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(54) METHOD AND DEVICE FOR MONITORING A BABY AND FOR INTERACTION

VERFAHREN UND VORRICHTUNG ZUR ÜBERWACHUNG EINES SÄUGLINGS UND ZUR INTERAKTION

PROCÉDÉ ET DISPOSITIF POUR SURVEILLER UN BÉBÉ ET POUR INTERACTION

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Description

[0001] The present invention relates to video monitoring devices and methods for monitoring a baby, in particular for the purposes of monitoring a baby sleeping in its crib in dim or nocturnal conditions, or in other words in partial or total darkness; the present invention also relates to methods for interaction between a baby and its parent or caregiver.

[0002] More specifically, the invention relates to a method and device for monitoring certain vital signs of the baby, in particular the heart rate and respiratory rate.

[0003] US8094013 discloses a device of this type. However, according to this document a strap must be attached around the baby's body, which is tedious to perform and is not suitable if the baby is already asleep.

[0004] WO2013170035 also discloses a device of this type; however, it is necessary to install a monitoring pad under the baby's body, which is not suitable if the baby is already asleep, and the system is ineffective if the baby moves beyond the sensitive area of the pad. US2014/155759 also discloses a device of this type; involving video based surveillance by contactless photoplethysmographic monitoring of a baby.

[0005] The present invention is intended to overcome at least some of the disadvantages of the prior art.

[0006] To this end, a first general aspect of the invention provides a method for video evaluation of the heart rate and/or respiratory rate of a baby in dim or nocturnal conditions according to claim 1 and a device comprising a video camera and a source of infrared light and a computing unit according to claim 9. According to the invention, the video evaluation comprises:

B1- determining the position of the baby's head by detecting edges (borders) forming portions of an ellipse substantially coinciding with the outline of the head,

B2- identifying an area of interest substantially centered on the ellipse,

C- evaluating, by photoplethysmographic analysis of the area of interest, the baby's heart rate and/or respiratory rate.

[0007] The method further comprises a step **D-** of identifying a significant movement of the baby, in which case step **C-**of photoplethysmographic analysis is suspended; this avoids erroneous results when the baby changes position or makes a significant movement that does not allow the photoplethysmographic analysis to continue correctly.

[0008] The method further comprises a step **D2-** of identifying a return to a stable state where there is no significant movement by the baby (after the movements have stopped), in which case steps **B1-B2** are executed once again, and step **C-** of photoplethysmographic analysis is reinitialized with the new area of interest determined at step **B2;** which allows the method to redetermine the position of the baby's head and to resume the photoplethysmographic analysis.

[0009] With these arrangements, a method is provided that requires no contact with the baby to implement it, and can therefore be applied even if the baby is already asleep in its crib. In addition, such a method is compatible with the baby moving, changing position, and turning over; and the device that implements the method has a contactless interaction with the baby, being based on video monitoring and an advantageous analysis of the captured images, and is easy to install.

[0010] In various embodiments of the above invention, one or more of the following arrangements may possibly be used.

[0011] The images are preferably captured in color and the photoplethysmographic analysis is preferably based on the red component of the video images; as the red component of the video signal provides the most relevant information during dim or nocturnal conditions under infrared light for performing the photoplethysmographic analysis.

[0012] A method of image convolution with statistical thresholding is preferably used in step B1 to detect edges or edge segments in the image. The edge segments can thus be extracted from the analyzed image in an effective manner.

[0013] In step **B1-,** candidate ellipses are formed from the identified edge segments, and a selection filter is applied to the candidate ellipses to retain only one selected ellipse coinciding with the outline of the baby's head; this provides a comprehensive and systematic method for extracting candidate ellipses from the edge segments, and for choosing among them the most relevant ellipse that can correspond to the baby's head.

[0014] In step **C-,** to determine the heart rate, a digital filter with passband of 0.75 Hz - 3.5 Hz is applied to the light signal spatially averaged over the area of interest, to obtain a filtered signal; this advantageously eliminates the continuous component of the signal as well as all interference signals having a frequency higher than the upper limit of the digital filter, here 3.5 Hz, which is advantageous for extracting the heart rate.

[0015] A validity criterion concerning the relevance of the filtered signal is defined, for selectively validating or not validating the heart rate information, the validity criterion being based on the signal-to-noise ratio; whereby the method only delivers the heart rate information if it is reliable, otherwise the heart rate information output is invalidated.

[0016] The captured images may be divided into an array of sub-images of identical size; processing can thus be applied to the sub-images successively, requiring less computing power and fewer resources.

[0017] Preferably, at step B1 the sub-images having a neutral content, meaning with no significant variation in color or intensity within the area of the sub-image, are eliminated, and after step B2 the sub-images located outside said selected ellipse are eliminated; this avoids processing the sub-images of no interest, and means a shorter time for processing the complete image.

[0018] The invention also relates to a device for evaluating the heart rate and/or respiratory rate of a baby in dim or nocturnal conditions, comprising a video camera, a source of infrared light, and a computing unit, wherein the infrared source is configured to illuminate the baby, the video camera is configured to capture video images of the baby, and the computing unit is configured to implement the method as described above.

[0019] Advantageously, the device may further comprise a wireless communication interface for transmitting the baby's heart rate and/or respiratory rate data to a remote entity; in this manner, the information about the baby's vital signs can be displayed on the screen of a smartphone at a distance from the crib where the baby is sleeping.

[0020] According to a second aspect, which may be combined with the invention, a device is provided having the general function of monitoring a baby, and which further comprises a volatile organic compounds sensor (known as a "VOC sensor") which provides an indication of the quality of the air within the room. Such a sensor can detect multiple organic gases, such as butane, propane, octane, methanol, ethanol, propanol, butanol, and even aromatic compounds such as benzene, ethylbenzene, and toluene. The baby monitoring device may record the concentration of organic compounds detected by the sensor over one or more periods of time, and send this information either in real time or in deferred mode to a remote entity such as a smartphone.

[0021] A device is thus proposed having the general function of monitoring a baby, comprising a computing unit, a communication interface, and a volatile organic compounds sensor, said computing unit being configured to record the concentration of organic compounds reported by the volatile organic compounds sensor, and to send this information to a remote entity such as a smartphone. Alternatively, the computing unit stores the organic compound concentration data in memory, for transmission at regular intervals to the smartphone. In addition, an alert threshold may be provided in the computing unit of the monitoring device, which allows immediately sending an alert when the VOC concentration exceeds a predetermined threshold, and immediately alerting the smartphone holder.

[0022] According to a third aspect, which may be combined with the invention, a method for detecting the cries of a baby is provided. Specifically, the computing unit records audio signals from the microphone, and performs digital processing to identify a sound signature characteristic of a crying baby.

[0023] A device is thus provided that has the general function of monitoring a baby, comprising a computing unit, a communication interface, and a microphone, said computing unit being configured to analyze the audio signals received from the microphone in order to carry out a spectral or statistical analysis of the audio signal, for the purposes of processing it with an algorithm able to detect a baby's cries and if such are detected to send a high-level alert (SMS or equivalent message) to a remote entity such as a smartphone.

[0024] The detection algorithm can be calibrated to reference sound signatures originating, for example, from a general library of signals. The reference sound signatures may also come from previous recordings obtained on the same device, preferably for the same baby when crying. This improves the relevance of the detection, through learning.

[0025] A fourth aspect, which may be combined with the invention, proposes a monitoring device and a method for helping the baby to fall asleep, by controlling an atmospheric lighting and playing soft music. Specifically, the monitoring device comprises a computing unit, a microphone, and a detection function for detecting the heart rate and/or movements of the baby. The detection function can be provided via the video monitoring and the heart rate determination as described in the first aspect of the invention. The detection function may also be provided alternatively or in combination with the above by a sensor in the form of a sheet that detects the baby's movements, this sheet being intended for placement between the baby and the mattress of the bed. The baby's drowsiness phase could be determined as being, for example, when the heart rate slows and becomes more regular with no significant movement of the baby.

[0026] A method for guiding the baby's drowsiness phase is thus provided, comprising a step of monitoring certain vital signs such as the baby's heart rate and movement(s), a step of identifying the beginning of the drowsiness phase in which certain vital signs substantially correspond to parameters predetermined as being a drowsiness phase, a step of activating atmospheric lighting of decreasing intensity, and a step of activating atmospheric sound of decreasing intensity. The vital signs are detected, either through video monitoring and in particular the identification of the baby's heart rate and head movements, or through the use of a detection sensor sheet.

[0027] A fifth aspect of the invention, which may be combined with the above aspects or be independent of the above aspects, proposes a monitoring device which further comprises a detection sheet to be placed between the baby and the mattress, this sheet being intended to capture the baby's movements, both macroscopic and microscopic. The baby's respiratory rate can thus be determined by analysis and processing of the signal.

[0028] A device is thus provided having the general function of monitoring a baby, comprising a computing unit, a microphone, and a detection sheet to be placed between the baby and the mattress in order to capture the baby's movements, the computing unit being adapted to determine the baby's respiratory rate based on audio information captured by the microphone and movement information captured by the detection sheet.

[0029] The detection sheet may be formed by a thin air bladder; alternatively this detection sheet may be formed by piezoelectric sensor elements.

[0030] In addition, the device may be equipped with a communication interface for transmitting the respiratory rate data to a remote device such as a smartphone.

[0031] According to a sixth aspect, which may be combined with the invention, a method is provided for producing stimuli for the baby that mimic the mother's heartbeats, as sound through a speaker and/or via the detection sheet which can be equipped with an active pneumatic device capable of generating pressure pulses similar to heartbeats.

[0032] Other features, objects, and advantages of the invention will be apparent from reading the following description of an embodiment of the invention, given by way of non-limiting example. The invention will also be better understood by referring to the accompanying drawings, in which:

- figure 1 is a general view of a crib containing a baby to be monitored by a method according to the invention,
- figure 2 is a view of the video monitoring device,
- figure 3 shows a schematic block diagram of the device of figure 2,
- figure 4 represents a sample image captured by the camera,
- figure 5 illustrates the construction of edge segments,
- figure 6 illustrates the selection of an ellipse and of the area of interest,
- figure 7 illustrates an example of a filtered signal,
- figure 8 shows a flowchart illustrating the method,
- figure 9 illustrates a variant of the monitoring device with a detection sheet.

[0033] In the various figures, the same references designate identical or similar elements.

[0034] Figure 1 shows a baby **B** lying in a crib **13.** In the context of the invention, baby is understood to mean an infant or child less than 10 years old. We are particularly interested in the case where the baby is placed in the crib for a nap or for the night. Typically, in this configuration, the general lighting in the room will be low or very low, referred to herein as dim or nocturnal conditions providing partial or total darkness.

[0035] In the example shown, a video monitoring system, denoted **10,** comprises a video monitoring device **1** to be discussed in detail below, a mounting foot **12,** and a mounting clamp **11.** In the example shown, the mounting clamp is attached to a side rail of the crib or more generally of the bed. Note that in the monitoring assembly, it could also be secured to the crosspiece at the head or the foot of the bed.

[0036] Alternatively, the monitoring assembly may also be located elsewhere in the room.

[0037] The video monitoring device 1 may be attached to a different support, to a wall, to a bed canopy, etc. However, it is advantageous that the position of the video monitoring device be relatively stable compared to the bed or crib **13.**

[0038] As illustrated in more detail in figure 2, the video monitoring device **1** comprises a video camera **2,** which in the illustrated example, has a wide viewing angle over a solid angle of at least 90° or more (110° or 135°) so that the camera can capture images of the entire relevant area of the crib. In addition, the monitoring device comprises light-emitting diodes **3** (LED) capable of emitting in the infrared band, thus forming a source of infrared light.

[0039] In the example shown, the LEDs **3** are arranged all around the camera lens, but could be arranged otherwise with the camera and infrared lighting functions physically separated.

[0040] The video monitoring device **1** further comprises a computing unit **4** with a memory **40** as well as a battery **28** or alternatively a power supply unit connecting to the grid.

[0041] The video monitoring device 1 preferably also comprises a wireless communication interface **42** configured for exchanging data with a remote entity such as a smartphone **22.**

[0042] The video monitoring device **1** may further comprise a microphone **9** for capturing sound, and a sound generator in the form of a small speaker **19.**

[0043] In addition, there may be a light source **23** for dim atmospheric lighting whose intensity can be controlled by the monitoring device, an air quality sensor **37,** and auxiliary sensors **27** for example for sensing temperature and/or humidity and/or air quality.

[0044] The video monitoring device **1** may further comprise one or more buttons **18,** intended to be operated by a user (for example to configure the device, turn it on and turn it off) as well as a small display **15** for displaying states or parameters of the device (in which case the buttons **18** may be touch-sensitive).

[0045] The device may comprise a connector **74,** and holes **9'** near the bottom of the front face to improve pick-up by the microphone.

[0046] Advantageously according to the invention, the camera **2** periodically captures video images **5** of the baby **B.** The image capture frequency will be a few hertz or tens of hertz, preferably higher than 8 Hz. It should be noted that in the context of the invention the same camera is used to capture images in daylight and images in the dark.

[0047] An optical filter may be provided having two positions, i.e. a day position and a night position.

[0048] The device controls excitation of the infrared LEDs **3** either continuously or at times coinciding and consistent with the capture of images. The infrared LEDs are arranged so as to substantially illuminate the entire solid angle of view of the camera.

[0049] Advantageously according to this version, the method for image processing and analysis will seek to determine the position of the baby's head **T.**

[0050] To do so, a step of the method, denoted **B1,** consists of detecting edges or edge segments in one or more successive images captured by the camera.

[0051] The images **5** are captured in color in the example illustrated, and in dim or dark conditions under infrared light. One may preferably choose to work specifically with the red component of each image (among the components red, green and blue of the 'RGB' color space). It is also possible to work with the green component or a configured mix of colors.

[0052] For each image, spatial convolution with statistical thresholding is performed, or calculation of the correlation to the mean of the red component or of the configured mix of colors. This allows identifying and memorizing the curve portions **61,62,63,64** where the spatial gradient of the signal is the highest, corresponding in practice to edge segments within the image.

[0053] Identification of these edge segments can be confirmed by sequential analysis of several successive images; if similar edge segments are found at the same location in these multiple images, then the determination is confirmed.

[0054] Otherwise it may concern a macroscopic movement of the baby, a case which will be explained below.

[0055] When sequential analysis of several successive images has confirmed the presence of several edge segments, we proceed to the next step in which several edge segments are associated and together they are compared to an elliptical shape (ellipse) with which said several edge segments might match.

[0056] A relevance criterion is established for quantifying the correspondence of the combined edge segments **62,64** with the candidate ellipse.

[0057] Of course, if a continuous outline is found which forms a circle or a closed ellipse in the analyzed image, then the relevance criterion will assume the maximum value; but in practice often the image analysis only detects portions of the candidate ellipse, and the ellipse must be reconstructed and assigned a relevance criterion value.

[0058] This step, referenced **B2,** may in addition identify a plurality of candidate ellipses, in which case a selection filter is applied to the candidate ellipses to choose only one selected ellipse **6** coinciding with the outline of the baby's head **T.** This filter may use the size of the ellipse, the ratio of its major axis to minor axis, and also the proportion of the outline actually found in the previous step.

[0059] Note that the method presented could also work for detecting two (or more) baby heads in a crib containing two babies, in which case the filter would not be limited to identifying a single candidate ellipse but two ellipses.

[0060] In the typical case of one head to be detected, the selection of such a selected ellipse **6** allows eliminating from the subsequent analysis all image areas outside of the ellipse, and defining an area of interest centered on the ellipse.

[0061] Once the area of interest has been determined, and subject to the baby making no significant movements (see below), then the step denoted **C** of the method is carried out, this step corresponding to a photoplethysmographic analysis intended to determine vital signs of the baby, particularly the heart rate **HR** but also the respiratory rate **RR.**

[0062] Advantageously, one can determine a first area of interest **7** for evaluating the heart rate, and a second area of interest that may be distinct from the first, for evaluating the respiratory rate.

[0063] Preferably, for the heart rate determination, first there is applied to the light signal spatially averaged over the first area of interest, a sliding-window based offset calculation to eliminate the continuous component of the signal. This results in a signal denoted 80 in figure 7, which remains relatively noisy but no longer contains a continuous component.

[0064] Next, a digital filter with passband of 0.75 Hz - 3.5 Hz is applied to the signal 80 in order to obtain a filtered signal **81.** This eliminates spurious signals outside the frequency band of interest.

[0065] A peak detection step is then applied to the resulting filtered signal **81.** This processing is intended to find the peaks **86** (only the first ones are indicated by crosses in figure 7).

[0066] The time interval between each consecutive peak **86** allows calculating the heart rate as illustrated in curve **82.**

[0067] Optionally, a validity criterion relating to the relevance of the filtered signal **8** may be defined, to be used for selectively validating or not validating the heart rate information. This validity criterion may be based on the signal-to-noise ratio (S/N) of the signal **81.**

[0068] A filtered and corrected signal is denoted **83.**

[0069] If the heart rate value from step C satisfies the validity criterion, this value may be stored in memory and/or transmitted to a remote device **22** such as a smartphone connected by wireless link to the monitoring device 1.

[0070] Step **C** is carried out almost continuously, repeating periodically, for example obtaining a measurement every 5 seconds or every 10 seconds, knowing that to obtain each measurement, when appropriate, the device can increase the rate at which it captures images in the area of interest.

[0071] In parallel to step **C,** the method monitors that the baby is remaining substantially motionless, or in other words that the edge segments identified in step B1 remain substantially stable.

[0072] A special case is handled by the method according to the invention: when there is significant (macroscopic) movement of the baby. In this case, the baby's head moves, and the head's position must be determined again.

[0073] Detection of a significant movement of the baby (step D-) can be achieved by analysis of the position of the edge segments and their evolution over successive images. Additionally or alternatively, the information provided by the microphone **9** can also be used, because a macroscopic motion of the baby will generate audio signals received by the microphone.

[0074] Those skilled in the art understand that a plethysmographic analysis cannot yield valid results when the baby is making significant movements.

[0075] However, it is arranged that the evolution of these movements are monitored (the steps denoted **D,D2**) in order to identify a return to a stable state where there is no significant movement by the baby, in which case steps **B1-B2** are performed again, step **C-** of photoplethysmographic analysis being repeated with the new area of interest **7** established in step B2.

[0076] Therefore, advantageously, no particular precaution is required to focus on the head of the baby, since the systems re-determine the position of the head after each macroscopic movement of the baby. The photoplethysmographic analysis (C-) is automatically suspended during movement(s) and resumed after return to a stable position of the baby.

[0077] The abovementioned processing may be performed on the entire captured image 5. However, as a variant, the image may be subdivided to limit the computation resources required and the memory required. For example, the captured image **5** can be divided into an array of sub-images **50,** each sub-image **50** being the same size to facilitate processing. In the illustrated example, the captured image is divided into 5x5 sub-images.

[0078] This has the advantage that certain images of flat or neutral content 50a (meaning with no significant variation in color or intensity over the area of the sub-image) can be eliminated during the edge detection in step **B1.** One criterion for eliminating the sub-images 50 of no interest can be based on a low light intensity and/or a low variation in the analyzed area.

[0079] It is also possible to eliminate, after choosing the selected ellipse 6, all sub-images with flat or neutral content **50a** located outside the ellipse or even outside the area of interest 7.

[0080] Of course, if the method discovers edge segments overlapping multiple sub-images, new processing is performed on the combined sub-images in question.

[0081] Note that the first area of interest, for the heart rate, preferably concerns the baby's forehead, while for the second area of interest, for the respiratory rate, the entire face can be part of the area of interest.

[0082] Now referring to figure 8, since steps **B1-B2** have identified an area of interest, the transition **96** initializes the plethysmographic analysis (C-), and this is repeated (denoted **95**) as long the baby is not moving. If the baby moves, then the plethysmographic analysis is suspended **97,98** and the step of monitoring the macroscopic movements (step **D**) puts the plethysmographic process on hold until a stable state is restored (step D2), illustrated by transition **99.** Then the method restarts steps **B1-B2,** and then proceeds to step **C-.**

[0083] Advantageously, the plethysmographic analysis can be preformed even if the baby's head is viewed from behind.

[0084] Advantageously according to the invention, even if the baby's position changes a lot during sleep, and even if the baby turns over, detection of the position of the head by the proposed method allows continuously monitoring the baby's vital signs.

[0085] It should also be noted that the device installation does not require any special precautions, as automatic detection of the baby's head is possible even if the framing by the camera is not perfect relative to the crib.

[0086] For the determination of the respiratory rate, step C must be adapted, for example with the passband limits of the digital filter being three times lower.

[0087] The analysis criteria for the filtered signal for detection of the respiratory rate, as well as the validation criteria for the resulting signal, rely in this case on an iteration mechanism.

[0088] It should be noted that the method for detecting the baby's head as disclosed above can also function in the daytime under natural lighting, and not only under dark illumination conditions.

[0089] Furthermore, in the example illustrated, a single camera CCD allows detection of day and night; according to a possible variant, however, the video monitoring device comprises a conventional camera CCD for daylight viewing, and a thermometric or thermal infrared camera for night viewing.

[0090] In a complementary aspect, the video monitoring device **1** further comprises a volatile organic compounds sensor **37** (known as a VOC sensor). Such a sensor can detect several organic gases, such as butane, propane, octane, methanol, ethanol, propanol, butanol, and even aromatic compounds such as benzene, ethylbenzene, and toluene. The baby monitoring device may record the concentration of organic compounds during one or more periods of time, and send this information either in real time or in deferred mode to the smartphone **22.**

[0091] The VOC sensor **37** in question is an ion detector using photoionization of the molecules in an air sample collected in the room where the baby's crib is located. It thus provides a level of organic compounds which combines all the organic compounds present.

[0092] According to a complementary aspect, the microphone **9** included in the device **1** continuously analyzes the ambient noise. The dynamics and energy of the signal are observed and when they exceed some adaptive thresholds, crying recognition function begins.

[0093] This mechanism preferably uses short sequences (10 to 100 ms) and performs an advanced spectral analysis. From this information, a classifier calculates the probability that the sequence comes from crying. For this purpose, the computing unit 4 stores sound signatures typical of baby cries in spectral form (these are reference values).

[0094] In addition, a detection sheet 72 may be provided that acts as a motion sensor, as shown in figure 9.

This detection sheet **72** is installed on the mattress and the baby **B** is placed above it, in other words the detection sheet 72 is placed between the baby B and the mattress. The detection sheet may comprise a signal conditioning interface **77** and is connected to the monitoring device **1** by a flexible link **73,** either electrical or pneumatic or a combination. This link **73** is connected to the device via the connector **74.** The signal conditioning may be performed by the conditioning interface **77** or even directly wholly or in part by the monitoring device itself.

[0095] In the example illustrated, the detection sheet is formed by a thin air bladder, which allows detecting the baby's movements by ballistography. Alternatively, the detection sheet can be also formed by a plurality of piezoelectric or piezoresistive sensors.

[0096] In the case where the detection sheet **72** is formed by an air bladder, there may be an air pump (not shown) configured to generate an average measured pressure in the sheet and to generate pneumatic pulses that are used to replicate, for the baby, pulses similar to the mother's heartbeats felt by the baby during pregnancy.

[0097] Advantageously in an optional aspect of the device, the computing unit **4** may be configured to detect the beginning of a drowsiness phase of the baby **B,** for example by monitoring the heart rate and/or monitoring the respiratory rate and/or monitoring the movements of the baby.

[0098] To help the baby fall asleep more quickly and more easily, atmospheric lighting is provided by the atmospheric lighting means **23** and soft music through the speaker **19,** both of them preferably decreasing in intensity.

[0099] To trigger the light and sound sequence, the beginning of the drowsiness phase can be detected by video determination of the heart rate as explained above. When the heart rate **82** slows and becomes more regular, then the control unit **4** triggers the light and sound sequence.

[0100] According to an advantageous aspect, there may be a particular sound sequence that mimics the mother's heartbeats as heard by the baby during pregnancy.

[0101] Alternatively, the computing unit uses not only the heart rate information but also the respiratory rate information detected for example by means of the microphone **9** and/or of said detection sheet **72.** The computing unit **4** may also use video detection of movements of the baby's head **T** by means of the edge detection method as explained above.

[0102] When the computing unit **4** has triggered the sound and light sequence to assist with falling asleep and the baby starts to move about or to cry, then the sequence can be extended or restarted at the beginning.

[0103] If the sound and light sequence comes to an end with no change in the heart rate and with no movement of the baby, then the monitoring device turns the atmospheric lighting completely off and switches to night monitoring mode.

[0104] According to a particular aspect, based on the selected area of interest (position of the head), the video monitoring device can store in memory a plurality of images of the baby's face, taken at intervals spaced somewhat apart to form a slideshow of the change and growth of the baby.

[0105] According to a particular aspect, the video monitoring device can be configured to take larger images than only the baby's crib, which allows generating alerts for the parent and/or caregiver by sending complete images of the room where the crib is located and based on detection of movement, displaying the image of the person(s) present with the baby.

[0106] In a particular aspect, the video monitoring device can save the highlights of the day and/or night, in other words it can save images of events which occurred earlier; for example, based on detection of movement near the baby, saving images and audio whenever someone enters or leaves the room, and based on detection of crying, saving images and audio whenever the baby starts to cry, whenever there is a significant change in environmental parameters, whenever the baby smiles, etc.

[0107] According to a particular aspect, the video monitoring device can generate an alert sent to a remote device such as a smartphone or other device, upon detection of abnormal conditions such as environmental parameters exceeding preset thresholds, an unusually quiet or unusually restless environment, movement, pollution detection, etc.

[0108] Lastly, according to a particular aspect, the video monitoring device can be equipped with a two-way simultaneous audio connection, in other words a full-duplex connection, which allows the parent(s) and baby to exchange words or sound signals truly at the same time.

Claims

1. **Method** of video evaluation of one or more of the heart rate and respiratory rate of a baby (B) in dim or nocturnal conditions, using a device (1) comprising a video camera (2) and a source of infrared light (3), the method comprising the steps of:

   A1- illuminating the baby with the infrared source,

   A2- capturing **video images** (5) of the baby,

   B1- determining the position of the baby's head (T) by detecting, in one or more successive video images, **edge** segments forming portions of an ellipse (6) substantially coinciding with the outline of the head,

   B2- identifying an **area of interest** (7) within the ellipse (6),

   C- evaluating, by photoplethysmographic analysis of the area of interest, one or more of the

heart rate (HR) and **respiratory rate** (RR) of the baby,

D- identifying, by one or more of an analysis of the position of the edge segments and their evolution over successive video images and an analysis of audio signals received by a microphone, whether there is a **macroscopic movement** of the baby, and in case a macroscopic movement is identified, suspending step **C-** of photoplethysmographic analysis, and

D2-identifying by one or more of an analysis of the position of the edge segments and their evolution over successive video images and an analysis of audio signals received by a microphone, whether there is a return to a stable state where there is no macroscopic movement of the baby, and in case a return to a stable is identified, executing steps **B1-B2** once again, and resuming step **C-** of photoplethysmographic analysis, with a new area of interest determined in step **B2.**

2. Method according to claim 1, wherein the video images (5) are captured in color and the photoplethysmographic analysis is based on the red component of the video images.

3. Method according to claim 1 or 2, wherein at step B1, a method of image convolution with statistical thresholding is used to find the edge segments in the one or more successive video images (5).

4. Method according to any of claims 1 to 3, wherein at step B1, candidate ellipses are formed from the identified edge segments, and a selection filter is applied to the candidate ellipses to retain one selected ellipse (6) coinciding with a likely outline of the baby's head.

5. Method according to any of claims 1 to 4, wherein in **step C,** a light signal resulting from spatially averaging the video images over the area of interest (7) is obtained and a digital filter with passband of 0.75 Hz - 3.5 Hz is applied to the light signal, to obtain a filtered signal (81).

6. Method according to claim 5, wherein a validity criterion concerning the relevance of the filtered light signal (81) is defined, for selectively validating or not validating the heart rate information (HR), the validity criterion being based on the signal-to-noise ratio of the filtered light signal.

7. Method according to any of claims 1 to 6, wherein the captured video images (5) are each divided into an array of sub-images (50) of identical size.

8. Method according to claim 7, wherein at step **B1** the sub-images (50) having a neutral content, meaning with no significant variation in color or intensity within the area of the sub-image (50), are eliminated, and after step **B2** the sub-images located outside said ellipse are eliminated.

9. **Device** for video evaluation of one or more of the heart rate and respiratory rate of a baby in dim or nocturnal conditions, comprising a video camera (2), a source of infrared light (3), a microphone (9) and a computing unit (4), wherein the infrared source is configured to illuminate the baby, the video camera is configured to capture video images (5) of the baby, and the computing unit is configured to implement the method according to any of claims 1 to 8.

10. Device according to claim 9, comprising a wireless communication interface for transmitting to a remote entity (22), data associated with one or more of the evaluated heart rate (HR) and respiratory rate (RR) of the baby.

Patentansprüche

1. Verfahren einer Videoauswertung der Herzschlagfrequenz und/oder der Atemfrequenz eines Babys (B) unter dunklen oder nächtlichen Bedingungen unter Verwendung einer Vorrichtung (1), die eine Videokamera (2) und eine Quelle von Infrarotlicht (3) umfasst, wobei das Verfahren die folgenden Schritte umfasst:

A1- Beleuchten des Babys mit der Infrarotquelle,

A2- Aufnehmen von Videobildern (5) des Babys,

B1- Bestimmen der Position des Kopfes (T) des Babys durch Detektieren, in einem oder mehreren aufeinanderfolgenden Videobildern, von Kantensegmenten,

die Teile einer Ellipse (6) ausbilden, die im Wesentlichen mit dem Umriss des Kopfes übereinstimmt,

B2- Identifizieren eines Interessengebiets (7) innerhalb der Ellipse (6),

C- Auswerten, durch photoplethysmographische Analyse des Interessengebiets, der Herzschlagfrequenz (HR) und/oder der Atemfrequenz (RR) des Babys,

D- Identifizieren, durch eine Analyse der Position der Kantensegmente und deren Entwicklung über aufeinanderfolgende Videobilder hinweg und/oder eine Analyse von durch ein Mikrofon empfangenen Audiosignalen, ob es eine makroskopische Bewegung des Babys gibt, und im Falle, dass eine makroskopische Bewegung identifiziert wird, Suspendieren von Schritt

C- von photoplethysmographischer Analyse, und

D2- Identifizieren, durch eine Analyse der Position der Kantensegmente und deren Entwicklung über aufeinanderfolgende Videobilder hinweg und/oder eine Analyse von durch ein Mikrofon empfangenen Audiosignalen, ob es eine Rückkehr zu einem stabilen Zustand gibt, bei dem es keine makroskopische Bewegung des Babys gibt, und im Falle, dass eine Rückkehr zu einer Stabilität identifiziert wird, nochmaliges Ausführen von Schritten B1-B2 und Wiederaufnehmen von Schritt C- von photoplethysmographischer Analyse mit einem in Schritt B2 bestimmten neuen Interessengebiet.

2. Verfahren nach Anspruch 1, wobei die Videobilder (5) in Farbe aufgenommen werden und die photoplethysmographische Analyse auf der roten Komponente der Videobilder basiert.

3. Verfahren nach Anspruch 1 oder 2, wobei bei Schritt B1 ein Verfahren von Bildfaltung mit statistischem Schwelleneinsatz zum Finden der Kantensegmente in dem einen oder den mehreren aufeinanderfolgenden Videobildern (5) verwendet wird.

4. Verfahren nach einem der Ansprüche 1 bis 3, wobei bei Schritt B1 Kandidatenellipsen aus den identifizierten Kantensegmenten ausgebildet werden und ein Auswahlfilter auf die Kandidatenellipsen angewandt wird, um eine ausgewählte Ellipse (6) festzuhalten, die mit einem wahrscheinlichen Umriss des Kopfes des Babys übereinstimmt.

5. Verfahren nach einem der Ansprüche 1 bis 4, wobei bei Schritt C ein durch räumliches Mitteln der Videobilder über dem Interessengebiet (7) resultierendes Lichtsignal erhalten wird und ein digitales Filter mit einem Durchlassband von 0,75 Hz - 3,5 Hz auf das Lichtsignal angewandt wird, um ein gefiltertes Signal (81) zu erhalten.

6. Verfahren nach Anspruch 5, wobei ein Gültigkeitskriterium hinsichtlich der Relevanz des gefilterten Lichtsignals (81) definiert wird zum selektiven Validieren oder Nichtvalidieren der Herzschlagfrequenzinformationen (HR), wobei das Gültigkeitskriterium auf dem Signal-Rausch-Verhältnis des gefilterten Lichtsignals basiert.

7. Verfahren nach einem der Ansprüche 1 bis 6, wobei die aufgenommenen Videobilder (5) jeweils in ein Feld von Unterbildern (50) mit identischer Größe aufgeteilt werden.

8. Verfahren nach Anspruch 7, wobei bei Schritt B1 die einen neutralen Inhalt aufweisenden Unterbilder (50), was keine signifikante Variation von Farbe oder Intensität innerhalb des Gebiets des Unterbilds (50) bedeutet, eliminiert werden und nach Schritt B2 die außerhalb der Ellipse befindlichen Unterbilder eliminiert werden.

9. Vorrichtung zur Videoauswertung der Herzschlagfrequenz und/oder der Atemfrequenz eines Babys unter dunklen oder nächtlichen Bedingungen, umfassend eine Videokamera (2), eine Quelle von Infrarotlicht (3), ein Mikrofon (9) und eine Recheneinheit (4), wobei die Infrarotquelle ausgelegt ist zum Beleuchten des Babys, die Videokamera ausgelegt ist zum Aufnehmen von Videobildern (5) des Babys und die Recheneinheit ausgelegt ist zum Implementieren des Verfahrens nach einem der Ansprüche 1 bis 8.

10. Vorrichtung nach Anspruch 9, umfassend eine drahtlose Kommunikationsschnittstelle zum Senden an eine Fernentität (22) von mit der ausgewerteten Herzschlagfrequenz (HR) und/oder der ausgewerteten Atemfrequenz (RR) des Babys verknüpften Daten.

Revendications

1. Procédé d'évaluation vidéo d'une ou plusieurs de la fréquence cardiaque et de la fréquence respiratoire d'un bébé (B) dans des conditions de faible éclairement ou nocturnes, à l'aide d'un dispositif (1) comprenant une caméra vidéo (2) et une source de lumière infrarouge (3), le procédé comprenant les étapes suivantes :

A1 - éclairage du bébé avec la source infrarouge,
A2 - capture d'images vidéo (5) du bébé,
B1 - détermination de la position de la tête du bébé (T) par détection, dans une ou plusieurs images vidéo successives, de segments de contour formant des parties d'une ellipse (6) coïncidant sensiblement avec le contour de la tête,
B2 - identification d'une zone d'intérêt (7) à l'intérieur de l'ellipse (6),
C - évaluation, par analyse photopléthysmographique de la zone d'intérêt, d'une ou plusieurs de la fréquence cardiaque (HR) et de la fréquence respiratoire (RR) du bébé,
D - identification, par une ou plusieurs d'une analyse de la position des segments de contour et de leur évolution sur des images vidéo successives et d'une analyse de signaux sonores reçus par un microphone, du fait qu'il existe ou non un mouvement macroscopique du bébé, et dans le cas où un mouvement macroscopique est identifié, suspension de l'étape C d'analyse

photopléthysmographique, et
D2- identification par une ou plusieurs d'une analyse de la position des segments de contour et de leur évolution sur des images vidéo successives et d'une analyse de signaux sonores reçus par un microphone, du fait qu'il existe ou non un retour à un état stable où il n'existe pas de mouvement macroscopique du bébé, et dans le cas où un retour à un état stable est identifié, nouvelle exécution des étapes B1 - B2, et reprise de l'étape C d'analyse photopléthysmographique, avec une nouvelle zone d'intérêt déterminée dans l'étape B2.

2. Procédé selon la revendication 1, dans lequel les images vidéo (5) sont capturées en couleur et l'analyse photopléthysmographique est basée sur la composante rouge des images vidéo.

3. Procédé selon la revendication 1 ou 2, dans lequel à l'étape B1, un procédé de convolution d'image avec seuillage statistique est utilisé pour rechercher les segments de contour dans l'image ou les images vidéo successives (5).

4. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel à l'étape B1, des ellipses candidates sont formées à partir des segments de contour identifiés, et un filtre de sélection est appliqué aux ellipses candidates pour retenir une ellipse sélectionnée (6) coïncidant avec un contour probable de la tête du bébé.

5. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel dans l'étape C, un signal lumineux résultant du calcul de moyenne dans l'espace des images vidéo sur la zone d'intérêt (7) est obtenu et un filtre numérique à bande passante de 0,75 Hz à 3,5 Hz est appliqué au signal lumineux, pour obtenir un signal filtré (81).

6. Procédé selon la revendication 5, dans lequel un critère de validité concernant la pertinence du signal lumineux filtré (81) est défini, pour valider ou ne pas valider sélectivement les informations de fréquence cardiaque (HR), le critère de validité étant basé sur le rapport signal sur bruit du signal lumineux filtré.

7. Procédé selon l'une quelconque des revendications 1 à 6, dans lequel les images vidéo capturées (5) sont chacune divisées en une matrice) de sous-images (50) de taille identique.

8. Procédé selon la revendication 7, dans lequel à l'étape B1 les sous-images (50) ayant un contenu neutre, ce qui signifie sans variation significative de couleur ou d'intensité à l'intérieur de la zone de la sous-image (50), sont éliminées, et après l'étape B2, les sous-images situées en dehors de ladite ellipse sont éliminées.

9. Dispositif pour évaluation vidéo d'une ou plusieurs de la fréquence cardiaque et de la fréquence respiratoire d'un bébé dans des conditions de faible éclairement ou nocturnes, comprenant une caméra vidéo (2), une source de lumière infrarouge (3), un microphone (9) et une unité de calcul (4), dans lequel la source infrarouge est configurée pour éclairer le bébé, la caméra vidéo est configurée pour capturer des images vidéo (5) du bébé, et l'unité de calcul est configurée pour mettre en oeuvre le procédé selon l'une quelconque des revendications 1 à 8.

10. Dispositif selon la revendication 9, comprenant une interface de communication sans fil pour transmettre à une entité distante (22), des données associées à une ou plusieurs de la fréquence cardiaque (HR) et de la fréquence respiratoire (RR) évaluées du bébé.

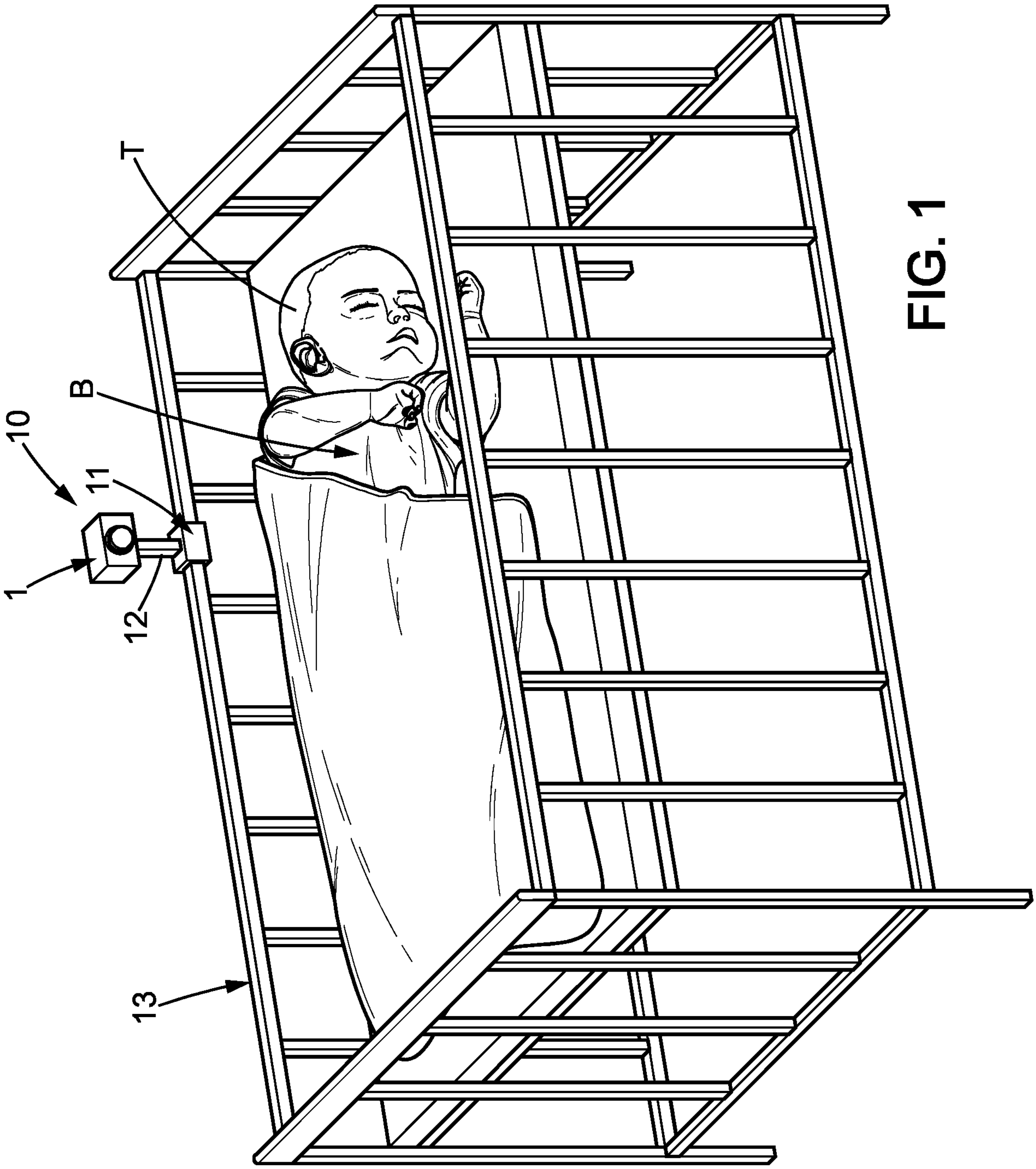


FIG. 1

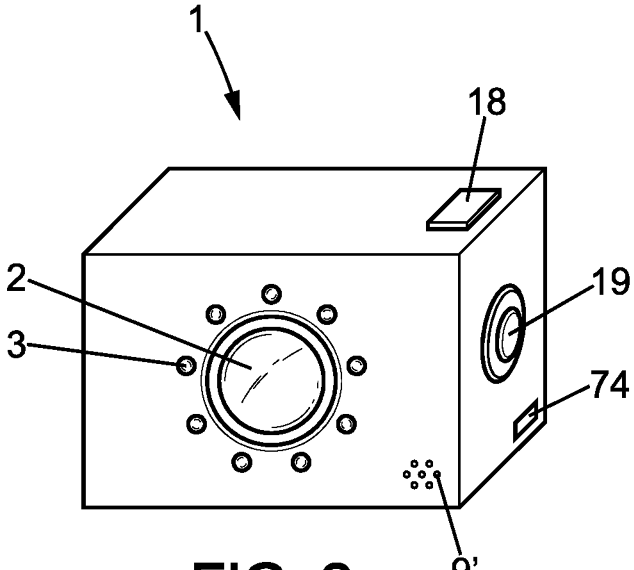


FIG. 2

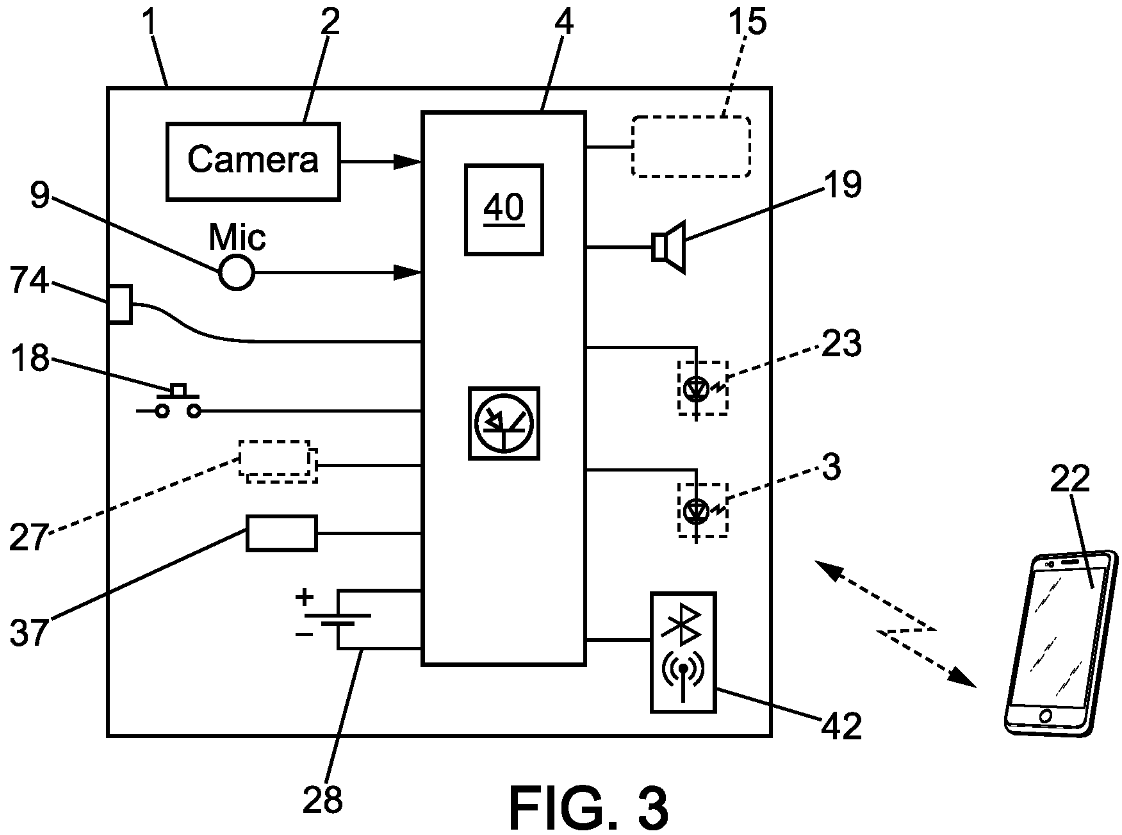


FIG. 3

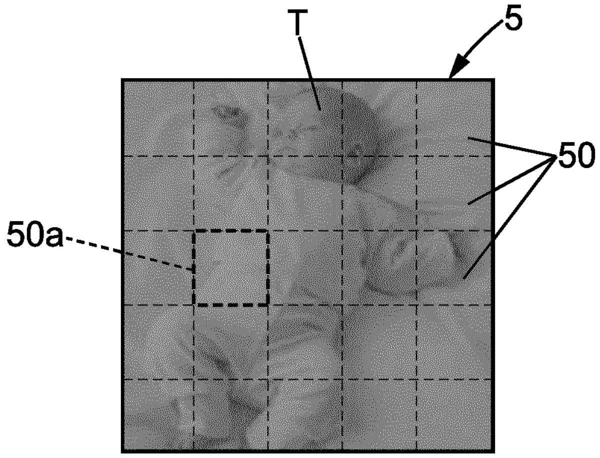


FIG. 4

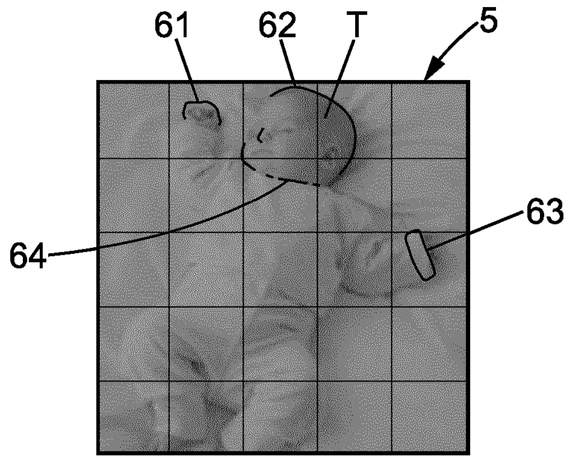


FIG. 5

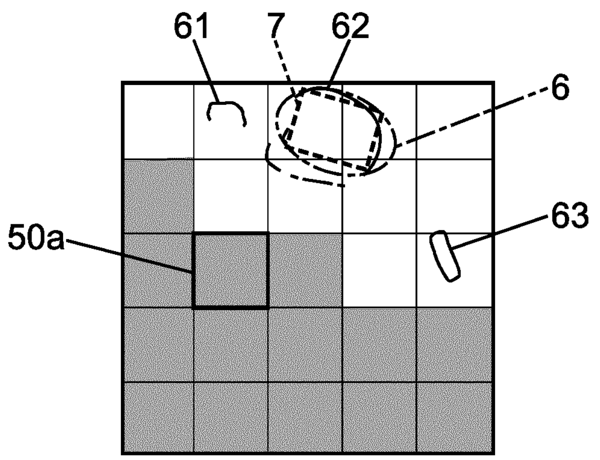


FIG. 6

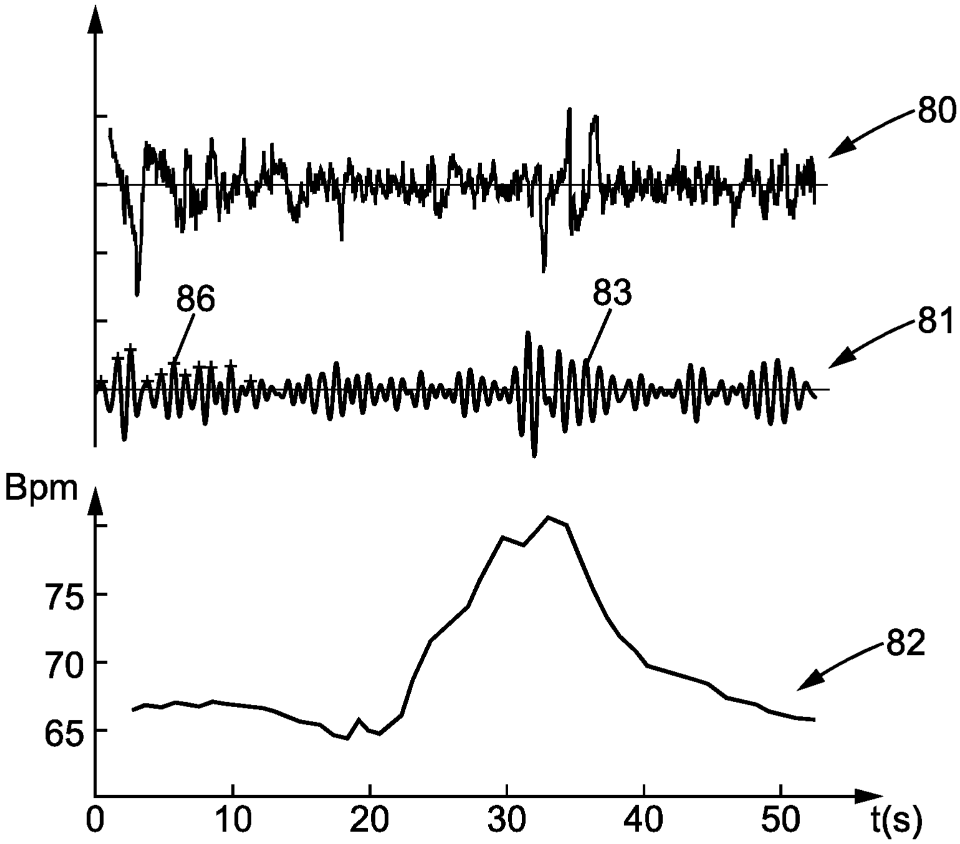
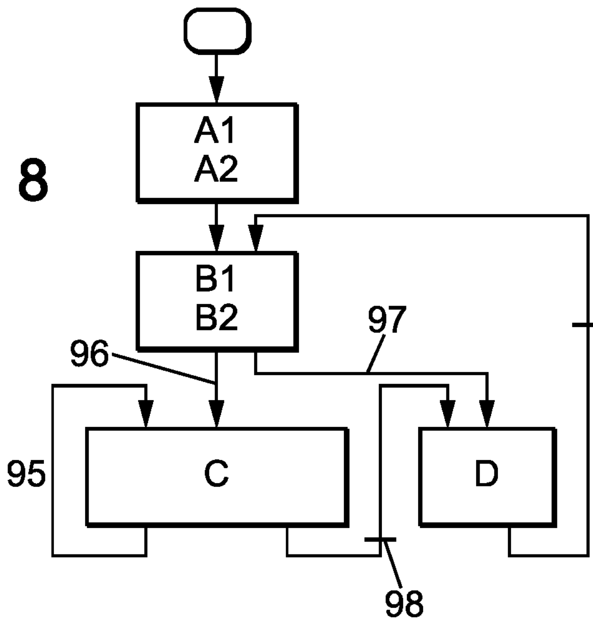

80
86
83
81
Bpm
75
70
65
82
0
10
20
30
40
50
t(s)

FIG. 7

FIG. 8


A1
A2
B1
B2
99
97
96
C
D
95
98

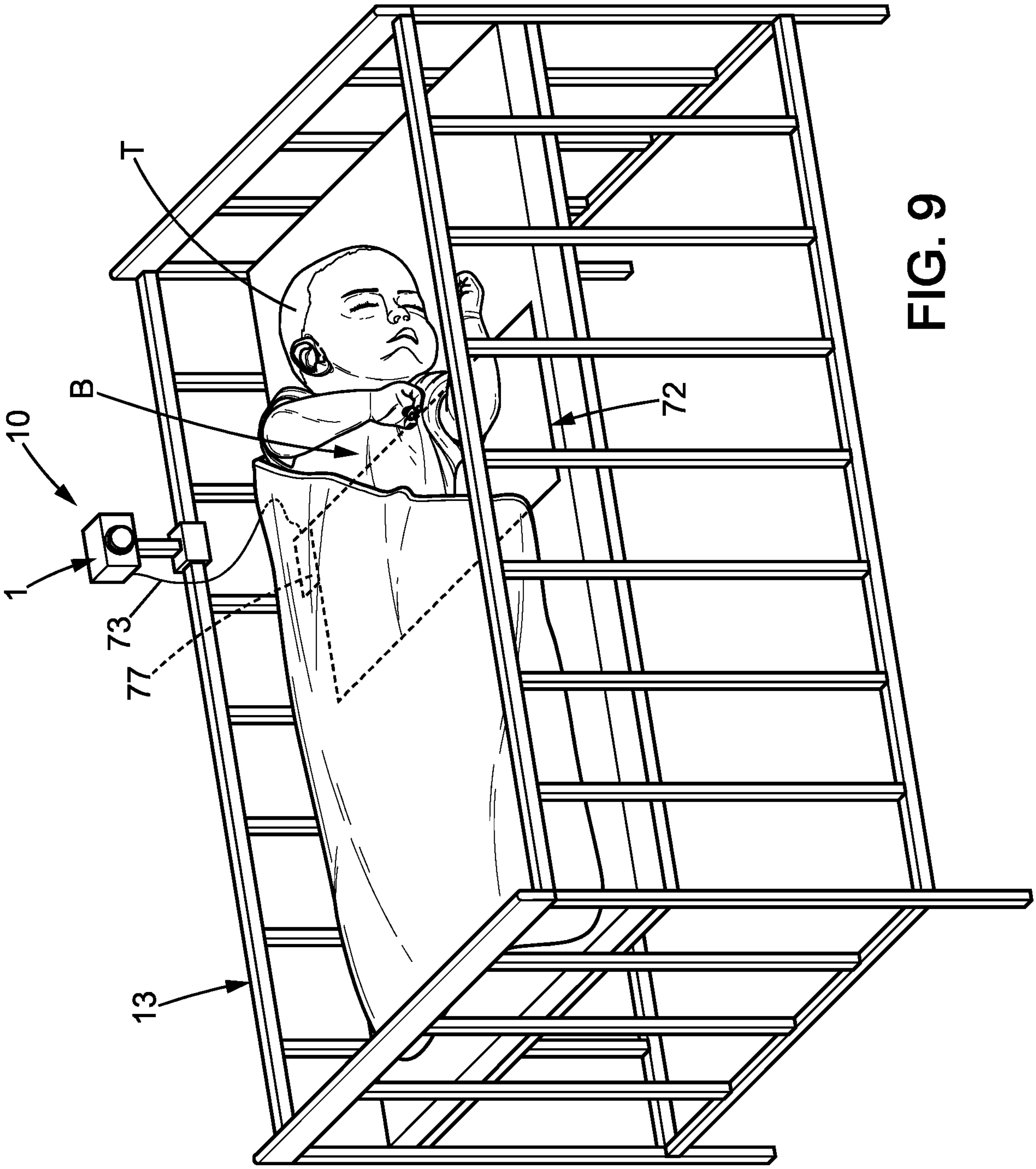


FIG. 9

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 8094013 B **[0003]**
- WO 2013170035 A **[0004]**
- US 2014155759 A **[0004]**

专利名称(译)	用于监控婴儿和进行交互的方法和设备		
公开(公告)号	EP2976998B1	公开(公告)日	2018-06-06
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当前申请(专利权)人(译)	NOKIA TECHNOLOGIES OY		
[标]发明人	DUMOULIN AMAURY MATHIAS GUILLAUME CARREEL ERIC		
发明人	DUMOULIN, AMAURY MATHIAS, GUILLAUME CARREEL, ERIC		
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外部链接	Espacenet		

摘要(译)

视频监视设备（1），包括计算单元（4），摄像头（2），通信接口（42）和挥发性有机化合物传感器（37），该传感器配置为至少测量房间内有机化合物的浓度感兴趣的是，所述计算单元被配置为记录由挥发性有机化合物传感器报告的有机化合物的浓度，并且被配置为将照相机拍摄的图像和挥发性有机化合物的浓度发送到远程实体，例如智能手机（22）。无线链接。

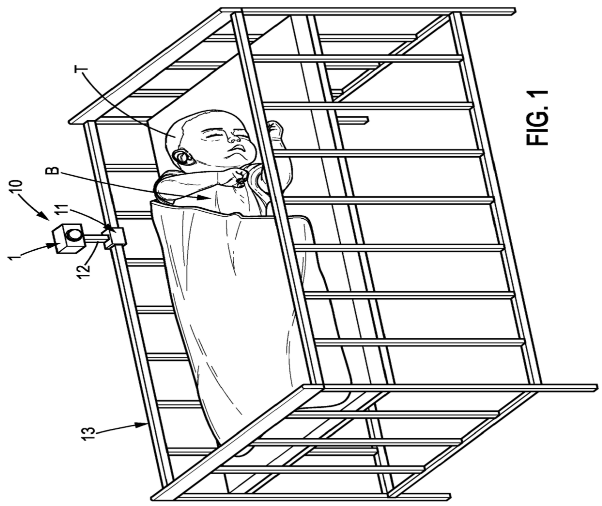

FIG. 1