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(54) OPERATING METHOD FOR A COMPUTER AND CORRESPONDING DEVICES

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(57) **ABSTRACT**

Two sequences (**13, 15**) of data sets (**14, 16**) having at least two dimensions and referring to an object (**17**) which changes over time are specified to a computer (**1**). Each data set (**14, 16**) in each sequence (**13, 15**) is assigned a measure of time which can be used to determine the temporal relationship of the data sets (**14, 16**) to the other data sets (**14, 16**) in the respective sequence (**13, 15**). The computer (**1**) compares the first data set (**14**) in the first sequence (**13**) with the data sets (**16**) in the second sequence (**15**) and automatically determines a first data set (**16**) from the second sequence (**15**) corresponding to a first data set (**14**) from the first sequence (**13**). With the aid of the corresponding first data sets (**14, 16**) in the first and second sequences (**13, 15**) and the measures of time assigned to the data sets (**14, 16**), the computer then determines, for each of the other data sets (**14**) in the first sequence, the corresponding data set (**16**) from the second sequence.

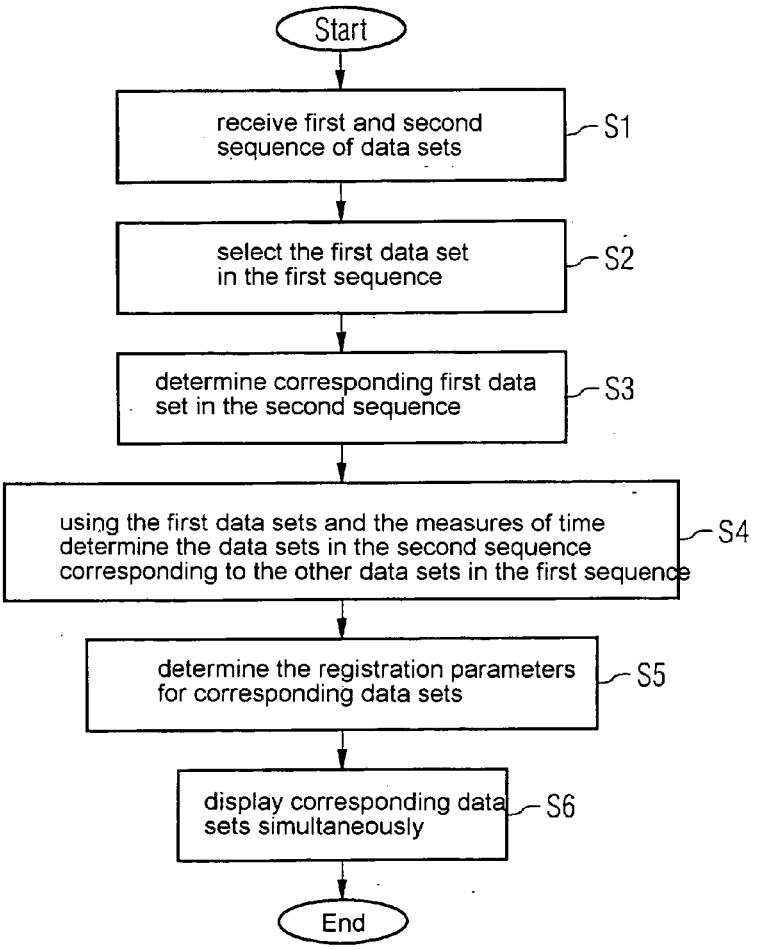


FIG 1

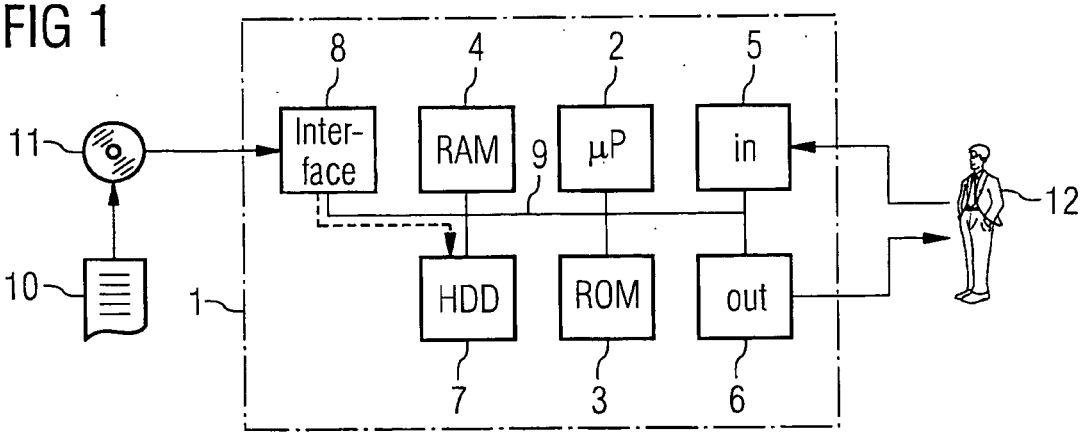

8
4
2
5
11
Inter-face
RAM
9
µP
in
12
10
1
HDD
ROM
out
7
3
6

FIG 2

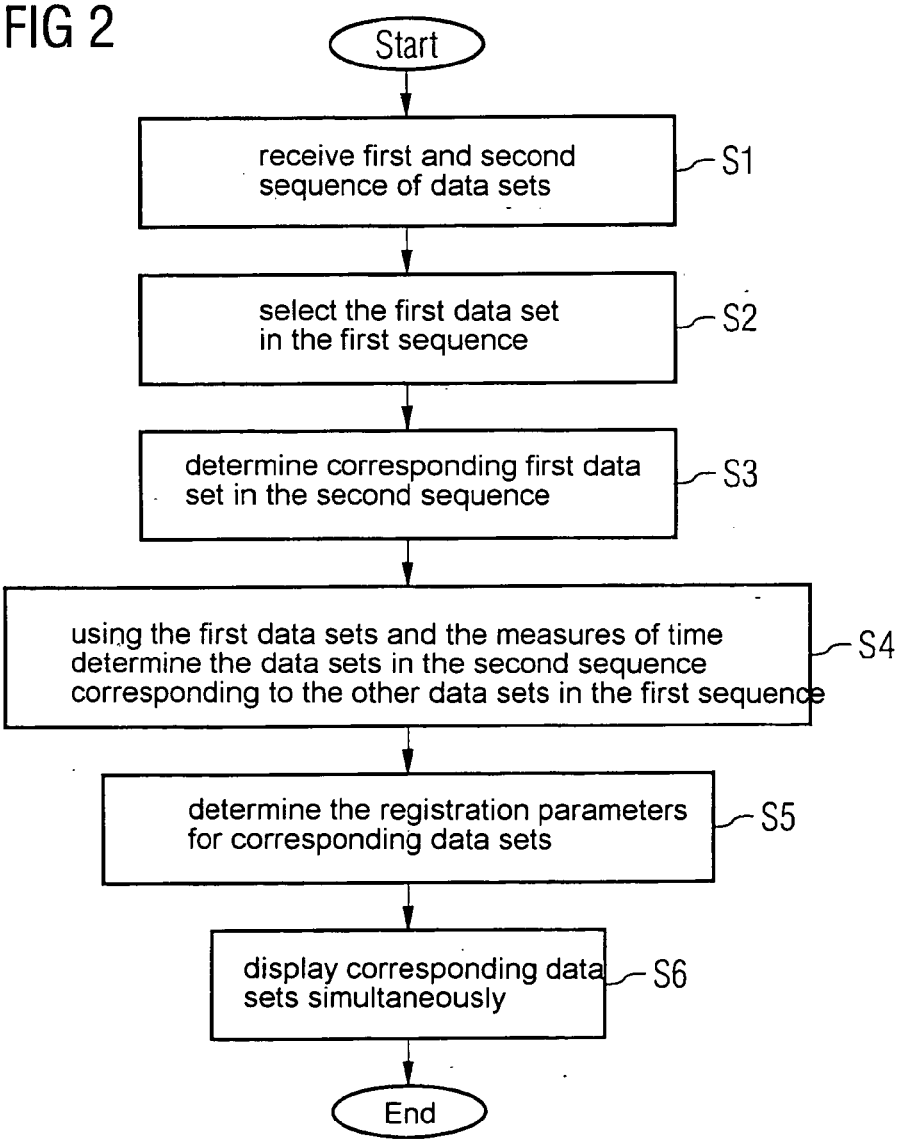

Start
receive first and second sequence of data sets
S1
select the first data set in the first sequence
S2
determine corresponding first data set in the second sequence
S3
using the first data sets and the measures of time determine the data sets in the second sequence corresponding to the other data sets in the first sequence
S4
determine the registration parameters for corresponding data sets
S5
display corresponding data sets simultaneously
S6
End

FIG 3

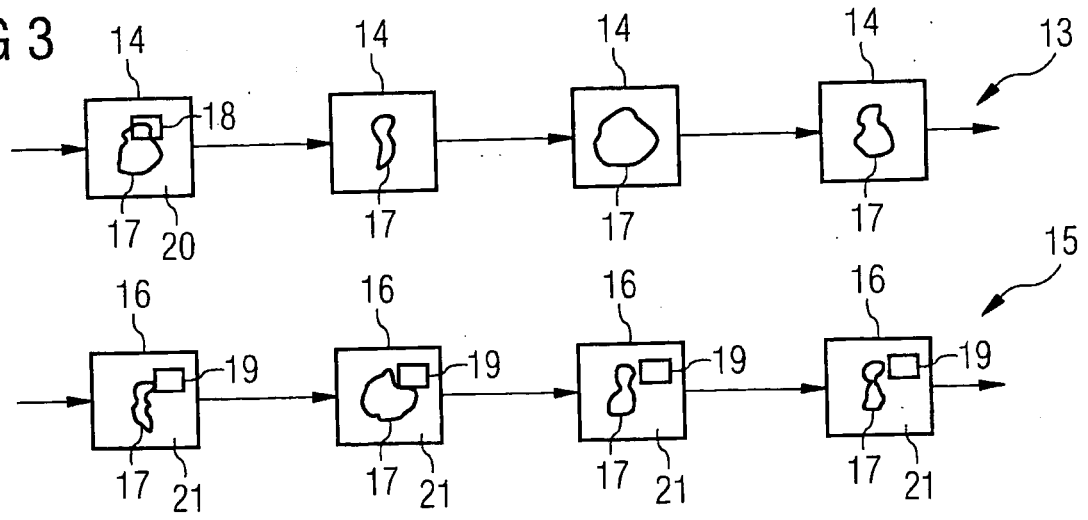



FIG 4

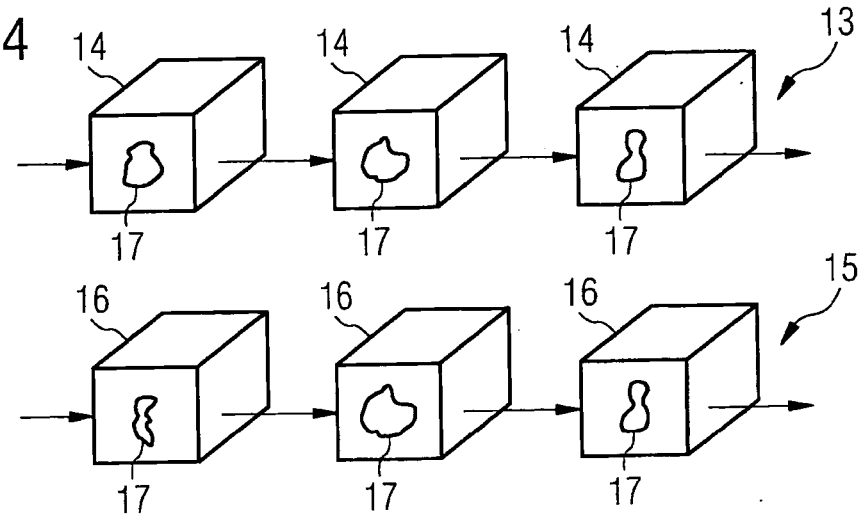



FIG 5

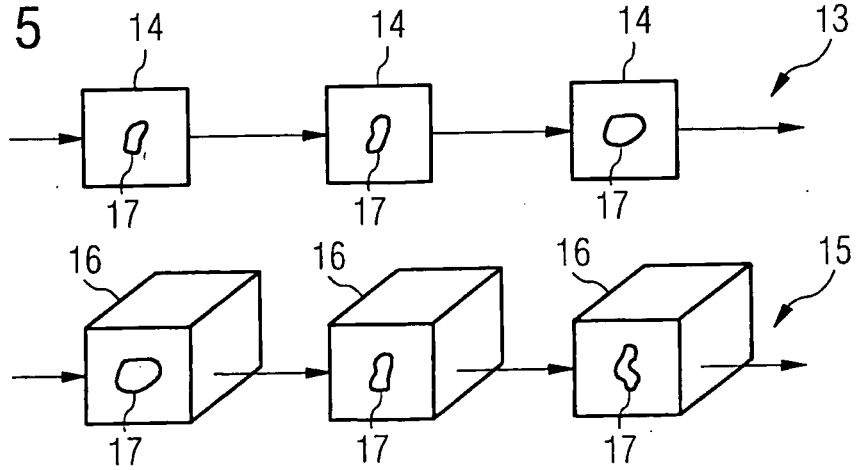


FIG 6

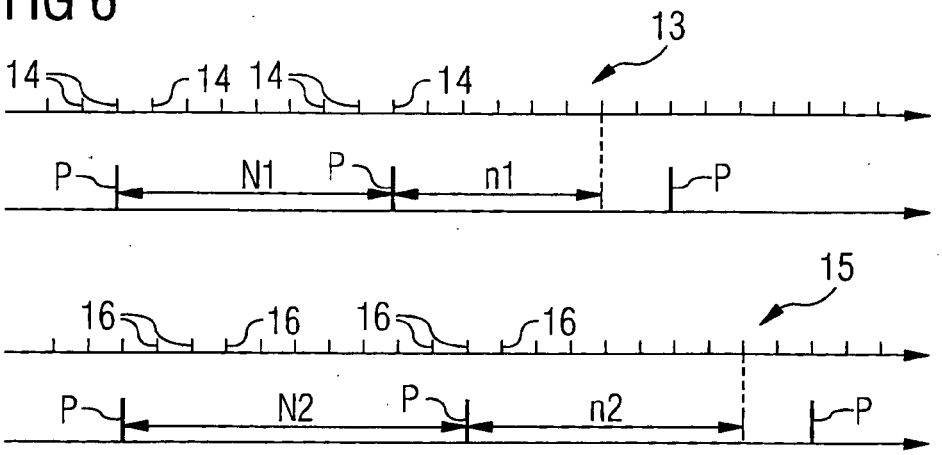

13
14
14
14
14
P
N1
P
n1
P
15
16
16
16
16
P
N2
P
n2
P

FIG 7

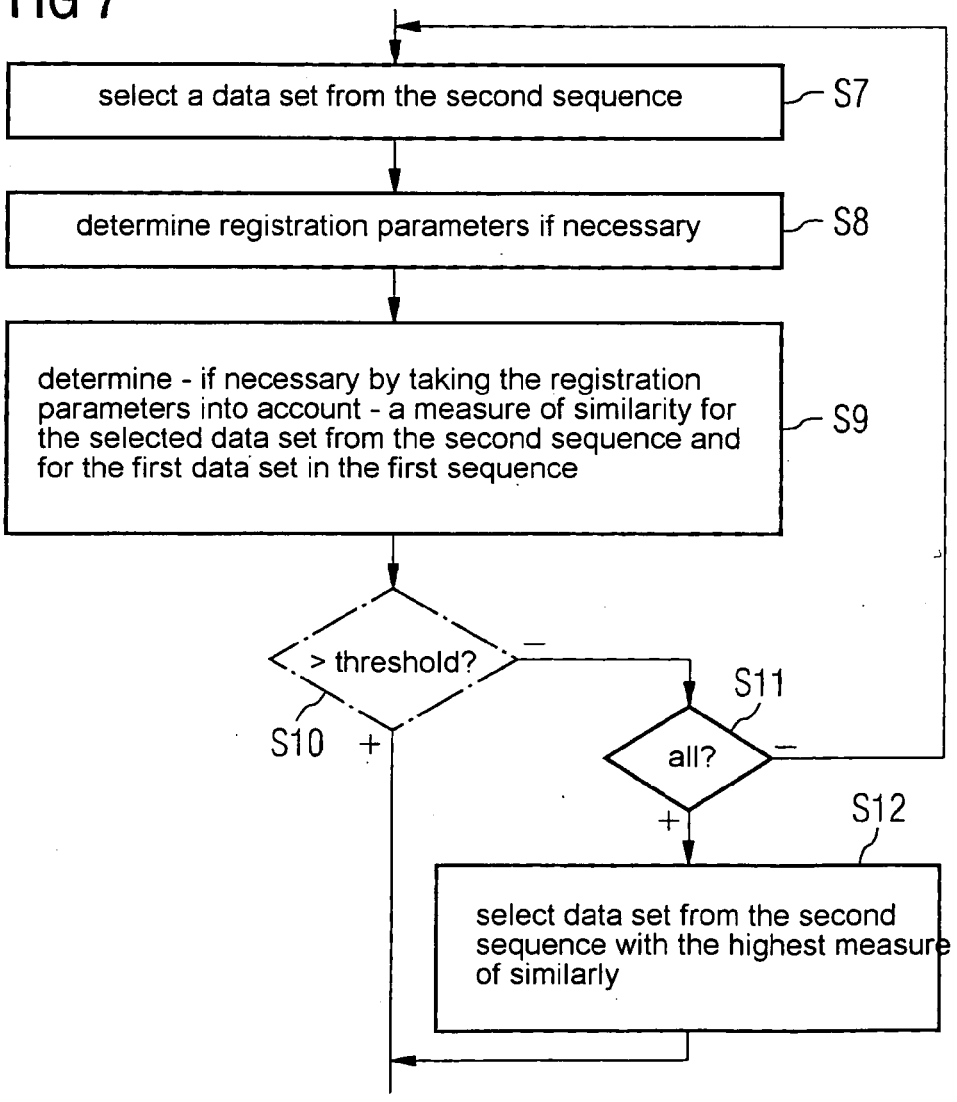

select a data set from the second sequence
S7
determine registration parameters if necessary
S8
determine - if necessary by taking the registration parameters into account - a measure of similarity for the selected data set from the second sequence and for the first data set in the first sequence
S9
> threshold?
S10
+
−
S11
all?
+
−
S12
select data set from the second sequence with the highest measure of similarly

FIG 8

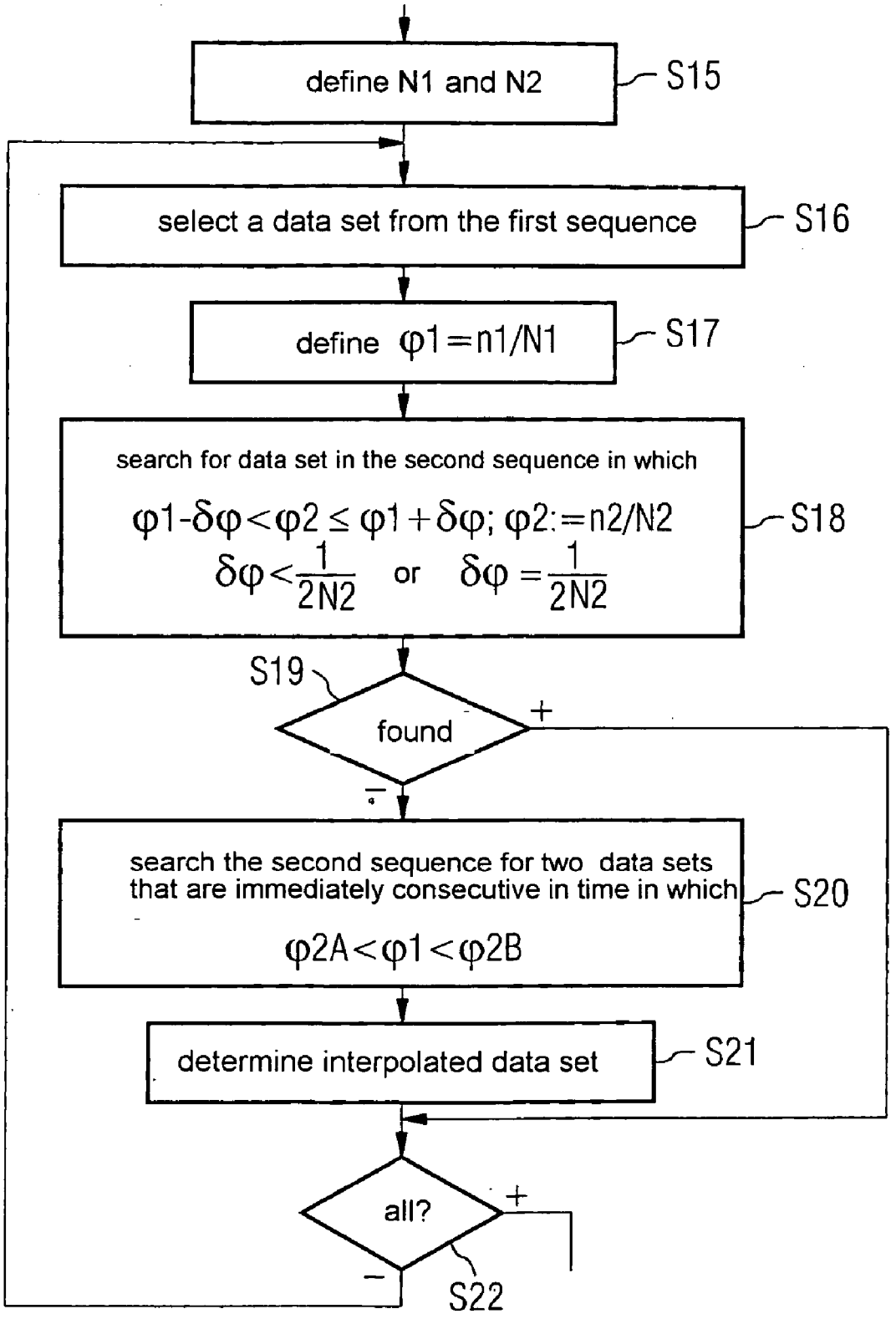
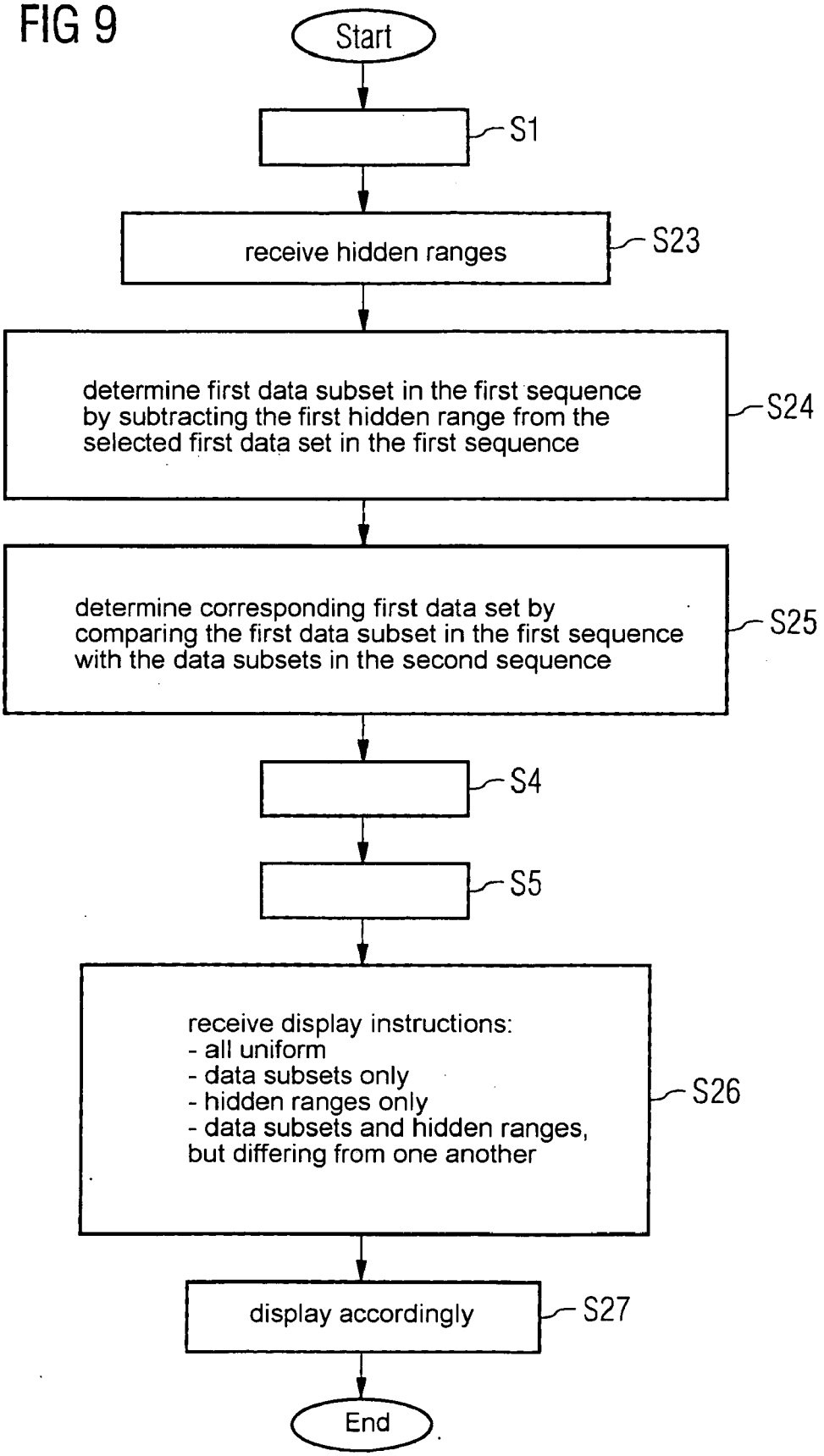

define N1 and N2
S15
select a data set from the first sequence
S16
define φ1=n1/N1
S17
search for data set in the second sequence in which
φ1-δφ<φ2≤φ1+δφ; φ2:=n2/N2
δφ<1/2N2 or δφ=1/2N2
S18
S19
found
+
−
search the second sequence for two data sets that are immediately consecutive in time in which
φ2A<φ1<φ2B
S20
determine interpolated data set
S21
all?
+
−
S22

FIG 9


Start
S1
receive hidden ranges
S23
determine first data subset in the first sequence by subtracting the first hidden range from the selected first data set in the first sequence
S24
determine corresponding first data set by comparing the first data subset in the first sequence with the data subsets in the second sequence
S25
S4
S5
receive display instructions:
- all uniform
- data subsets only
- hidden ranges only
- data subsets and hidden ranges, but differing from one another
S26
display accordingly
S27
End

# OPERATING METHOD FOR A COMPUTER AND CORRESPONDING DEVICES

[0001] The present invention relates to an operating method for a computer.

[0002] The present invention further relates to a data medium on which is stored a computer program for executing such an operating method. The present invention further relates to a computer having bulk storage in which a computer program is stored so that the computer executes such an operating method when the computer program is called.

[0003] A number of established methods exist for the registration and merging (joint display) of static data sets having at least two dimensions, such as images or volume data sets. Said methods are implemented on computers, and have been put into practice in a plurality of disciplines, particularly in the area of medical technology.

[0004] However, medical technology includes not only static data sets but also sequences of such data sets. Such sequences occur for example when recording heartbeats or in the thoracic region during respiratory procedures.

[0005] DE-A-102 14 763 discloses an operating method for a computer, which enables the automatic assignment of corresponding pairs of data sets from two sequences of such data sets. Said assignment is determined by evaluating ECG traces associated with the data sets.

[0006] JP-AA-06 125 499 discloses an operating method for a computer to which a data set and a sequence of data sets are specified. In this case the data sets are images of an object which changes over time. By comparing the first data set with the data sets in the sequence of data sets, the computer automatically determines a data set from the second sequence that corresponds to the first data set.

[0007] The object of the present invention is to create an operating method for a computer and corresponding elements, in order to create a further capability for determining the corresponding pairs of data sets at least to a large extent automatically in a way which is capable of being applied more widely.

[0008] This object is achieved by means of the elements specified in the individual claims **1**, **15** and **16**.

[0009] According to the invention a first sequence of data sets and a second sequence of data sets are specified to the computer, said data sets being images or volume data sets of an object which changes over time. Each data set in each sequence is assigned a measure of time which can be used to determine the temporal relationship of said data set to the other data sets in the sequence concerned. The computer first compares the first data set in the first sequence with the data sets in the second sequence and automatically determines a first data set from the second sequence corresponding to a first data set from the first sequence. With the aid of the corresponding first data sets in the first and second sequences and the measures of time assigned to the data sets the computer then determines, for each of the other data sets in the first sequence, the corresponding data set from the second sequence.

[0010] According to the invention, therefore, the corresponding pairs of data sets are determined in two stages, that is, by first of all determining a first mutually corresponding pair of data sets independently of the measure of time, and then using said pair of data sets and the measures of time to determine the remaining mutually corresponding pairs of data sets. In order to determine the first pair of data sets, the first data set in the first sequence and the data sets in the second sequence are checked for similarity. If a measure of the similarity between one of the data sets in the second sequence and the first data set in the first sequence exceeds a threshold, this data set in the second sequence is defined as the corresponding data set. It is of course also possible for the most similar of the data sets in the second sequence to be defined as the corresponding data set.

[0011] If necessary it is possible for the computer to determine registration parameters of the first data set in the first sequence and of the data sets in the second sequence relative to one another and then to make use of these registration parameters in determining the first data set of the second sequence that corresponds to the first data set of the first sequence. Fully automatic methods for determining said registration parameters are known: see for instance Pluim, J. P. W., Maintz, J. B. A., Viergever, M. A. (2003), "Mutual-information-based registration of medical images: a survey", IEEE Transactions on Medical Imaging **22**, pages 986 to 1004. However it is also possible for registration parameters to be defined interactively or semi-automatically. Methods of this kind are also generally known. An example of this is Maintz, J. B. A., Viergever, M. A. (1998), "A survey of medical registration", Medical image analysis 2 (1), pages 1 to 36.

[0012] In many cases the first data set in the first sequence is assigned an additional item of information which differs from the measure of time in that it characterizes the status of the object. Furthermore in these cases such an additional item of information is also assigned to at least one of the data sets in the second sequence. If said object is a heart, the additional information may be cardiac current signals or ECG pulses.

[0013] Frequently the object is one which changes periodically. In such cases therefore, the object changes with a first period according to the data sets in the first sequence, and with a second period according to the data sets in the second sequence. The periods may in fact be the same, but this need not be the case and they may therefore be unequal. For instance it is possible to imagine a heart that beats at a rate of 60 beats/minute when the data sets in the first sequence are recorded and at a heart rate of 70 beats/minute when the data sets in the second sequence are recorded. In such cases the measures of time in the first and second sequences are preferably directly related to the first or second period. If this is not the case, the computer must take the periods in the sequences into account when determining which of the data sets in the second sequence correspond to the various data sets in the first sequence.

[0014] A possible way for the computer to take the periods of the frequencies into account is first of all to determine, for each data set in the first sequence, a first phase position relative to the first period in each case. The computer should then preferably determine from the second sequence a data set having a second phase position relative to the second period that corresponds at least in some respects, and should define said data set as the corresponding data set. This

method is always used when the phase positions of the corresponding data sets are actually equal or differ only slightly from one another. It can also be used when the phase positions differ from one another. This situation is known as nearest interpolation. Depending on the position in each individual case, nearest interpolation can give better results than if the computer were to determine from the second sequence two data sets being immediately consecutive in time and having second phase positions which bisect the first phase position, and if the computer used an interpolation of the said two immediately consecutive data sets from the second sequence to determine an interpolated data set and were to define this as the corresponding data set. However, this last-mentioned method, which is known as true interpolation, is also conceivable and possible. As already indicated, it all depends on the position in each individual case.

[0015] With regard to mutually corresponding data sets the computer as a rule also determines their registration parameters. However, if this takes place at an earlier stage, when the first mutually corresponding pair of data sets is being determined, there is obviously no need to determine the registration parameters again at a later stage.

[0016] As a rule the computer displays mutually corresponding data sets simultaneously via an output device. Alternatively the traces can be displayed side by side or overlaid within one another according to choice.

[0017] It is possible that the computer may determine the mutually corresponding data sets in the first and second sequences with the aid of subsets of the data sets in the first and second sequences. This method can prove effective if the object has changed noticeably in the time between recording the data sets in the first sequence and recording the data sets in the second sequence. For example a lengthy interval may have elapsed between capturing the data sets in the first and second sequences, during which time a pathological change may have taken place in the object. By selecting appropriate, unchanged sub-ranges it is then possible to determine the corresponding pairs of data sets more reliably than by using all of the data sets.

[0018] It is possible for the computer to determine the data subsets itself. As a rule, however, the user specifies them to the computer. For example the user can specify hidden ranges to the computer, and the computer can then determine the data subsets from the data sets by subtracting the hidden ranges.

[0019] When specifying data subsets or hidden ranges, it is often the case that the only relevant ranges are those hidden ranges in which the changes actually took place. It is therefore possible for the computer to display only the data subsets, or only the differences between the data subsets and the data sets (i.e. the hidden ranges), or even the data subsets and the differences between the data subsets and the data sets (i.e. the hidden ranges) separately from one another.

[0020] The data sets in the sequences are mostly either all images or all volume data sets. However it is also possible for the data sets in one of the sequences to be images and the data sets in the other sequence to be volume data sets.

[0021] Further features and advantages of the invention will emerge from the description which follows of embodiments and from the accompanying drawings. These are schematic diagrams which show the following:

[0022] **FIG. 1** A block diagram of a computer,

[0023] **FIG. 2** A flow chart,

[0024] **FIG. 3** to **6** In each case schematic diagrams of a first and a second sequence of data sets, and

[0025] **FIG. 7** to **9** Flow charts.

[0026] According to **FIG. 1** a normal computer **1** has normal components **2** to **9**. These components **2** to **9** are a processor unit **2**, a read-only memory or ROM **3**, a working memory or RAM **4**, an input device **5**, an output device **6**, a bulk storage **7** and a data medium interface **8**, said components being interconnected via a bus system **9**.

[0027] A computer program **10**, which has been previously stored in exclusively machine readable form on a data medium **11**, can be stored in the bulk storage **7** of the computer **1** via the data medium interface **8**. When the computer program **10** has been stored in the bulk storage **7**, the computer program **10** can be called by a user **12** with the aid of appropriate call commands. When the computer program **10** is called, the computer **1** executes an operating method which is explained in detail below in conjunction with **FIG. 2**.

[0028] According to **FIG. 2**, in a step S1 a first sequence **13** of data sets **14** and a second sequence **15** of data sets **16** are first of all specified to the computer **1**. In this case the data sets **14**, **16** are data sets **14**, **16** of an object **17**, for example a heart **17**, which changes over time.

[0029] The data sets **14**, **16** in the sequences **13**, **15** are images **14**, **16** (see **FIG. 3**). Alternatively they can also be volume data sets **14**, **16** (see **FIG. 4**). **FIG. 5** shows that mixed forms, in which one of the sequences **13**, **15** has images and the other has volume data sets **14**, **16**, are also possible. Which of the sequences **13**, **15** has the images and which has the volume data sets **14**, **16** is of minor significance in the context of the present invention.

[0030] As shown in **FIG. 6**, each data set **14**, **16** in each sequence **13**, **15** is assigned a measure of time. Said measure of time can be used within the respective sequence **13**, **15** to determine the temporal relationship of a data set **14**, **16** to the other data sets **14**, **16** in the sequence **13**, **15** concerned.

[0031] According to **FIG. 2** a first data set **14** is selected from the first sequence **13** in a step S2. This selection will be dealt with in greater detail later in conjunction with **FIG. 8**. In a step S3 the computer **1** uses information other than the measures of time to determine automatically a first data set **16**, from the second sequence **15**, which corresponds to the first data set **14** in the first sequence **13**. With the aid of the pair of data sets **14**, **16** determined in the step S3 and the measures of time assigned to the data sets **14**, **16**, the computer **1** then also determines in a step S4, for each of the other data sets **14** in the first sequence **13**, the corresponding data set **16** from the second sequence **15**.

[0032] After determining the mutually corresponding data sets **14**, **16** from the sequences **13**, **15** the computer **1** then determines, in a step S5, the registration parameters relating to mutually corresponding data sets **14**, **16**. In a step S6 it then displays mutually corresponding data sets **14**, **16** simultaneously via the output device **6**. Alternatively the traces can be displayed side by side or overlaid within one another.

[0033] **FIG. 7** shows a possible implementation of the step S3 from **FIG. 2**. According to **FIG. 7** it is possible, in a step S7, to initially select a first data set **16** from the second sequence **15** in order to determine the first pair of data sets. In this case the computer **1** also determines if necessary, in a step S8, registration parameters of the first data set **14** in the first sequence **13** and of the data set **16**, selected from the second sequence **15** in the step S7, relative to one another. As already mentioned, it is possible for the registration parameters to be determined either fully automatically or interactively. In a step S9 the computer **1** determines a measure of similarity for this pair of data sets **14**, **16**. If step S8 has been executed, the computer **1** takes into account in step S9 the registration parameters determined in step S8.

[0034] From here on there are two possible ways of proceeding.

[0035] In the first of these it is possible, as shown by broken lines in **FIG. 7**, to check in a step S10 whether the measure of similarity determined in step S9 exceeds a predefined threshold. If this is the case, the method described above in connection with **FIG. 7** can be terminated. The most recently selected data set **16** from the second sequence **15** then corresponds to the first data set **14** in the first sequence **13**. If however the measure of similarity is below the threshold, the method proceeds to step S11. In this step the computer **1** checks whether it has yet selected all the data sets **16** in the second sequence **15**. If this is not the case, the computer **1** returns to step S7, where it then selects from the second sequence **15** another data set **16** that has not yet been checked. Otherwise in a step S12 it selects from the second sequence **15** the data set **16** which exhibits the highest measure of similarity.

[0036] The step S10 is indicated in **FIG. 7** by broken lines only, since it is optional. It can therefore be omitted. In this event the loop consisting of steps S7, S8, S9 and S11 is then executed until all the data sets **16** in the second sequence have been selected once. Step S12 is then executed. The difference between the two methods (with step S10 and without step S10) resides in the fact that in one case, examination of the data sets **16** in the second sequence **15** is terminated as soon as a sufficiently similar data set **16** is found, whereas in the other case the most similar data set **16** from the second sequence **15** is always determined. In both cases, however, the computer **1** determines the corresponding first data set **16** from the second sequence **15** by comparing the first data set **14** from the first sequence **13** with the data sets **16** in the second sequence **15**.

[0037] As can be seen from **FIG. 6**, at least some of the data sets **14** in the first sequence **13** are assigned additional information P, which differs from the measure of time. This additional information P characterizes the status of the object **17**. As already indicated, if said object **17** is a heart **17**, the additional information P may be cardiac current signals which can be used to determine the contraction phases of the heart **17**. Similarly it can be seen from **FIG. 6** that items of additional information P are also assigned to a plurality of the data sets **16** in the second sequence **15**.

[0038] **FIG. 6** also shows that the object **17** changes with a first period N1 according to the data sets **14** in the first sequence **13**, and with a second period N2 according to the data sets **16** in the second sequence **15**. In this example, in which the object **17** is a heart **17**, the pulse rates recorded for the first sequence **13** differ from those recorded for the second sequence **15**. In this case the computer **1** must take the periods N1, N2 in the sequences **13**, **15** into account when determining which of the data sets **16** in the second sequence **15** correspond to the various data sets **14** in the first sequence **13**. This is explained in detail below by reference to **FIG. 9**.

[0039] According to **FIG. 9**, in a step S15 the computer **1** first determines the periods N1, N2. In a step S16 it then selects a data set **14** from the first sequence **13**. In a step S17 it goes on to define a time interval $\phi 1$ between the selected data set **14** and the nearest preceding data set **14** to which the additional information P is assigned together with a corresponding first phase position $\phi 1$. By reference to the said data set **14**, in a step S18 the computer **1** looks in the second sequence **15** for a data set **16** separated by a time interval n2 from the nearest preceding data set **16** to which the additional information P is assigned. This data set **16** has to fulfill the condition that it must have a second phase position $\phi 2$ in which the separation from the first phase position $\phi 1$ of the selected data set **14** in the first sequence **13** is not greater than a maximum permitted phase difference $\delta\phi$. In a step S19 the computer **1** checks whether it can find a data set **16** of this kind in the second sequence **15**. If so, said data set **16** in the second sequence **15** has a phase position $\phi 2$ relative to the second period N2 that corresponds at least in some respects to the first phase position $\phi 1$. In this case the computer **1** is in a position to define this data set **16** as the corresponding data set **16**.

[0040] If on the other hand the computer **1** cannot find a data set **16** of this kind in the second sequence **15**, in a step S20 the computer **1** looks in the second sequence **15** for two data sets **16** that are immediately consecutive in time. These two data sets **16** have second phase positions $\phi 2A$ and $\phi 2B$ which bisect the first phase position $\phi 1$. The second phase positions $\phi 2A$ and $\phi 2B$ are determined in the same way as the second phase position $\phi 2$. In this case, by interpolation from these two data sets **16** from the second sequence **15** that are immediately consecutive in time, the computer **1** determines an interpolated data set and defines said interpolated data set as the corresponding data set in the second sequence **15**.

[0041] In a step S22 the computer **1** then checks whether it has yet executed the sequence of steps from S16 to S21 for all data sets **14** in the first sequence **13**. If this is not the case, the computer **1** returns to step S16 and selects another data set **14** from the first sequence **13**. Otherwise the process of determining the corresponding data sets **14**, **16** is terminated.

[0042] The method described above by reference to **FIG. 9**, in particular the steps S19 to S21, is effective and worthwhile if interpolation from data sets **16** that are immediately consecutive in time in the second sequence **15** is both advisable and feasible. In this case the maximum permitted phase difference $\delta\phi$ is preferably defined so that it is smaller than the reciprocal of twice the second period N2. This is expressed as follows:

$$\delta\phi < 1/2N2$$

[0043] If on the other hand a true interpolation from immediately consecutive data sets **16** of the second sequence **15** is not desired, the phase difference $\delta\phi$ is preferably set equal to twice the period of the second sequence **15**. In this

case the maximum permitted phase difference $\delta\phi$ is determined according to the following formula:

$$\delta\phi=1/2N2$$

[0044] In this case it is always possible to find in step S18 exactly one data set **16** from the second sequence **15** that fulfills the condition specified in the said step S18. The steps S19 to S21 can therefore be omitted in this case.

[0045] A variant of the method according to **FIG. 2** and **FIG. 7** will now be explained by reference to **FIG. 10**. The steps S1, S4 and S5 shown in **FIG. 10** correspond to those in **FIG. 2**. These steps will not therefore be described again here. Instead only the other steps appearing in **FIG. 10** will be explained, namely steps S23 to S27.

[0046] In step S23 the user **12** specifies to the computer **1** hidden ranges **18** for the data sets **14** in the first sequence **13** and hidden ranges **19** for the data sets **16** in the second sequence **15**. In step S24 the computer **1** uses the first data set **14** in the first sequence **13** to determine a first data subset **20** by subtracting the hidden range **18**. In step S25 the computer **1** uses data subsets **21** in the second sequence **15** to determine a first data set **16** in the second sequence **15**. The computer **1** then determines the data subsets **21** in the second sequence **15** by subtracting the second hidden ranges **19** from the data sets **16** in the second sequence **15**.

[0047] In step S27 the computer **1** receives an item of information from the user **12** defining what the computer **1** must display via the output device **6** and how the display is to be laid out. The information can specify that the computer **1** must display all the data sets **14**, **16** in a uniform manner. It is also possible for the computer **1** to be instructed to display only the data subsets **20**, **21** or only the hidden ranges **18**, **19**. It can also be instructed to display the data subsets **20**, **21** and the hidden ranges **18**, **19** together, but each in a different manner. In step S27 the computer **1** then displays the desired information via the output device **6** in accordance with the specifications in step S26. Here too the information is preferably displayed simultaneously.

[0048] The present invention thus makes possible a simple method for registering and merging sequences **13**, **15** of images and volume data sets **14**, **16**. The data sets **14**, **16** may originate from the same medical procedure, from similar medical procedures or from medical procedures that differ from one another. For example it is possible to register a sequence of two dimensional recordings of the heart **17** with a four dimensional data set produced by computer tomography. The additional information P in the form of ECG data should also be used in such a case.

**1-16**. (canceled)

**17**. A method for operating a computer, comprising:

specifying a first sequence of data sets and a second sequence of data sets to the computer and the data sets are images or volume data sets of an object that change over time;

assigning a measure of time to each data set in each sequence and is used to determine the temporal relationship of the data set to the other data sets in the respective sequence;

comparing the first data set in the first sequence with the data sets in the second sequence and automatically determining a first data set from the second sequence corresponding to a first data set from the first sequence; and

determining for each of the other data sets in the first sequence the corresponding data set from the second sequence with the aid of the corresponding first data sets in the first and second sequences and the measures of time assigned to the data sets.

**18**. The operating method according to claim 17, wherein the computer determines registration parameters of the first data set in the first sequence and of the data sets in the second sequence relative to one another and that the computer uses the registration parameters in determining the first data set of the second sequence corresponding to the first data set of the first sequence.

**19**. The operating method according to claim 17, wherein the first data set in the first sequence is assigned an additional item of information that differs from the measure of time in that it characterizes the status of the object and that the additional item of information is also assigned to at least one of the data sets in the second sequence.

**20**. The operating method according to claim 19, wherein the object is a heart and that the additional information consists of cardiac current signals.

**21**. The operating method according to claim 17, wherein the object changes with a first period according to the data sets in the first sequence and with a second period according to the data sets in the second sequence and the computer takes the periods in the sequences into account when determining which of the data sets in the second sequence correspond to the various data sets in the first sequence.

**22**. The operating method according to claim 21, wherein the computer determines a first phase position for each data set in the first sequence relative to the first period in each case and that in each case and for each data set in the first sequence the computer either preferably determines from the second sequence a data set having a second phase position relative to the second period that corresponds at least in some respects, and defines said data set as the corresponding data set or determines two data sets from the second sequence that are immediately consecutive in time and have second phase positions which bisect the first phase position and by interpolation from the two data sets from the second sequence that are immediately consecutive in time determines an interpolated data set which it defines as the corresponding data set.

**23**. The operating method according to claim 17, wherein the computer determines registration parameters relating to mutually corresponding data sets.

**24**. The operating method according to claim 17, wherein the computer displays mutually corresponding data sets simultaneously via an output device.

**25**. The operating method according to claim 17, wherein the computer determines the mutually corresponding data sets in the first and second sequences with the aid of subsets of the data sets in the first and second sequences.

**26**. The operating method according to claim 25, wherein a user specifies the data subsets to the computer.

**27**. The operating method according to claim 26, wherein the user specifies to the computer hidden ranges and the computer determines the data subsets from the data sets by subtracting the hidden ranges.

**28**. The operating method according to claim 25, wherein the computer displays mutually corresponding data sets

simultaneously via an output device and the computer displays only the data subsets, or only the differences between the data subsets and the data sets, or the data subsets and the differences between the data subsets and the data sets separately from one another.

**29**. The operating method according to claim 17, wherein the data sets in the first sequence are images and the data sets in the second sequence are volume data sets.

**30**. The operating method according to claim 17, wherein sets in the first sequence are volume data sets and the data sets in the second sequence are images.

**31**. A computer readable medium, comprising:

a computer program for executing an operating method, comprising:

specifying a first sequence of data sets and a second sequence of data sets to the computer and the data sets are images or volume data sets of an object that change over time;

assigning a measure of time to each data set in each sequence and is used to determine the temporal relationship of the data set to the other data sets in the respective sequence;

comparing the first data set in the first sequence with the data sets in the second sequence and automatically determining a first data set from the second sequence corresponding to a first data set from the first sequence; and

determining for each of the other data sets in the first sequence the corresponding data set from the second sequence with the aid of the corresponding first data sets in the first and second sequences and the measures of time assigned to the data sets.

**32**. A computer having bulk storage, comprising:

a computer program stored so that the computer executes an operating method, comprising:

specifying a first sequence of data sets and a second sequence of data sets to the computer and the data sets are images or volume data sets of an object that change over time;

assigning a measure of time to each data set in each sequence and is used to determine the temporal relationship of the data set to the other data sets in the respective sequence;

comparing the first data set in the first sequence with the data sets in the second sequence and automatically determining a first data set from the second sequence corresponding to a first data set from the first sequence; and

determining for each of the other data sets in the first sequence the corresponding data set from the second sequence with the aid of the corresponding first data sets in the first and second sequences and the measures of time assigned to the data sets.

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