

## DESCRIPTION

## 3 DIAGNOSIS SUPPORT PROGRAM

## 6 Technical Field

 $[0001]$ 

The present invention relates to a technique to  
9 analyze an image of a human body and display analysis  
results.

## 12 Background Art

 $[0002]$ 

When a doctor diagnoses a lung by dynamic state  
15 images of the chest, important is observation of  
time-series chest dynamic state images in which a  
subject is photographed in a natural breathing state.  
18 A spirometer with which it is easy to acquire  
physiological data, an RI (Radio Isotope) inspection,  
a simple X-ray photography with which it is possible  
21 to obtain morphological data, CT (Computed Tomography),  
and so on, are known as a method of evaluating lung  
functions. However, it is not easy to acquire both  
24 physiological data and morphological data efficiently.  
[0003]

In recent years, a method is attempted in which  
27 dynamic state images of the chest of a human body are  
photographed by making use of a semiconductor image

sensor, such as an FPD (Flat Panel Detector) and used  
for a diagnosis. For example, Non Patent Literature 1  
3 has disclosed a technique to generate a difference image  
indicating a difference in signal value between a  
plurality of frame images making up a dynamic state  
6 image and to find and display a maximum value of each  
signal value from the difference image.

[0004]

9 Further, Patent Literature 1 has disclosed a  
technique to extract a lung field area from each frame  
image of a plurality of frame images indicating the  
12 dynamic state of the chest of a human body and divide  
the lung field area into a plurality of small areas,  
and to perform an analysis by associating the divided  
15 small areas to each other between the plurality of frame  
images. With this technique, a feature amount  
indicating the movement of the divided small area is  
18 displayed.

#### Citation List

21 Patent Literature

[0005]

PTL 1: Japanese Patent No. 5874636

24 Non Patent Literature

[0006]

NPL 1: "Basic Imaging Properties of a Large Image  
27 Intensifier-TV Digital Chest Radiographic System"  
Investigative Radiology: April 1987; 22: 328 - 335.

## Summary of Invention

### 3 Technical Problem

[0007]

However, only by displaying the maximum value of  
6 the difference value between frames for each pixel of  
the dynamic state image as in the technique described  
in Non Patent Literature 1, it is not easy for a doctor  
9 to grasp the state of a disease. Further, only by  
displaying the feature amount as in the technique  
described in Patent Literature 1, it is also not  
12 sufficient to grasp the state of a disease.  
Consequently, it is desirable to display images in  
accordance with the state of respiration and lung blood  
15 vessels. That is, it is desirable to grasp the  
breathing state and the entire dynamic state of blood  
vessels of a human body, which is a subject, and based  
18 on respiration, blood vessels of the heart and the hilum  
pulmonis portion, or the waveform or frequency of blood  
flows, to display images indicating the movement  
21 corroborated by those.

[0008]

The present invention has been made in view of the  
24 aforementioned circumstances and has an object to  
provide a diagnosis support program capable of  
displaying the movement of an area whose shape changes  
27 for each respiration or for each heartbeat. More  
specifically, it has an object to generate images that

assist a diagnosis by calculating numerical values that  
assist a diagnosis by digitizing the concordance rate  
3 or another non-concordance rate for the waveform and  
Hz already acquired for new target data to be measured  
and further by turning these numerical values into  
6 images.

#### Solution to Problem

9 [0009]

(1) In order to achieve the above-described object,  
the present application has taken steps as follows.  
12 That is, a diagnosis support program according to an  
aspect of the present invention is a diagnosis support  
program that analyzes images of a human body and  
15 displays analysis results, and causes a computer to  
execute processing of acquiring a plurality of frame  
images from a database that stores the images;  
18 processing of specifying a respiratory cycle based on  
pixels in a specific area in each of the frame images;  
processing of detecting a lung field based on the  
21 specified respiratory cycle; processing of dividing the  
detected lung field into a plurality of block areas and  
calculating a change in image in a block area in each  
24 of the frame images; processing of performing a Fourier  
analysis of a change in image in each block area in each  
of the frame images; and processing of displaying each  
27 image after the Fourier analysis on a display.

[0010]

(2) Further, a diagnosis support program according to an aspect of the present invention is a diagnosis support program that analyzes images of a human body and displays analysis results, and causes a computer to execute processing of acquiring a plurality of frame images from a database that stores the images; processing of specifying a blood vessel beat cycle of a subject; processing of specifying a respiratory cycle based on pixels in a specific area in each of the frame images; processing of detecting a lung field based on the specified respiratory cycle; processing of dividing the detected lung field into a plurality of block areas and calculating a change in image in a block area in each of the frame images; processing of performing a Fourier analysis of a change in image in each block area in each of the frame images based on the specified blood vessel beat cycle; and processing of displaying each image after the Fourier analysis on a display.

[0011]

(3) Further, a diagnosis support program according to an aspect of the present invention is a diagnosis support program that analyzes images of a human body and displays analysis results, and causes a computer to execute processing of acquiring a plurality of frame images from a database that stores the images; processing of specifying a blood vessel beat cycle of a subject; processing of dividing an analysis range that is set for each of the frame images into a plurality

of block areas and calculating a change in image in a  
block area in each of the frame images; processing of  
3 performing a Fourier analysis of a change in image in  
each block area in each of the frame images based on  
the specified blood vessel beat cycle; and processing  
6 of displaying each image after the Fourier analysis on  
a display.

[0012]

9 (4) Further, a diagnosis support program according  
to an aspect of the present invention specifies a  
respiratory cycle of a subject based on a movement of  
12 a diaphragm, a movement of a thorax, or other pieces  
of data including a spirogram.

[0013]

15 (5) Further, a diagnosis support program according  
to an aspect of the present invention specifies a blood  
vessel beat cycle of the subject based on measurement  
18 results by other modality devices including an  
electrocardiogram or a pulsimeter, and alternatively,  
extracts a movement of a diaphragm and a thorax and  
21 specifies a respiratory cycle of a subject based on an  
image of a diaphragm and an image of a thorax at least  
included in each of the frame images, detects a lung  
24 field based on the specified respiratory cycle,  
specifies a position of a heart, a position of a hilum  
pulmonis, and blood vessel cycles of a main lung blood  
27 vessel and a large blood vessel from the detected lung  
field, and specifies a blood vessel beat cycle based

on a change in image of each specified region.

[0014]

3           (6) Further, a diagnosis support program according  
to an aspect of the present invention calculates a  
relative position relationship between an inside of a  
6 lung field and blood vessels based on the specified  
respiratory cycle and specifies a shape of a lung of  
a subject as a standard lung and specifies a dynamic  
9 state of a blood flow of the subject as a standard blood  
vessel area.

[0015]

12           (7) Further, a diagnosis support program according  
to an aspect of the present invention divides a lung  
field into a plurality of block areas by plotting a  
15 plurality of points in accordance with a fixed rule on  
opposing contours of a lung field and by connecting  
opposing points by a segment.

18 [0016]

          (8) Further, in a diagnosis support program  
according to an aspect of the present invention, the  
21 processing of performing a Fourier analysis  
Fourier-transforms an image in each block area in each  
of the frame images and performs inverse Fourier  
24 transform by extracting only waveforms substantially  
indicating a respiratory cycle or a blood vessel beat  
cycle from a waveform after Fourier transform.

27

Advantageous Effects of Invention

[0017]

According to an aspect of the present invention,  
3 it is made possible to display a movement of an area  
whose shape changes for each respiration or for each  
heartbeat. That is, by calculating numerical values  
6 that assist a diagnosis and further by turning these  
numerical values into images, it is made possible to  
generate images that assist a diagnosis. As a result  
9 of this, it is made possible to visualize a difference  
between a normal movement and an abnormal movement and  
to visually recognize the difference, and therefore,  
12 this is appropriate for the field of the image medical  
practice.

#### 15 Brief Description of Drawings

[0018]

FIG. 1A is a diagram illustrating an outline  
18 configuration of a diagnosis support system according  
to the present embodiment.

FIG. 1B is a diagram illustrating an example of  
21 a division method of a lung area.

FIG. 1C is a diagram illustrating an example of  
a division method of a lung area.

24 FIG. 1D is a diagram illustrating an example of  
a division method of a lung area.

FIG. 1E is a diagram illustrating an example of  
27 a division method of a lung area.

FIG. 1F is a diagram illustrating an example of

a division method of a lung area.

FIG. 1G is a diagram illustrating an example of  
3 a division method of a lung area.

FIG. 1H is a diagram illustrating an example of  
a division method of a lung area.

6 FIG. 2A is a diagram illustrating a change in  
intensity in a specific block and results of performing  
a Fourier analysis thereof.

9 FIG. 2B is a diagram illustrating Fourier  
transform results of extracting frequency components  
close to a heartbeat and a change in intensity of the  
12 frequency components close to the heartbeat obtained  
by performing inverse Fourier transform thereof.

FIG. 2C is a diagram schematically illustrating  
15 a change rate of a lung.

FIG. 3 is a flowchart showing an outline of a  
respiratory function analysis according to the present  
18 embodiment.

FIG. 4 is a flowchart showing an outline of a lung  
blood flow analysis according to the present  
21 embodiment.

FIG. 5 is a flowchart showing an outline of another  
blood flow analysis according to the present  
24 embodiment.

## Description of Embodiments

27 [0019]

First, the basic concept of the present invention

will be explained. In the present invention, for movements that can be captured so as to repeat in a fixed  
3 cycle in respiration and biological movements of blood vessels and others in a human body, a fixed iteration or a fixed movement (routine) on the time axis in the  
6 entire or partial range is captured as a wave and measured.

[0020]

9 For measurement results of a wave, (A) a form of the wave itself or (B) intervals (Hz) of the wave are used.

12 [0021]

Waves that are linked similarly during the same period of time may exist. For example, in the case of  
15 respiration, an approximation as follows may be considered.

(average of change in density in a rough area)  $\approx$   
18 (change in thorax)  $\approx$  (movement of diaphragm)  $\approx$  (lung function inspection  $\approx$  (thoracoabdominal respiration sensor)

21 [0022]

By using any of these pieces of data or data obtained by combining these pieces of data, it is made  
24 possible to extract an image with higher accuracy. At this time, there is a case where calculation is mutually performed a plurality of times. In this case, the  
27 artifact for the results is removed again and extraction of the function is performed by extracting from the

extracted waveform of new data, the data waveform that becomes the first base, the waveform of another modality  
3 and the like, the waveform of the ambience, and the waveform of a plurality of times. At this time, the number of times may be one or more.

6 [0023]

Here, when base data is created, by a plurality of modalities (for example, two or more of a fixed  
9 density, volumetry, movement of a thorax, movement of a diaphragm, spirometry, and thoracoabdominal respiration sensor) or a plurality of times of waveform  
12 measurement of the same respiratory cycle, the mutual component extraction is complemented for each other, and thereby, accuracy is improved. Due to this, it is  
15 made possible to reduce the artifact and to improve the accuracy based on a fixed prediction of a line and the like.

18 [0024]

Further, fluctuations in axis, width, range, and Hz due to the mutual component extraction and the width  
21 are estimated. That is, by a plurality of times of superimposition, the axis setting of Hz is averaged and the optimum range of the axis, width, range, and Hz is  
24 calculated by the variance. At this time, there is a case where Hz (noise) of another behavior is extracted and if its wave exists, the degree in which the wave  
27 is not included is measured relatively.

[0025]

By the above, it is made possible to obtain master data. For the above-described master data, a new target  
3 desired to be measured is extracted in a fixed width  
and range of the waveform of the above-described master  
data and Hz of the wave. For example, only respiration  
6 is extracted or extraction is performed in the width  
and range as the framework of the degree of blood vessel  
extraction. Note that this waveform and the width of  
9 Hz are determined relatively and comprehensively based  
on statistics by using the waveform element in another  
function, the artifact, such as noise, the waveform of  
12 another modality deemed to have another conformity, the  
reproducibility performed a plurality of times, and so  
on. Then, adjustment and experience are required (it  
15 is also possible to apply machine learning). The reason  
is that while the width and range are extended, the  
element of another function begins to enter, if the  
18 width and range are too narrow, the element of the  
function itself is eliminated, and therefore, as to the  
range, adjustment is necessary. For example, in the  
21 case where there is data of a plurality of times, it  
is easy to specify the range, concordance width between  
Hz and measurement, and so on.

24 [0026]

Next, for the data of the new target desired to  
be measured, by digitizing the waveform originally  
27 captured and the concordance rate or another  
non-concordance rate for Hz, the numerical values that

assist a diagnosis are calculated. For example, it is made possible to apply to a diagnosis auxiliary device  
3 by measuring the waveform matching rate of the master disease and calculating the concordance rate of the disease waveform as well as removing noise in the  
6 pulsimeter and stethoscope.

[0027]

Further, for the data of the new target desired  
9 to be measured, by turning the waveform originally captured and the concordance rate or another non-concordance rate for Hz into images, the images that  
12 assist a diagnosis are calculated. For example, the difference between the normal deglutition and that of a patient is visualized and the difference between the  
15 behavior conventionally performed and that currently performed is displayed. For example, a change, a difference, and so on, in how to move one's feet in  
18 walking and swing.

[0028]

The extracted amount of change is visualized and  
21 extracted as an image. This is the respiratory function analysis and the blood vessel analysis to be explained below. Then, the change rate of the thorax and the  
24 diaphragm is visualized. At this time, there is a case where the artifact for the results is excluded again and extraction of the function is performed by  
27 extracting from the extracted waveform of new data, the data waveform that becomes the first base, the waveform

of another modality and the like, the waveform of the  
ambience, and the waveform of a plurality of times.

3 [0029]

Further, there is a case where the feature amount  
is grasped by those from which the change components  
6 extracted from other than the above are excluded. For  
example, when the movement of the abdominal intestinal  
tract is grasped, an attempt is made to extract the  
9 movement of the abdominal intestinal tract by excluding  
the influence of respiration and the influence of blood  
vessels from the abdomen.

12 [0030]

Further, by correcting the image (CT, MRI, special  
roentgenography, PET/scintigraphy, and so on) that  
15 requires a fixed photographing time by the change rate  
due to the extraction, a clearer and more accurate image  
is provided. This is effective in, for example,  
18 correction of the ascending aorta heart, correction of  
the heart figure, correction in fluctuations in the  
bronchial tube, evaluation of the surroundings of the  
21 thorax, and photographing in the state where breath  
cannot be held (several minutes are required for a  
patient and photographing).

24 [0031]

Hereinafter, an embodiment of the present  
invention will be explained with reference to the  
27 drawings. FIG. 1A is a diagram illustrating an outline  
configuration of a diagnosis support system according

to the present embodiment. This diagnosis support system exhibits a specific function by causing a computer to execute a diagnosis support program. A basic module 1 includes a respiratory function analysis unit 3, a lung blood flow analysis unit 5, an another blood flow analysis unit 7, a Fourier analysis unit 9, a waveform analysis unit 10, and a visualization/digitization unit 11. The basic module 1 acquires image data from a database 15 via an input interface 13. In the database 15, for example, images by DICOM (Digital Imaging and COmmunication in Medicine) are stored. An image signal output from the basic module 1 is displayed on a display 19 via an output interface 17. Next, the function of the basic module according to the present embodiment will be explained.

[0032]

#### [Respiratory cycle analysis]

In the present embodiment, based on the following indexes, the respiratory cycle is analyzed. That is, the respiratory cycle is analyzed by using at least one of density/intensity in a fixed area within the lung field, the movement of the diaphragm, and the movement of the thorax. Further, it may also be possible to use the data obtained from the range consisting of fixed volume density/intensity measured in a region where permeability of X-ray (further, a plurality of kinds of modality, such as CT and MRI) is high and obtained by other measurement methods, such as spirogram. Note

that it is desirable to improve accuracy of data by  
comparing the analysis results for each respiration and  
3 analyzing the tendency from a plurality of pieces of  
data.

[0033]

6 [Blood vessel beat analysis]

In the present embodiment, based on the following  
indexes, the blood vessel beat is analyzed. That is,  
9 the heart/position of hilum pulmonis/main blood vessel  
are specified from the measurement results of other  
modalities, such as an electrocardiogram and a  
12 pulsimeter, or the lung contour, and the blood vessel  
beat is analyzed by using a change in density/intensity  
of each region. Further, it may also be possible to  
15 analyze a change in density/intensity of a target region  
by manually performing plotting on an image. Note that  
it is desirable to improve accuracy of data by comparing  
18 the analysis results for each beat and analyzing the  
tendency from a plurality of pieces of data.

[0034]

21 [Lung field identification]

From the database (DICOM), images are extracted  
and the lung contour is automatically detected by using  
24 the above-described respiratory cycle analysis results.  
For this automatic detection of the lung contour, it  
is possible to use the technique known conventionally.  
27 For example, it is possible to use the technique  
disclosed in Japanese Patent Laid-Open No. S63-240832

or Japanese Patent Laid-Open No. H2-250180.

[0035]

3           Next, the lung field is divided into a plurality  
of block areas and a change in each block area is  
calculated. Here, it may also be possible to determine  
6 the size of the block area in accordance with the  
photographing speed. In the case where the  
photographing speed is slow, it becomes difficult to  
9 specify a corresponding region in a frame image next  
a certain frame image, and therefore, the block area  
is made large. On the other hand, in the case where the  
12 photographing speed is fast, the number of frame images  
per unit time is large, and therefore, it is made  
possible to follow even when the block area is small.  
15 Further, it may also be possible to calculate the size  
of the block area in accordance with which timing of  
the respiratory cycle is selected. Here, there is a  
18 case where it is necessary to correct a deviation in  
the lung field area. At this time, the movement of the  
thorax, the movement of the diaphragm, and the position  
21 relationship of blood vessels of the entire lung field  
are identified, and further, the relative position of  
the lung contour is grasped, and evaluation is made  
24 relatively based on the movement. Note that, when the  
block area is too small, there is a case where a flicker  
occurs in the image. In order to prevent this, it is  
27 necessary for the block area to have a fixed size.

[0036]

[Creation of block area: first method]

A method of dividing the lung field into a  
3 plurality of block areas will be explained. As  
illustrated in FIG. 1B, a first method is a method of  
dividing the lung transversely by plotting points in  
6 the vertical direction of the lung. By the first method,  
for example, it is possible to find the distance on the  
mediastinum side of the lung and the distance on the  
9 outside of the lung and to plot points obtained by  
equally dividing the distances, respectively. Then,  
division is performed by determining the enlargement  
12 ratio of the mediastinum side and the outside. Note  
that, in the lung, the diaphragm side moves more than  
the pulmonary apex side, and therefore, it may also be  
15 possible to plot points whose size becomes smaller  
toward the diaphragm side. Further, in FIG. 1B, it may  
also be possible to divide the lung into a plurality  
18 of rectangular (square) block areas by additionally  
drawing lines (dot lines) in the vertical direction.  
Due to this, it is made possible to represent the  
21 movement of the lung more accurately.

[0037]

[Creation of block area: second method]

24 A second method is also a method of dividing the  
lung transversely, but as illustrated in FIG. 1C,  
parallel lines are drawn between the pulmonary apex and  
27 the end portion of the diaphragm (or the vicinity  
thereof) in the area of the lung and a plurality of points

is plotted therebetween. Then, at the portions facing each other, the enlargement ratio is determined and  
3 division is performed. In the second method, the length of the curved portion of the lung is not calculated, and therefore, there is a merit that the amount of  
6 calculation is small. Further, as illustrated in FIG. 1B, it may also be possible to divide the lung into a plurality of rectangular (square) block areas by  
9 additionally drawing lines (dot lines) in the vertical direction.

[0038]

12 [Creation of block area: third method]

A third method is a method of dividing the lung vertically by plotting points in the transverse  
15 direction of the lung as illustrated in FIG. 1D. With the third method, for example, it is possible to find the distance on the mediastinum side of the lung and  
18 the distance on the outside of the lung and to plot points obtained by equally dividing the distances, respectively. Then, at the portions facing each other,  
21 the enlargement ratio is determined and division is performed. Note that, in the lung, the diaphragm side moves more than the pulmonary apex side, and therefore,  
24 it may also be possible to plot points whose size becomes smaller toward the diaphragm side. Further, as illustrated in FIG. 1B, it may also be possible to  
27 additionally draw lines in the transverse direction so as to divide the lung into a plurality of rectangular

(square) block areas.

[0039]

3           [Creation of block area: fourth method]

          A fourth method is also a method of dividing the lung vertically, but as illustrated in FIG. 1E, parallel  
6 lines are drawn in the vertical direction of the pulmonary apex and in the vertical direction of the end portion of the diaphragm (or the vicinity thereof) in  
9 the area of the lung and a plurality of points is plotted therebetween. Then, at the portions facing each other, the enlargement ratio is determined and division is  
12 performed. In the fourth method, the length of the curved portion of the lung is not calculated, and therefore, there is a merit that the amount of  
15 calculation is small. Further, as illustrated in FIG. 1B, it may also be possible to additionally draw lines in the transverse direction to as to divide the lung  
18 into a plurality of rectangular (square) block areas.

[0040]

          [Creation of block area: fifth method]

21           In a fifth method, as illustrated in FIG. 1F, a tangent line at the pulmonary apex portion and a tangent line at the diaphragm are drawn and the intersection  
24 of the tangent lines is determined to be a center point and the lung is divided by segments drawn from a straight line (for example, a plumb line) including the point  
27 at fixed angle intervals. With the fifth method, depending on how to determine the center point, the

division method becomes close to the transverse  
division of the lung or becomes close to the vertical  
3 division of the lung. Further, as illustrated in FIG.  
1B, it may also be possible to additionally draw lines  
in the vertical direction or in the transverse direction  
6 so as to divide the lung into a plurality of rectangular  
(square) block areas.

[0041]

9 [Creation of block area: sixth method]

A sixth method is a method in which creation of  
block areas is considered three-dimensionally. As  
12 illustrated in FIG. 1G, it may also be possible to cut  
the lung in a plurality of planes perpendicular to a  
straight line connecting the pulmonary apex (or hilum  
15 pulmonis) and the diaphragm end portion. Further, in  
the diaphragm, the trunk portion side moves more than  
the body surface side, and therefore, it can be said  
18 that the spring coefficient of the diaphragm differs  
depending on the position. Consequently, as  
illustrated in FIG. 1H, it may also be possible to divide  
21 the lung by sets of points (planes) at which the amount  
of displacement accompanying the movement of the  
diaphragm is equal. Further, as illustrated in FIG. 1B,  
24 it may also be possible to additionally draw lines in  
the vertical direction or in the transverse direction  
so as to divide the lung into a plurality of rectangular  
27 (square) block areas.

[0042]

Next, the artifact is removed and image data is interpolated. That is, if a bone or the like is included within the analysis range, the bone or the like appears as noise, and therefore, it is desirable to remove the noise by using a noise-cut filter. In an X-ray image, within the lung field area, X-rays easily permeate on the periphery of the position where neither blood vessel nor bone exists, and therefore, the X-ray image becomes black. That is, the pixel value of the X-ray image becomes high. On the other hand, at the position where a blood vessel and a bone exist, it is hard for the X-rays to permeate, and therefore, the X-ray image becomes white. That is, the pixel value of the X-ray image becomes low. This also applies to the other CT and MRI. Here, from the results of the above-described respiratory cycle analysis, it is made possible to interpolate data by using a value in the same phase based on the waveform per respiration and to remove the artifact.

[0043]

[Fourier analysis]

Based on the respiratory cycle and the blood vessel beat cycle analyzed as described above, a Fourier analysis is performed for the value of density/intensity in each block area and the amount of change thereof. FIG. 2A is a diagram illustrating a change in intensity in a specific block and results of performing a Fourier analysis thereof. FIG. 2B is a

diagram illustrating Fourier transform results of extracting frequency components close to a heartbeat and a change in intensity of frequency components close to the heartbeat obtained by performing inverse Fourier transform thereof. For example, when the change in intensity in a specific block is Fourier-transformed (Fourier analysis), the results as illustrated in FIG. 2A are obtained. Then, by extracting frequency components close to the heartbeat from the frequency components illustrated in FIG. 2A by using, for example, a band-pass filter, the results as illustrated on the right side in FIG. 2B are obtained. By performing inverse Fourier transform for the results, it is possible to obtain the change in intensity in conformity with the change in heartbeat as illustrated on the left side in FIG. 2B.

[0044]

Note that it is possible to use an AR method (Autoregressive Moving average model) so that calculation is performed in a short time when performing Fourier transform. As the AR method, mention is made of a method of using a Yule-walker equation or a Kalman filter in an autoregressive moving average model and by using Yule-walker estimates derived by the method, a PARCOR method, and a least squares method, it is possible to complement the calculation. Due to this, it is made possible to acquire an image close to a real-time image, to assist the calculation, and to

correct the artifact at a higher speed. Due to such a Fourier analysis, it is made possible to extract and  
3 display the nature of an image in each block area.

[0045]

[Waveform analysis]

6 For the blood vessel, the brain wave, and what is recognized as a fixed waveform in other inspections, a waveform analysis is performed. The movement  
9 repeated in a fixed state, such as the movement of the foot, is included. For example, in the case of the lung, a difference between left and right is compared.  
12 Further, by superimposing Hz of the movement performed repeatedly, whether the same tendency exists is analyzed. By comparing waveform data, the concordance  
15 rate of two pieces of data is calculated. Then, the data after a Fourier analysis is compared.

[0046]

18 [Visualization/digitization]

The results of the above-described analysis are visualized and digitized. As the standard uptake, the  
21 value is displayed relatively/logarithmically by taking the average value of the measured density/intensity in the entire area of the lung field  
24 as 1. Further, because only the direction of the blood flow is employed, the change in a specific direction is cut out. Due to this, it is made possible to take  
27 out only data of a significant method. By using the lung field identification results, pseudo colorization is

performed following the change in analysis range. That is, in accordance with a specific shape (minimum, maximum, mean, median) fitted to the phase, the analysis results of each individual (subject) are fitted to a relative area. Further, a plurality of analysis results is changed into a specific shape/phase that can be compared. Furthermore, when the standard lung is created, by using the results of the above-described respiratory cycle analysis, the relative position relationship within the lung field is calculated. Note that the standard lung is created by using a line obtained by comprehensively averaging the thorax lines, the density, the diaphragm, and so on, of a plurality of patients. When the standard lung is created, in the case of the lung blood flow, it is possible to measure the distance radially from the hilum pulmonis to the lung end portion. Further, in the case of respiration, it is necessary to perform correction in accordance with the movement of the thorax and the diaphragm. Furthermore, it may also be possible to compositely perform calculation by taking into consideration the distance from the pulmonary apex. Note that, in the present embodiment, the way the entire diaphragm moves is acquired in advance and the necessary movement of the diaphragm is made use of in accordance with the measurement of each region. That is, for the hertz of the movement of the entire diaphragm, respiration synchronization and blood vessel synchronization are

taken.

[0047]

3           After the standard lung is created, it is made  
possible to digitize and present the conformity, the  
concordance rate, and the non-concordance rate.  
6 Further, it is possible to display a deviation from the  
normal state. According to the present embodiment, by  
performing a Fourier analysis, it is made possible to  
9 discover a possibility of a new disease, to compare with  
oneself in the normal state, to compare one's hand and  
foot, and to compare one's hand and foot on the opposite  
12 side. Further, it is made possible to grasp which  
portion is abnormal in moving one's foot and in  
deglutition by digitizing the conformity. Furthermore,  
15 it is made possible to determine whether a person in  
the disease state has changed after a fixed time elapses  
and in the case where the person has changed, to compare  
18 the states before and after the change.

[0048]

          As illustrated in FIG. 2C, it is made possible to  
21 grasp how many percents the lung differs in the human  
body when the standard lung is taken to be 100 and to  
display the change rate. Further, it is also possible  
24 to grasp a difference for part of the lung in addition  
to the entire lung. Furthermore, by performing  
"Variation classification", it is also possible to  
27 specify the standard blood flow. That is, it is made  
possible to specify the respiratory cycle, to calculate

the relative position relationship of the blood vessels,  
and to specify the blood flow dynamic state of a subject  
3 as the standard blood flow.

[0049]

Due to this, a comparison between a patient and  
6 another patient and digitization are enabled. Further,  
a comparison between the normal lung or normal blood  
vessel and the typically abnormal pulmonary function  
9 or abnormal blood flow and digitization are enabled.  
Furthermore, as a relative evaluation of the pulmonary  
function and the lung blood flow at different times of  
12 a patient, it is made possible to use the standard lung  
and the standard blood flow. It is possible to use the  
standard lung and the standard blood flow such as these  
15 as the indexes at the time of evaluation by applying  
those morphologically to a patient as the standard lung  
and the standard blood flow by collecting the typical  
18 examples of various types of typical patients and  
healthy persons. Next, the operation of each module  
according to the present embodiment will be explained.

21 [0050]

[Respiratory function analysis]

First, the respiratory function analysis will be  
24 explained. FIG. 3 is a flowchart showing an outline of  
the respiratory function analysis according to the  
present embodiment. The basic module 1 extracts images  
27 of DICOM from the database 15 (step S1). Here, at least  
a plurality of frame images included within one

respiratory cycle is acquired. Next, in each acquired  
frame image, by using the density (density/intensity)  
3 at least in a fixed area within the lung field, the  
respiratory cycle is specified (step S2). By fitting  
a periodic function to this respiratory cycle, the range  
6 of the lung field is specified.

[0051]

It is also possible to specify the respiratory  
9 cycle by using the movement of the diaphragm and the  
movement of the thorax. Further, it may also be  
possible to use the data obtained from the range  
12 consisting of fixed volume density/intensity measured  
in a region where permeability of X-ray is high and  
obtained by other measurement methods, such as  
15 spirogram.

[0052]

Next, in FIG. 3, the lung field is automatically  
18 detected (step S3). In the automatic detection of the  
contour of the lung, there is a case where fluctuations  
occur for each frame image, but by interpolating each  
21 frame image based on the respiratory cycle specified  
at step S2, the lung contour in each frame image is  
specified. Next, the detected lung field is divided  
24 into a plurality of block areas (step S4). Then, a  
change in each block area in each frame image is  
calculated (step S5). Here, the value of the change  
27 within each block area is averaged and represented as  
one piece of data. Next, for the value of

density/intensity in each block area and the amount of  
change thereof, a Fourier analysis is performed based  
3 on the above-described respiratory cycle (step S6).  
Due to this, it is made possible to extract and display  
the nature of the image in each block area.

6 [0053]

Next, noise is removed from the results obtained  
by the Fourier analysis (step S7). The operation at  
9 step S5 to step S7 described above is performed once  
or more times and whether the processing is completed  
is determined (step S8). In the case where the  
12 processing is not completed, a transition is made to  
step S5 and in the case where the processing is completed,  
the results obtained by the Fourier analysis are  
15 displayed on the display as a pseudo color image (step  
S9). Further, a white and black image may be displayed.  
By repeating a plurality of cycles as described above,  
18 it is made possible to improve the accuracy of data.

[0054]

[Lung blood flow analysis]

21 Next, the lung blood flow analysis will be  
explained. FIG. 4 is a flowchart showing an outline of  
the lung blood flow analysis according to the present  
24 embodiment. The basic module 1 extracts images of DICOM  
from the database 15 (step T1). Here, at least a  
plurality of frame images included within one heartbeat  
27 cycle is acquired. Next, based on each acquired frame  
image, the blood vessel beat cycle is specified (step

T2). As described above, the blood vessel beat cycle is specified, for example, based on measurement results  
3 by other modalities, such as an electrocardiogram and a pulsimeter, or by specifying the heart/hilum pulmonis position/main blood vessel from the lung contour, and  
6 the blood vessel beat is analyzed by using a change in density/intensity of each region.

[0055]

9       Next, in FIG. 4, the respiratory cycle is specified by the above-described method (step T3) and the lung field is automatically detected by using the  
12 respiratory cycle (step T4). In the automatic detection of the lung contour, there is a case where fluctuations occur for each frame image, but by  
15 interpolating each frame image based on the respiratory cycle specified at step T3, the lung contour in each frame image is specified. Next, the detected lung field  
18 is divided into a plurality of block areas (step T5). Then, a change in each block area in each frame image is calculated (step T6). Here, the value of the change  
21 within each block area is averaged and represented as one piece of data. Next, for the value of density/intensity in each block area and the amount of  
24 change thereof, a Fourier analysis is performed based on the above-described blood vessel beat cycle (step T7). Due to this, it is made possible to extract and  
27 display the nature of the image in each block area.

[0056]

Next, noise is removed from the results obtained by the Fourier analysis (step T8). The operation at  
3 step T6 to step T8 described above is performed once or more times and whether the processing is completed is determined (step T9). In the case where the  
6 processing is not completed, a transition is made to step T6 and in the case where the processing is completed, the results obtained by the Fourier analysis are  
9 displayed on the display as a pseudo color image (step T10). Further, a white and black image may be displayed. Due to this, it is made possible to improve the accuracy  
12 of data.

[0057]

[Another blood flow analysis]

15 Next, another blood flow analysis will be explained. It is also possible to apply an aspect of the present invention to the blood flow analysis of the  
18 aorta, the abdominal blood vessel, the head internal carotid artery, and so on. FIG. 5 is a flowchart showing an outline of another blood flow analysis according to  
21 the present embodiment. The basic module 1 extracts images of DICOM from the database 15 (step R1). Here, at least a plurality of frame images included within  
24 one beat cycle is acquired. Next, based on each acquired frame image, the blood vessel beat cycle is specified (step R2). As described above, the blood  
27 vessel beat cycle is specified, for example, based on measurement results of other modalities, such as an

electrocardiogram and a pulsimeter, or by specifying  
the heart/hilum pulmonis position/main blood vessel  
3 from the lung contour, and the blood vessel beat is  
analyzed by using a change in density/intensity of each  
region.

6 [0058]

Next, the analysis range is set (step R3) and the  
set analysis range is divided into a plurality of block  
9 areas (step R4). Then, the value of the change within  
each block area is averaged and represented as one piece  
of data. Next, for the value of density/intensity in  
12 each block area and the amount of change thereof, a  
Fourier analysis is performed based on the  
above-described blood vessel beat cycle (step R5). Due  
15 to this, it is made possible to extract and display the  
nature of the image in each block area.

[0059]

18 Next, noise is removed from the results obtained  
by the Fourier analysis (step R6). The operation at  
step R5 and step R6 described above is performed once  
21 or more times and whether the processing is completed  
is determined (step R7). In the case where the  
processing is not completed, a transition is made to  
24 step R5 and in the case where the processing is completed,  
the results obtained by the Fourier analysis are  
displayed on the display as a pseudo color image (step  
27 R8). Further, a white and black image may be displayed.  
Due to this, it is made possible to improve the accuracy

of data.

[0060]

3           Note that, in the case where consideration is given  
three-dimensionally as described above, by measuring  
the respiration rate, the cardiac output, and the center  
6 bloodstream by different devices, it is made possible  
to measure the "partial pulmonary ventilation", the  
"lung bloodstream", and the "blood flow rate" in each  
9 section from those rates. In the case where measurement  
of the respiration rate, the cardiac output, and the  
blood flow on the center side is enabled by another  
12 modality or the like as quantitative measurement, it  
is made possible to estimate the estimated function  
amount by the amount of one frame, its rate, and the  
15 amount of change rate in the area. That is, in the case  
of the respiratory function analysis, estimation of the  
pulmonary ventilation is enabled by the respiration  
18 rate, in the case of the lung blood flow analysis,  
estimation of the lung bloodstream is enabled by the  
cardiac output (lung blood vessel output), and in the  
21 case of another bloodstream analysis, estimation of the  
estimated bloodstream (rate) in the branched blood  
vessel extracted from the bloodstream (rate) on the  
24 center side is enabled.

[0061]

As explained above, according to the present  
27 embodiment, it is made possible to evaluate the image  
of a human body although there are several problems in

other modalities, such as CT and MRI, by the photographing method at the present point in time. At least, as to the X-ray moving image device using a flat panel detector, it is possible to perform calculation favorably on the whole by the already existing facility device and the introduction cost is low. Further, in the X-ray moving image device using a flat panel detector, it is made possible to perform inspection of a subject in a simple manner. Furthermore, as to the lung blood flow, screening of the lung thrombus obstruction is enabled. For example, in the X-ray moving image device using a flat panel detector, by executing the diagnosis support program according to the present embodiment before performing CT, it is possible to exclude wasteful inspections. Further, the inspection is simple, and therefore, it is made possible to discover a highly emergent disease in an earlier stage and to deal with it with priority. Furthermore, in other modalities, such as CT and MRI, it is made possible to perform an elaborated diagnosis in each area.

[0062]

Further, it is also possible to apply the present invention to various blood vessels, for example, to screening of cervical blood flow narrowing and also to blood flow evaluation and screening of great vessels. Further, as to the pulmonary respiration data, the present invention is effective as the partial function

inspection of the lung and it is made possible to use  
the present invention for the pulmonary function  
3 inspection. Alternatively, identification of the  
disease, such as COPD and pulmonary emphysema, is also  
enabled. Further, it is also made possible to apply the  
6 present invention to grasp the properties and condition  
before and after an operation. Furthermore, by  
performing a Fourier analysis of the respiratory cycle  
9 and the blood flow cycle and removing the waveform of  
respiration and the waveform of the blood flow in the  
X-ray image of the abdomen, it is made possible to  
12 observe the abnormality of the other biological  
movements, for example, the intestinal tract ileus.

[0063]

15 Note that the present international application  
is based upon and claims the benefit of priority of the  
prior Japanese Patent Application No. 2016-141658,  
18 filed on July 19, 2016, the entire of which are  
incorporated herein by reference.

## 21 Reference Signs List

[0064]

- 1 basic module
- 24 3 respiratory function analysis unit
- 5 lung blood flow analysis unit
- 7 another blood flow analysis unit
- 27 9 Fourier analysis unit
- 10 waveform analysis unit

|   |    |                                 |
|---|----|---------------------------------|
|   | 11 | visualization/digitization unit |
|   | 13 | input interface                 |
| 3 | 15 | database                        |
|   | 17 | output interface                |
|   | 19 | display                         |
| 6 |    |                                 |

## CLAIMS

1. A diagnosis support program that analyzes images of a human body and displays analysis results, the program causing a computer to execute:

processing of acquiring a plurality of frame images from a database that stores the images;

processing of selecting a specific area from each of the frame images and specifying a respiratory cycle based on pixels in the selected specific area;

processing of detecting a lung field based on the specified respiratory cycle;

processing of dividing the detected lung field into a plurality of block areas and calculating a change in image in each of the block areas based on a relative position between each of the block areas and a lung contour;

processing of Fourier-transforming a change in image in each block area in each of the frame images;

processing of performing inverse Fourier transform by extracting frequency components corresponding to the respiratory cycle for Fourier transform results of a change in image in each of the block areas; and

processing of displaying each image after the Fourier analysis on a display.

2. A diagnosis support program that analyzes images of a human body and displays analysis results, the program causing a computer to execute:

processing of acquiring a plurality of frame images from a database that stores the images;

processing of specifying a blood vessel beat cycle of a subject;

processing of specifying a respiratory cycle based on pixels in a specific area in each of the frame images;

processing of detecting a lung field based on the specified respiratory cycle;

processing of dividing the detected lung field into a plurality of block areas and calculating a change in image in a block area in each of the frame images;

processing of Fourier-transforming a change in image in each block area in

each of the frame images;

processing of performing inverse Fourier transform by extracting frequency components corresponding to the blood vessel beat cycle for Fourier transform results of a change in image in each of the block areas; and

processing of displaying each image after the Fourier analysis on a display.

3. A diagnosis support program that analyzes images of a human body and displays analysis results, the program causing a computer to execute:

processing of acquiring a plurality of frame images from a database that stores the images;

processing of selecting a specific area from each of the frame images and specifying a blood vessel beat cycle of a subject based on pixels in the selected specific area;

processing of dividing an analysis range that is set for each of the frame images into a plurality of block areas and calculating a change in image in each block area in each of the frame images;

processing of Fourier-transforming a change in image in each block area in each of the frame images;

processing of performing inverse Fourier transform by extracting frequency components corresponding to the blood vessel beat cycle for Fourier transform results of a change in image in each of the block areas; and

processing of displaying each image after the Fourier analysis on a display.

4. The diagnosis support program according to claim 1 or 2, wherein

a respiratory cycle of a subject is specified based on a movement of a diaphragm, a movement of a thorax, or data of a spirogram.

5. The diagnosis support program according to claim 2 or 3, wherein

a blood vessel beat cycle of the subject is specified based on measurement results by other modality devices including an electrocardiogram or a pulsimeter,

and alternatively, a movement of a diaphragm and a thorax is extracted and a respiratory cycle of a subject is specified based on an image of a diaphragm and an image of a thorax at least included in each of the frame images, a lung field is detected based on the specified respiratory cycle, a position of a heart, a position of a hilum pulmonis, and blood vessel cycles of a main lung blood vessel and a large blood vessel are specified from the detected lung field, and a blood vessel beat cycle is specified based on a change in image of each specified region.

6. The diagnosis support program according to claim 1 or 2, wherein a relative position relationship between an inside of a lung field and blood vessels is calculated based on the specified respiratory cycle, and a shape of a lung of a subject is specified as a standard lung and a dynamic state of a blood flow of the subject is specified as a standard blood vessel area.

7. The diagnosis support program according to any of claims 1 to 3, wherein a lung field is divided into a plurality of block areas by plotting a plurality of points in accordance with a fixed rule on opposing contours of a lung field and by connecting opposing points by a segment.