (STEP 3: YES), a learning rate of the model M which is already learned and in an initial state is set to an initial value (STEP 5). The initial value of the learning rate may be set to 0.001, for example. Further, the extraction range in the extraction unit 5 is set to an initial value (STEP 5). The initial value of the extraction range may be set to 3, for example. The contents of the extraction range will be described below.

[0041]

Next, an extraction processing, i.e., extraction step, is performed by the extraction unit 5 (STEP 6). In the extraction processing, the teacher candidate data 12 and the modified teacher candidate data 13 are set as the population 14, the data of the population 14 is entered to the model M, the evaluation value is calculated in the model M, wherein if the evaluation value is within the extraction range, extraction is performed as the extraction data 15, and if the evaluation value is out of the extraction range, extraction is not performed.

[0042]

FIG. 3 is a schematic image of an extraction processing performed in the learning device 1 according to the present embodiment. In the extraction processing performed in the extraction unit 5, an evaluation value is calculated using the model M for each data of the population 14. In FIG. 3, the evaluation value becomes higher toward the right side in the drawing, and lower toward the left side. In the present embodiment, the first label is assigned to those having higher evaluation, and the second label is assigned to those having lower evaluation.

[0043]

In FIG. 3, a border line B between the first label and the second label serves as a threshold value dividing the two labels, and a predetermined range including the threshold value is referred to as the extraction range. As illustrated in FIG. 3, those assigned with the first label in the area having an evaluation value close to the threshold value is close to the second label, and the difference between a good product and a defective product in such an area is small. In the present embodiment, 3 is set as the value of the extraction range in FIG. 3, but a value of 1 to 20 may be set. This value may be varied arbitrarily according to the extraction condition or the learning target.

[0044]

As described, by performing learning of the model M using the data within the predetermined range of the first and second labels, learning may be performed based on the data that is difficult to distinguish between whether to assign the first label or the second label. The model M having performed learning based on such data may be able to perform precise determination on minute differences. That is, such a data is recognized as a good data that enables efficient learning of the model M.

[0045]

The contents of the extraction processing performed in the extraction unit 5 is similar to the processing disclosed in Patent Document 1. Specifically, the teacher candidate data 12 and the modified teacher candidate data 13 are entered to the model M, and based on the model M and the teacher data 11, a feature quantity, i.e., vector, that is represented in a feature space of a predetermined dimension is calculated for each data. Further, the distances between the teacher data 11 and both the teacher candidate data 12 and the modified teacher candidate data 13 in the feature space are respectively calculated. Processing is performed to extract the data if the distance is within the extraction range, and not extract the data if the distance is out of the extraction range. The method of calculating the distance in the feature space is similar to that disclosed in Patent Document 1, such that detailed descriptions thereof are omitted.

[0046]

According to the learning device 1 of the present embodiment, when performing extraction processing by the extraction unit 5, if there are a plurality of data having a common teacher candidate data 12 serving as a basis of modification of the modified teacher candidate data 13 in the population 14, a limitation processing of extracting only data having a predetermined limited extraction number in one extraction processing is performed (STEP 6).

[0047]

By performing the limitation processing, when having the model M learn from a new teacher data 11 in STEP 5 described below, the teacher data 11 will not be incremented suddenly, such that the learning processing may be performed promptly. According to the present embodiment, the limited extraction number is set to 1. Therefore, according to the present embodiment, even if a plurality of modified teacher candidate data 13 is generated from the same teacher candidate data 12, only one teacher candidate data 12 or modified teacher candidate data 13 will be extracted in one extraction processing. The limited extraction number may be varied arbitrarily according to the state of the model M or the state of the hardware.

[0048]

Next, the control unit 4 confirms the number of extraction data 15 extracted by the extraction unit 5 (STEP 7). Specifically, as (1), confirmation is performed on whether a number x of the extraction data 15 has exceeded a predetermined stop number, and whether the number is equal to or greater than a predetermined reference number of data or whether the extraction range is an extended range is performed (in STEP 7 of FIG. 2, the “reference number of data” is denoted as “reference number”). Further, according to STEP 7, as (2), it is confirmed whether the extraction data 15 has exceeded the stop number but is less than the reference number of data.

[0049]

In the description, stop number refers to a number that serves as a reference regarding whether to stop the learning performed by the learning device 1, and for example, it may be set to 0. In that case, learning will be stopped when the data extracted by the extraction unit 5 becomes 0.

[0050]

Further, the reference number of data is a number for reducing the frequency of a confirmation operation (STEPS 8 to 9) of the user described below, and for example, the first label may be set to 20, and the second label may be set to 20. The reference number of data may be varied arbitrarily due to causes such as the data type or the learning environment.

[0051]

In this case, if the number of the extraction data 15 to be extracted by the extraction unit 5 is less than 20 for the first label and less than 20 for the second label, the extraction processing is performed again without the confirmation operation by the user being performed, and when the number of the extraction data 15 exceeds 40, the confirmation operation by the user is performed. According to this process, the frequency of confirmation operation of the user may be reduced, such that the load on the user may be reduced.

[0052]

In a case where the number of the extraction data 15 exceeds the stop number and is equal to or greater than the reference number of data (1 in STEP 7), the extraction data 15 is displayed on the display unit 7 (STEP 8). FIG. 4 illustrates a state in which the extraction data 15 is displayed on the display unit 7. A modification display 18 for confirming whether a label 17 assigned to the extraction data 15 by the label modification unit 8 is appropriate, and for modifying the label 17 is displayed on a display screen 16.

[0053]

In FIG. 4(A), a description stating “Is this really a good product?” is displayed on an upper portion the display screen 16, the extraction data 15 being extracted is displayed at a center of the display screen 16, the label 17 stating “good product” is displayed on a left side of the extraction data 15, and three buttons “YES”, “NO”, and “NOT SURE” are displayed as the modification display 18 on a lower portion of the display screen 16. By performing an operation of tapping the button on the modification display 18, for example, the user may confirm whether the label 17 (which in this case is “good product”) assigned to the extraction data is appropriate, and if not appropriate, the label 17 may be modified.

[0054]

In the case of FIG. 4(B), an image stating that the label 17 is a “defective product” and determining that the extraction data 15 is a defective product is displayed. When the user selects “not sure” on the modification display 18, the determination by the user is deferred, and the determination may be performed afterwards.

[0055]

After the confirmation of the extraction data 15 by the user is performed, the control unit 4 stores the extraction data 15 as the teacher data 11, and a new teacher data 11 is used for a subsequent learning of the label 17. Further, the control unit 4 removes the extraction data 15 from the population 14, and creates a new population 14 (STEP 10).

[0056]

Next, whether the processing is performed for the first time is confirmed again (STEP 3), and in this case, the processing of the first time has already been completed and processing is performed for the second or subsequent times (NO in STEP 3), the control unit 4 uses a model M having added a new teacher data 11 thereto to perform the learning processing, i.e., learning step (STEP 4). The teacher data 11 that had been added newly is the extraction data 15 having a high learning effect that has been extracted by the extraction unit 5, such that the accuracy of evaluation by the model M is improved. Thereafter, the learning rate is set to the initial value, and the extraction range by the extraction unit 5 is set to the initial value (STEP 5).

[0057]

The control unit 4 repeats the extraction processing and the learning processing described above until the number of the extraction data 15 becomes 0, which is the stop number. When the extraction data 15 becomes 0, which is the stop number (3 in STEP 7), the processing is ended.

[0058]

Meanwhile, if the extraction data 15 has exceeded the stop number but is less than the reference number of data (2 in STEP 7), an expansion processing is performed to expand the width of the extraction range to an extended range (for example, 3.7) and lower the learning rate (for example, 0.0002) (STEP 11). If extraction processing is performed in this state (STEP 6), the width of the extraction range has been widened, such that the number of data extracted by the extraction unit 5 is incremented. Further, fine tuning of the learning rate is performed by the extraction processing.

[0059]

Next, the control unit 4 confirms the number of extraction data (STEP 7), and in the present case, the extraction range has been set to the extended range by STEP 11 (1 in STEP 7), such that

display and confirmation of extraction data extracted by the extraction processing is performed (STEPS 8 and 9). If the extraction range is the extended range, it is in a state where the expansion processing of STEP 11 has been performed, such that even if the number of the extraction data 15 is less than the reference number of data, it is still assumed that there exists a number of data close to the reference number of data.

[0060]

Next, with reference to FIG. 5, the actual example of the incrementation processing performed by the incrementation processing unit 3 will be described. FIG. 5(A) is an explanatory view illustrating a state in which flip processing has been performed, wherein based on the teacher candidate data 12 serving as an original image, an image data subjected to vertical inversion, an image data subjected to horizontal inversion, and an image data subjected to 180°-rotation are created by flip processing. By performing the flip processing, three modified teacher candidate data 13 may be obtained in addition to the teacher candidate data 12.

[0061]

FIG. 5(B) is an explanatory view illustrating a state where shift processing has been performed, wherein regarding a total of four data, which are the teacher candidate data 12 serving as an original image data, and three modified teacher candidate data 13 generated through flip processing, the image is shifted very slightly in the X-Y direction, such as in the form of (-1, -1), (-1, 1), and so on. According to the shift processing, thirty-two image data may be obtained. The units of shifting may be pixels in the case of an image, or may be units such as mm or μm . The range of the shifting may be modified arbitrarily according to the object of the learning.

[0062]

FIG. 5(C) is an explanatory view illustrating a state where minute rotation processing has been performed, wherein based on the image data that has not been rotated, an image data that has been rotated for 1° to the left and an image data that has been rotated for 1° to the right are created. The angle of this minute rotation may be modified arbitrarily according to the object of learning.

[0063]

FIG. 5(D) is an explanatory view illustrating a state where filter processing has been performed, wherein with respect to the image data without a filter, a data that has been subjected to a median filter and data that has been subjected to a Gaussian filter are created. The median filter is a filter that is used to remove noise from an image. The Gaussian filter is one type of a smoothing filter, which is a filter that blurs the image according to a Gaussian distribution to make the image smooth. Further, other known filters may be used for the filter processing.

[0064]

Regarding the incrementation processing performed in the incrementation processing unit 3, if only the flip processing of FIG. 5(A) is performed, the number of data is increased by four times. If the shift processing of FIG. 5(B) is performed further, the number of data will be increased by 32 times, and by adding the four data that have not been subjected to shift processing, the number of data will be increased by 36 times. If the minute rotation processing of FIG. 5(C) is performed even further, the data that have been subjected to shift processing and increased by 32 times is further tripled to result in 96 data, and by adding the initial four data, the number of data is

increased by 100 times. If the filter processing of FIG. 5(D) is performed in addition, the data increased by 100 times will be further tripled to 300 times.

[0065]

As described, according to the learning device 1 of the present embodiment, a large number of the modified teacher candidate data 13 that approximates the teacher candidate data 12 may be created by incrementation processing, such that a large number of data having a high learning effect may be extracted through the extraction processing.

[0066]

Next, the effects of the learning device 1 according to the present embodiment will be described with reference to FIG. 6. FIG. 6 is a graph illustrating the relationship between the number of target data and learning time. In the graph, the data illustrated by the solid line indicates the learning device 1 according to the present embodiment, and the data illustrated by the dotted line indicates the conventional learning device, i.e., comparative example. As illustrated by the graph of FIG. 6, the learning device 1 according to the present embodiment may complete the learning even in a case where the number of target data was increased by 300 times. Meanwhile, according to the comparative example, it was not possible to complete the learning if the number of times of incrementation of the number of target data exceeded eight times.

[0067]

As described above, the learning device 1 according to the present embodiment may improve the quality of learning by incrementing the number of target data compared to the conventional learning device, and may complete the learning even when the target data is incremented.

[0068]

According to the embodiment described above, in a case where the number of the extraction data 15 exceeds the stop number and it is greater than the reference number of data (1 in STEP 7), the extraction data 15 is displayed on the display unit 7 and the user is caused to perform the confirmation operation, but it may also be possible to have the extraction data 15 added to the teacher data 11 without displaying the data on the display unit 7. For example, in the incrementation processing, if the modified teacher candidate data 13 that has been created based on the teacher candidate data 12 is already displayed and subjected to confirmation operation, the displaying of the data on the display unit 7 may be omitted.

[0069]

Moreover, in the embodiment described above, an example where the target data is the image data has been described, but the target data may be other data, such as audio data, graph data, or video data. According further to the embodiment described above, the stop number confirmed in STEP 7 is set to 0, but the present technique is not limited thereto, and the number may be other numbers, i.e., an integer such as 1 or 10.

[0070]

According to the embodiment described above, an example has been described in which the model M performs determination of a first label or a second label so as to determine whether the image object is a good product or a defective product, but the model M that performs

determination of the image object type, such as a person, a vehicle, or an animal, may be adopted similarly as the embodiment described above.

[0071]

For example, in the case of a model that classifies the image object type into label A, label B, and label C, if the number of extractions of the respective labels of label A, label B, and label C have all exceeded the reference number of data in STEP 7, the processing of STEP 8 to STEP 10 is performed, and if the number of extraction for each of the labels exceeds the stop number and is less than the reference number of data, the processing of STEP 11 will be performed.

[0072]

Further, according to the embodiment described above, the flip processing, the shift processing, the minute rotation processing, and the filter processing are described as examples of the incrementation processing, but the present technique is not limited thereto, and various processes such as an addition of impulse noise, contrast adjustment, brightness adjustment, magnification and reduction, partial masking, trimming, deformation, and discoloration may be performed. Therefore, the number of data being incremented is not limited to 300 times as according to the embodiment described above, and may be varied arbitrarily.

[0073]

According to the embodiment described above, an example of learning using a model M that has already performed learning has been described, but the present technique is not limited thereto, and the processing may be performed using an unlearned model M. In that case, learning may be performed by the unlearned model M using a teacher data for learning as a preprocessing of STEP 1 of FIG. 2, and thereafter, the processing of STEP 1 and subsequent processing may be performed.

[0074]

According further to the embodiment described above, if the extraction range is an extended range in STEP 7, the processing advances to the (1) side to display and confirm the extraction data having been extracted by the extraction processing (STEPS 8 and 9), but the present technique is not limited thereto, and the processing may advance to the (2) side to set the extraction range again as the extended range (STEP 11) and perform the extraction processing (STEP 6). In that case, the value of the extended range may be varied, or the number of times of extraction processing (STEP 6) may be limited.

[Description of the Reference Numeral]

[0075]

M model

- 1 learning device
- 2 data acquisition unit
- 3 incrementation processing unit
- 4 control unit
- 5 extraction unit
- 6 learning unit
- 7 display unit

- 8 label modification unit
- 11 teacher data
- 12 teacher candidate data
- 13 modified teacher candidate data
- 14 population
- 15 extraction data
- 16 display screen
- 17 label
- 18 modification display

[TITLE OF THE DOCUMENT] CLAIMS

[Claim 1] A learning device configured to calculate an evaluation value based on a target data, and to cause learning to be performed by a model that performs learning using a teacher data to compare the evaluation value with a predetermined threshold value and classify the target data as at least one of labels of a first label and a second label, the learning device comprising:

a data acquisition unit configured to acquire a teacher candidate data classified as at least either the first label or the second label;

an incrementation processing unit configured to modify a portion of a content of the teacher candidate data and generate one or a plurality of modified teacher candidate data;

an extraction unit configured to perform an extraction processing of calculating, by adopting the teacher candidate data and the modified teacher candidate data as a population, an evaluation value using the model regarding the population, and extracting data the evaluation value of which is within a predetermined extraction range including the threshold value;

a learning unit configured to cause the model to perform a learning processing by a predetermined learning rate; and

a control unit configured to control the extraction unit and the learning unit,

wherein, in a state where a number of extraction data having been extracted as a result of performing the extraction processing by the extraction unit exceeds a predetermined stop number, the control unit is configured to add the extraction data to the teacher data to perform the learning processing, perform the extraction processing, and execute the learning processing and the extraction processing until a new number of extraction data reaches the stop number.

[Claim 2] The learning device according to claim 1,

wherein, in a state where the extraction processing is performed using an already learned model, the control unit creates a new population having extruded the extraction data from the population, and causes the extraction unit to perform the extraction processing to the new population.

[Claim 3] The learning device according to claim 1,

wherein, in the extraction processing, if there are a plurality of the modified teacher candidate data having a common teacher candidate data that serves as a basis of modification, a limitation processing of extracting only a predetermined limited extraction number of the teacher candidate data or the modified teacher candidate data is performed in the extraction processing performed once.

[Claim 4] The learning device according to claim 1, further comprising:

a display unit of displaying the extraction data, and a label modification unit capable of modifying the label of the extraction data displayed on the display unit,

wherein modification of the label by the label modification unit is enabled before adding the extraction data to the teacher data.

[Claim 5] The learning device according to claim 4,

wherein, in a state where a number of the extraction data has exceeded the stop number and is less than a predetermined reference number of data, the control unit is configured to perform the extraction processing by performing an expansion processing of expanding a width of the extraction range, and

in a state where the number of the extraction data has become equal to or greater than the reference number of data, the learning processing is performed.

[Claim 6] The learning device according to claim 5,

wherein the control unit is configured to expand the width of the extraction range and to lower the learning rate as the expansion processing.

[Claim 7] A learning device configured to calculate an evaluation value based on a target data, and to cause learning to be performed by a model that performs learning using a teacher data to compare the evaluation value with a predetermined threshold value and classify the target data as at least one of labels of a first label and a second label, the learning device comprising:

a data acquisition unit configured to acquire a teacher candidate data classified as at least either the first label or the second label;

an extraction unit configured to perform an extraction processing of calculating, by adopting the teacher candidate data as a population, an evaluation value using the model regarding the population, and extracting data the evaluation value of which is within a predetermined extraction range including the threshold value;

a learning unit configured to cause the model to perform a learning processing by a predetermined learning rate; and

a control unit configured to control the extraction unit and the learning unit,
wherein the control unit is configured to

in a state where a number of extraction data extracted by the extraction unit exceeds a predetermined stop number and is less than a predetermined reference number of data, perform an expansion processing of expanding a width of the extraction range to execute the extraction processing, and

in a state where the number of the extraction data has become equal to or greater than the reference number of data, perform the learning processing by adding the extraction data to the teacher data, and perform the extraction processing, to thereby execute the learning processing and the extraction processing until a new number of extraction data reaches the stop number.

[Claim 8] A learning method of calculating an evaluation value based on a target data, and causing learning to be performed by a model that performs learning using a teacher data to compare the evaluation value with a predetermined threshold value and classify the target data as at least one of labels of a first label and a second label, the learning method comprising:

a data acquisition step of acquiring a teacher candidate data classified as at least either the first label or the second label;

an incrementation processing step of modifying a portion of a content of the teacher candidate data and generating one or a plurality of modified teacher candidate data;

an extraction step of calculating, by adopting the teacher candidate data and the modified teacher candidate data as a population, an evaluation value using the model regarding the population, and extracting data whose evaluation value is within a predetermined extraction range including the threshold value, and a learning step of causing the model to perform a learning processing by a predetermined learning rate,

wherein, in a state where a number of extraction data having been extracted by the extraction step exceeds a predetermined stop number, the extraction data is added to the teacher data to execute the learning step, a new population having removed the extraction data from the population is created, the extraction step is executed to the new population, and the learning step and the extraction step are executed until a new number of extraction data reaches the stop number.

[Claim 9] A learning program causing a computer to function as the learning device according to any one of claims 1 to 7.