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(54) Title: DEVICE AND METHOD FOR PROVIDING A STATE PARAMETER WHICH IS INDICATIVE OF THE WELLNESS OF AN ANIMAL

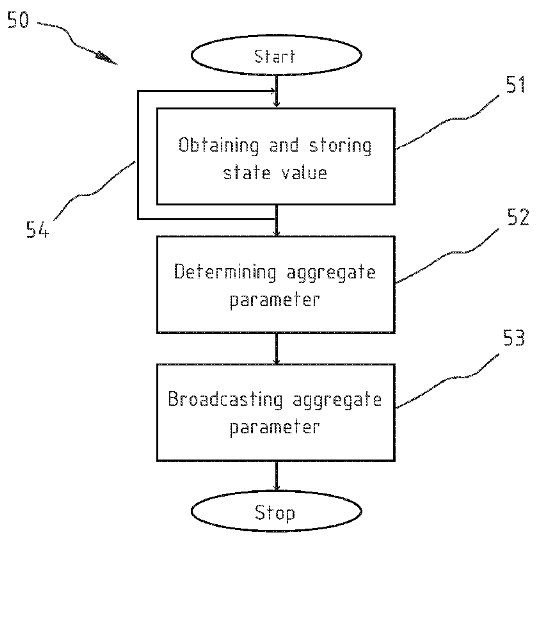

FIG. 3

(57) Abstract: A device configured for providing a state parameter which is indicative of the wellness of an animal, the device comprising a sensor comprising a memory, a processor and a transmitter. The sensor is configured to obtain a state value, the memory is configured to store each measured state value, the processor is configured to determine an aggregate parameter on the basis of a plurality previously measured state values, and the transmitter is configured to broadcast the determined aggregate parameter as the state parameter indicative of the wellness of the animal.

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DEVICE AND METHOD FOR PROVIDING A STATE PARAMETER WHICH IS INDICATIVE OF THE WELLNESS OF AN ANIMAL

The invention relates to a device which is configured for providing a state parameter which is indicative of the wellness of an animal.

Such a device can advantageously be used in for instance the field of cattle breeding, in which it is important to assess the wellness of animals during their lifetime. In particular it may be important to assess the wellness of for instance calves during their lifetime e.g. from closely after birth until processing after a number of months. Knowing the wellness of animals may serve several purposes, such as determining if a certain animal has been treated sufficiently well, e.g. according to regulations or agreements. Moreover, if it can be shown an animal is well, i.e. not sick and/or exhibiting out-of-ordinary behaviour, the animal can be sold for a higher price. Finally, if the wellness of animals is known, individual animals that are sick can be timely identified and separated from healthy animals, in order to avoid contamination.

In theory, it is advantageous to analyse a plurality of state values indicative of the current state of an animal at different points in time. For example, an animal's temperature could be measured in one-minute intervals during its lifetime. The time-evolution of the animal's temperature could then be analysed to indicate the wellness of the animal. However, providing a plurality of state values is a relatively laborious operation.

The invention therefore has as a purpose, next to other purposes, to provide a state parameter which is indicative of the wellness of an animal.

For this purpose, and other purposes, a device according to appended claim 1 is provided. Specifically, the device comprises a sensor, a memory, a processor and a transmitter. The sensor, for instance comprising measuring means, is configured to obtain, every first time interval and preferably using the measuring means, at least one state value which is indicative of the current state of the animal, such as animal activity and/or animal temperature. The memory is preferably configured to at least temporarily store each state value measured by the sensor, preferably the measuring means. The processor is preferably configured to determine an aggregate parameter on the basis of a plurality of previously measured state values, and the transmitter is preferably configured to broadcast the determined aggregate parameter as the state parameter indicative of the wellness of the animal.

The aggregate parameter, being based on a plurality of measured state values, may be indicative of the wellness of the animal and may assist a user, such as a cattle breeder, to determine the wellness of the animal. In particular, the aggregate parameter may be more indicative of the wellness of an animal than the most recently measured state value corresponding to the aggregate parameter. For instance, directly after transporting an animal, the animal's temperature may be elevated due to stress and/or the circumstances of transport. Therefore, measuring the animal's temperature directly after transport may give a somewhat elevated state value. Consequently, the current state value may not be sufficiently indicative for the wellness of the animal, since the elevation of temperature due to transport may mask deviations with respect to a normal temperature, which deviations are due to the animal being unwell. The aggregate parameter however, is based on a plurality of measured state values, which were each measured with the first time interval in between.

The aggregate parameter is preferably based on a relatively longer time period, e.g. at least several times the first time interval. The aggregate parameter may for instance be based on state values measured over a relatively long time, such as several hours, days, weeks or months. More particularly, the aggregate parameter may be based on all stored state values, i.e. the state values stored in the memory. The state values may be stored until shortly before or after the animal is processed. For these reasons, an aggregate parameter may be more indicative of the wellness of the animal, since recent deviations from a normal state caused by e.g. transport influence the aggregate parameter to a lesser extent than the current state value.

If the device is used starting shortly after birth of an animal, the aggregate parameters may act as a lifetime total indication of the state of the animal. The influence of recent and relatively short events, such as transport, on the aggregate parameter, is limited. The aggregate parameter can therefore more suitably be used to determine the wellness of the animal than the current state value.

Moreover, as multiple animals having been under the same circumstances would show a similar aggregate parameter, deviations between the aggregate parameters of different animals may indicate one or more of the animals are not well.

Further, since the aggregate parameter is based on a plurality of previously measured state values, it is to at least some extent based on a historic state of the animal. Therefore, if an animal has been unwell this may still reflect in the aggregate parameter at a later point in time, even if the animal has gotten well in the meantime.

The advantages described above may be achieved without actually analysing the entire time-evolution of the state value, which would have required making available the plurality of state values. Accordingly, it may not be necessary to transmit all state values for analysis in all cases. Consequently, providing the state parameter indicative of the wellness of the animal as an aggregate parameter as discussed has become less laborious. In particular, providing the aggregate parameter instead of a plurality of state values may reduce power consumption of the device. This may be especially advantageous when a power source for the device is limited, such as when the device is battery powered.

The processor may be configured to repeatedly calculate the aggregate parameter, for instance after every first time interval, so that the aggregate parameter can be updated with a state value measured anew. The transmitter may be configured to repeatedly broadcast the aggregate parameter, for instance after every first time interval. The intervals at which the processor calculates and the transmitter broadcasts the aggregate parameter may be different than the first time interval, in particular they may be longer than the first time interval. The transmitter may also be configured to continuously broadcast the aggregate parameter.

The aggregate parameter may be sent together with information identifying the device or the animal to which it relates, such as a registration code. Additionally or alternatively, a status of the device may be broadcast along, and/or a time stamp.

The transmitter may be a Bluetooth low energy (BLE) transmitter. Accordingly the aggregate parameter and/or state values may be transmitted in a BLE advertising packet.

The device may be configured to perform the below-described method according to the invention, with any features described in relation thereto, alone or in combination.

It is noted the broadcasted aggregate parameter may be received by another device suitable therefor, such as handheld terminal comprising a receiver and a processor.

In a particular embodiment of the device, the device is configured to transmit the at least one aggregate parameter together with the most recently obtained at least one state value. In particular the transmitter of the device may be configured therefor. The aggregate parameter and the state value may for instance be sent in the same BLE advertising packet.

Such a device may offer the advantage that the aggregate parameter and the most recently obtained state value are available at substantially the same time. Consequently, some historic information from the aggregate parameter can be compared to recent information from the most recently obtained state value. Therefore, it may be determined if the most recently measured state of an animal differs from its historic state, which could indicate a lack of wellness. A device providing the most recently measured state value and the aggregate parameter in a single transmission thus allows comparing the recently measured state value to the aggregate parameter.

Instead of only the most recently obtained at least one state value as described above, a number of recently obtained state values may be transmitted together with the at least one aggregate parameter. That number may be smaller than the total available number of the at least one state value, so that at least some instances of the at least one state value are not transmitted. The applicant has realized that sending all available state values may consume a relatively large amount of energy and/or take a relatively large amount of time, so that energy and/or time can be saved by transmitting no more than a limited number of recently measured state values. The number of recently obtained state values may be the most recently obtained state values. Alternatively the number of recently obtained state values may be a selection of the most recently obtained state values, the selection may for instance be a regular selection, e.g. every n^{th} most recent at least one state value may be selected, where n is a natural number (excluding zero) such as 1, 2, 3, 4, 5, 6, 7, 8, 9, or a higher number.

The number of at least one state values may be transmitted in e.g. the same BLE transmission packet.

The aggregate parameter may be broadcasted repeatedly at regular or irregular intervals, regardless of whether it is likely of being received. The most recently obtained at least one state value, or the number thereof, may be broadcasted accordingly.

Repeatedly broadcasting offers the advantage that no communication between a receiver and the device is needed prior to broadcasting. However, repeatedly broadcasting a relatively large amount of data could consume a relatively large amount of energy. The applicant has found that sufficient information can be inferred if the aggregate parameter is broadcast together with the most recently obtained at least one state value, or with a number thereof. Accordingly, energy can be saved, so that the device can be used longer, e.g. the entire lifetime of an animal.

The device may be attached to the animal in any suitable manner e.g. via a collar or an earmark. It is however preferred if the device is a sub-cutaneous device. Such a device could remain with an animal for a prolonged period of time. Therefore, the state of the animal could be measured during a prolonged period of time with relative ease. A sub-cutaneous device may also provide a measurement method which relatively robust against tampering, since it may be removable from an animal only with relatively difficulty.

It is possible the broadcasted information, such as the aggregate parameter, can not be received at all times. For instance, if an animal equipped with a sub-cutaneous device moves outside, into a truck for transport, or somewhere else out of range of any receivers, the broadcasted information may not be received. However, since the aggregate parameter is based on a plurality of state values, and thus to some extent is based on a historic state of the animal, receiving the aggregate parameter when the animal moves back in range of receivers may be sufficient for indicating the wellness of the animal.

The sensor of the device may comprise an accelerometer. The sensor may accordingly be configured to measure a magnitude of acceleration for obtaining the at least one state value. The magnitude of acceleration may be a suitable indication of animal activity. Animal activity may be interpreted as whether the animal is active, i.e. whether it is performing movements such as walking, shaking its head, standing up, or inactive, e.g. whether it is standing still or lying.

The acceleration may be measured in three components corresponding to three respective axes which are perpendicular to each other, i.e. the acceleration may be measured as a 3D vector. The magnitude may then be determined by taking the root of the sum of the squared magnitude for each individual axis. Accordingly, the determined magnitude may be a scalar, which can thus be represented by a single value.

In particular, the device may be configured to high pass filter the measured acceleration for obtaining the state value. More in particular, the sensor and/or processor may be configured to high pass filter the measured acceleration.

The acceleration signal measured may include a force vector caused by gravity. Since the force vector exerted on the device by gravity is constant, the influence of gravity may be eliminated using high-pass filtering. It is noted that when an animal moves, especially if the movement involves rotations, the device may move and/or rotate as well. Therefore, the force vector of gravity may change with respect to the device. In practice however, an animal often moves sufficiently slowly to filter out the influence of gravity by selecting an appropriate threshold frequency for the high pass filter. Accordingly, movement of the animal does not necessarily detriment the filtering of gravity.

A magnitude of acceleration may be measured every second time interval, which is equal to or smaller than the first time interval. Further, the device may be configured to determine a value indicative of the amount of time during the first time interval wherein the magnitude of acceleration is above a predefined threshold for obtaining the state value.

It was found that the total time an animal was active during an interval, e.g. a first time interval, gives a reliable measure for animal activity during said time interval. Moreover, the amount of time during said interval can be represented by a single value, so that limited hardware resources are necessary for storing, transmitting and processing it. A threshold value of 250 mg, i.e. approximately 2,45 m/s^2 may be selected. Practical tests have revealed this threshold to give measurement results that can be reliably correlated to the animals actual behaviour.

The state value indicating animal activity may be obtained by dividing the amount of time the animal was active during said interval by the length of said interval, so that the state value is a ratio of active time in said interval over total duration of said interval.

For obtaining the state value, e.g. to determine the value indicative of the amount of time the animal was active during the first time interval, the device may be configured to count the amount of measurements conducted every second time interval within the first time interval, for which the magnitude of the acceleration was above the predefined threshold.

By counting the measurements for which the threshold was exceeded, relatively little power is consumed. Moreover, power may be saved when the threshold is not exceeded, because during those times counting is not necessary. Furthermore, no communication, such as serial communication, is necessary between the accelerometer and the processor for counting the measurements. Since communication may be power intensive, counting provides an effective way of reducing power consumption.

The device may further comprise a counter separate from the processor, configured to perform said counting. This may offer the advantage that the processor may idle even when the counter is counting, so that energy may be saved. It is noted the counter may be a counter internal to the processor, which can be activated separate from the main processor. Such an internal counter can still perform counting whilst the processor is idle.

Practically, the counter may be configured to start and stop based on an interrupt signal provided by the sensor, for instance by the accelerometer, wherein the interrupt signal is based on a comparison between the magnitude of the measured value such as acceleration and the predetermined threshold. Since the accelerometer, or other type of sensor, may provide the interrupt signal, no further processing is required to start and stop the counter. Therefore, the relatively little power is consumed. In particular, the interrupt signal may be provided at an input pin of the counter which may be configured as edge-sensitive, so that the counter can start and/or stop when the interrupt signal changes.

For determining the at least one aggregate parameter, the device may be configured to sum said plurality of obtained state values. In particular, the processor may be configured to sum said plurality of obtained state values.

Summing the obtained state values indicating the animal’s activity over the first time interval results in an overall indication of the animal’s activity over the period represented by the plurality of state values. Together with the total duration of the period during which the plurality of state values were observed, an average activity level for the animal may be determined. The average activity level may then be used to compare to the average activity level of other animals of e.g. the same age, and/or to recently measured or observed activity levels. In both cases large deviation may indicate a lack of wellness.

When state values are summed to determine the aggregate parameter, state values that have already been accounted for in the aggregate parameter need not necessarily be stored in the memory any longer. Instead, an updated aggregate parameter can be determined by adding newly measured state values to an old aggregate parameter. It may however be advantageous to store the individual state values so that they may be retrieved for analysis later, if so desired.

In yet another embodiment of the device, the device further comprises temperature measuring means configured to measure a temperature of the animal for obtaining the at least one state value.

The temperature of an animal may be used to determine whether an animal is well. Particularly, changes in the temperature of an animal may be an indication that the animal is not well.

Accordingly, the device's processor may be configured to determine the aggregate parameter for the state value based on the temperature by determining a value indicative of the fluctuation of temperature measurements, such as the total variation of the temperature measurements taken every first time interval.

Using the total variation as an aggregate parameter results in an aggregate parameter that is higher when the temperature has fluctuated more strongly. Consequently, for animals of a certain age, a higher aggregate parameter may indicate a higher chance of the animal being or having been unwell. Alternatively or additionally, a higher total variation of temperature may indicate the living conditions of the animal have been undesirable.

The sensor may be configured to obtain more than one type of state value. For instance, the sensor may be configured to obtain the acceleration as well as the temperature as described above. The processor may accordingly be configured to determine separate aggregate parameters for each of the types of state values. In particular, an aggregate parameter for the temperature may be determined based on temperature measurements and an aggregate parameter for the activity may be determined based on the accelerometer measurements. More types of state values may be obtained, however it is not strictly necessary to provide aggregate parameters for all types of state values.

In yet another embodiment of the device, the device further comprises a receiver for receiving a request for transmitting one or more stored state values from an external device, wherein the transmitter is configured to, upon receipt of the request, transmit the one or more stored state values.

Transmitting stored state values on request has the advantage that if one or more state values have not been received (e.g. because they have not been sent, or have been sent when out of range of the receiver), the state values may later still be obtained. This embodiment is particularly practical in combination with a device which also broadcasts aggregate parameters, since the aggregate parameter may be used to determine whether one or more state values are of interest. Accordingly, using the aggregate parameter, only those state values that are of interested may be requested from the device. State values that are not of interest may not be requested and thus not sent by the device. Therefore, the amount of state values sent is limited with respect to e.g. a situation in which all state values were requested or broadcasted. Since transmitting state values requires power, this embodiment may aid in saving power, by limiting the amount of state values to be sent.

In yet another embodiment of the device, the processor is configured to calculate state values for every third time interval on the basis of the stored state values measured every first time interval within said third time interval, upon receipt of a request by receiver, if said request specifies a third time interval included in the request transmitted by the external device, which third time interval is preferably greater than the first time interval. The device is thus arranged to receive a length value for the third time interval and calculate and possibly transmit the state values within the third interval.

In such an embodiment the amount of state values to transmit may be limited. Consequently the time to transmit the data and the power required therefore may be limited accordingly.

Preferably the third interval is or is adjusted to be an integer multiple of the first time interval.

The current disclosure also relates to a method of providing a state parameter which is indicative of the wellness of an animal, the method comprising the steps of a) obtaining, every first time interval, by using at least a sensor, at least one state value being indicative of the current state of the animal, such as animal activity and/or animal temperature, and at least temporarily storing each measured state value in a memory; b) determining, using a processor, at least one aggregate parameter on the basis of a plurality of obtained respective state values; and c) broadcasting, using a transmitter, the determined at least one aggregate parameter as the state parameter indicative of the wellness of the animal.

The method according to the invention may be performed by a device as described above. Accordingly, the method may include any of the steps and/or features presented in relation to the device, alone or in any combination whatsoever. The method may offer the corresponding advantages.

In step a) of the method, the at least one state value may be obtained. Preferably, the step of obtaining comprises measuring using at least a sensor. Alternatively or additionally, the step of obtaining one state value may include obtaining from the sensor obtained sensor data including at least one state value.

It is further to be noted that the at least one aggregate parameter may assist a user, such as a cattle breeder, in determining the wellness of an animal. Preferably, the method is as such not a diagnostic method.

The disclosure also relates to a method of obtaining a state parameter which is indicative of the wellness of an animal, the method comprising receiving an aggregate parameter using a receiver, wherein the aggregate parameter is provided using the method as described above. This method may be particularly useful if use is made of a sub-cutaneous device, and the transmission is wireless.

The method preferably further comprises receiving the aggregate parameter at a first point in time; receiving the aggregate parameter at a second point in time which is later than the first point in time, and determining a measure indicative of state values upon which the aggregate parameter is based during a time interval between the first and second points in time, preferably by subtracting the aggregate parameter received at the first point in time from the aggregate parameter received at the second point in time.

Using the two aggregate parameters received at different times, a measure of the state of the animal in between the moments at which the aggregate parameters have been determined can be derived. This measure may then be used, for instance to assist in determining animal wellness, but also to determine if the state values need to be downloaded from the device by sending a request for them.

The method may further include: d) determining that one or more measured state values are of sufficient interest to be requested by comparing the received aggregate parameter to a predetermined condition; e) requesting the transmittal of one or more stored measured state values by transmitting a request; and f) receiving the transmitted one or more stored measured state values.

Such a method has the advantage that state values are only requested if they are of sufficient interest. Consequently, the device from which the state values are requested does not have to provide all state values. Therefore, the method may facilitate reducing the power consumption of a device capable of sending state values. Such a device may e.g. be a device as described above. Determining whether the state values are of sufficient interest may be performed by comparing the aggregate parameter to a predetermined condition.

Therefore the method may comprise determining that the one or more measured state values are of sufficient interest to be requested if and when: the aggregate parameter lies outside a predetermined range; and/or the most recently measured at least one state value differs from a normal and/or average situation indicated by the respective aggregate parameter by a predetermined amount or more.

The aggregate parameter may thus be used as a measure for, or may assist in determining, the animal's condition. The aggregate parameter can be used for comparison with predefined ranges, i.e. normal or average values of the aggregate parameter, and/or to aggregate parameters achieved from animals of the same age being subjected to the same circumstances, such as animals in the same flock or group.

The aggregate parameter lying outside the predetermined range may mean any or more of the following:

- the aggregate parameter exceeds a predetermined threshold;

- the aggregate parameter is smaller than a predetermined threshold;

- the aggregate parameter deviates more than a predetermined threshold from an expected or average value.

The predetermined thresholds and/or expected or average values may be set based on the aggregate parameters obtained from other animals, such as animals of the same age subjected to similar conditions, e.g. animals in the same flock or group. Alternatively or additionally, the predetermined expect or average value may be based on a previous value of the aggregate parameter of the same animal.

The disclosure also relates to a device comprising a transmitter, a receiver and a processor, which is configured to perform the method steps described above in relation to receiving the aggregate parameter.

The disclosure further relates to an assembly of such a device and a device described above in relation to measuring state values and broadcasting the aggregate parameter.

The device and method will be further elucidated with reference to the attached figures, wherein:

- Figure 1 schematically shows an embodiment of the device, for providing an aggregate parameter;
- Figure 2 schematically shows an embodiment of another device, for receiving an aggregate parameter;

- Figure 3 shows a flow diagram of an embodiment of the method;
- Figure 4 shows a flow diagram of an exemplary method of obtaining a state value;
- Figure 5 shows a flow diagram of an exemplary method of determining an aggregate value;
- Figures 6a and 6b show exemplary acceleration data;
- Figure 7 shows exemplary temperature data; and
- Figure 8 schematically shows communication between two devices, one providing an aggregate parameter and state values, the other requesting state values.

In the figures, like elements are referred to by like reference numerals.

Figure 1 shows a device 1 configured for providing a state parameter which is indicative of the wellness of an animal. The device comprises a sensor 2, a processor 3 and a transceiver 4. The transceiver 4 is a combination of a transmitter and a receiver. In this example, the sensor 2 includes a memory 5, an accelerometer 6 and temperature measuring means 7. The processor 3 includes an internal counter 3a, which can be activated separately and independently from the processor 3 itself. In this embodiment the temperature measuring means 7 comprise a thermometer, but other suitable temperature measuring means 7 could be used. The device 1 is a sub-cutaneous device and it may therefore be introduced under the skin of an animal. The device 1 is appropriately shielded to be installed sub-cutaneous, and the transceiver functions wirelessly. The device 1 is powered by a battery (not shown).

Figure 2 shows a device 8 comprising a transceiver 9 and a processor 10. The transceiver 9 of device 8 is configured to receive and transmit information from and to the device 1 of figure 1, via its transceiver 4. The device 8 of figure 2 may further include a display 11, which is configured to display a received aggregate parameter and state values. The display 11 may further include a user interface, allowing a user to perform inputs for e.g. indicating that certain state values are requested.

The devices 1 and 8 are configured to perform methods as described. Therefore, the device will be further explained with reference to figures 3 - 5 which show flow diagrams of described methods.

Figure 3 shows a flowchart of an embodiment of the method 50 according to the invention. The method 50 is performed by the device 1 of figure 1, which is placed sub-cutaneous in an animal (not shown). The method 50 includes a first step 51 of obtaining at least one state value which is indicative of the current state of an animal. In this first step 51, the sensor 2 is used to obtain the state value. In the exemplary embodiment shown, two separate state values are obtained via the sensor 2. The accelerometer 6 is used to obtain a state value indicating animal activity and the temperature measuring means 7 are used to obtain a state value indicating animal temperature. Both state values are stored in the memory 5 of the sensor 2. Figure 3 indicates using repeat line 54 that the first step 51 is repeated every first time interval. As an example, each obtained state value may be saved, so that they remain available for retrieval and further analysis at a later point in time. Alternatively, the state values may be saved temporarily, e.g. until they have been accounted for in an aggregate parameter.

In a second step 52 of the method 50, two aggregate parameters are determined on the basis of a plurality of respective state values. In other words, an aggregate parameter is determined on the basis of the state values indicating animal activity, and another aggregate parameter is determined on the basis of the state values indicating animal temperature. The processor 3 of device 1 is employed to perform this second method step 52.

In a third method step 53 the determined aggregate parameter is broadcasted. The device 1 employs the transceiver 4 for this purpose. The aggregate parameter is indicative of the wellness of the animal. In the third method step 53, also the most recently obtained state value is broadcasted. In fact, the aggregate parameter is broadcasted together with said state value in a single BLE advertising packet.

Although not indicated here, the second and third method steps 52, 53 are repeated every first interval as well, however any other time interval could be chosen.

Figure 4 shows a method 60 according to which a state value relating to animal activity is obtained. Accordingly, the method 60 is performed every first time interval as part of the first method step 51 of the method 50 according to the invention presented in figure 3. In a first method step 61 a counter is reset, i.e. its value its set to zero. This first method step 61 can be performed by the processor 3, e.g. by sending a signal to the counter 3a. In a second method step 62, an acceleration vector is measured using the device’s 1 accelerometer 6. Next, the acceleration is high-pass filtered in a third step 63, and a magnitude of the acceleration is determined in a fourth step 64. In some embodiments, determining the magnitude 64 may take place before filtering 63. The accelerometer 6 of the device 1 is configured to perform the high pass filtering, and to determine the magnitude. The accelerometer 6 further includes an interrupt-output which is set up to indicate whether a threshold acceleration value is exceeded. The accelerometer 6 thus compares the measured acceleration with a predetermined threshold. In this example the accelerometer measures a 3D acceleration vector, and separately compares all three components of the acceleration vector to a predetermined threshold of 250 mg. It is however possible use a threshold for only one or some of the axes, or to base the comparison on a combination of axes, e.g. on the magnitude of the complete acceleration vector. The accelerometer 6 raises a signal via the interrupt-output when the measured acceleration is higher than the predefined threshold. The interrupt-output of the accelerometer 6 is connected to an input of the counter 3a which is configured as edge-sensitive, so that the counter 3a starts and/or stops when the interrupt-output changes. Consequently, in a fifth method step 65, the counter 3a is started if the measured acceleration value exceeds the predetermined threshold, and is stopped otherwise. As indicated by repeat line 66, the second, third, fourth and fifth method steps 62, 63, 64, 65 are repeated every second time interval. The second time interval is smaller than the first time interval. At the end of every first time interval, the counter 3a has a value indicative of the amount of time during said first time interval the acceleration was above a predefined threshold. This value is used as state value for animal activity. It is however possible to instead use a ratio of the counter value and the duration of the first interval.

To determine the aggregate parameter for animal activity, the processor 3 sums all state values pertaining to the animal activity in the third method step 53 of the method 50 of figure 3.

Figure 5 shows a method 70 for obtaining an aggregate value relating to animal temperature. The method includes a first step 71 of measuring an animal temperature. The animal temperature is used as a state value directly in the method 50 of figure 3. Therefore, the first method step 71 is an exemplary implementation of the method step 51 of obtaining and storing a state value. The animal temperature is thus stored in the memory 5 of the sensor 2. As shown using repeat line 74, the animal temperature is measured and stored every first time interval. To determine the aggregate parameter (step 52 in the method 50 of figure 3), a second step 72 of determining the total variation of animal temperature follows.

Figure 6a shows a graph 80 including a curve 81 connecting data points 82 indicating measured acceleration at different points in time on a time axis t and acceleration axis a. Each data point 8 corresponds to a second time interval. Two dotted lines show an upper threshold 83 and a lower threshold 84. As explained above, the accelerometer 6 is configured to raise an interrupt signal if the measured acceleration exceeds a threshold. Since the measured acceleration is directional, also a lower threshold 84 is shown here. In practice, one could compare the magnitude of the measured acceleration to a single (positive) threshold 83. The graph 80 further includes the interrupt signal 85 corresponding to the acceleration measurements shown. As shown, the interrupt signal 85 is high when the measured acceleration exceeds the threshold 83. The interrupt signal is however only raised when at least two consecutive data points 82 exceed the threshold 83, so that a run-up period 86 is implemented. The run-up period 86 could be extended to more data points if desired, or could be left out.

Figure 6b shows a similar graph 80’ over a larger span of time, e.g. a first time interval. The graph 80’ shows two periods 87 during which the measured acceleration exceeded the upper threshold 83 or dropped below the lower threshold 84. Consequently, the interrupt signal 85 was raised during these two periods. As explained above, the counter 3a runs only during these periods, so that after the first time interval has passed, the counter 3a shows a value indicative of the time during which the measured acceleration exceeded a threshold 83, 84

Figure 7 shows a graph 90 including temperature curves constructed from animal temperatures measured from two different animals. The first temperature curve 91 corresponds to an animal that is well, whereas the second temperature curve 92 corresponds to an animal that is unwell. The curves are plotted on a horizontal time axis t and a vertical temperature axis T. The horizontal time axis spans several first time intervals. At a first moment in time t_1 and at a second moment in time t_2 the curves show similar temperatures. However, the temperature curve 92 of the animal that is unwell has fluctuated more than the temperature curve 91 for the animal that is well. Consequently, a value indicative of said fluctuation may be used to determine if an animal is unwell. Accordingly, the total variation can be suitably used.

Figure 8 shows a first device 1 and a second device 8, configured for performing embodiments of the method. The first device 1 performs the method 50 as shown in figure 3, and thus broadcasts aggregate parameters as shown via first communication line 101. As the first device 1 is sub-cutaneous, i.e. installed under the skin of an animal (not shown) the communication between the first and second device 1, 8 is wireless. The second device 8 receives the aggregate parameter at a first point in time. As explained above, the first device 1 repeatedly updates and broadcasts the aggregate parameter, so that the second device 8 receives an updated aggregate parameter from the first device 1 at a second, later point in time. The second device 8 then subtract the previously received aggregate parameter from the updated aggregate parameter, to obtain a measure indicative of state values upon which the aggregate parameter is based during a time interval between the first and second points in time. The second device 8 also uses the aggregate parameter to determine that the stored state values in the first device 1 are of sufficient interest to be requested by comparing the received aggregate parameter to a predetermined range. In other words, if the aggregate parameter shows an unexpected value, or otherwise indicates a condition of interest to e.g. a user of the second device 8, the second device 8 requests the first device 1 to transmit stored state values. This is shown by second communication line 102. The first device 1 replies by transmitting the requested state values upon receiving the request, as shown by third communication line 103. In a situation where the state values are stored on the first device 1 at a relatively high temporal resolution, the second device 8 may include in its request for transmittal a third time interval for requesting state values every third time interval. The first device 1 can then calculate, using its processor 3, the state values for every third time interval on the basis of the stored state values measured every first time interval within said third time interval, and transmit the calculated state values instead of all the state values measured every first time interval.

A person of skill in the art would readily recognize that steps of various above-described methods can be performed by programmed computers. Herein, some embodiments are also intended to cover program storage devices, e.g., digital data storage media, which are machine or computer readable and encode machine-executable or computer-executable programs of instructions, wherein said instructions perform some or all of the steps of said above-described methods. The program storage devices may be, e.g., digital memories, magnetic storage media such as a magnetic disks and magnetic tapes, hard drives, or optically readable digital data storage media. The embodiments are also intended to cover computers programmed to perform said steps of the above-described methods.

The functions of the various elements shown in the figures, including any functional blocks labelled as “units”, “processors” or “modules”, may be provided through the use of dedicated hardware as well as hardware capable of executing software such as firmware in association with appropriate software. When provided by a processor, the functions may be provided by a single dedicated processor, by a single shared processor, or by a plurality of individual processors, some of which may be shared. Moreover, explicit use of the term “unit”, “processor” or “controller” should not be construed to refer exclusively to hardware capable of executing software, and may implicitly include, without limitation, digital signal processor (DSP) hardware, network processor, application specific integrated circuit (ASIC), field programmable gate array (FPGA), read only memory (ROM) for storing software, random access memory (RAM), and non volatile storage. Other hardware, conventional and/or custom, may also be included. Similarly, any switches shown in the FIGS. are conceptual only. Their function may be carried out through the operation of program logic, through dedicated logic, through the interaction of program control and dedicated logic, or even manually, the particular technique being selectable by the implementer as more specifically understood from the context.

Although the invention has been described here above with reference to a number of specific examples and embodiments, the invention is not limited thereto. Instead, the invention also covers the subject matter defined by the claims, which now follow.

Claims

1. Device configured for providing a state parameter which is indicative of the wellness of an animal, the device comprising a sensor comprising measuring means, a memory, a processor and a transmitter, wherein:

- the sensor is configured to obtain, every first time interval and using the measuring means, at least one state value which is indicative of the current state of the animal, such as animal activity and/or animal temperature;

- the memory is configured to at least temporarily store each state value measured by the measuring means; and

- the processor is configured to determine an aggregate parameter on the basis of a plurality of previously measured state values; and

- the transmitter is configured to broadcast the determined aggregate parameter as the state parameter indicative of the wellness of the animal.

2. Device according to claim 1, further configured to transmit the at least one aggregate parameter together with the most recently obtained at least one state value.

3. Device according to any one of the preceding claims, wherein the device is a sub-cutaneous device.

4. Device according to any of the preceding claims, wherein the sensor comprises an accelerometer, and wherein the sensor is configured to measure a magnitude of acceleration for obtaining the at least one state value.

5. Device according to claim 4, being configured to high pass filter the measured acceleration for obtaining the state value.

6. Device according to any one of the claims 4 – 5, wherein the sensor is arranged to measure a magnitude of acceleration every second time interval, which is equal to or smaller than the first time interval, and wherein the processor is configured to determine a value indicative of the amount of time during the first time interval wherein the magnitude of acceleration is above a predefined threshold for obtaining the state value.

7. Device according to claim 6, being configured to count the amount of measurements conducted every second time interval within the first time interval, for which the magnitude of the acceleration was above the predefined threshold for obtaining the state value.

8. Device according to claim 7, further comprising a counter separate from the processor, configured to perform said counting.

9. Device according to claim 8, wherein the counter is configured to start and stop based on an interrupt signal provided by the accelerometer, wherein the interrupt signal is based on a comparison between the magnitude of the measured acceleration and the predetermined threshold.

10. Device according to any one of the preceding claims, being configured to sum said plurality of obtained state values for determining the at least one aggregate parameter.

11. Device according to any one of the preceding claims, further comprising temperature measuring means configured to measure a temperature of the animal for obtaining the at least one state value.

12. Device according to claim 11, wherein the processor is configured to determine the aggregate parameter for the state value based on the temperature by determining a value indicative of the fluctuation of temperature measurements, such as the total variation of the temperature measurements taken every the first time interval.

13. Device according to any of the preceding claims, further comprising a receiver for receiving a request for transmitting one or more stored state values from an external device, wherein the transmitter is configured to, upon receipt of the request, transmit the one or more stored state values.

14. Device according to claim 13, wherein the processor is configured to calculate state values for every third time interval on the basis of the stored state values measured every first time interval within said third time interval, upon receipt of a request by receiver, if said request specifies a third time interval included in the request transmitted by the external device, which third time interval is greater than the first time interval.

15. Method of providing a state parameter which is indicative of the wellness of an animal, the method comprising the steps of:

a) obtaining, every first time interval, by using at least a sensor, at least one state value being indicative of the current state of the animal, such as animal activity and/or animal temperature, and at least temporarily storing each measured state value in a memory;

b) determining, using a processor, at least one aggregate parameter on the basis of a plurality of obtained respective state values; and

c) broadcasting, using a transmitter, the determined at least one aggregate parameter as the state parameter indicative of the wellness of the animal.

16. Method according to claim 15, wherein in step c) the determined at least one aggregate parameter is broadcasted together with the most recently obtained at least one state value.

17. Method according to any of the preceding claims, wherein the sensor, the processor and the transmitter are placed sub-cutaneous.

18. Method according to any of the preceding claims, wherein obtaining the at least one state value comprises measuring, every second time interval, which is equal to or smaller than the first time interval, using an accelerometer, a magnitude of acceleration.

19. Method according to claim 18, wherein obtaining the state value comprises high pass filtering the measured acceleration.

20. Method according to any one of the claims 18 - 19, wherein obtaining the state value comprises determining a value indicative of the amount of time during the first time interval the magnitude of acceleration is above a predefined threshold.

21. Method according to claim 20, wherein obtaining the state value comprises counting the amount of measurements conducted every second time interval within the first time interval, for which the magnitude of the acceleration was above the predefined threshold.

22. Method according to claim 21, wherein the counting is performed by a counter which is separate from the processor.

23. Method according to claim 22, further comprising starting and stopping the counter based on an interrupt signal provided by the accelerometer, wherein the interrupt signal is based on a comparison between the magnitude of the measured acceleration and the predetermined threshold.

24. Method according to any one of the preceding claims, wherein determining the at least one aggregate parameter comprises summing said plurality of obtained state values.

25. Method according to any of the preceding claims, wherein obtaining the at least one state parameter comprises measuring a temperature of the animal.

26. Method according to claim 25, wherein determining the aggregate parameter for the state value based on the temperature comprises determining a value indicative of the fluctuation of temperature measurements, such as the total variation of the temperature measurements within the first interval.

27. Method according to any one of the preceding claims, further comprising:

- transmitting one or more stored state values upon receiving by a receiver a request by an external device.

28. Method according to claim 27, wherein if the request specifies a third time interval greater than the first time interval, by including it in a request transmitted by the external device and received by the receiver, calculating, by the processor, the state values for every third time interval on the basis of the stored state values measured every first time interval within said third time interval.

29. Method of obtaining a state parameter which is indicative of the wellness of an animal, the method comprising:

- receiving an aggregate parameter using a receiver, wherein the aggregate parameter is provided using the method according to any one of claims 16 – 28.

30. Method according to claim 29, further comprising:

- receiving the aggregate parameter at a first point in time;

- receiving the aggregate parameter at a second point in time which is later than the first point in time; and

- determining a measure indicative of state values upon which the aggregate parameter is based during a time interval between the first and second points in time, by subtracting the aggregate parameter received at the first point in time from the aggregate parameter received at the second point in time.

31. Method according to claim 29 or 30, further comprising:

d) determining that one or more measured state values are of sufficient interest to be requested by comparing the received aggregate parameter to a predetermined condition;

e) requesting the transmittal of one or more stored measured state values by transmitting a request; and

f) receiving the transmitted one or more stored measured state values.

32. Method according to claim 31, further comprising in step d) determining that the one or more measured state values are of sufficient interest to be requested if and when:

- the aggregate parameter lies outside a predetermined range; and/or

- the most recently measured at least one state value differs from a normal and/or average situation indicated by the respective aggregate parameter by a predetermined amount or more.

33. Device comprising a transmitter, a receiver and a processor, configured to perform the method steps of any one of claims 29 – 32.

34. Assembly of a device according to claim 33 and a device according to any one of claims 1 – 14.

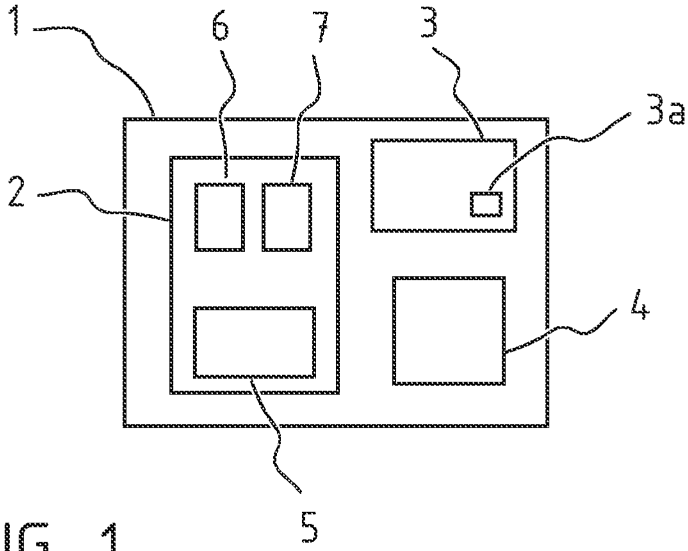

FIG. 1

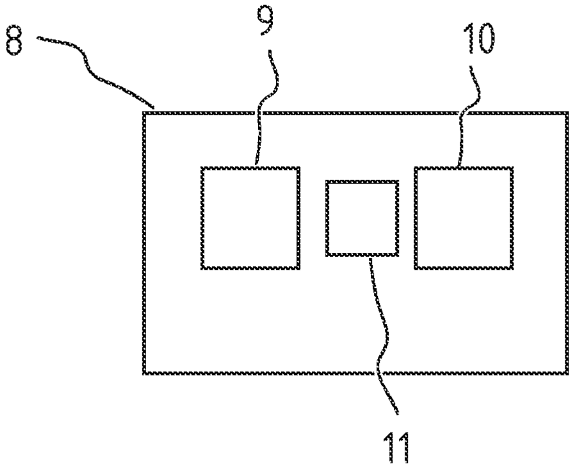

FIG. 2

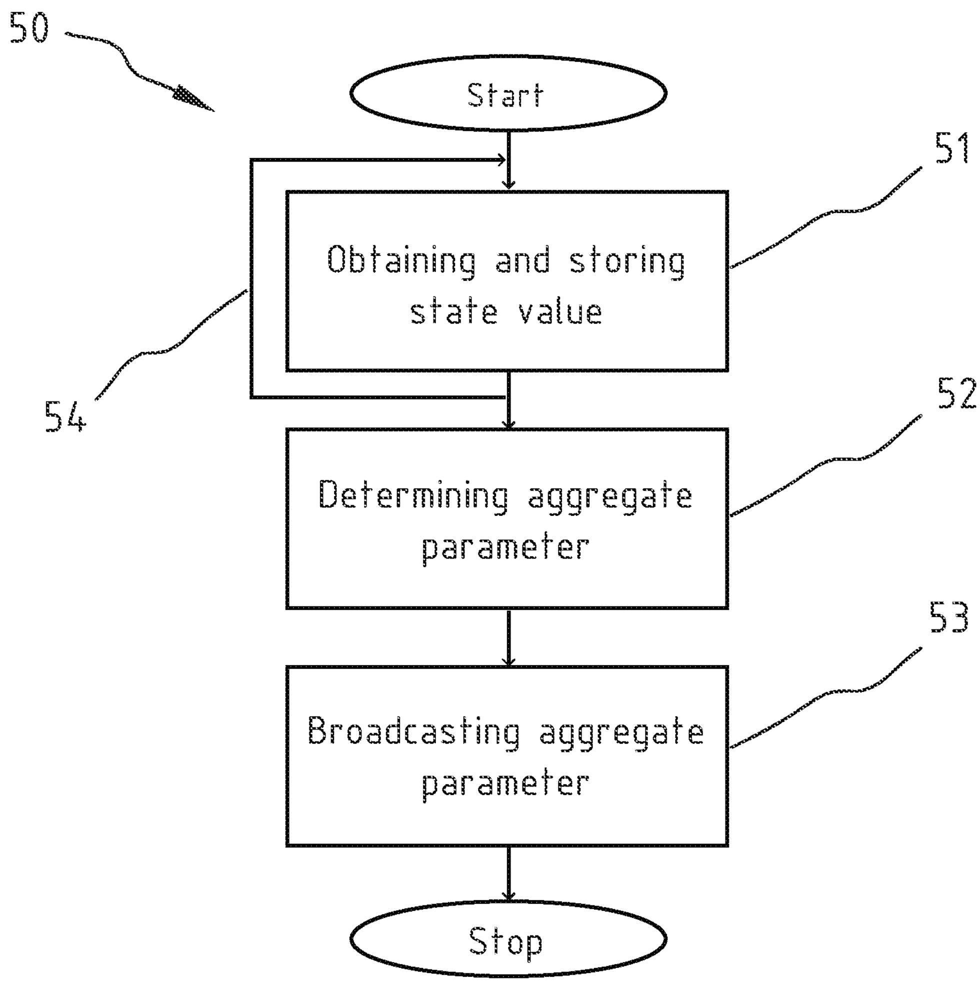
50
Start
51
Obtaining and storing state value
54
52
Determining aggregate parameter
53
Broadcasting aggregate parameter
Stop

FIG. 3

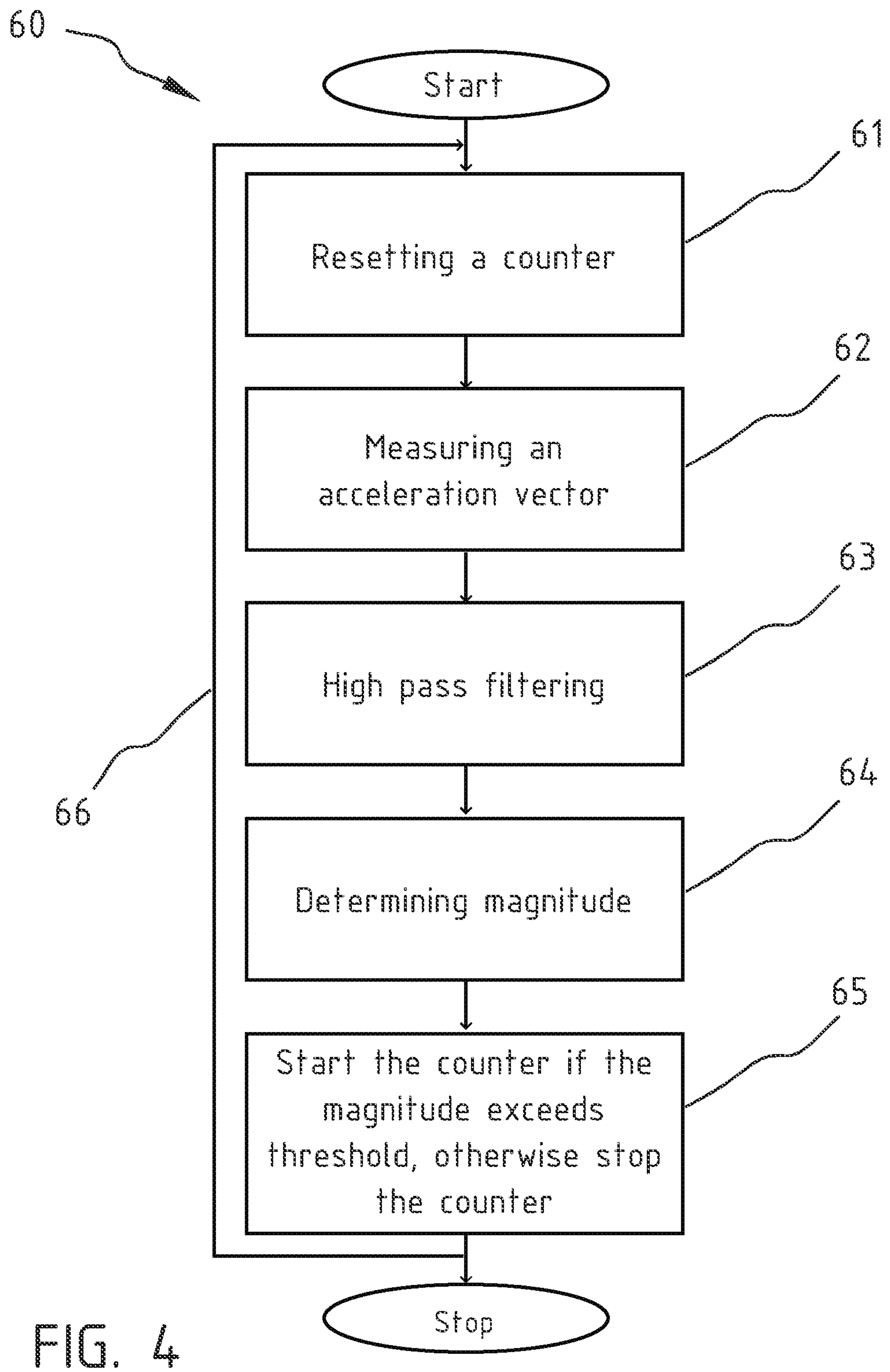
60
Start
61
Resetting a counter
62
Measuring an acceleration vector
63
High pass filtering
66
64
Determining magnitude
65
Start the counter if the magnitude exceeds threshold, otherwise stop the counter
Stop

FIG. 4

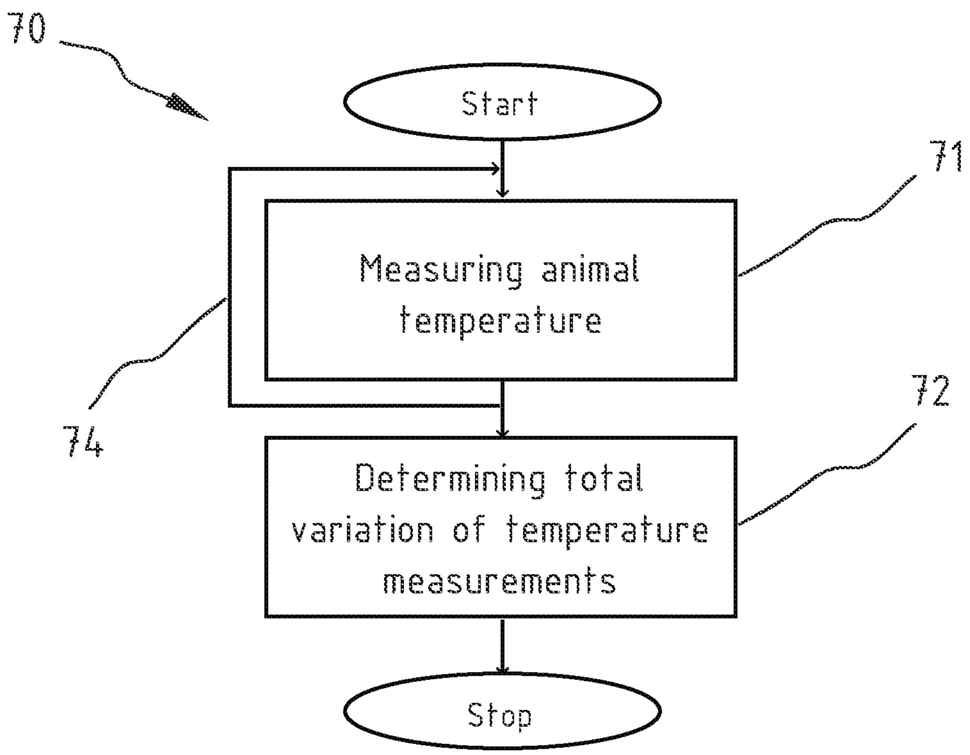
70
Start
71
Measuring animal temperature
74
72
Determining total variation of temperature measurements
Stop

FIG. 5

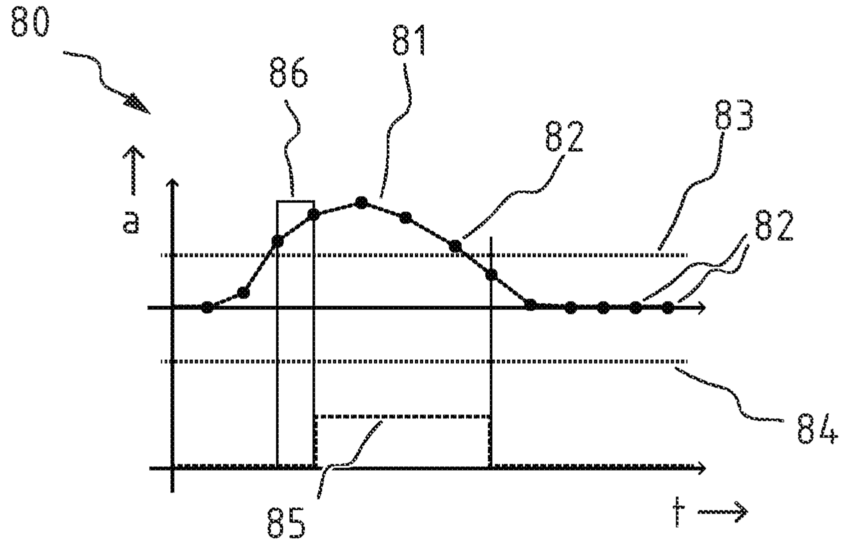

FIG. 6A

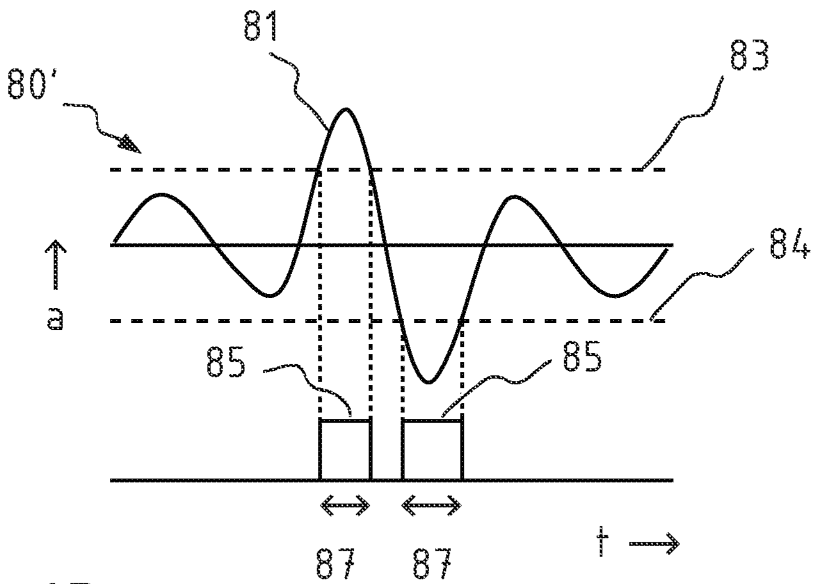

FIG. 6B

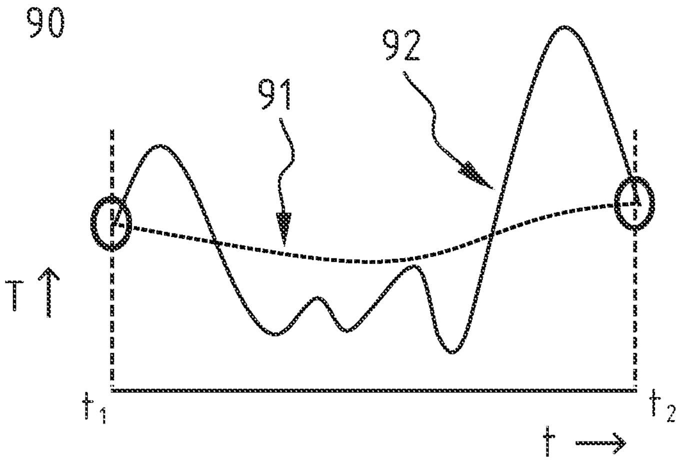

FIG. 7

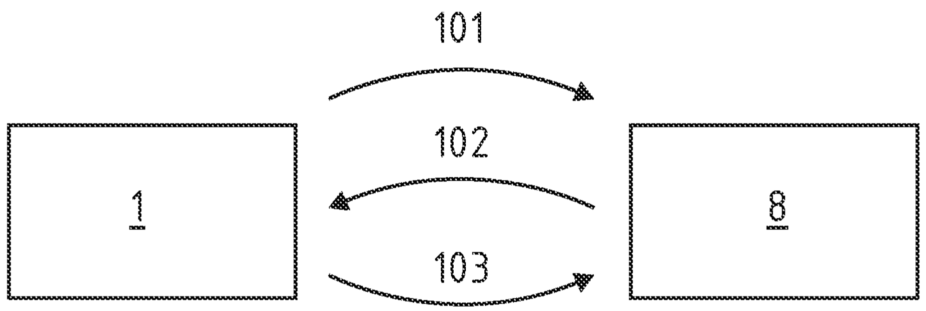

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2020/050485

A. CLASSIFICATION OF SUBJECT MATTER
INV. A01K29/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A01K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 549 081 A1 (STICHTING INST MECH [NL]) 30 June 1993 (1993-06-30)	1-13, 15-27, 29,30, 33,34
A	column 3, line 24 - column 4, line 32; figures 1-2 -----	14,28, 31,32
A	EP 0 898 882 A1 (INNOTEK INC [US]) 3 March 1999 (1999-03-03) paragraphs [0014] - [0036]; figures 1-5 -----	1-34
A	US 2008/110405 A1 (VORONIN VLADIMIR [IL] ET AL) 15 May 2008 (2008-05-15) paragraphs [0015] - [0057]; figures 1-3 -----	1-34

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 September 2020	30/09/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Pacevicius, Matthias

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2020/050485

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