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(54) Title: SYSTEMS AND METHODS FOR DETERMINING LIKELIHOOD OF STATES IN CATTLE ANIMAL

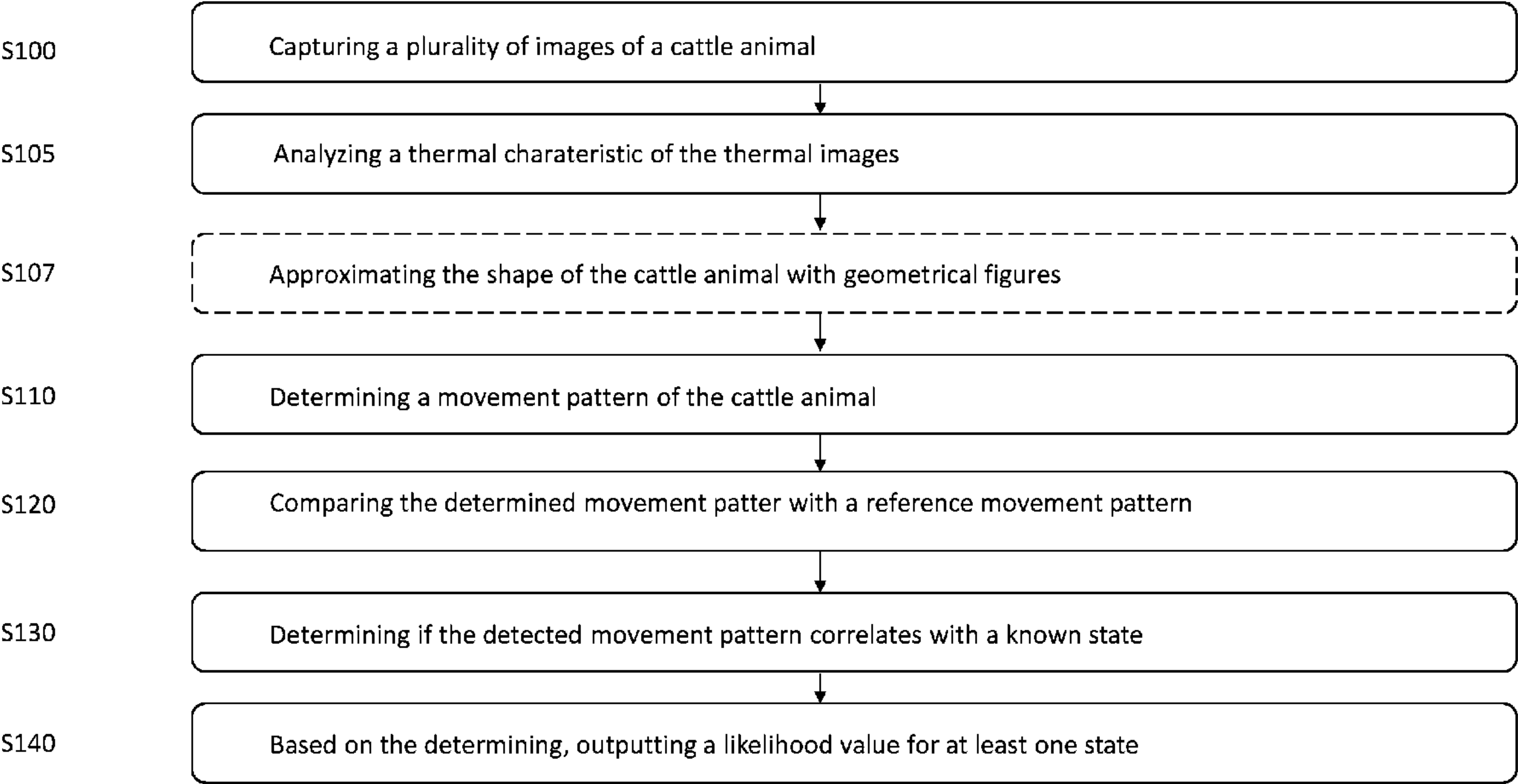


Fig. 1

(57) **Abrégé/Abstract:**
Disclosed is a method for determining a likelihood for a state of a cattle animal. The method comprises capturing (S100), by a thermal imager, a plurality of images of a cattle animal, analyzing (S105) a thermal characteristic of the images, and determining (S110), based on the plurality of images, a movement pattern of the cattle animal. The method further comprises comparing (S120) the determined movement pattern with a reference movement pattern and then determining (S130), based on the comparison, if the detected movement pattern correlates with a known state out of a plurality of known states, the plurality of known states including at least oestrus, pregnancy and parturition. The method further comprises outputting (S140), based on the determining, a likelihood value for at least one of the plurality of known states.

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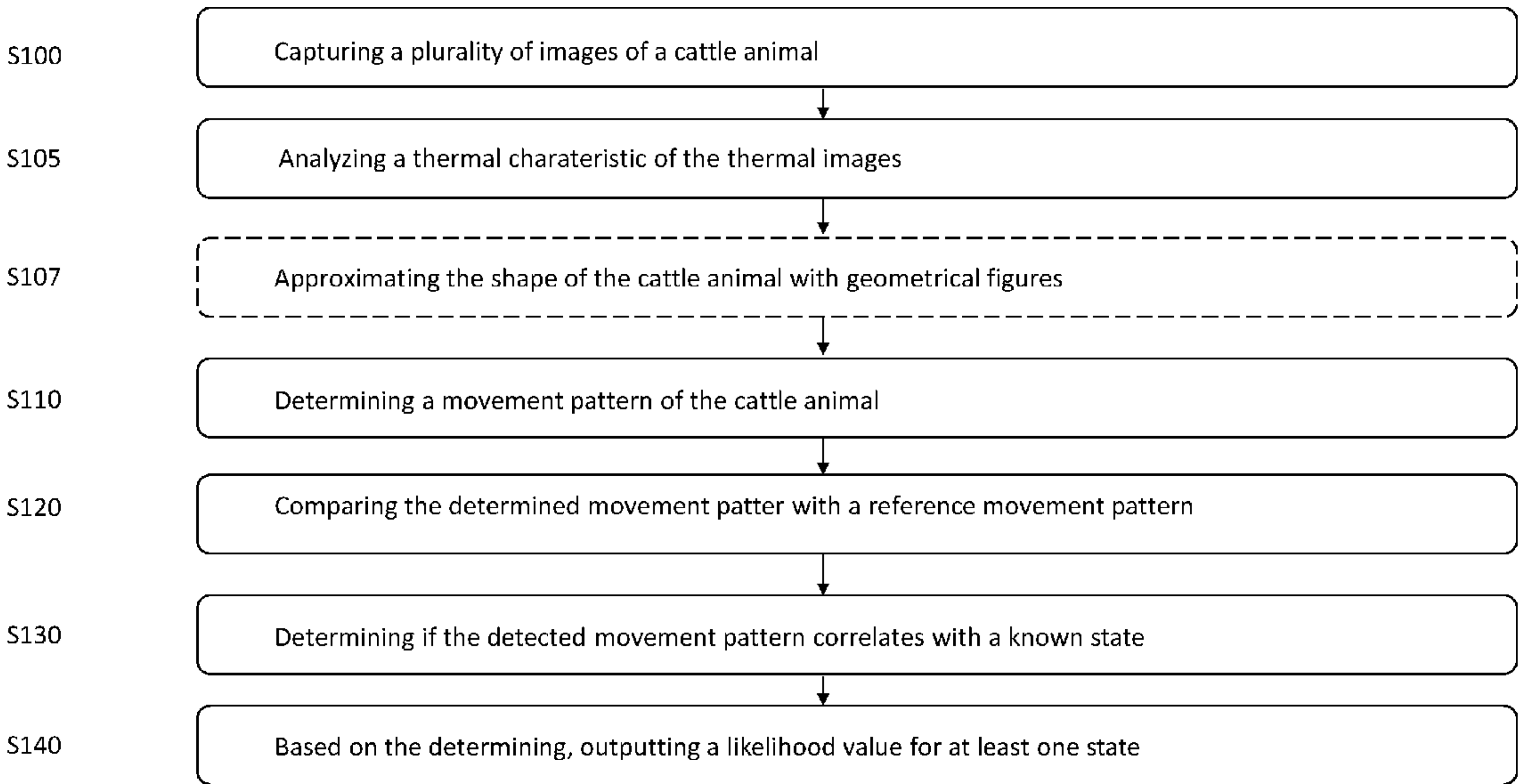


Fig. 1

(57) Abstract: Disclosed is a method for determining a likelihood for a state of a cattle animal. The method comprises capturing (S100), by a thermal imager, a plurality of images of a cattle animal, analyzing (S105) a thermal characteristic of the images, and determining (S110), based on the plurality of images, a movement pattern of the cattle animal. The method further comprises comparing (S120) the determined movement pattern with a reference movement pattern and then determining (S130), based on the comparison, if the detected movement pattern correlates with a known state out of a plurality of known states, the plurality of known states including at least oestrus, pregnancy and parturition. The method further comprises outputting (S140), based on the determining, a likelihood value for at least one of the plurality of known states.

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SYSTEMS AND METHODS FOR DETERMINING LIKELIHOOD OF STATES IN CATTLE ANIMAL

Technical field

[0001] The present invention relates to a method and device for determining likelihoods of states in cattle animal.

Background art

[0002] Traditional methods for identifying and determining that a cow is in the state of oestrus involve spending a lot of time physically present in the stables, at least 20-30 minutes per day, four to five times a day. Naturally, this method is very time consuming while still being approximate, and cattle animal only go into oestrus for short periods of time. Furthermore, the likelihood of succeeding with artificial insemination of cattle animals are at best 70%. In combination with the uncertainties regarding if the cattle animal really is in oestrus, the accumulated success rate is generally quite low. On top of that, a feedback inspection to investigate if the insemination was successful is also critical in these kinds of systems, since it is needed to determine if the process needs to be repeated. Furthermore, insufficient monitoring around the time of parturition might prolong the birth process unnecessarily, thereby increasing the risk of stillbirth.

[0003] Thus, there is a need for better ways of determining how likely a cattle animal is to be in any significant state, including at least one of oestrus, pregnancy and parturition.

Summary of invention

[0004] An object of the present invention is to solve at least some of the problems outlined above. An object is to provide systems and method for determining likelihoods of states in cattle animal, such as oestrus, pregnancy and parturition. By having such a determination of likelihoods, resource efficiency can be greatly increased, e.g. by decreasing the amount of failed inseminations.

[0005] According to a first aspect, there is provided a method for determining a likelihood for a state of an animal. The method comprises capturing a plurality of images of a cattle animal, in some embodiments this is done with a thermal imager. The method further comprises analyzing a thermal characteristic of the plurality of images and determining, based on the plurality of images, a movement pattern of the cattle animal, and comparing the determined movement pattern with a reference movement pattern. The method further comprises determining, based on the comparison, if the detected movement correlates with a known state out of a plurality of known states, the plurality of known states typically including at least oestrus, pregnancy and parturition; and based on the determining, outputting a likelihood for at least one of the plurality of known states. In some embodiments, the method may only to determine the likelihood of one state, such as oestrus.

[0006] By having such a method, it is possible to determine when cattle animals move in ways that are indicative of certain states, including oestrus, pregnancy or parturition. Further, by using thermal images, cattle animals may easily be distinguished from one another and from the background, irrespective of the shape and color of the background and of lighting conditions.

[0007] According to optional embodiments, the step of determining a movement of the cattle animal comprises comparing measurements from the captured images with images in a database and choosing a movement that correlates best with the captured images, from a database with a plurality of movements. In some embodiments, the step of determining a movement may comprise using predetermined variables to specify what kind of movement is being searched for.

[0008] According to optional embodiments, the thermal images are taken from a position above the cattle animals. This makes it easier to distinguish between different cattle animals when using thermal images.

[0009] According to optional embodiments, the reference movement pattern is another movement pattern related to the same cattle animal. In some embodiments, the reference movement pattern may be a previously recorded movement pattern of another cattle animal, or it may be a combination of a

movement pattern from other cattle animals and previous movement patterns from the same cattle animal. In some embodiments, the reference movement pattern may be a statistically derived movement pattern obtained by analyzing a number of movement patterns in a database.

[0010] In some embodiments, the reference movement pattern may be a change in movement measured over time. The reference movement pattern may be a single movement, or it may be a sequence of multiple movements.

[0011] According to optional embodiments, the reference movement is a movement obtained from a database comprising historical records with movements of cattle animals.

[0012] According to optional embodiments, the method further comprises outputting an alert if the detected movement does not correlate with any known state.

[0013] According to optional embodiments, the method comprises the usage of abductive reasoning in order to determine likelihoods.

[0014] According to a second aspect, there is provided a system for determining a likelihood of a state in a cattle animal. The system comprises a thermal imager adapted to capture a plurality of images of a cattle animal and a processing unit with a memory, operatively connected to the thermal imager. The system further comprises a database, operatively connected to the processing unit and to the thermal imager. The processing unit is adapted to analyze a thermal characteristic of the thermal images, and to determine, based on the plurality of images, a movement pattern of the cattle animal. It is further adapted to determine, based on the comparison, if the detected movement pattern correlates with a known state of a plurality of known states, the plurality of known states including at least oestrus, pregnancy and parturition. The system is further adapted to, based on the determining, outputting a likelihood value for at least one of the plurality of known states.

[0015] According to optional embodiments, the thermal imager may be positioned above the area intended to be covered.

[0016] The aspects and embodiments described above are freely combinable with each other. There are optional embodiments of the second aspect that correspond to the optional embodiments of the first aspect.

Brief description of drawings

[0017] The solution will now be described more in detail, by way of example, with reference to the accompanying drawings, in which:

[0018] Fig. 1 is a flow chart of a method according to the present disclosure.

[0019] Fig. 2 shows a system according to the present disclosure.

[0020] Fig. 3 shows the positioning of a thermal imager according to one embodiment.

[0021] Fig. 4 shows a thermal image comprising three cattle animals.

[0022] Fig. 5 shows a first way of approximating cattle animals, using ellipses.

[0023] Fig. 6 shows a second way of approximating cattle animals, using dots.

[0024] Fig. 7 shows a third way of approximating cattle animals, using vectors.

Description of embodiments

[0025] In the following, a detailed description of a system and a method according to the invention will be given.

[0026] Visual observation is generally considered the most effective method for determining the time of oestrus, however it is very time consuming. By measuring, tracking and classifying an animal's movement pattern using video motion detection, it is possible to determine their point in the reproductive cycle. One of the main indications is so called standing oestrus and is simply the changes in animal behaviour that are associated with an animal standing to be mounted by a

bull or another female. Other indications include chin resting, sniffing and licking of the urogenital region. All these movements and behaviour can be detected, distinguished and characterised using video imaging and image processing. When detecting and analyzing movement patterns, the above are some examples of movement patterns that may be detected which are indicative of oestrus.

[0027] By monitoring these movements and correlating them to known movement patterns and/or movement pattern fluctuations, it is possible to determine the point in the reproductive cycle, with a certain likelihood value. As will be understood, the likelihood value can be 100%, indicating that the animal would definitely be in a specific state and it can be 0%, indicating that the animal would definitely not be in a specific state.

[0028] Available systems for monitoring cattle animals have the problem of distinguishing between the animals and the background. This problem is made even more difficult since areas where cattle animals are active are highly diverse. Thus, it is difficult to achieve a monitoring system that is widely applicable for various environments. Furthermore, considering that different breeds of cattle animals have different patterns, colors, shapes, sizes and so on, it is also difficult to achieve a monitoring system that is widely applicable to many different types of cattle animals.

[0029] Shortly described, the methods and systems of the present disclosure relate to determining likelihoods for different states in animals. The disclosure relates to monitoring an area and distinguishing movements of an individual animal or a group of animals within that area. The movement information is tracked, logged, analysed and characterised. If the movement data corresponds to a known state that can be attributed to a distinctive characteristic, including at least one of oestrus, pregnancy or parturition, i.e. can be correlated to a database, the result is characterised and flagged. If the movement data is noteworthy but cannot be attributed to a distinctive characteristic the result is flagged and characterised as an unknown event so further investigations can be instigated.

[0030] Further, the methods and systems of the present disclosure builds upon the realization that thermal imagers are suitable for use when monitoring and determining the movement patterns of cattle animal, especially when monitoring multiple cattle animals simultaneously, which is suitable for free-ranging cattle animals. The detail of thermal images acquired by thermal imagers are enough to identify and determine such movement patterns. Further, thermal images are much less sensitive to variations in e.g. lighting conditions, backgrounds and shapes of the area in which the cattle animals are active, as well as less sensitive to variations between individual cattle animals and variations between different breeds of cattle animals.

[0031] Another advantage of using thermal imagers for capturing images of cattle animals is that the usage of thermal images generally does not breach any laws regarding personal integrity, and thus may be implemented without worrying about such regulations.

[0032] Looking now at Fig. 1, the steps of a method according to the present disclosure will now be described in more detail.

[0033] The method comprises a step S100 of capturing a plurality of images of a cattle animal. The capturing is performed by way of a thermal imager with the capability taking and storing thermal images, such as an infrared (IR) camera.. The reason for capturing a plurality of images, over a period of time, is to be able to identify a movement of a cattle animal. According to one embodiment, the step S100 of capturing images lasts for approximately 30 seconds. In some embodiments, the step of capturing images lasts for approximately 1 minute. In other embodiments, the thermal images may be captured over a longer period of time, such as 30 minutes or 60 minutes. In embodiments lasting a longer time, it is possible that multiple movement patterns are recorded for each monitored cattle animal. In some embodiments, the method comprises capturing video, by the thermal imagers, rather than multiple images of the animal or animals for which the likelihood of a state is being determined.

[0034] In some embodiments, step S100 comprises continually monitoring an area comprising a plurality of cattle animals, either by capturing video or by capturing multiple images over time with a relatively low time in between images, and continuously performing the subsequent steps of the method as well, for each of the plurality of cattle animals being monitored. Thus the method may be used in order to monitor an area with cattle animals and automatically detect signs that would indicate that any of the animals within the area being monitored is in any of the states oestrus, pregnancy and parturition, which makes it suitable for implementing where there are free-ranging animals.

[0035] In some embodiments, the step S100 comprises monitoring a group of animals, and detecting and identifying an individual animal within the group of animals, for which the likelihood of a state is to be determined. Such detecting and identifying may be done by identifying an unusual amount of movement of an animal within the group of animals, for example by using image recognition technology.

[0036] The method may optionally comprise a step of storing the detected movement pattern in a database. Generally speaking, systems that implement the method according to the present disclosure will have functionalities that allow for results to be stored in a database, and in cases where the result is not stored during the process of analyzing a specific cattle animal, it will in most cases be stored at some point, even though it may be after all the measurements and analyses have been performed.

[0037] The method then comprises a step S105 of analyzing a thermal characteristic of the captured thermal images. The thermal characteristic may in some embodiments comprise the shape or contour, or the thermal representation of the shape or contour, of one or multiple cattle animals that are being monitored, such that the cattle animals are distinguished from the background and/or from other cattle animals, wherein such distinctions may be made irrespective of lighting conditions and background of the images. In some embodiments, the thermal characteristic may also comprise the temperature of the cattle animal(s) at

various places, such as at the urogenital area or around the eyes of the cattle animals, or a skin temperature of the cattle animal(s). In some embodiments, the temperature at such places may be outputted together with the likelihood value for a cattle animal being in a certain state. In some embodiments, the temperature at such places may be used as a variable to determine the likelihood of the cattle animal being in a state, since high temperatures in these places may be indicative of such states, particularly of oestrus.

[0038] By the step S105 of analyzing a thermal characteristic, the method becomes applicable to use on various types, shapes, sizes, colors and patterns of cattle animals, and usable in different types of environments, lighting conditions and times of the day. Previous monitoring systems have the problem of making an accurate distinction between cows and the background in an effective manner, which is one of the problems solved by the present disclosure.

[0039] In some embodiments, the method may further comprise a step of determining a thermal characteristic of a cattle animal in the thermal images. This determination may e.g. determine the shape of the cattle animal based on the thermal images, and/or the temperature of the cattle animals, e.g. at the areas described above. The step of analyzing 105 and the step of determining a thermal characteristic may be performed more or less as one step, wherein the thermal characteristic is first analyzed and then determined.

[0040] Step S105 may further comprise processing the images in order to better distinguish the cattle animals. An illustrative example of such processing will now be described. A first step comprises optimizing and compressing an image comprising at least one cattle animal in order to minimize the amount of data used in calculations. A second step comprises detecting all edges present in the compressed image. A third step comprises using knowledge regarding the average sizes and shapes of cattle animal in order to determine the outer edges of each cattle animal present in the image, i.e. the contours, based on all of the edges detected in the second step. and thus also distinguishing between different individual animals. In some embodiments, the processing of the images may

further comprise adding visually distinguishable information for each cattle animal, in order to be able to distinguish between different cattle animals.

[0041] In some embodiments, the method may further comprise a step S107 of approximating the cattle animals of the captured images with geometrical figures. This may be especially relevant if the method is performed with thermal image devices of lower quality, since it may be difficult to accurately define the boundaries for a cattle animal if the resolution of the captured images is not high enough.

[0042] There are different shapes and figures, and/or combinations of shapes and figures, that may be used for approximating the animals. Different ways of approximating the shape of cattle animals will now be described, with reference to Figs. 4-6. Something the different techniques have in common is that image recognition technology is used in order to indicate a probable location of at least the tail, wickers and nose of the cattle animals.

[0043] Fig. 4 shows a figure captured with a thermal imager, which may or may not have been processed as described above, comprising three cattle animals 400, 410, 420. The head of the first animal 400 as well as most of the neck is not visible in the image. As for the second animal 410, the head isn't visible either, but the neck is. However, a full view of the third animal 420 is available in the image.

[0044] In one embodiment, step S107 comprises approximating the cows identified in a figure with ellipses, such that one ellipse approximates the body and one ellipse approximates the head of the cow. This can be seen in Fig. 5, comprising the same cows as in the first image, with the addition of the ellipses approximating the shapes of the animals 500, 510, 520. In case there is not sufficient data to draw conclusions regarding where the head is located, as is the case for the first cattle animal 500, no approximation of the head will be done. However, even an approximation of the only body of an animal may be useful for determining movement patterns. Even if the entire head is not visible, having some more information available might be enough in order to infer the location of the head and subsequently approximate it with an ellipse, as is done for the second

animal 510. As for the third animal 520, the whole animal is visible and therefore it is possible to approximate both the body and the head with one ellipse each. The area where the ellipse approximating the body and the ellipse approximating the head meet, is considered to be the wickers of the animal.

[0045] In one embodiment, shown in Fig. 6, the animals 600, 610, 620 may be approximated with three dots, one for the tail, one for the wickers and one of the nose. In the same manner as in Fig. 5, the first animal 600 does not have a dot for the nose, since the head of the cow is not present in the image.

[0046] Fig. 7 shows another method of approximating cattle animals, wherein a vector is drawn from the tail to the nose. In some embodiments, dots indicating the nose, wickers and tail may be used as guidance for drawing the vector, as is seen in Fig. 7, however this is not necessary.

[0047] In some embodiments comprising the step S107 of approximating the shapes of the cattle animals, the subsequent steps S110, S120, S130 and S140 are performed using the approximations obtained in step S107. The steps of approximating the shapes of the cows with geometrical figures is also made easier by the use of thermal images rather than regular cameras.

[0048] One of the reasons for using approximations of the cattle animals rather than unprocessed images of the animals is in order to minimize the amount of data needed for the calculations, which makes for a more efficient and faster method. Further, it has been found that the accuracy of determinations made based on approximations of cattle animals are very high with the methods of approximating described above.

[0049] Thus, after capturing S100 a plurality of images, the method comprises a step S110 of determining a movement pattern of the cattle animal. The phrase “movement pattern” can mean both a single movement and multiple movements, or it may entail a change in movement. In some embodiments, movement pattern may also mean a result from measuring and analyzing multiple movements over a period of time, possibly with certain time intervals in between measurement

periods. It is also possible for the movement pattern to be a combination of these things, e.g. a change over time in combination with a specific movement currently being determined.

[0050] In a typical embodiment of the method, determining a movement pattern comprises determining a movement. This may be done by comparing the captured images with previously stored images of cattle animal in movement, and comparing the captured images with the stored results in order to determine if they match. It is also possible to determine specific variables to look for before the images are captured, such as being on the lookout for a specific movement of the leg. In most embodiments, the method is used for determining a movement rather than looking for a specific movement.

[0051] In some embodiments, step S110 comprises determining an interaction between cattle animals as the movement pattern. As will be understood, this requires that at least two cattle animals are being monitored and analyzed, e.g. that method steps S100 and S105, and optionally S107, are performed for at least two cattle animals simultaneously, wherein both animals are in view of the video monitoring system.

[0052] In embodiments comprising the step of approximating S107, step S110 comprises making the determination of a movement pattern based on the approximations of the cattle animals of the images being analyzed.

[0053] In some embodiments, the step S110 may comprise determining the movement pattern in terms of changes in data. For example, a series of images of the same cattle animal over time is compressed and approximated with geometrical figures. The differences in the positions of the geometrical approximations between images are then calculated in order to determine a movement pattern, which may be expressed as data, for example as the changes in distance and angle of the geometrical approximations. The differences in position may also be calculated and expressed as data based on images without using approximations.

[0054] When a movement of the cattle animal has been determined, the method further comprises a step S120 of comparing the determined movement pattern with a reference movement pattern. The reference movement pattern is typically obtained from a database comprising large amounts of previously recorded movement data related to cattle animal. In some embodiments, the reference movement pattern may be multiple movement patterns. Each reference movement pattern may correlate with at least one specific known state, including at least oestrus, pregnancy and parturition. It is also possible for a reference movement pattern to correlate with multiple different states at once, possibly to a varying degree.

[0055] In some embodiments, the known states may include only one of oestrus, pregnancy and parturition. In some embodiments, the known states may include all three of oestrus, pregnancy and parturition. In other embodiments, the known states may include two of oestrus, pregnancy and parturition. Correspondingly, the step of outputting a likelihood value for at least one of the plurality of states, may entail outputting a likelihood value for only one state, or for two states, or outputting a likelihood value for each of the three states.

[0056] In some embodiments, the reference movement pattern comprises another movement pattern related to the same cattle animal. Depending on the embodiment, as will be evident from the description above, the reference movement pattern may include at least one reference movement pattern from the same cattle animal that is being examined, and at least one reference movement pattern from at least one other cattle animal. By doing this, it may be possible to detect changes in behavior in the cattle animal both relative to themselves, and relative to other cattle animal, and also relative to statistical changes derived from a vast number of measurements.

[0057] In some embodiments, the reference movement patterns may include behavior related to standing heat, as described previous, mounting the head side of other cattle animals, mounting or attempting to mount other cattle animals,

resting with chin on another cattle animal, sniffing the genital area of other cows, being mounted but not standing, and general restlessness.

[0058] In some embodiments, the comparing step S120 is a comparison between approximations of cattle animal of interest and of approximations of reference movement patterns. The same type of approximation is then used for the reference movement patterns as is used for the approximation of the cattle animal of interest. In some embodiments, the comparing step S120 comprises comparing data extracted from the thermal images of the cattle animals of interest with data extracted from reference images, such as e.g. the positional differences of the geometrical approximations between images. Comparing data extracted from the thermal images may be done by comparing data extracted from images using approximations of cattle animals as well as by comparing data extracted from images without approximations.

[0059] Following the comparison step, the method comprises determining S130 whether the detected movement pattern correlated with a known state or not, wherein the known states includes at least oestrus, pregnancy and parturition. In some embodiments, the steps of comparing S120 and determining S130 may be performed more or less as one step, wherein the detected movement pattern is compared to a number of reference movement patterns, each being indicative of at least one state, and then the determination follows directly from which reference movement pattern(s) the detected movement pattern correlates best with. Thus, determining if the detected movement pattern correlates with a known state may entail determining if the detected movement pattern correlates with previously detected and recorded movement patterns that, in turn, are indicative of certain states. In embodiments comprising the step S107 of approximating the cattle animals with geometrical figures, the determining step S130 may also be performed using approximations of the cattle animals, both in the captured images and in the reference images. Further, in some embodiments the determining S130 comprises using data extracted from the images rather than using the images themselves, wherein the extracted data may be extracted from images with or without using approximations of cattle animals.

[0060] After it has been determined if the detected movement pattern correlates with a known state, and preferably which state it correlates with, the method comprises a step S130 of outputting a likelihood value for at least one state, meaning the likelihood of the cattle animal being in that particular state at the time of performing the measurements. In some embodiments, the method comprises outputting the likelihood for at least each of the states including oestrus, pregnancy and parturition. As will be understood, it is possible for the likelihood of certain states to be 0% or 100%, and anything in between.

[0061] In some embodiments, the method comprises the usage of abductive reasoning in order to infer correlations from likelihoods, in such a way that when at least two different values are available, the certainty of an indicator which is dependent on two variables will be a great deal higher than the certainty of an indicator is dependent on only one variable. The usage of abduction, as opposed to deduction, does not guarantee the conclusion, but may instead be seen as an inference to the best possible explanation, i.e. the most likely one.

[0062] In some embodiments, the method comprises using a cumulating scoring scale, measured during a predetermined time period, in order to determine the likelihood of a cattle animal being in at least one of the states of oestrus, pregnancy and parturition. This could entail performing the described method several times during the predetermined time period, which is typically around 24 hours, and outputting a high likelihood for at least one state if multiple indications of being in said at least one state are recorded. The different determined motion patterns indicative of at least one of the states may further be assigned with a score, which is indicative of how likely the determined motion pattern is to correlate with the at least one state.

[0063] An example of how abductive reasoning may be used in the context of the present disclosure will now be described. If we assume that event B follows from event A, we can measure B in order to determine the likelihood of the event A. An example being representative of the present disclosure: If oestrus follows a

specific pattern of movement, we can measure body movement patterns to determine likelihoods of oestrus.

[0064] In some embodiments, the method comprises monitoring multiple animals, capturing a plurality of thermal images, or video, of multiple cattle animals, and then performing the method steps for an individual animal among said multiple cattle animals. In some embodiments, the method comprises monitoring multiple animals, capturing a plurality of thermal images, or video, of multiple cattle animals, and then performing the method steps for each animal among said multiple cattle animals. In some embodiments, the method comprises monitoring multiple animals, capturing a plurality of thermal images, or video, of multiple animals, and then performing the method steps for some, but not all, of said multiple cattle animals.

[0065] Looking now at Fig. 2, a system according to the present disclosure will now be described.

[0066] The system comprises a thermal imager 200, typically a camera of higher quality having, together with its optics a resolution of more than 1000 pixels per square meter, a temperature resolution of better than 0.1 degrees and frame rate of no less than 10 frames during the duration of a movement to be captured. For most movements, 5 frames per second is a sufficient frame rate, i.e. most movements occur over a period of time of 2 seconds or more. However, as will be understood, the faster the movement is the faster the frame rate must be in order to capture the movement accurately. Thus, if the method is intended to look for quick movements the frame rate should be higher, such as 20 frames per second. The camera is adapted for capturing a plurality of images of a cattle animal, and the camera may be both portable and stationary depending on the specific implementation.

[0067] The thermal imager 200 is operatively connected to a database 210, comprising historical movement data of cattle, wherein the database may further be used to store the images captured by the thermal imager 200 and all data

related to them, as well as results and other data that is generated when applying e.g. a method according to the present disclosure.

[0068] In some embodiments, the system may be adapted such that the thermal imager is mounted a certain distance above ground level, and/or at a certain angle, such that the thermal images may be captured from above, in order to better distinguish between individual cattle animals, as described previously.

[0069] The system further comprises an entity capable of processing data, such as a computer 220. The computer 220 comprises a memory and a processor and is operable to execute instructions and is also operatively connected to the thermal imager 200. In some embodiments, the database 210 and the computer 220 are also operatively connected to each other.

[0070] The entities of the system may be connected to each other by any means suitable for the implementation, such as for instance by means of cable or wirelessly. It is also possible to have a mix between wired and wireless connections in the system.

[0071] In some embodiments, the system is stationary, and the cattle animals that are to be inspected are moved to the location of the system. In other embodiments, the system may be portable.

[0072] A typical usage of the system will now be described as an example. An area comprising multiple cattle animals is continually monitored by the thermal imager. Whenever an unusual amount of movement is detected in a specific one of the multiple animals, or in multiple animals at the same time, the system uses embodiments of the method according to the present disclosure to determine the likelihood of that cattle animal being within any one of the states oestrus, pregnancy and parturition. When an animal, or multiple animals, has been singled out and the likelihood of that animal being within one of the known states is to be determined, plurality of thermal images of the cattle animal(s) of interest is captured with the thermal imager 200. The thermal images may be the same thermal images that would have been recorded by the monitoring system during

normal observation, or it may be images more focused on the cattle animal of interest. The capturing of images may be performed by moving the cattle animal to the thermal imager 200, or it may entail moving the thermal imager 200 close to the cattle. Typically, the cattle animal would already be within the field of view of the thermal imager.

[0073] After images, or video, of the cattle animal of interest have been captured, the cattle animal may in some embodiments be approximated using geometrical figures, as described earlier in this application. Then, the plurality of images captured by the thermal imager 200, are sent to the computer 220 in order to determine which movement pattern is being captured. In some embodiments, images with approximations of the cattle animals are used. In some embodiments, only data extracted from the images is sent to the computer, such data regarding positional changes between images. The computer does this processing by retrieving data from the database 210 and comparing it to the captured images. In some embodiments, the data extracted from the images is compared with data from reference images in the database 210.

[0074] When the computer 220 has decided which movement pattern is being captured, the next step is to compare this movement pattern with a reference movement pattern. However, there is a possibility that the captured images would not correlate with any images stored in the database, in this case the system may be adapted to trigger an alarm to signal this. In embodiments comprising approximating the cattle animals with geometrical figures, the comparison may be made with approximations of reference figures as well, using the same method of approximation as for the captured images. In some embodiments, data representing the movement patterns of the animal of interest will be compared with data representing movement patterns of the reference movement patterns, with or without using approximations.

[0075] The reference movement pattern is typically retrieved from the database 210, and is used to determine if the movement pattern detected from the captured images correlates with any known state, including at least the states of oestrus,

pregnancy and parturition. In some embodiments, this entails comparing the captured movement pattern with a vast number of stored movement patterns in order to determine which movement pattern is the best match.

[0076] Then, based on the determining, the system will output a likelihood value for at least one of the states, such as for example a 67% chance of the cattle animal being in oestrus. The outputting may be done on the computer 220 or on the thermal imager 200, depending on the specific implementation. Typically, the results are shown on a display which is operatively connected to at least one of the computer 220 and the thermal imager 200.

[0077] The system may further comprise various input and output devices, that may be used to interact with the other parts of the system.

[0078] It should be understood that the system may also be implemented as a thermal imager 200 having a processing device and memory thereon, adapted to perform the same functions as the computer 220, in which implementation the thermal imager 200 is able to perform the processing as well.

[0079] In some embodiments, the thermal images are taken from a position above the cattle animals, which makes it easier to distinguish between different cattle animals. This is shown in Fig. 3, which comprises a thermal imager 300 at a certain position above an area to be monitored 320. The field of view of the thermal imager is denoted by the dotted lines 310. The area 330 is the area being monitored by the thermal imager, which area typically comprises one or multiple cattle animals. If capturing images at a too low height and/or from a frontal position, the thermal images may become too cluttered. This is not generally a problem when using regular cameras, but it may be a problem when using infrared cameras. Capturing the images from an appropriate height is especially important when monitoring a larger number of cattle animals, since that results in a larger number of individual thermal representations which need to be distinguished from each other.

[0080] In some embodiments, the thermal images are taken from a position directly above the cattle animals, with a vertical alignment of the thermal imager 300, such as shown in Fig. 3. As will be understood, the thermal imager 300 which would be pointed downward in a vertical direction, would be mounted at a distance from ground level such that a relevant area of cattle animal could be monitored. In some embodiments, the thermal imager is mounted at a distance of approximately 2-10 meters above the cattle animals, which entails approximately 4-12 meters above ground level. The exact distance depends on the area that is to be covered, which typically varies depending on the location wherein the cattle animals are present. As will also be understood, the angle with which the thermal imager taking the pictures is angled may also be varied, depending on the area that is to be covered by the thermal imager.

[0081] In some embodiments, the systems and methods described herein are used to determine the movement patterns for a single cattle animal, wherein the cattle animal is the only cattle animal being monitored. In other embodiments, the systems and methods are used for determining a movement pattern of a single cattle animals when a plurality of cattle animals are being monitored. In some embodiments, the systems and methods are used for determining a movement pattern of a plurality of cattle animals simultaneously, wherein a plurality of cattle animals is being monitored.

[0082] Although the description above contains a plurality of specificities, these should not be construed as limiting the scope of the concept described herein but as merely providing illustrations of some exemplifying embodiments of the described concept. It will be appreciated that the scope of the presently described concept fully encompasses other embodiments which may become obvious to those skilled in the art, and that the scope of the presently described concept is accordingly not to be limited. Reference to an element in the singular is not intended to mean "one and only one" unless explicitly so stated, but rather "one or more". Moreover, it is not necessary for an apparatus or method to address each and every problem sought to be solved by the presently described concept, for it to be encompassed hereby.

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CLAIMS

1. Method for determining a likelihood for a state of a cattle animal, comprising the steps of:

capturing (S100), a plurality of thermal images of a cattle animal;

analyzing (S105) a thermal characteristic of the thermal images;

determining (S110), based on the plurality of thermal images, a movement pattern of the cattle animal;

comparing (S120) the determined movement pattern with a reference movement pattern;

determining (S130), based on the comparison, if the detected movement pattern correlates with a known state out of a plurality of known states, the plurality of known states including at least oestrus, pregnancy and parturition; and

outputting (S140), based on the determining (S130) a likelihood value for at least one of the plurality of known states.

2. The method according to any one of the previous claims, wherein the step of determining a movement of the cattle animal comprises comparing the captured images with images in a database and choosing a movement that correlates best with the captured images, from a database with a plurality of movements.

3. The method according to any one of the previous claims, wherein the thermal images are captured from a position above the cattle animals.

4. The method according to any one of the previous claims, wherein the reference movement pattern is a movement pattern related to the same cattle animal.

5. The method according to any one of the previous claims, further comprising, after the step of analyzing (S105):

approximating (S107) a shape of the cattle animal with a geometrical figure.

6. The method according to any one of the previous claims, further comprising:

using a cumulative score scale measured during a predetermined time period for determining the likelihood value.

7. A system for determining a likelihood for a state of an animal, comprising:

a thermal imager (200), adapted to capture a plurality of thermal images of a cattle animal;

a processing unit and a memory (220), operatively connected to the thermal imager;

a database (210), operatively connected to the processing unit and to the thermal imager,

wherein the processing unit is adapted to:

analyze a thermal characteristic of the thermal images;

determine, based on the plurality of thermal images, a movement pattern of the cattle animal;

determine, based on the comparison, if the detected movement pattern correlates with a known state of a plurality of known states, the plurality of known states including at least oestrus, pregnancy and parturition; and

based on the determining, outputting a likelihood value for at least one of the plurality of known states.

8. The system according to claim 7, wherein the processing unit is further adapted to determine a movement of the cattle animal by comparing the captured images with images in a database and choosing a movement that correlates best with the captured images, from a database with a plurality of movements.

9. The system according to any one of claims 7 or 8, wherein the thermal imager (200) is positioned above an area to be covered by the system.

10. The system according to any one of claims 7-9, wherein the reference movement is obtained from a database comprising historical records with movements of cattle animals.

11. The system according to any one of claims 7-10, wherein the processing unit is further adapted to:

approximate the shape of the cattle animal with geometrical figures.



Fig. 1

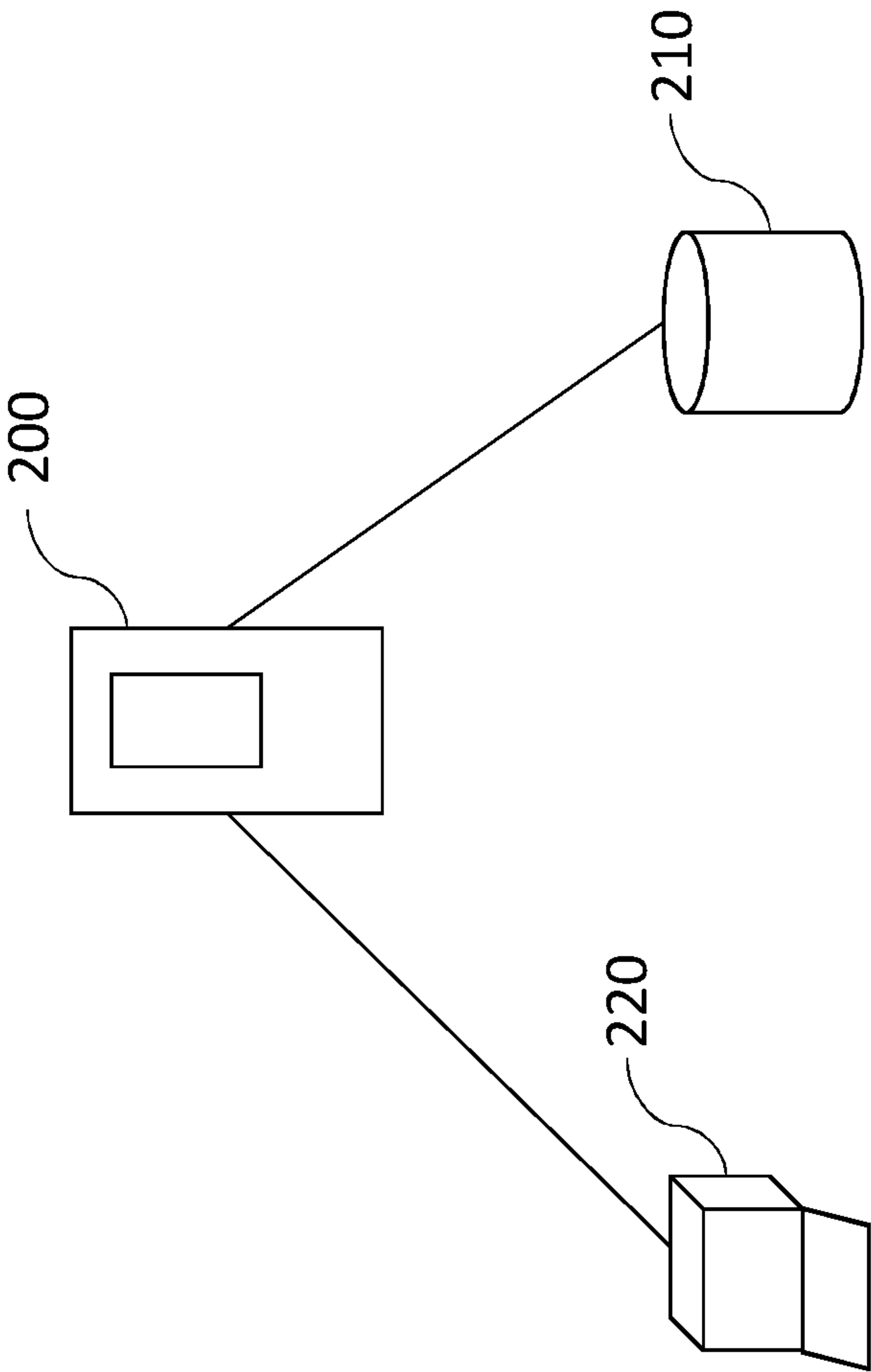


Fig. 2

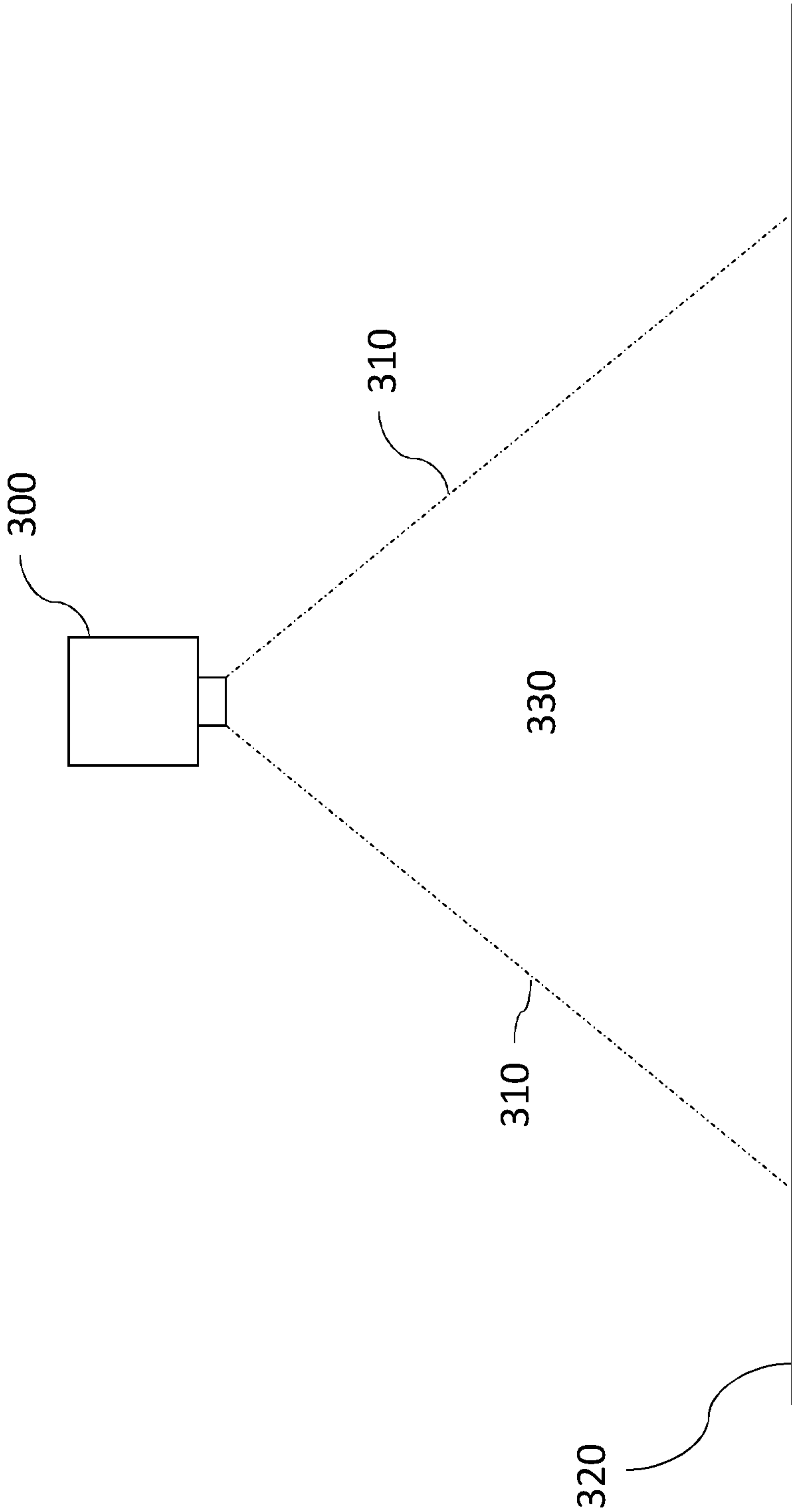


Fig. 3

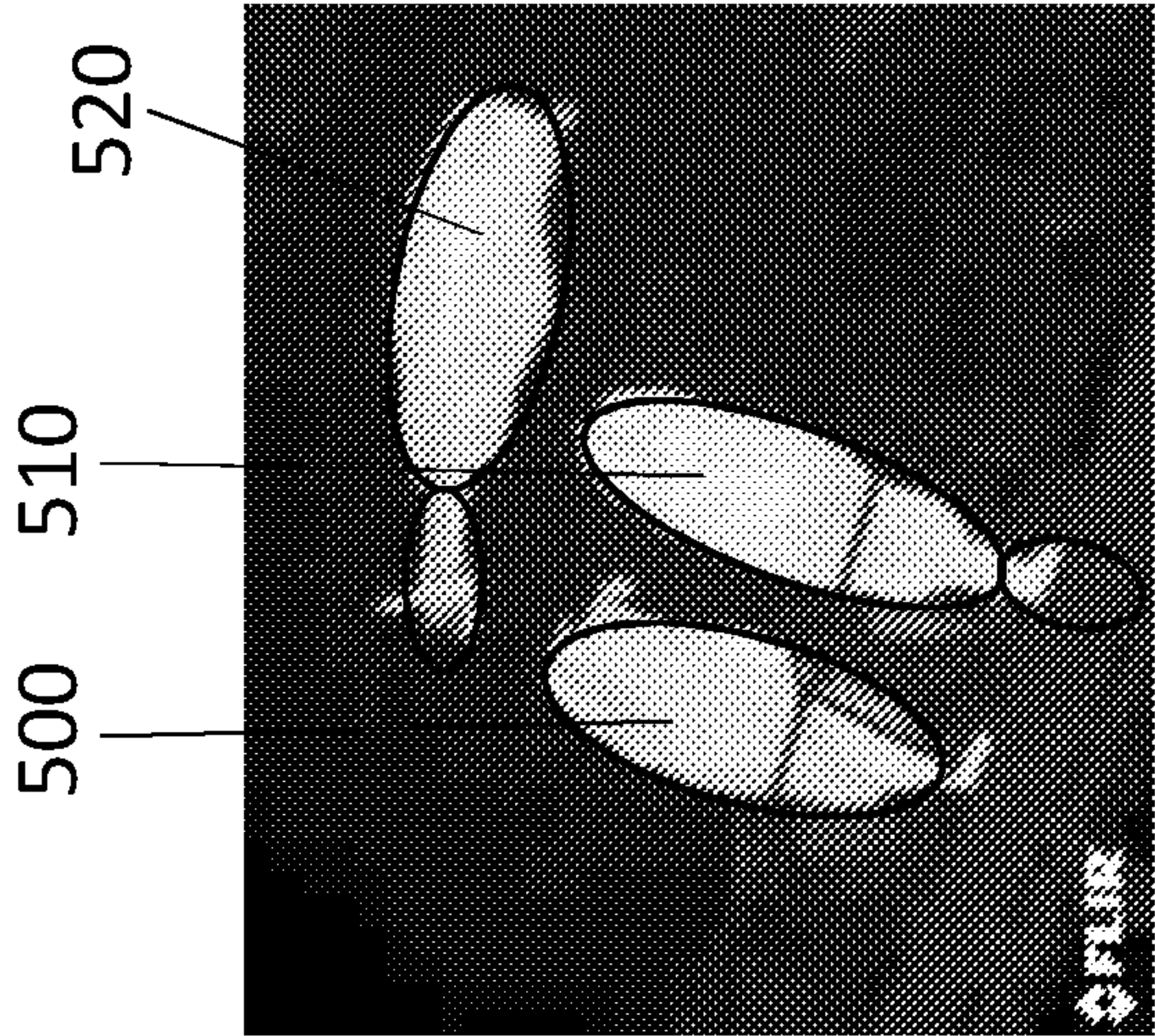


Fig. 5

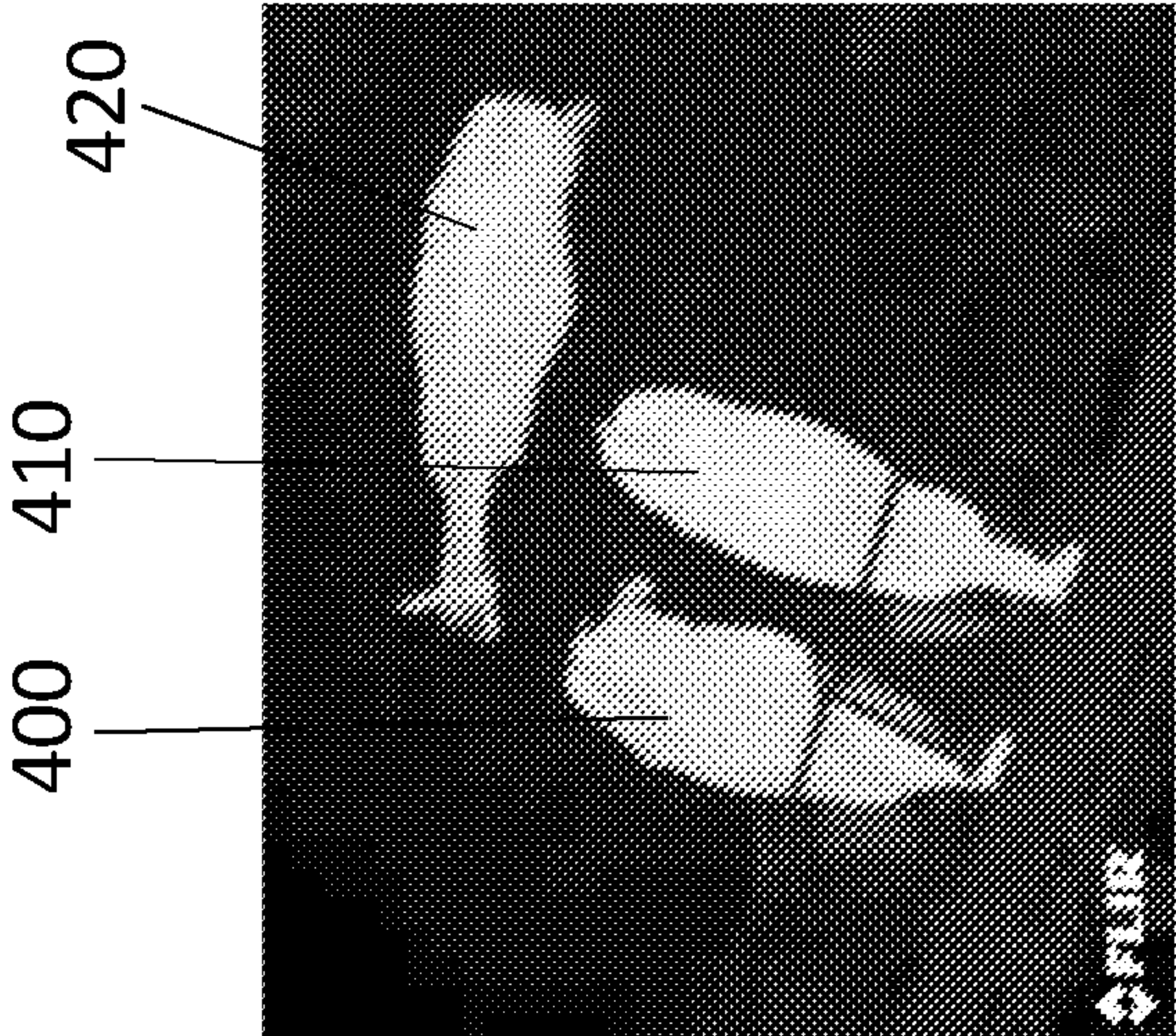


Fig. 4

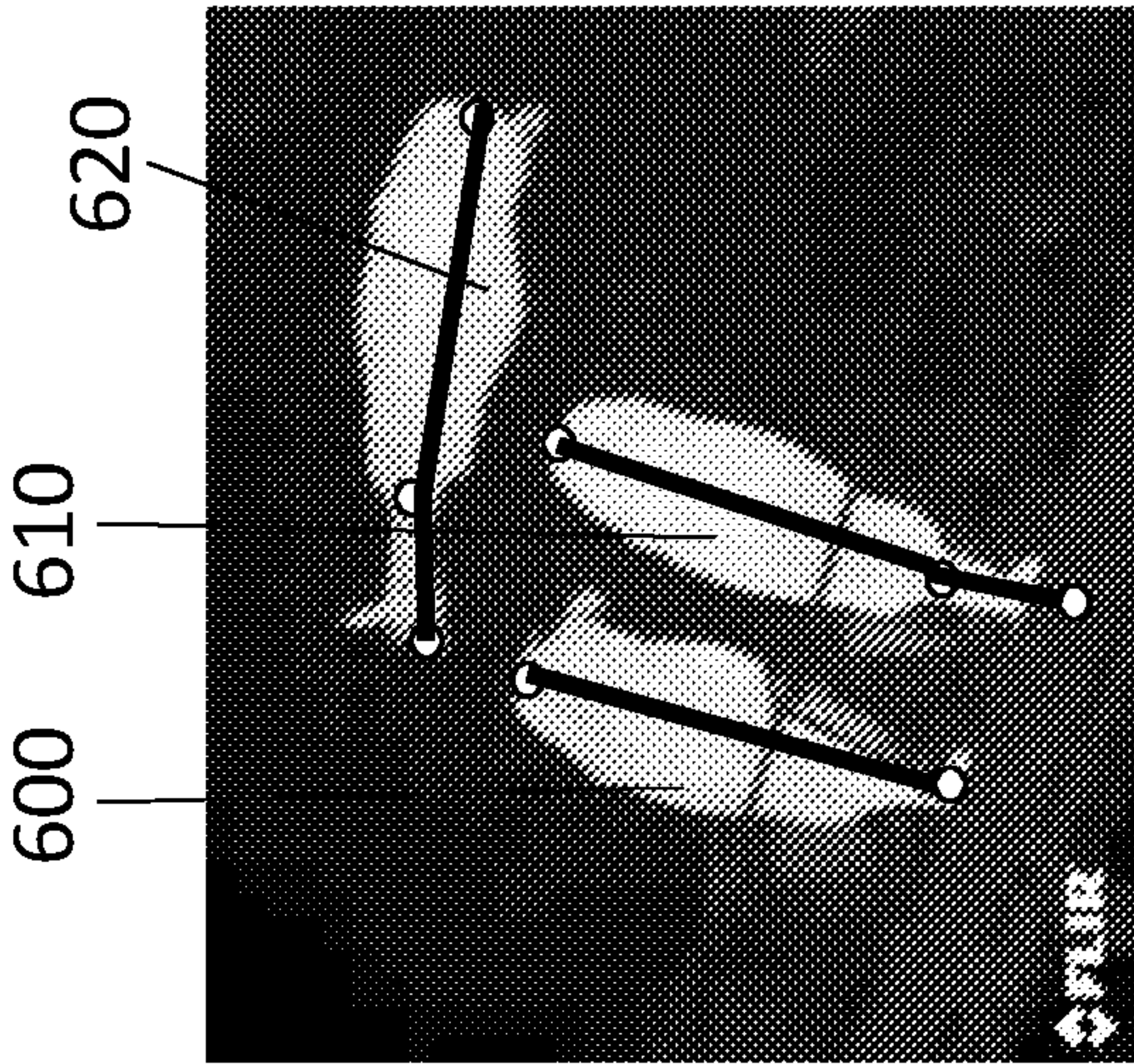


Fig. 6

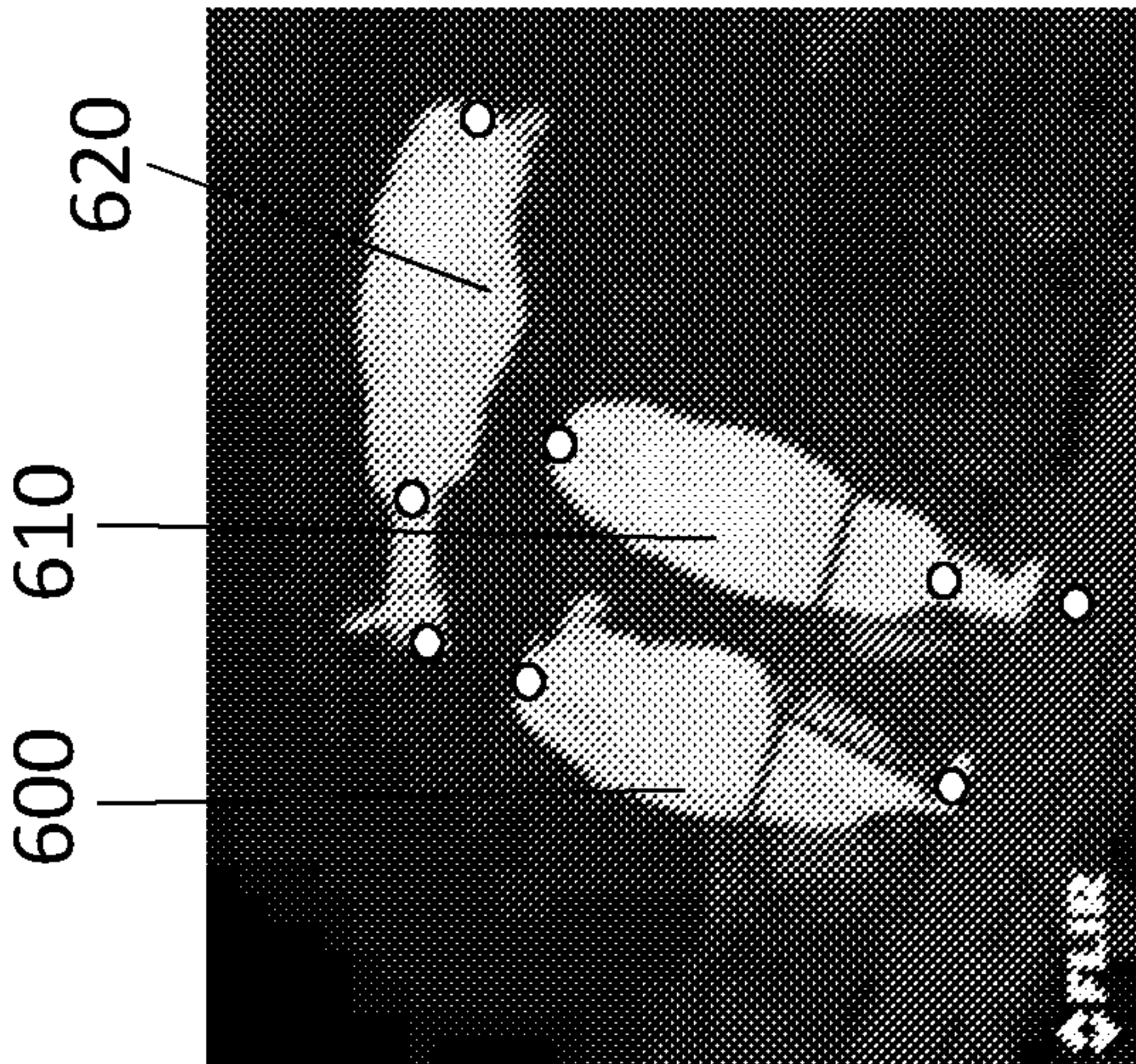


Fig. 7

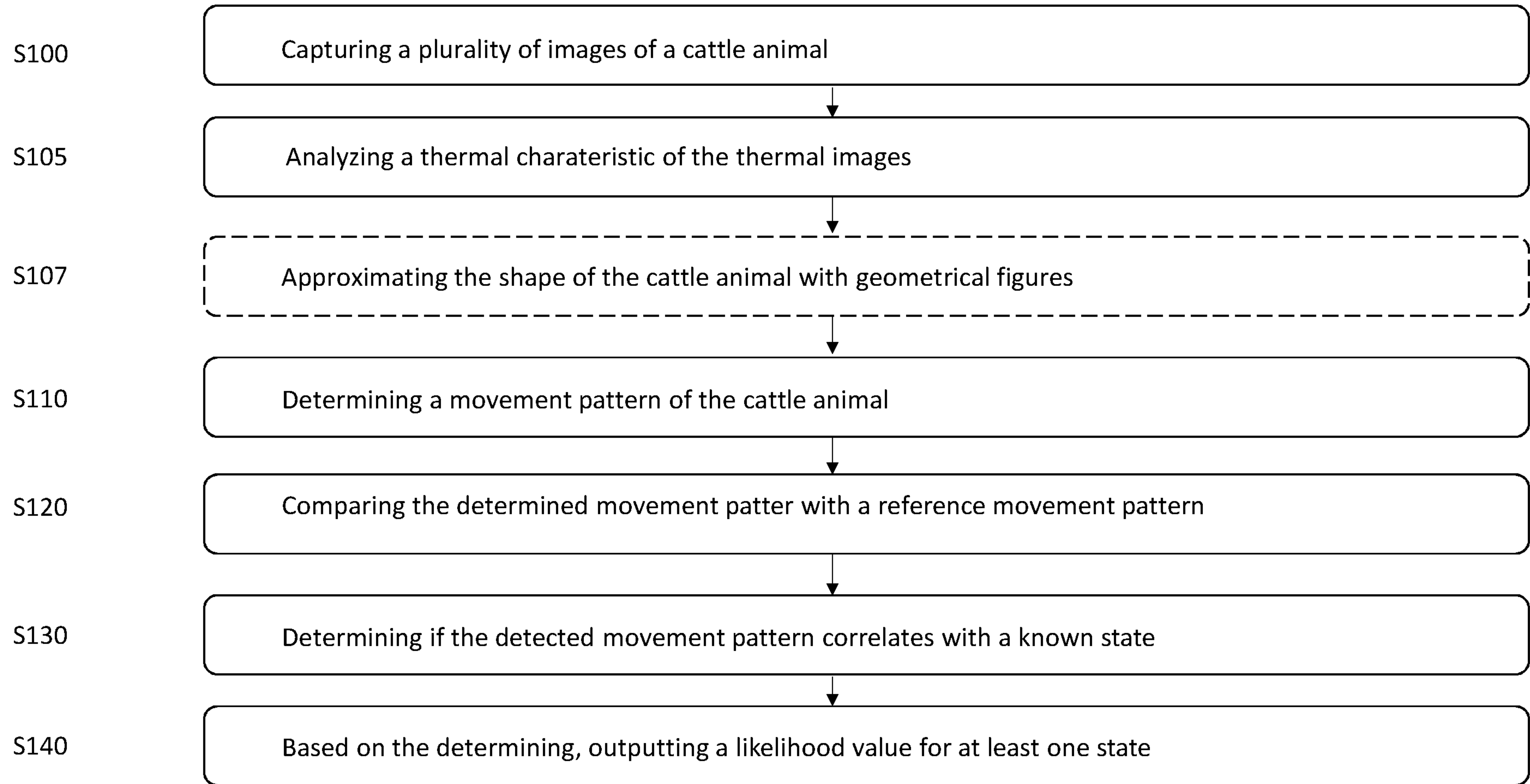


Fig. 1