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- (71) **Applicant:** DELAVAL HOLDING AB [SE/SE]; P.O. Box 39, S-147 21 Tumba (SE).
- (72) **Inventor:** KRIEF, Haim; Chativat Hanachal 10/30, Hadera (IL).
- (74) **Agent:** KEIJSER BERGÖÖ, Malin; DeLaval International AB, Intellectual Property Support/Legal Affairs, P.O. Box 39, S-147 21 Tumba (SE).
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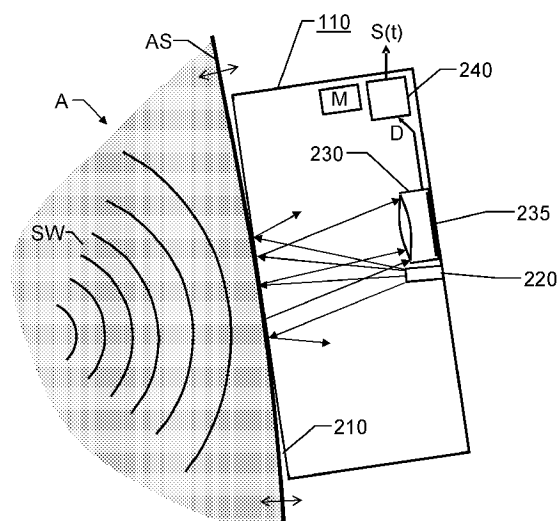
(54) **Title:** REGISTERING OF PHYSIOLOGICAL PARAMETERS BASED ON IMAGE ANALYSIS OF LIGHT REFLECTION

Fig. 2

(57) **Abstract:** An apparatus (110) includes a housing with a flexible wall (210). The flexible wall (210) has an outer side configured to contact an external body surface (AS) of an animal (A). An inner side of the flexible wall (210) has a light reflective surface towards an interior of the housing. A light source (220) illuminates the light reflective surface, and an image registering means (230) captures image data (D) representing the light reflective surface. A data processing means (240) receives the image data (D), and based thereon produces at least one signal (S(t)) indicative of at least one physiological parameter of the animal (A). For example, the apparatus (110) may be arranged on the animal (A), such that the outer side of the flexible wall (210) contacts a neck region of the animal (A); and the data processing means (240) may derive a primary signal (S(t)) representing a chewing related parameter.



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Registering of Physiological Parameters Based on Image Analysis of Light Reflection

THE BACKGROUND OF THE INVENTION AND PRIOR ART

The present invention relates generally to solutions for determining physiological parameters of an animal. More particularly the invention relates to an apparatus according to the preamble of claim 1, a neckband according to claim 6 and a method according to the preamble of claim 8. The invention also relates to a computer program according to claim 13 and a computer readable medium according to claim 14.

To accomplish an efficient and animal friendly livestock handling it is important that the animals' physiological state and health condition be monitored. Of course, to this aim, regular farmer's inspections and veterinary examinations can never be excluded. However, as a complement thereto and to provide an ongoing supervision, various automatic systems can be employed. Today, a so-called activity meter may be employed, which is arranged in a neckband on the animal in order to register and report the animal's activity level to a remote location, e.g. via radio. The activity level is indicative of whether or not the animal is healthy. Nevertheless, the activity level is a very crude measure. Therefore, for ruminating animals such as cows, chewing behavior, rumen activity, cardiac activity and respiration would provide more valuable data. Known sensors for measuring cardiac activity are often based on the well known technology of pulse oximetry, as described e.g. in US 2009/0105605.

US 2010/0226543 discloses solutions for imaging objects, for example living body parts, wherein the objects are illuminated from a distance and surface vibrations thereof are image analyzed to extract various data, e.g. representing speech or heart beats.

PROBLEMS ASSOCIATED WITH THE PRIOR ART

It is known to use pulse oximetry for measuring the heart rate of animals. Further, general solutions are known wherein, based on advanced image analysis, signals are derived that originate from internal body vibrations (or sounds). However, there is no example of a practical and cost-efficient solution for using this type of technology instead of e.g. pulse oximetry for registering physiological signals of animals in the field, e.g. in a farm environment.

10 SUMMARY OF THE INVENTION

The object of the present invention is to solve the above problem, and thus offer a reliable, robust and animal-friendly solution for registering signals indicative of physiological parameters of a given animal.

15 According to one aspect of the invention, the object is achieved by the initially described apparatus, wherein the apparatus includes a housing. The housing, in turn, contains a flexible wall, a light source, an image registering means and a data processing means. The flexible wall has an outer side configured to contact an external body surface of an animal. An inner side of the flexible wall contains a light reflective surface towards an interior of the housing. The light source is configured to illuminate the light reflective surface, and the image registering means is configured to capture image data representing the light reflective surface.

20

25 The data processing means is configured to receive the image data, and based thereon; produce at least one signal indicative of at least one physiological parameter of the animal.

This apparatus is advantageous because it enables registering of highly complex signals in a very uncomplicated and straightforward manner.

30

According to one preferred embodiment of this aspect of the invention, the apparatus is configured to be arranged on the

animal, such that the outer side of the flexible wall contacts a neck region of the animal. The data processing means is specifically configured to derive a primary signal representing a chewing related parameter. Thereby, important information concerning the animal's physiological status is obtainable, for instance related to food intake and digestion. Further preferably, the data processing means is configured to derive at least one secondary signal representing: rumen activity, a cardiogram, heart rate, respiration rate, and/or a general activity level of the animal.

10 According to another preferred embodiment of this aspect of the invention, the light source includes a green laser. Green laser light is associated with a relatively low penetration, and therefore a large proportion of such light will be reflected back from the light reflective surface of the flexible wall, which is equivalent to
15 a high degree of efficiency in terms of energy used.

According to a yet another preferred embodiment of this aspect of the invention, the data processing means is configured to determine a strongest light reflection in each image registered by an image sensor in the image registering means. From a set of
20 such strongest light reflections determined in a series of images, the data processing means is further configured to derive the at least one signal. Hence, an uncomplicated time-varying signal is produced, which may serve as a basis for further analysis.

According to another aspect of the invention, the object is achieved by a neckband adapted to be carried around the neck of a cow. The neckband includes the above-proposed apparatus and a fitting member configured to grip around the back of the neck of the cow, so as to reduce rotation movements of the neckband relative to the cow's neck. Thus, the apparatus is held in a relatively fix position without requiring a high pressure against the
25 animal, which is advantageous from an animal-comfort point-of-view.
30

According to one preferred embodiment of this aspect of the in-

vention, the neckband includes a weight member arranged essentially opposite to the fitting member on the neckband. The weight member is configured to pull the fitting member towards the back of the neck of the cow, and the proposed apparatus is
5 arranged between the fitting member and the weight member. As a result, when the neckband is carried around the neck of a cow, the flexible wall will contact an external body surface of the animal while the risk of rotation movements of the neckband relative to the cow's neck is held relatively low and the flexible wall ex-
10 erts a relatively low pressure on the external body surface. Of course, the weight member, in turn, may contain useful components, such a transponder and/or units for radio communication.

According to another aspect of the invention, the object is achieved by the method described initially, which presumes the use of
15 an apparatus that has a housing including a flexible wall with an outer side and an inner side that is light reflective. The method involves arranging the apparatus on an animal, such that the flexible wall contacts an external body surface of the animal. The light reflective surface is illuminated from an interior of the hou-
20 sing, and image data are captured representing the reflective surface. The image data are processed to produce at least one signal indicative of at least one physiological parameter of the animal. The advantages of this method, as well as the preferred embodiments thereof, are apparent from the discussion above
25 with reference to the proposed apparatus.

According to a further aspect of the invention the object is achieved by a computer program, which is directly loadable into the memory of a computer, and includes software adapted to im-
30 plement the method proposed above when said program is run on a computer.

According to another aspect of the invention the object is achieved by a computer readable medium, having a program recorded thereon, where the program is to control a computer to perform the method proposed above when the program is loaded into the

computer.

Further advantages, beneficial features and applications of the present invention will be apparent from the following description and the dependent claims.

5 BRIEF DESCRIPTION OF THE DRAWINGS

The invention is now to be explained more closely by means of preferred embodiments, which are disclosed as examples, and with reference to the attached drawings.

- | | | |
|----|----------|---|
| 10 | Figure 1 | shows a ruminant animal carrying a neckband containing the proposed apparatus; |
| | Figure 2 | illustrates an apparatus according to one embodiment of the invention that is arranged on an animal; |
| 15 | Figure 3 | shows an image sensor according to one embodiment of the invention illustrating an example of a set of strongest light reflections registered in a set of images; |
| 20 | Figure 4 | shows an example of a time-varying function derived from the set of strongest light reflections in a set of images in Figure 3; and |
| | Figure 5 | illustrates, by means of a flow diagram, the general method according to the invention. |

DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

- 25 We refer initially to Figure 1, which shows a ruminant animal A carrying a neckband 100 containing the proposed apparatus 110 around its neck. The neckband 100 has a fitting member 130 configured to grip around the back of the cow's neck, so as to reduce rotation movements of the neckband 100 relative to the

cow's neck. The fitting member 130 may thus include a section (e.g. of plastic) that is pre-shaped to fit the general contour of the back of the cow's neck.

5 According to one preferred embodiment of the invention, the neckband 100 includes a weight member 120, which is arranged essentially opposite to the fitting member 130 on the neckband 100, and is configured to pull the fitting member 130 towards the back of the neck of the cow. The apparatus 110 is arranged between the fitting member 130 and the weight member 120, such
10 that when the neckband 100 is carried around the neck of a cow a sensor part of the apparatus 110 is drawn towards and to contact an external body surface of the animal A so that the sensor part of the apparatus 110 contacts the external body surface. At the same time, the risk that the neckband 100 rotates relative to
15 the cow's neck is held relatively low, and said sensor part exerts a relatively low pressure on the animal's A body. The weight member 120 preferably contains high-density components, such as batteries and/or radio components, e.g. for transmitting any signals S(t) produced by the apparatus 110.

20 Naturally, according to the invention, in addition to the proposed apparatus 110 and any weight member 120, the neckband 100 may include one or more other types of sensors, preferably configured to register signals different from those registered by the apparatus 110.

25 Referring to Figure 2, more specifically, a flexible wall 210 of the apparatus 110 will exert a relatively low pressure on an external body surface AS of the animal A while the risk of rotation movements of the neckband 100 relative to the cow's neck is held relatively low. Figure 2 shows a side view of the apparatus 110
30 according to one embodiment of the invention when arranged on an animal A.

The apparatus 110 includes a housing, which, in turn, contains: a flexible wall 210, a light source 220, an image registering

means 230 and a data processing means 240.

The flexible wall 210 represents the above-mentioned sensor part and has an outer side configured to contact the external body surface AS of the animal A. An inner side of the flexible wall
5 210 contains a light reflective surface towards an interior of the housing.

The light source 220 is configured to illuminate the light reflective surface. Preferably, the light source 220 contains a green laser because due to the relatively low degree of penetration of
10 green laser light, such a light source is associated with comparatively high degree of energy efficiency.

The image registering means 230 is configured to capture image data D representing the light reflective surface. To this aim, the image registering means 230 includes an image sensor 235 (see
15 Figure 3).

The data processing means 240 is configured to receive the image data D, and based thereon; produce at least one signal S(t) indicative of at least one physiological parameter of the animal A.

20 As mentioned above, the apparatus 110 is preferably configured to be arranged on the animal A, such that the outer side of the flexible wall 210 contacts a neck region of the animal A. Thereby, any signals SW (typically sounds, i.e. mechanical waves) originating from internal organs in the animal A may propagate
25 through the animal's A body and cause vibrations of the external body surface AS of the animal A. Consequently, by studying the vibrations of the external body surface AS, it is possible to draw conclusions concerning the animal's A chewing behavior, rumen activity, cardiac activity (cardiogram and/or heart rate) as well as
30 respiration rate. In fact, a general activity level of the animal A may also be derived, since animal activity corresponds to low-frequency noise of high magnitude (relative to the other signals).

According to embodiments of the invention, the data processing means 240 is configured to derive a primary signal $S(t)$ representing a chewing related parameter. Additionally, the data processing means 240 may also be configured to derive at least one secondary signal $S(t)$ representing: rumen activity, a cardio-gram, heart rate, respiration rate and/or a general activity level of the animal A.

Figure 3 shows the image sensor 235 according to one embodiment of the invention. Here, we see an example of a set of strongest light reflections $p(t_1)$, $p(t_2)$, ... $p(t_i)$, ... $p(t_n)$ registered in a set of images, say n images. Thus, each image essentially results in a point in a two-dimensional plane, where the point represents the location of the strongest light reflection in that image. This, in turn, may be translated by the data processing means 240 into a one-dimensional function $S(t)$ of time t as illustrated in Figure 4.

In Figure 4 we an example of a time-varying function $S(t)$ derived from the set of strongest light reflections $p(t_1)$, $p(t_2)$, ... $p(t_i)$, ... $p(t_n)$ in Figure 3, where the magnitude of $S(t)$ is equivalent to a distance between two consecutive strongest light $p(t_i)$. Preferably, the data processing means 240 is configured to apply a threshold, such that a strongest light reflection corresponding to an exceptionally large magnitude is discarded. Naturally, according to the invention, many alternative (and more complex) parameters may also be derived from the image data D captured by the image sensor 235.

The above procedure implemented by the processing means 240 is preferably controlled by a computer program M loaded into a memory of the processing means 240, or an external memory unit accessible by the processing means 240. The computer program, in turn, contains software for controlling the steps of the procedure when the program is run on the processing means 240.

In order to sum up, we will now describe the general method according to the invention with reference to the flow diagram in Figure 5.

5 In a first step 510, an apparatus 110 is arranged on an animal A, so that an outer side of its flexible wall 210 contacts an external body surface AS, preferably in the neck region.

10 In a following step 520, the light reflective surface is illuminated from an interior of the apparatus' 110 housing. A step 530, parallel to step 520, registers image data D representing the reflective surface of the inner side of the flexible wall 210. A step 540, parallel to steps 520 and 530, processes the image data D to produce at least one signal S(t) indicative of at least one physiological parameter of the animal A. Then, the procedure loops back to steps 520, 530 and 540 for repeated measurement.
15

All of the process steps, as well as any sub-sequence of steps, described with reference to Figure 5 above may be controlled by means of a programmed computer apparatus. Moreover, although the embodiments of the invention described above with
20 reference to the drawings comprise computer apparatus and processes performed in computer apparatus, the invention thus also extends to computer programs, particularly computer programs on or in a carrier, adapted for putting the invention into practice. The program may be in the form of source code, object
25 code, a code intermediate source and object code such as in partially compiled form, or in any other form suitable for use in the implementation of the process according to the invention. The program may either be a part of an operating system, or be a separate application. The carrier may be any entity or device
30 capable of carrying the program. For example, the carrier may comprise a storage medium, such as a Flash memory, a ROM (Read Only Memory), for example a DVD (Digital Video/Versatile Disk), a CD (Compact Disc) or a semiconductor ROM, an EP-ROM (Erasable Programmable Read-Only Memory), an EEPROM

(Electrically Erasable Programmable Read-Only Memory), or a magnetic recording medium, for example a floppy disc or hard disc. Further, the carrier may be a transmissible carrier such as an electrical or optical signal which may be conveyed via electrical or optical cable or by radio or by other means. When the
5 program is embodied in a signal which may be conveyed directly by a cable or other device or means, the carrier may be constituted by such cable or device or means. Alternatively, the carrier may be an integrated circuit in which the program is embedded,
10 the integrated circuit being adapted for performing, or for use in the performance of, the relevant processes.

Although the invention has been described primarily with reference to cows, the invention is equally well adapted for any other kind of animals, such as goats, sheep or buffaloes.

15 The term “comprises/comprising” when used in this specification is taken to specify the presence of stated features, integers, steps or components. However, the term does not preclude the presence or addition of one or more additional features, integers, steps or components or groups thereof.

20 The invention is not restricted to the described embodiments in the figures, but may be varied freely within the scope of the claims.

Claims

1. An apparatus (110) for registering signals indicative of physiological parameters of an animal (A) based on illumination of a surface and analysis of light reflections from the surface, **characterized in that** the apparatus includes a housing comprising:
 - 5 a flexible wall (210), an outer side of which is configured to contact an external body surface (AS) of the animal (A), the flexible wall (210) having an inner side containing a light reflective surface towards an interior of the housing;
 - 10 a light source (220), configured to illuminate the light reflective surface;
 - an image registering means (230), configured to capture image data (D) representing the light reflective surface; and
 - a data processing means (240), configured to receive the
 - 15 image data (D) and based thereon produce at least one signal (S(t)) indicative of at least one physiological parameter of the animal (A).
2. The apparatus (110) according to claim 1, wherein the apparatus is configured to be arranged on the animal (A) such that the outer side of the flexible wall (210) contacts a neck region of the animal (A), and the data processing means (240) is configured to derive a primary signal (S(t)) representing a chewing related parameter.
3. The apparatus (110) according to claim 2, wherein the data processing means (240) is configured to derive at least one secondary signal (S(t)) representing at least one of: rumen activity, a cardiogram, heart rate, respiration rate, and a general activity level of the animal (A).
4. The apparatus (110) according to any one of claims 1 to 2, wherein the light source (220) comprises a green laser.
5. The apparatus (110) according to any one of the preceding claims, wherein the data processing means (240) is configured

to determine a strongest light reflection $((p(t_1), \dots, (p(t_n)))$ in each image registered by an image sensor (235) in the image registering means (230), and derive the at least one signal $(S(t))$ from a set of strongest light reflections $((p(t_1), \dots, (p(t_n)))$ determined in a series of images.

6. A neckband (100) adapted to be carried around the neck of a cow, comprising the apparatus (110) according to any one of the preceding claims, and a fitting member (130) configured to grip around the back of the neck of the cow so as to reduce rotation movements of the neckband (100) relative to the cow's neck.

7. The neckband (100) according to claim 6, comprising a weight member (120) arranged essentially opposite to the fitting member (130) on the neckband (100), and configured to pull the fitting member (130) towards the back of the neck of the cow, the apparatus (110) being arranged between the fitting member (130) and the weight member (120) such that when the neckband is carried around the neck of a cow the flexible wall (210) contacts an external body surface (AS) of the animal (A) while a risk of rotation movements of the neckband (100) relative to the cow's neck is held relatively low and the flexible wall (210) exerts a relatively low pressure on the external body surface (AS).

8. A method for registering signals indicative of physiological parameters of an animal (A) based on illumination of a surface and analysis of light reflections from the surface, **characterized by** using an apparatus (110) having a housing including a flexible wall (210) with an outer side and an inner side that is light reflective, said method comprising:

arranging the apparatus (110) such that the flexible wall (210) contacts an external body surface (AS) of the animal (A);
illuminating the light reflective surface from an interior of the housing;

capturing image data (D) representing the reflective surface; and

processing the image data (D) to produce at least one signal (S(t)) indicative of at least one physiological parameter of the animal (A).

9. The method according to claim 8, comprising arranging the apparatus (110) so that the outer side of the flexible wall (210) contacts a neck region of the animal (A), wherein the at least one signal (S(t)) comprising a primary signal representing a chewing related parameter.

10. The method according to claim 9, comprising deriving at least one secondary signal (S(t)) representing at least one of: rumen activity, a cardiogram, heart rate, respiration rate, and a general activity level of the animal (A).

11. The method according to any one of claims 8 to 10, wherein the illuminating of the light reflective surface is carried out using a green laser (220).

12. The method according to any one of the claims 8 to 11, comprising:

determining a strongest light reflection ((p(t₁), ..., (p(t_n))) in each image registered by an image sensor (235) in the image registering means (230), and

deriving the at least one signal (S(t)) from a set of strongest light reflections ((p(t₁), ..., (p(t_n))) determined in a series of images.

13. A computer program loadable into the memory (M) of a computer, comprising software for controlling the steps of any of the claims 8 to 12 when said program is run on the computer.

14. A computer readable medium (M), having a program recorded thereon, where the program is to make a computer control

the steps of any of the claims 8 to 12 when the program is loaded into the computer.

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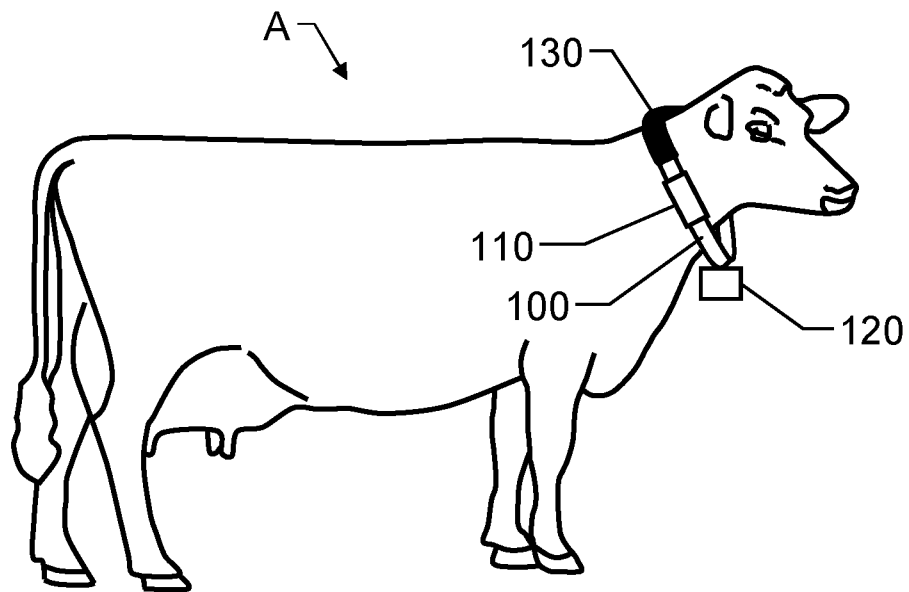


Fig. 1

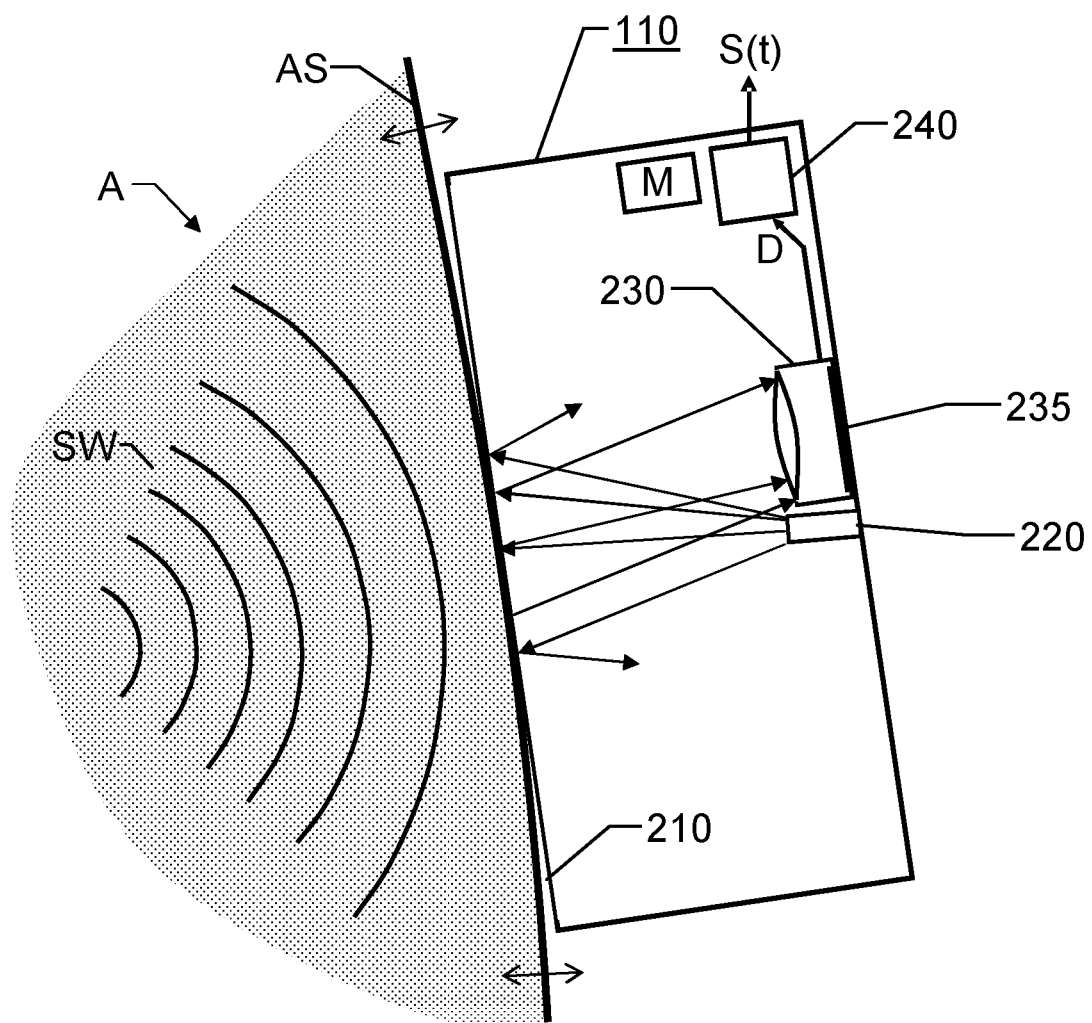


Fig. 2

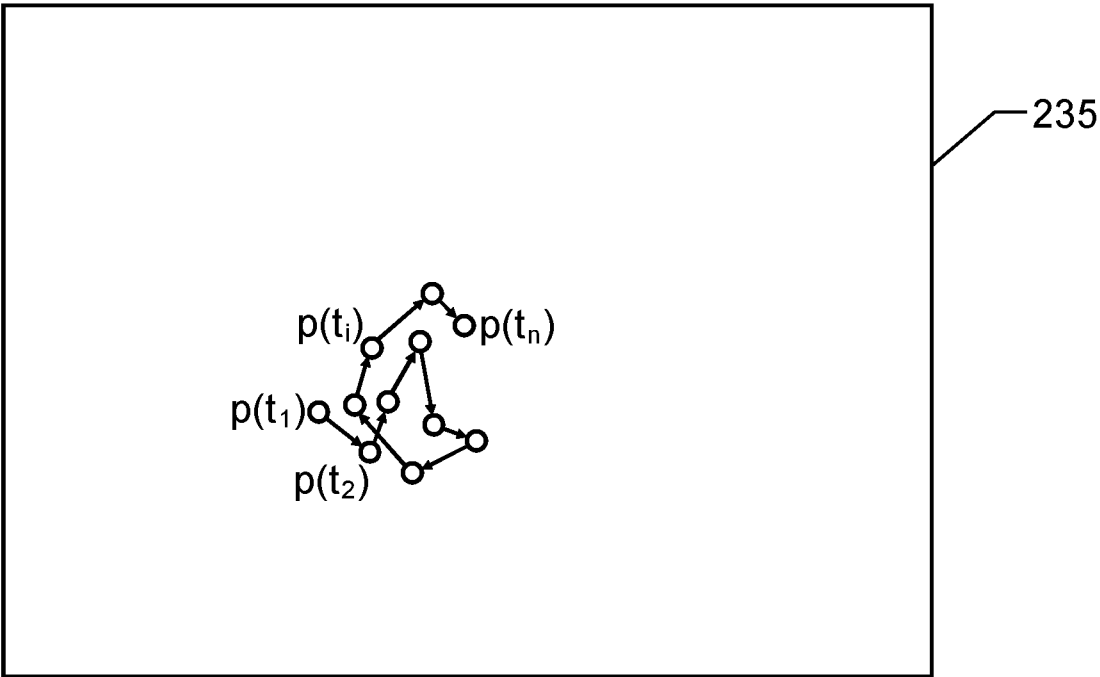


Fig. 3

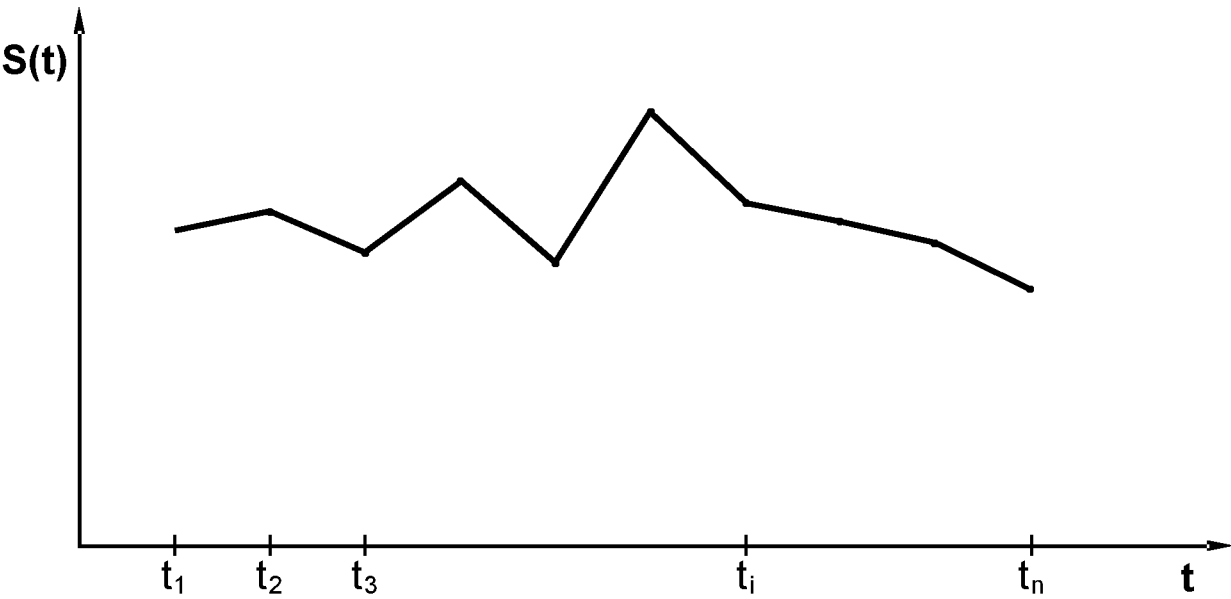
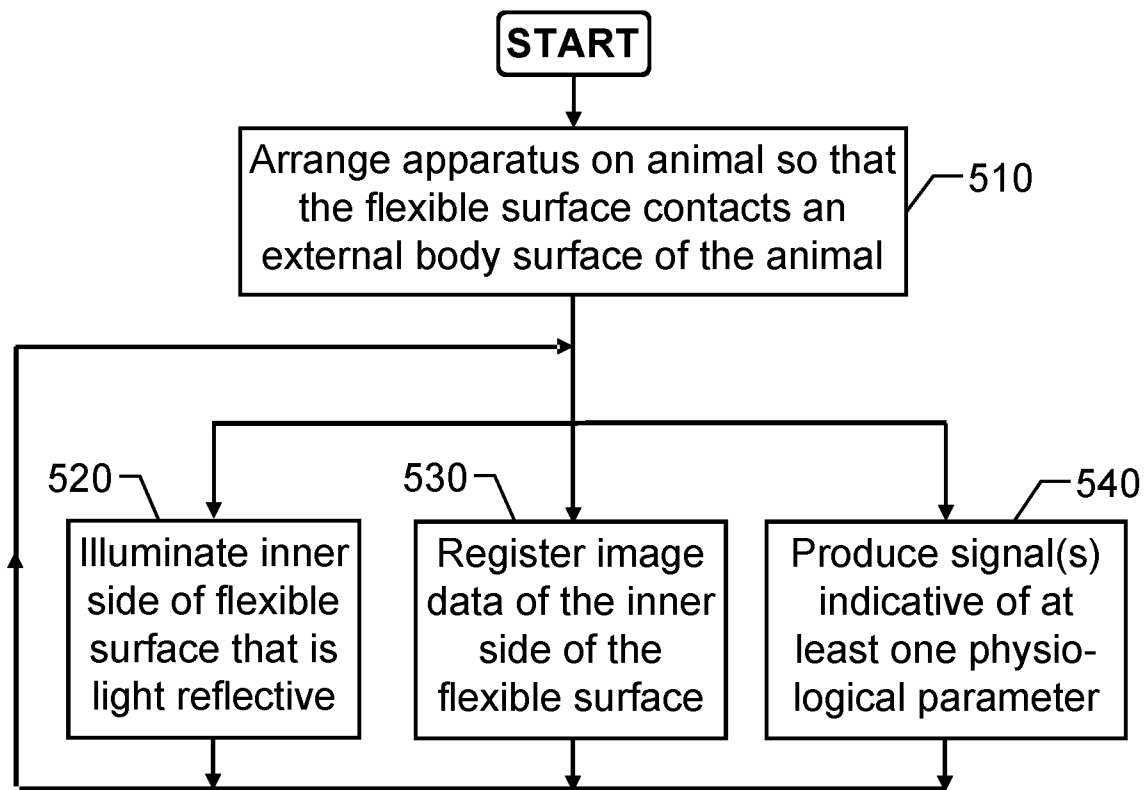


Fig. 4

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**Fig. 5**

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2013/050880

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00 A61B5/11
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)
A61B

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)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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

☒ See patent family annex.

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Date of the actual completion of the international search

29 November 2013

Date of mailing of the international search report

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European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Vanderperren, Yves

INTERNATIONAL SEARCH REPORT

International application No
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专利名称(译)	基于光反射图像分析的生理参数配准		
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申请(专利权)人(译)	DELAVAL HOLDING AB		
当前申请(专利权)人(译)	DELAVAL HOLDING AB		
[标]发明人	KRIEF HAIM		
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其他公开文献	EP2872032B1		
外部链接	Espacenet		

摘要(译)

装置 (110) 包括具有柔性壁 (210) 的壳体。柔性壁 (210) 具有外侧，其构造成接触动物 (A) 的外部体表 (AS)。柔性壁 (210) 的内侧具有朝向壳体内部的光反射表面。光源 (220) 照亮光反射表面，并且图像记录装置 (230) 捕获表示光反射表面的图像数据 (D)。数据处理装置 (240) 接收图像数据 (D)，并且基于此产生指示动物 (A) 的至少一个生理参数的至少一个信号 (S (t))。例如，装置 (110)。) 可以布置在动物 (A) 上，使得柔性壁 (210) 的外侧接触动物的颈部区域 (A)；并且数据处理装置 (240) 可以导出主要信号 (S) (t) 表示与咀嚼相关的参数。