

[DESCRIPTION]

[Title of Invention] CONCENTRATION LEVEL CALCULATION SYSTEM,
CONCENTRATION LEVEL CALCULATION METHOD, PROGRAM, AND
CONCENTRATION LEVEL CALCULATION MODEL GENERATION SYSTEM

5 [Technical Field]

[0001]

The present disclosure relates to a concentration level
calculation system and a concentration level calculation method.

[Background Art]

10 [0002]

Information processing apparatuses which calculate a degree
of concentration of a person (also referred to as concentration level)
are known in the related art. For example, an information
processing apparatus disclosed in Patent Literature (PTL) 1
calculates the concentration level by multiplying the sum of a change
amount in expression and a change amount in action by a rate of face
orientation and subtracting the obtained value from 100, which is the
maximum value of the concentration level.

[Citation List]

20 [Patent Literature]

[0003]

[PTL 1] Japanese Unexamined Patent Application Publication No.
2014-120137

[Summary of Invention]

25 [Technical Problem]

[0004]

In the information processing apparatus above in the related
art, a greater concentration level is calculated as a subject watches
a single object with more concentrated. However, actually, the
concentration level of a subject who sees a single object is not always
great, and that of a subject who sees several objects is not always
low. For example, in the case where a subject who performs an
intellectual task such as learning or office work is watching television,
the information processing apparatus in the related art calculates a
great concentration level irrespective of whether this situation

indicates that the subject concentrates. Moreover, in the case where the subject alternately sees a reference book and a notebook in learning, the information processing apparatus in the related art calculates a low concentration level although the situation indicates that the subject concentrates on learning. Thus, the information processing apparatus in the related art has a problem of low accuracy in calculation of the concentration level.

[0005]

Accordingly, the present disclosure provides a concentration level calculation system and a concentration level calculation method which can calculate a concentration level with higher accuracy.

[Solution to Problem]

[0006]

To solve the above problem, the concentration level calculation system according to one aspect of the present disclosure includes an image obtainer which obtains an image stream in which images of a subject are captured; a region obtainer which obtains concentration target regions each corresponding to a different one of concentration target objects to be watched by the subject; and a concentration level calculator which calculates a concentration level of the subject. Here, the concentration level calculator calculates an orientation of a face or line of sight of the subject from the image stream obtained; determines, based on the orientation of the face or line of sight of the subject calculated and the concentration target regions obtained, whether the subject is in a watching state where the subject is watching any one of the concentration target objects; and calculates the concentration level of the subject based on a result of the determination, and outputs the concentration level.

[0007]

The concentration level calculation method according to one aspect of the present disclosure includes obtaining an image stream in which images of a subject are captured; obtaining concentration target regions each corresponding to a different one of concentration target objects to be watched by the subject; calculating an orientation of a face or line of sight of the subject from the image

stream obtained; determining, based on the orientation of the face or line of sight of the subject calculated and the concentration target regions obtained, whether the subject is in a watching state where the subject is watching any one of the concentration target objects; and calculating a concentration level of the subject based on a result of the determination, and outputting the concentration level.

[0008]

The concentration level calculation method according to one aspect of the present disclosure can be implemented as a program for causing a computer to execute the method above. Alternatively, concentration level calculation method according to one aspect of the present disclosure can be implemented as a computer-readable recording medium having recorded thereon the program for causing a computer to execute.

[Advantageous Effects of Invention]

[0009]

The present disclosure can calculate the concentration level with higher accuracy.

[Brief Description of Drawings]

[0010]

[FIG. 1]

FIG. 1 is a diagram illustrating a usage example of the concentration level calculation system according to an embodiment.

[FIG. 2]

FIG. 2 is a block diagram illustrating the configuration of the concentration level calculation system according to the embodiment.

[FIG. 3]

FIG. 3 is a diagram for illustrating the concentration target region according to the embodiment.

[FIG. 4]

FIG. 4 is a flowchart illustrating the concentration level calculation method according to an embodiment.

[FIG. 5]

FIG. 5 is a diagram for illustrating determination of the watching state according to the embodiment.

[FIG. 6]

FIG. 6 is a diagram for illustrating determination of the transition state according to the embodiment.

[FIG. 7]

5 FIG. 7 is a diagram illustrating the concentration level calculated according to the embodiment.

[FIG. 8]

FIG. 8 is a diagram illustrating another example of the concentration target object.

10 [FIG. 9]

FIG. 9 is a block diagram illustrating another example of the functional configuration of the concentration level calculator.

[Description of Embodiments]

[0011]

15 (Underlying Knowledge Forming Basis of the Present Disclosure)

As disclosed in PTL 1, an information processing apparatus which calculates the concentration level of a person is known in the related art. The information processing apparatus disclosed in PTL 1 can calculate the concentration level only in specific situations.

20 Specifically, the information processing apparatus calculates a greater concentration level as a subject watches a single object with more concentrated. Accordingly, to apply the information processing apparatus to a subject who is doing a task and calculate the concentration level of the subject on the task which the subject is
25 doing, the task which the subject is doing need to be a task which the subject is doing while watching a single object, and the information processing apparatus cannot be used only in limited applications.

[0012]

For example, for an office worker who does office business
30 using a computer including a display and a subdisplay, it is naturally assumed that the office worker selectively (or alternatively) watches both of the display included in the computer and the subdisplay. For this reason, in a configuration in which the concentration level is calculated based on only watching of the display included in the
35 computer, an inaccurate concentration level may be calculated in a

situation where the subject, even when concentrated, watches the subdisplay. For a student who learns using a tablet terminal which reproduces a lecture movie, a textbook, and a notebook, it is naturally assumed that the student selectively watches all of the tablet terminal, the textbook, and the notebook. For this reason, in a configuration in which the concentration level is calculated based on only watching of the tablet terminal, an inaccurate concentration level may be calculated in a situation where the student watches the textbook or the notebook.

[0013]

Thus, it cannot be said that the concentration level calculated using the information processing apparatus has high accuracy.

[0014]

The present disclosure has been made in circumstances above, and can provide a concentration level calculation system which can be used in broad applications, and can calculate the concentration level of the subject with high accuracy.

[0015]

Hereinafter, embodiments according to the present disclosure will be described with reference to the drawings. The embodiments described below illustrate general or specific examples of the present disclosure. Accordingly, numeric values, components, arrangement positions of components, connection forms thereof, steps, order of steps, and the like shown in the embodiments below are exemplary, and should not be construed as limitations to the present disclosure. Thus, among the components of the embodiment below, the components not described in an independent claim will be described as optional components.

[0016]

The drawings are schematic views, and are not necessarily precise illustrations. Thus, the scale is not always consistent among the drawings. In the drawings, identical reference signs will be given in substantially identical configurations, and overlapping description will be omitted or simplified.

[0017]

Although a first concentration target object and a second concentration target object will be illustrated as concentration target objects in the embodiment described below, three or more concentration target objects may be present.

5 [0018]

[Embodiments]

[Configuration of concentration level calculation system]

First, with reference to FIG. 1, the concentration level calculation system according to an embodiment will be described.

10 FIG. 1 is a diagram illustrating the concentration level calculation system according to the embodiment.

[0019]

As illustrated in FIG. 1, concentration level calculation system 100 (see FIG. 2 described later) according to the present embodiment is built in a computer (one example of first concentration target object 97) used by subject 99 and implemented, for example. By implementing concentration level calculation system 100 in the form of a concentration level calculation system built in a computer used by subject 99, the camera and the display provided in the computer can be used as part of the configuration of concentration level calculation system 100. In the present embodiment, a camera of an external connection type attached to the subdisplay (one example of second concentration target object 98) used by subject 99 is used as imaging device 20.

25 [0020]

Thus, by building concentration level calculation system 100 in a computer used by subject 99, the input to concentration level calculation system 100 can be obtained using the camera, and the output from concentration level calculation system 100 can be presented using the display. In the case where the task done by subject 99 is a task for which a computer is used, the concentration level of subject 99 can be calculated in parallel with the task using the computer. In concentration level calculation system 100, part of processing functions and information storing functions may be implemented by a cloud server or the like.

[0021]

Concentration level calculation system 100 according to the present disclosure is a system which uses an image stream in which images of subject 99 are captured and calculates the concentration level of subject 99 on the image stream. Accordingly, as long as concentration level calculation system 100 obtains an image stream in which images of subject 99 are captured, concentration level calculation system 100 can calculate the concentration level even when the object watched by subject 99 changes among two or more concentration target objects. In other words, concentration level calculation system 100 can be used for subject 99 who watches concentration target objects in a time division manner.

[0022]

Next, with reference to FIG. 2, the functional configuration of concentration level calculation system 100 according to the present embodiment will be specifically described. FIG. 2 is a block diagram illustrating the configuration of the concentration level calculation system according to the embodiment.

[0023]

As illustrated in FIG. 2, concentration level calculation system 100 according to the present embodiment includes arithmetic device 10, imaging device 20, storage device 30, and output device 40. These devices included in concentration level calculation system 100 may be accommodated in a single housing or the like and integrated, or may be implemented as a plurality of individual devices by connecting these devices via a communication line.

[0024]

Arithmetic device 10 includes image obtainer 11, region obtainer 12, and concentration level calculator 13. Arithmetic device 10 is implemented by a processor, a storage, and a program to be executed using these. Arithmetic device 10 is provided as one of the functions in a computer as one example of first concentration target object 97.

[0025]

Image obtainer 11 is a functional unit which obtains an image

stream in which images of subject 99 are captured. Image obtainer 11 obtains an image stream in which images of subject 99 are captured by imaging device 20 as one example. Image obtainer 11 may be integrated with imaging device 20. In one example of the present embodiment, the concentration level of subject 99 is instantaneously calculated from the image stream obtained by image obtainer 11. Here, the term "instantaneously" includes a delay of about several milliseconds to several seconds in consideration of times of calculation processing and data transfer.

[0026]

Image obtainer 11 may be implemented in any manner as long as it can obtain the image stream. For example, image obtainer 11 may obtain the image stream stored in storage device 30 in the past. Thus, the calculation of the concentration level by concentration level calculation system 100 need not be instantaneous. Image obtainer 11 transmits the obtained image stream to concentration level calculator 13.

[0027]

Region obtainer 12 obtains concentration target regions each corresponding to a different one of concentration target objects to be watched by subject 99, the plurality of concentration target objects including first concentration target object 97 and second concentration target object 98. The concentration target region is a single region set for every concentration target object such that the orientation of the face of subject 99 falls within the region when subject 99 watches an concentration target object. Such a concentration target region will be described. FIG. 3 is a diagram for illustrating the concentration target region according to the embodiment. FIG. 3 illustrates the concentration target regions set for first concentration target object 97 and second concentration target object 98 as dot-hatched regions when subject 99 is viewed from above.

[0028]

As illustrated in FIG. 3, the concentration target region is a region set for each of first concentration target object 97 and second

concentration target object 98. Specifically, first concentration target region 97a is set for first concentration target object 97, and second concentration target region 98a is set for second concentration target object 98. The concentration target region is set between the virtual line connecting from the center of sight 99a of subject 99 (i.e., the position of subject 99, more specifically, position of the eyes of subject 99) to one end of the concentration target object and the virtual line connecting from the center of sight 99a of subject 99 to the other end of the concentration target object, for example. In other words, the concentration target region is set in a predetermined angle range of sight 99a of subject 99.

[0029]

Thus, the concentration target region is a region depending on subject 99, and therefore, is preferably set for each subject 99. For this reason, for example, an operation for setting the concentration target region for each subject is performed prior to calculation of the concentration level. In the present embodiment, for example, by displaying an instruction "Watch four corners on the screen sequentially" on the screen of the computer, the concentration target region is observationally determined from the orientation of the face of subject 99. The orientation of the face of subject 99 is calculated based on the region determination image obtained by capturing (an) image(s) of subject 99 with imaging device 20 when the above instruction is presented. This operation is the same as that in the calculation of the orientation of the face of subject 99 from the image stream which is performed in arithmetic device 10. Thus, the description thereof will be omitted, referring to the description of calculation of the concentration level described later.

[0030]

Moreover, by performing the same operation in the subdisplay or the like, second concentration target region 98a can be determined. The information concerning the determined concentration target region is preliminarily stored in storage device 30. Region obtainer 12 obtains a needed concentration target region by referring the information stored in storage device 30. In

other words, "to obtain the concentration target region" means that information indicating the concentration target region is read out and obtained. Referring to storage device 30 is not essential, and the concentration target region observationally determined may be
5 obtained as it is and used in calculation of the concentration level. Here, first concentration target region 97a and second concentration target region 98a are obtained as the concentration target regions.
[0031]

Although the configuration in which an instruction to watch
10 four corners of the concentration target object is given has been described above, five or more corners may be watched depending on the shape of the concentration target object, or only one and the other end of the concentration target object in a predetermined direction such as a horizontal or vertical direction may be watched.
15 When the concentration target object is in a size within the effective visual field of subject 99 (i.e., the sight region which extends from the central visual field in one direction to its surrounding region and from which information is effectively obtained), only the center of the concentration target object may be simply watched. In this case, a
20 region of about plus minus 10 degrees is automatically determined as the concentration target region from the direction such as the orientation of the face of subject 99.

[0032]

Alternatively, the concentration target region may be
25 determined through machine learning of the direction in which subject 99 who is working is likely to watch. In this case, when the center of sight 99a of position of subject 99 is detected, the concentration target region can be automatically determined independent of a physical concentration target object such as a
30 computer or a subdisplay.

[0033]

Furthermore, the concentration target region may be determined depending on the space used by subject 99. For example, it is naturally predicted that subject 99 who uses a desk
35 provided with a computer including two displays watches the two

displays. Accordingly, when the position of the center of sight 99a of subject 99 is detected, the concentration target region can be determined based on the positional relation between imaging device 20 and the two displays.

5 [0034]

Returning to FIG. 2, concentration level calculator 13 is a functional unit which calculates the concentration level of subject 99 based on the image stream obtained by image obtainer 11 and the concentration target region obtained by region obtainer 12. The calculation of the concentration level as the main function of concentration level calculator 13 will be specifically described later. The concentration level of subject 99 calculated in concentration level calculator 13 is output and displayed on the screen of the computer, for example. Alternatively, the calculated concentration level of subject 99 can be output and stored in a server apparatus or the like (not illustrated), enabling a manager who manages the work of subject 99 to check the concentration level thereof.

[0035]

Imaging device 20 is a camera which captures an image as described above. Imaging device 20 generates an image stream by continuously obtaining images, and outputs the image stream.

[0036]

Storage device 30 is a device for storing information, such as a semiconductor memory. Storage device 30 stores information such as the concentration target region, and accepts reference of the information by region obtainer 12 or the like.

[0037]

Output device 40 is a display controller, for example. To present the information of the concentration level calculated by concentration level calculator 13 to the display, output device 40 converts the information to an image for presentation, and outputs a signal for presenting the image for presentation to the display.

[0038]

[Operation of concentration level calculation system]

35 Next, with reference to FIG. 4, the operation of concentration

level calculation system 100 will be described. FIG. 4 is a flowchart illustrating the concentration level calculation method according to the embodiment. To be noted, in concentration level calculation system 100, part of the operation, such as determination of the concentration target region, which is not illustrated in FIG. 4, is performed in some cases. As illustrated in FIG. 4, when the operation of concentration level calculation system 100 is started, image obtainer 11 obtains an image stream (S101). The image stream is a group of images formed of images successively captured. Accordingly, image obtainer 11 obtains the image stream by sequentially obtaining images successively captured.

[0039]

Region obtainer 12 obtains concentration target regions each corresponding to a different one of concentration target objects by referring to storage device 30 (S102). The obtaining of the concentration target region (S102) may be performed before the obtaining of the image stream (S101). Thus, the order of steps may be changed in part of the operation of concentration level calculation system 100.

[0040]

In the next step, concentration level calculator 13 calculates the concentration level of subject 99 based on the obtained image stream and the obtained concentration target region (S103). Specifically, concentration level calculator 13 calculates the orientation of the face of subject 99 from the obtained image stream, and determines, based on the calculated orientation of the face of subject 99 and the concentration target regions each corresponding to a different one of the concentration target objects, whether subject 99 is in a watching state where subject 99 is watching one of the concentration target objects. Based on the result of determination, concentration level calculator 13 calculates and outputs the concentration level of subject 99.

[0041]

[Calculation of concentration level by concentration level calculation system]

Hereinafter, the operation of concentration level calculator 13 described above will be more specifically described. First, calculation of the orientation of the face of subject 99 will be described. The orientation of the face of subject 99 is calculated based on the obtained image stream. In concentration level calculator 13, by inputting the obtained image stream to a face orientation calculation model trained by machine learning, the orientation of the face of subject 99 on the image stream can be obtained as an output. More specifically, the face orientation calculation model outputs the orientation of the face of subject 99 as the normal line vector of the front of the face. In concentration level calculation system 100, where a direction connecting subject 99 to imaging device 20 which captures images of subject 99 with a straight line is defined as 0 degrees, the relative angle of the output normal line vector of the front of the face, more specifically, the orientation of the face of the subject to the imaging device which captures the image stream is considered as the orientation of the face of subject 99.

[0042]

The face orientation calculation model is one example of the orientation calculation model. Because the face orientation calculation model outputs a face orientation for each of the images which form the image stream, a change in orientation of the face of subject 99 according to the image stream can be obtained. To be noted, the face orientation calculation model is a learned model preliminarily trained using a data set of combinations of the supervisor image (corresponding to the image stream) of subject 99 with the correct data of the face orientation corresponding to the supervisor image (the correct data corresponding to the relative angle indicating the orientation of the face of the subject).

[0043]

The calculation of the orientation of the face of subject 99 is not limited to the example in which the face orientation calculation model is used. For example, the orientation of the face of subject 99 may be calculated by applying a three-dimensional model to the

images forming the image stream using the feature points of the face of subject 99 (such as the corners of eyes, the tip of nose, the corners of the mouth, and the chin of subject 99). Besides, concentration level calculator 13 may calculate the orientation of the face of subject 99 from the image stream using any existing techniques.

[0044]

Although an example in which the orientation of the face of subject 99 is used has been described in the present embodiment, the orientation of the face of subject 99 can be replaced by the orientation of the line of sight of subject 99. The orientation of the line of sight of subject 99 can be calculated by image analysis in which an eyeball of subject 99 is set as the center. The orientation of the line of sight of subject 99 can be regarded as substantially equivalent to the orientation of the face of subject 99. Accordingly, an example in which the orientation of the line of sight above is used will be described by appropriately replacing the "orientation of the face" in the description of the present disclosure by the "orientation of the line of sight".

[0045]

Here, with reference to FIGs. 5 and 6, the state of subject 99 in the present embodiment will be described. FIG. 5 is a diagram for illustrating determination of the watching state according to the embodiment. FIG. 6 is a diagram for illustrating determination of the transition state according to the embodiment. FIGs. 5 and 6 illustrate subject 99 with the same point of view as that in FIG. 3. In FIG. 5, subject 99 is in the watching state. In FIG. 6, subject 99 is in the transition state.

[0046]

In FIGs. 5 and 6, the orientation of the face of subject 99 described above is represented as direction 99b with the arrow of a dashed line (i.e., normal line vector). As illustrated in FIG. 5, when direction 99b falls within the concentration target region, concentration level calculator 13 determines that subject 99 is in the watching state. In other words, it is sufficient that direction 99b

falls within any one of the angle ranges of first concentration target region 97a and second concentration target region 98a.

[0047]

Because the human sight includes an effective sight, the face orientation may have an angle range of some extent. Specifically, the face orientation may be range 99c. Direction 99b is the direction which bisects range 99c (i.e., the center line). When range 99c is used, for example, when part of range 99c overlaps the concentration target region, it may be determined that subject 99 is in the watching state.

[0048]

On the other hand, as illustrated in FIG. 6, when direction 99b does not fall within the angle range of first concentration target region 97a or the angle range of second concentration target region 98a, conventionally, the subject can be determined to be in the non-watching state, namely, that the subject is watching another object. In contrast, in the present embodiment, because direction 99b is located between first concentration target region 97a and second concentration target region 98a, subject 99 is determined to be in the transition state where the line of sight thereof transits between two of the concentration target objects. Thus, in the calculation of the concentration level in the present embodiment, the concentration level is calculated with higher accuracy by discriminating the cases based on whether subject 99 is in the watching state, in the transition state, or in the non-watching state.

[0049]

In addition to the above method, the determination whether subject 99 is in the transition state or in the non-watching state may be calculated with a motion vector of the orientation of the face of subject 99 over time. In this example, in the case where the transition of the orientation of the face of subject 99 from a region which is not any of the concentration target regions and to a region which is not any of the concentration target regions accidentally passes through a region between the two concentration target regions, it is sufficient that it is configured not to determine this case

as the transition state. Moreover, the duration time of the state where the orientation of the face of subject 99 stays at a fixed position may also be considered. In this example, even when direction 99b stays at a position between first concentration target region 97a and second concentration target region 98a, it is sufficient that it is configured to determine this state as the non-watching state if this state continues for a predetermined time. [0050]

The expression "between one region and the other region" indicates a region of the line segment connecting any point of the one region to any point of the other region, the region not belonging to any of the one region and the other region.

[0051]

Concentration level calculator 13 further calculates a performance level from the obtained image stream, the performance level being the unit concentration level of subject 99. The performance level is a numeric value serving as the base of the concentration level calculated from the body movement, the posture, and the expression of subject 99 on an image. The performance level may be calculated using any existing techniques. For example, with respect to the body movement, when an image including a larger number of body movements or a larger degree of body movement than those in an image consecutive to and prior to the image is obtained, the performance level of subject 99 is calculated low. For example, with respect to the posture, the performance level is preliminarily linked to each of postures of subject 99, and the linked performance level is calculated by matching of the posture on the obtained image. For example, with respect to the expression, numeric values are given to some features observed in an expression of the subject, and the performance level is calculated by adding up the numeric values of the features observed in subject 99 on the image. In the calculation of the performance level, the state of subject 99 (whether subject 99 is in the watching state, in the transition stat, or in the non-watching state) may also be added.

[0052]

In the present embodiment, by further integrating the state of subject 99 into the performance level thus calculated, the performance level is optimized, and is calculated as the concentration level. For example, even when the performance level is a high value and when subject 99 is actually in the non-watching state, a low concentration level should be calculated. Accordingly, concentration level calculator 13 calculates the concentration level of subject 99 by multiplying the calculated performance level by a first coefficient when subject 99 is determined to be in the watching state, multiplying the calculated performance level by a second coefficient lower than or equal to the first coefficient when subject 99 is determined to be in the transition state, and multiplying the calculated performance level by a third coefficient lower than the second coefficient when subject 99 is determined to be not in the watching state and to be not in the transition state.

[0053]

To be noted, the habits of subject 99 which may appear when subject 99 is concentrated may contribute to the state of subject 99 and the coefficients for optimizing the performance level. For this reason, the coefficients may be set for each subject 99 by preliminarily performing a preparative test. The transition state and the watching state may be treated equally. In other words, the values of the first coefficient and the second coefficient may be the same.

[0054]

Hereinafter, with reference to FIG. 7, another example of the calculation of the concentration level will be described. FIG. 7 is a diagram illustrating the concentration level calculated in the embodiment. FIG. 7 illustrates a graph of the concentration level calculated per image forming the image stream, namely, per time. In this diagram, an example is illustrated in which different concentration levels are calculated depending on whether subject 99 is in the transition state (solid line in the graph) or whether subject 99 is in one of the watching state and the non-watching state (dashed line in the graph) particularly when the performance levels

are the same during the period represented by the double-headed arrow on the temporal axis.

[0055]

Here, in the case where subject 99 is in the transition state,
5 the reliability of the performance level calculated is lower than those
in the case where subject 99 is in the watching state and the case
where subject 99 is in the non-watching state, and thus calculation of
the concentration level for reducing influences on the concentration
level from the performance level calculated in the case where subject
10 99 is in the transition state.

[0056]

In this example, the concentration level is calculated by an
expression {concentration level at second time point = ($\beta \times$
performance level at first time point) + ((1 - β) $\times$ performance level
15 at second time point)}.

[0057]

Here, the performance level at the first time point and that at
the second time point are used for calculation of the concentration
level at the second time point. The second time point is a time point
20 consecutive to the first time point, and these time points each
contain a period of a minimal unit for calculating the concentration
level in concentration level calculation system 100. The period of
the minimal unit for calculating the concentration level in
concentration level calculation system 100 is 1 second, for example.
25 Accordingly, a concentration level for 1 second is calculated at the
second time point immediately after a concentration level for 1
second is calculated at the first time point.

[0058]

In the above expression, the first term on the right-hand side
30 represents a first value obtained by multiplying the performance
level at the first time point by a first coefficient of weight when
subject 99 is determined to be not in the transition state, or a third
value obtained by multiplying the performance level at the first time
point by a third coefficient of weight when subject 99 is determined
35 to be in the transition state. In the above expression, the second

term on the right-hand side represents a second value obtained by multiplying the performance level at the second time point by a second coefficient of weight when subject 99 is determined to be not in the transition state, or a fourth value obtained by multiplying the performance level at the second time point by a fourth coefficient of weight when subject 99 is determined to be in the transition state.
[0059]

Here, β in the expression is a coefficient of weight for determining which is more heavily weighed between the performance level at the first time point and the performance level at the second time point. For example, in the watching state and the non-watching state which are highly reliable, the performance level at the first time point need not be so much considered. In other words, because the performance level at the second time point in this case is sufficiently reliable, what is appropriate is an increase in weight of the performance level at the second time point. Accordingly, β is set to a relatively small value. To establish the above expression, β is a value of more than 0 and less than 1. When β is set to 0, the concentration level at the second time point can be calculated only from the performance level at the second time point without considering the performance level at the first time point.

[0060]

On the other hand, in the transition state which is less reliable, influences on the concentration level from the performance level at the second time point which is less reliable can be reduced by heavily weighing the performance level at the first time point. Accordingly, β is set to a relatively great value. Thus, the reliability of the performance level may be set as a numeric value (i.e., coefficient of weight) from the state of subject 99, and the performance level preceding by a period of one minimal unit may be taken into the calculation of the concentration level.

[0061]

As a result, as illustrated in FIG. 7, a change in time region of the concentration level in the transition state is milder than that in the watching state or the non-watching state (less influenced by the

performance level at the second time point).

[0062]

As described above, when concentration target objects are present, the concentration level of subject 99 can be calculated more accurately while the state of subject 99 is considered.

[0063]

[Effects]

As described above, concentration level calculation system 100 according to the present embodiment includes image obtainer 11 which obtains an image stream in which images of subject 99 are captured; region obtainer 12 which obtains concentration target regions each corresponding to a different one of concentration target objects to be watched by subject 99; and concentration level calculator 13 which calculates a concentration level of subject 99. Concentration level calculator 13 calculates the orientation of the face or line of sight of subject 99 from the obtained image stream, determines, based on the orientation of the face or line of sight of subject 99 calculated and the concentration target regions obtained, whether subject 99 is in a watching state where subject 99 is watching any one of the concentration target objects, calculates the concentration level of subject 99 based on a result of the determination, and outputs the concentration level.

[0064]

Such concentration level calculation system 100 can calculate the concentration level of subject 99 based on whether subject 99 is watching any one of the concentration target objects. A relatively great concentration level can be obtained when subject 99 is watching an concentration target object, and a relatively low concentration level can be obtained when subject 99 is not watching an concentration target object. In other words, even when a plurality of concentration target objects, e.g., two or more concentration target objects are present, a great concentration level is calculated when subject 99 is watching any one of the concentration target objects. In contrast, when subject 99 is watching none of the concentration target objects, a low

concentration level is calculated. Concentration level calculation system 100 can calculate the concentration level with higher accuracy even when a plurality of concentration target objects are present.

5 [0065]

For example, each of the concentration target regions may be determined based on the region determination image captured when an instruction to watch an concentration target object corresponding to the concentration target region is presented to subject 99, and
10 may be preliminarily stored in a storage. Region obtainer 12 may refer to the storage, and obtain the concentration target regions.
[0066]

In such a configuration, a concentration target region determined with the orientation of the face or line of sight of subject
15 99 when subject 99 is watching the concentration target object in response to the instruction to watch the concentration target object can be obtained.
[0067]

For example, when an instruction to watch one end and the
20 other end of the concentration target object corresponding to the concentration target region is presented to subject 99, each of the concentration target regions may be determined as a region between the orientation of the face or line of sight of subject 99 when watching the one end of the concentration target object and the
25 orientation of the face or line of sight of subject 99 when watching the other end of the concentration target object, and may be preliminarily stored in the storage.
[0068]

In such a configuration, a concentration target region can be
30 obtained which is determined as a region between the orientation of the face or line of sight of subject 99 when watching the one end of the concentration target object and the orientation of the face or line of sight of subject 99 when watching the other end thereof.
[0069]

35 For example, the concentration target regions may be

preliminarily set for each space used by subject 99, and may be stored in a storage. Region obtainer 12 may refer to the storage, and may obtain the concentration target regions.

[0070]

5 In such a configuration, concentration target regions set for each space can be obtained.

[0071]

For example, the concentration target regions may be preliminarily set for each subject 99, and may be stored in a storage.

10 Region obtainer 12 may refer to the storage, and may obtain the concentration target regions.

[0072]

In such a configuration, the concentration target regions preliminarily set for each subject 99 can be obtained.

15 [0073]

For example, the orientation of the face of subject 99 may be calculated as a normal line vector of the face of subject 99 from the image stream obtained, and each of the concentration target regions may include a predetermined angle range with subject 99 centered.

20 When the calculated normal line vector falls within the predetermined angle range, concentration level calculator 13 may determine that subject 99 is in the watching state where subject 99 is watching the concentration target object corresponding to the concentration target region including the predetermined angle range.

[0074]

In such a configuration, the normal line vector of the face of subject 99 can be calculated from the image stream, and whether subject 99 is in the watching state can be determined.

30 [0075]

For example, when concentration level calculator 13 determines that subject 99 is not in the watching state, concentration level calculator 13 may further determine whether subject 99 is in a transition state where the line of sight of subject 99 transits between two of the concentration target objects, and may

35

calculate the concentration level of subject 99 based on a result of the determination.

[0076]

In such a configuration, when subject 99 is not in the watching state, subject 99 can be determined to be in a transition state where the line of sight transits between one concentration target region and another concentration target region, rather than simply subject 99 is determined to be in the non-watching state. The concentration level can be calculated according to the result of determination.

[0077]

For example, concentration level calculator 13 may further calculate a performance level from the obtained image stream, the performance level being a unit concentration level of subject 99, and may calculate the concentration level by multiplying the calculated performance level by a first coefficient when subject 99 is determined to be in the watching state, multiplying the calculated performance level by a second coefficient lower than or equal to the first coefficient when subject 99 is determined to be in the transition state, and multiplying the calculated performance level by a third coefficient lower than the second coefficient when subject 99 is determined to be not in the watching state and to be not in the transition state.

[0078]

In such a configuration, the concentration level is calculated such that for the watching state, the highest numeric value is obtained based on the performance level, for the transition state, a numeric value lower than or equal to that in the watching state is obtained based on the performance level, and for the non-watching state, a numeric value lower than that in the transition state is obtained based on the performance level.

[0079]

For example, concentration level calculator 13 may further calculate a performance level at a first time point and a performance level at a second time point consecutive to the first time point from the image stream obtained, the performance level being a unit

concentration level of subject 99, and may calculate the concentration level of subject 99 by adding a first value obtained by multiplying the performance level at the first time point by a first coefficient of weight and a second value obtained by multiplying the performance level at the second time point by a second coefficient of weight, which is a difference between the first coefficient of weight and 1, when subject 99 is determined to be in the watching state and when subject 99 is determined to be not in the watching state and to be not in the transition state, and by adding a third value obtained by multiplying the performance level at the first time point by a third coefficient of weight different from the first coefficient of weight and a fourth value obtained by multiplying the performance level at the second time point by a fourth coefficient of weight, which is a difference between the third coefficient of weight and 1, when subject 99 is determined to be in the transition state. The first coefficient of weight and the third coefficient of weight may be a numeric value of more than 0 and less than 1.

[0080]

In such a configuration, the concentration level at the second time point can be calculated while the performance level at the first time point and that at the second time point are considered. At this time, a more accurate concentration level can be calculated by changing the weight for the performance level at the first time point and that for the performance level at the second time point (i.e., the degree of influences on the performance level at the second time point from the performance level at the first time point) based on whether subject 99 is in the watching state, the non-watching state, or the transition state.

[0081]

Moreover, the concentration level calculation method according to the present embodiment includes obtaining an image stream in which images of subject 99 are captured; obtaining concentration target regions each corresponding to a different one of concentration target objects to be watched by subject 99; calculating an orientation of the face or line of sight of subject 99 from the image

stream obtained; determining, based on the orientation of the face or line of sight of subject 99 calculated and the concentration target regions obtained, whether subject 99 is in a watching state where subject 99 is watching any one of the concentration target objects; and calculating a concentration level of subject 99 based on a result of the determination, and outputting the concentration level.

[0082]

Such a concentration level calculation method can provide the same effects as those of the concentration level calculation system.

[0083]

For example, the concentration level calculation method described above may be a program for causing a computer to execute the method.

[0084]

In such a configuration, a computer can be caused to execute the concentration level calculation method described above.

[0085]

(Other embodiments)

As above, the concentration level calculation system, the concentration level calculation method, and the program according to the present disclosure have been described based on the embodiments above, but the embodiments above should not be construed as limitations to the present disclosure. For example, the present disclosure also covers embodiments obtained by subjecting the embodiments to a variety of modifications conceived by persons skilled in the art, and embodiments implemented by optionally combining the components and the functions in the embodiments above without departing from the gist of the present disclosure.

[0086]

For example, the concentration level calculation system may include only an arithmetic device, and may be implemented only by the arithmetic device by providing a configuration in which the arithmetic device is connected to an external imaging device, an external storage device, and an external output device. Thus, the imaging device, the storage device, and the output device are not

essential components.

[0087]

For example, as illustrated in FIG. 8, the concentration target objects need not be physical objects. In the drawing, first application window 97b displayed on display 96 of a computer may be the first concentration target object and second application window 98b displayed thereon may be the second concentration target object, and the content of the present disclosure may be applied. Although the concentration level of the subject with high accuracy cannot be calculated by the traditional technique with a recent increase in size of the display apparatus, calculation of the concentration level of the subject with high accuracy the present disclosure is enabled by applying the content of the present disclosure.

[0088]

As illustrated in FIG. 9, a learning model trained by machine learning can also be used in the concentration level calculator according to the embodiment above. FIG. 9 is a block diagram illustrating another example of the functional configuration of the concentration level calculator according to the embodiment above. In this example, arithmetic device 10 includes concentration level calculator 13a rather than concentration level calculator 13 according to the embodiment. Concentration level calculator 13a can directly output the concentration level of subject 99 by inputting the obtained image stream and the obtained concentration target regions to concentration level calculation model 13b. Then, the output result output from concentration level calculation model 13b is output as it is as the concentration level of subject 99.

[0089]

Concentration level calculation model 13b is a learning model preliminarily trained by machine learning of the correlation among the image stream, the concentration target regions, and the concentration level. In this example, concentration level calculation system 100 further includes model generator 13c for generating concentration level calculation model 13b (for learning). To generate concentration level calculation model 13b, model generator

13c uses pieces of input data corresponding to two pieces of information, i.e., the image stream and the concentration target region, and pieces of output data of correct answers corresponding to the pieces of input data (or including correct and wrong answers) as supervisor data.

[0090]

In this example, as the input data, supervisor image/supervisor region D1 corresponding to the image stream and the concentration target region is input for learning. Moreover, in this example, as the output data, supervisor concentration level D2 of subject 99 is input for learning. Concentration level calculation model 13b is adjusted with a data set of combinations of supervisor image/supervisor region D1 and supervisor concentration level D2. For example, in concentration level calculation model 13b configured with a neural network including a plurality of layers, machine learning is performed such that coefficients of weight given to neurons are adjusted by an approach such as back propagation to obtain output data appropriate to the input data.

[0091]

Then, concentration level calculator 13a inputs the obtained image stream and the obtained concentration target region to concentration level calculation model 13b trained, thereby outputting an appropriate concentration level of subject 99. Thus, the calculation of the concentration level by concentration level calculator 13a can also be implemented by using a learning model trained by machine learning.

[0092]

Although concentration level calculation system 100 including model generator 13c has been described in this example, in manufacturing of concentration level calculation system 100, concentration level calculation system 100 can be implemented with a configuration in which concentration level calculation model 13b trained is recorded within arithmetic device 10, and thereafter, concentration level calculation model 13b recorded is only used without training. In this case, concentration level calculation

system 100 without model generator 13c can also be implemented.
[0093]

For example, the present disclosure can be implemented not only as a concentration level calculation system, but also as a program including processings executed by the components of the concentration level calculation system as steps and as a computer-readable recording medium having the program recorded thereon. The program may be preliminarily recorded on the recording medium, or may be fed to the recording medium through a wide area communication network such as the Internet.

[0094]

In other words, the above-mentioned general or specific aspects may be implemented with a system, an apparatus, an integrated circuit, a computer program, or a computer-readable recording medium, or may be implemented with any combination of a system, an apparatus, an integrated circuit, a computer program, and a recording medium.

[Reference Signs List]

[0095]

- 11 image obtainer
- 12 region obtainer
- 13 concentration level calculator
- 99 subject
- 100 concentration level calculation system

[CLAIMS]

[Claim 1]

A concentration level calculation system comprising:

an image obtainer which obtains an image stream in which
5 images of a subject are captured;

a region obtainer which obtains concentration target regions
each corresponding to a different one of concentration target objects
to be watched by the subject; and

a concentration level calculator which calculates a
10 concentration level of the subject,

wherein the concentration level calculator:

calculates an orientation of a face or line of sight of the subject
from the image stream obtained;

determines, based on the orientation of the face or line of sight
15 of the subject calculated and the concentration target regions
obtained, whether the subject is in a watching state where the subject
is watching any one of the concentration target objects; and

calculates the concentration level of the subject based on a
result of the determination, and outputs the concentration level.

20

[Claim 2]

The concentration level calculation system according to claim
1,

wherein each of the concentration target regions is
25 determined based on a region determination image captured when
an instruction to watch a concentration target object corresponding
to the concentration target region is presented to the subject, and is
preliminarily stored in a storage, and

the region obtainer refers to the storage, and obtains the
30 concentration target regions.

[Claim 3]

The concentration level calculation system according to claim
2,

35 wherein when an instruction to watch one end and an other

end of the concentration target object corresponding to the concentration target region is presented to the subject, each of the concentration target regions is determined as a region between the orientation of the face or line of sight of the subject when watching the one end of the concentration target object and the orientation of the face or line of sight of the subject when watching the other end of the concentration target object, and is preliminarily stored in the storage.

10 [Claim 4]

The concentration level calculation system according to claim 1,

wherein the concentration target regions are preliminarily set for each space used by the subject, and are stored in a storage, and the region obtainer refers to the storage, and obtains the concentration target regions.

[Claim 5]

The concentration level calculation system according to claim

20 1,

wherein the concentration target regions are preliminarily set for each subject, and are stored in a storage, and the region obtainer refers to the storage, and obtains the concentration target regions.

25

[Claim 6]

The concentration level calculation system according to any one of claims 1 to 5,

wherein the orientation of the face of the subject is calculated as a normal line vector of the face of the subject from the image stream obtained,

each of the concentration target regions includes a predetermined angle range with the subject centered, and

when the normal line vector calculated falls within the predetermined angle range, the concentration level calculator

determines that the subject is in the watching state where the subject is watching the concentration target object corresponding to the concentration target region including the predetermined angle range.

5

[Claim 7]

The concentration level calculation system according to any one of claims 1 to 6,

10 wherein when the concentration level calculator determines that the subject is not in the watching state, the concentration level calculator further determines whether the subject is in a transition state where the line of sight transits between two of the concentration target objects, and calculates the concentration level of the subject based on a result of the determination.

15

[Claim 8]

The concentration level calculation system according to claim 7,

20 wherein the concentration level calculator:
further calculates a performance level from the image stream obtained, the performance level being a unit concentration level of the subject; and

25 calculates the concentration level of the subject by multiplying the performance level by a first coefficient when the subject is determined to be in the watching state, multiplying the performance level by a second coefficient lower than or equal to the first coefficient when the subject is determined to be in the transition state, and multiplying the performance level by a third coefficient lower than the second coefficient when the subject is determined to
30 be not in the watching state and to be not in the transition state.

[Claim 9]

The concentration level calculation system according to claim 7,

35 wherein the concentration level calculator:

further calculates a performance level at a first time point and a performance level at a second time point consecutive to the first time point from the image stream obtained, the performance level being a unit concentration level of the subject; and

5 calculates the concentration level of the subject by adding a first value obtained by multiplying the performance level at the first time point by a first coefficient of weight and a second value obtained by multiplying the performance level at the second time point by a second coefficient of weight which is a difference between the first
10 coefficient of weight and 1 when the subject is determined to be in the watching state and when the subject is determined to be not in the watching state and to be not in the transition state; and by adding a third value obtained by multiplying the performance level at the first time point by a third coefficient of weight different from the
15 first coefficient of weight and a fourth value obtained by multiplying the performance level at the second time point by a fourth coefficient of weight which is a difference between the third coefficient of weight and 1 when the subject is determined to be in the transition state, and
20 the first coefficient of weight and the third coefficient of weight each are a numeric value of more than 0 and less than 1.

[Claim 10]

25 The concentration level calculation system according to any one of claims 1 to 9,

 wherein the orientation of the face or line of sight of the subject is calculated as an output result by inputting the image stream to an orientation calculation model trained by machine learning of a correlation between the image stream and the
30 orientation of the face or line of sight of the subject to an imaging device which captures the image stream.

[Claim 11]

 A concentration level calculation method comprising:
35 obtaining an image stream in which images of a subject are

captured;

obtaining concentration target regions each corresponding to a different one of concentration target objects to be watched by the subject;

5 calculating an orientation of a face or line of sight of the subject from the image stream obtained;

 determining, based on the orientation of the face or line of sight of the subject calculated and the concentration target regions obtained, whether the subject is in a watching state where the
10 subject is watching any one of the concentration target objects; and

 calculating a concentration level of the subject based on a result of the determination, and outputting the concentration level.

[Claim 12]

15 A program for causing a computer to execute the concentration level calculation method according to claim 11.

[Claim 13]

A concentration level calculation system comprising:

20 an image obtainer which obtains an image stream in which images of a subject are captured;

 a region obtainer which obtains concentration target regions each corresponding to a different one of concentration target objects to be watched by the subject; and

25 a concentration level calculator which calculates a concentration level of the subject,

 wherein the concentration level calculator calculates the concentration level of the subject by inputting the image stream and the concentration target regions to a concentration level calculation
30 model trained by machine learning of a correlation among the image stream, the concentration target regions, and the concentration level of the subject.

[Claim 14]

35 A concentration level calculation model generation system

comprising:

a model generator which generates the concentration level calculation model according to claim 13.