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(54) **MONITORING SYSTEM FOR MONITORING A PATIENT AND DETECTING DELIRIUM OF THE PATIENT**

ÜBERWACHUNGSSYSTEM ZUR ÜBERWACHUNG EINES PATIENTEN UND ZUR ERKENNUNG EINES DELIRIUMS DES PATIENTEN

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(56) References cited:
US-A- 6 049 281
US-A1- 2002 143 240
US-A1- 2009 005 648
US-A1- 2010 049 095
US-A1- 2010 280 336

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a monitoring system and a corresponding monitoring method for monitoring a patient and detecting delirium of the patient. Further, the present invention relates to a processor and a corresponding processing method for use in such a monitoring system. Still further, the present invention relates to a computer program for implementing said processing method.

BACKGROUND OF THE INVENTION

[0002] Delirium is a neuropsychiatric syndrome with a multifactorial etiology that occurs in a majority of ICU (Intensive Care Unit) patients. Delirium is associated with increased mortality, prolonged hospital stay, and long term effects such as decreased independent living, increased rate of institutionalization and increased risk to develop long-term cognitive impairment. Longer hospital stay and complications associated with delirium in the ICU lead to significantly higher costs of care. The prevalence rates of delirium in an ICU range from 11% to 87%. Accurate and early detection and treatment of delirium is the key to improving patient outcome and curbing delirium-related health care costs.

[0003] Currently, for the diagnosis of delirium in ICU patients a couple of validated screening questionnaires (such as CAM-ICU) are used. With these methods patients are checked at most three times a day. With the fluctuating character of delirium the delirious episodes are easily missed. Besides, under-detection of delirium is still the case even if screening instruments are used. Accurate and early detection methods may lead to more effective application of appropriate clinical interventions, leading to better outcome and reduced induced mortality. Hence, there is a need for a (semi-)automated, continuous and objective delirium monitoring system and method.

[0004] A disturbed motor activity pattern is a frequent manifested feature in delirious patients. Based on motoric alterations three clinical subtypes of delirium are distinguished: hyperactive, hypoactive and mixed. The definitions of the hypoactive, hyperactive and mixed motor subtypes are based on different psychomotor symptoms. A hyperactive delirium is characterized by increased quantity of motor activity, loss of control of activity, restlessness, and wandering. Patients with a hypoactive delirium demonstrate features such as decreased amount of activity, and decreased speed of actions. Patients with a mixed delirium shift between hypo- and hyperactivity.

[0005] Measurement of disturbed motor activity patterns to detect delirium is reported in a few studies. In these studies on-body accelerometer-based techniques were used to measure activity. Results showed that measurement of motoric alterations is a potential candidate for delirium detection.

[0006] The use of video monitoring for whole body motion detection was recently demonstrated by comparing video and wrist actigraphy for monitoring body movement in healthy subjects during sleep (Heinrich, A., van Vugt, H., A new video actigraphy method for non-contact analysis of body movement during sleep (2010), European Sleep Research Society ESRS, Journal on Sleep Research, vol. 19 (suppl. 2)). Motion data of both techniques corresponded for small, medium and large motions. Small and sometimes even medium movements were missed by conventional wrist actigraphy if the moving body part was not the one with the attached actigraphy system.

[0007] A disadvantage of wrist actigraphy methods is that it is measures the movements of the part of the body where it is attached to. So movements of other parts of the body are missed. Changes in motoric behavior are not limited to one part of the body, measurement of only one extremity might result in missed motions and as a consequence under-detection of delirium. Further, an extra on-body sensor might irritate or confuse patients.

[0008] Document US 2010/0049095 discloses a system and method using a motion sensor observing movement of a subject e.g. patient, and generating a data stream representative of the movement. A comparator detects abnormalities in a motion and compares the abnormalities to standard value.

[0009] US 6,049,281 discloses monitoring an individual to determine when the individual is likely to exit a supportive structure. An apparatus has an image capturing device that captures successive images of the monitored individual in the supportive structure. A processing device compares a current captured image to a previous image to detect predetermined characteristics of the monitored individual with respect to the supportive structure. An alarm is actuated when it is determined that the detected predetermined characteristics exceed predetermined threshold values for at least one of the predetermined characteristics.

SUMMARY OF THE INVENTION

[0010] It is an object of the present invention to provide a (semi-)automated, continuous and objective delirium monitoring system and method that avoid the above mentioned disadvantages. Further, a corresponding processor and processing method as well as a computer program shall be provided.

[0011] In a first aspect of the present invention a monitoring system for monitoring a patient and detecting delirium of the patient is presented comprising:

- a monitoring unit for obtaining image data of the patient over time,
- an image analysis unit for detecting motion events of the patient from the obtained image data,

- an evaluation unit for classifying the detected motion events into delirium-typical motion events and non-delirium-typical motion events, wherein said evaluation unit is further configured to determine high and/or low movement counts of detected motion events, and
- a delirium determination unit for determining a delirium score from the duration of high or low movement counts and the duration, intensity, type, location and/or occurrence of delirium-typical motion events, said delirium score indicating the likelihood and/or strength of delirium of the patient.

[0012] In a further aspect of the present invention a processor is presented comprising:

- a first processing unit for detecting motion events of the patient from image data obtained over time from the patient wherein said evaluation unit is further configured to determine high and/or low movement counts of detected motion events,
- a second processing unit for classifying the detected motion events into delirium-typical motion events and non-delirium-typical motion events,
- a third processing unit for determining a delirium score from the duration of high or low movement counts and the duration, intensity, type, location and/or occurrence of delirium-typical motion events, said delirium score indicating the likelihood and/or strength of delirium of the patient.

[0013] In yet another aspect of the present invention, a computer program is provided which comprises program code means for causing a computer to perform the steps of the processing method when said computer program is carried out on a computer.

[0014] Preferred embodiments of the invention are defined in the dependent claims. It shall be understood that the claimed methods, processor, and computer program have similar and/or identical preferred embodiments as the claimed system and as defined in the dependent claims.

[0015] According to the present invention image data of the patient over time are obtained (e.g. using video actigraphy) and evaluated since it has been found that such a monitoring e.g. by use of video actigraphy has the advantage that movements of selected or all parts of the body can be measured without extra on-body sensors. Furthermore, local image analysis allows for a more detailed analysis of the context of the movement, going beyond mere activity counts. Such a monitoring thus provides a promising and unobtrusive method for capturing full-body motion of ICU patients and detecting thereof motoric alterations typical for delirium. Further, since the obtained image data generally capture the motion of the entire body, not only full-body movements can be analyzed but also activity of separate extremities.

[0016] The proposed monitoring system is an unobtrusive system. Delirious patients perform particular activity patterns which are reoccurring over time. Examples of these movements are picking of e.g. bed sheets and grabbing in the air. Preferably, the magnitude of the activity and the location of the activity (in which part of the body) are used according to the invention to check if delirium-prone movement patterns occur. Generally, potential activity parameters that may be evaluated according to the present invention include the duration, intensity, type, location and/or occurrence of delirium-typical motion events.

[0017] The proposed monitoring system calculates a delirium score based on the various measured activity parameters. This score can support clinical staff to detect and treat delirium in an early stage. With the currently used questionnaires patients are checked at most three times a day. With the proposed monitoring system it is possible to check scores and activity levels at any time, at regular intervals or continuously, of the day.

[0018] In a proposed monitoring system said evaluation unit is configured to determine high and/or low movement counts of detected motion events and said delirium determination unit is configured to determine said delirium score from the duration of high or low movement counts and from the duration, intensity, type, location and/or occurrence of delirium-typical motion events. In this context "movement count" shall be understood as the intensity of motions of the patient. The larger / stronger the motions are, the higher is the movement count, which is sometimes also referred to as "activity count" or "activity level". Thus, both the duration of high or low movement counts and the duration, intensity, type, location and/or occurrence of delirium-typical motion events are used to determine the delirium score, which provides a higher accuracy and reliability of the determined delirium score.

[0019] In another preferred embodiment said delirium determination unit is configured to determine said delirium score to indicate a higher likelihood and/or higher strength of delirium of the patient the longer, more intense and/or more often delirium-typical events occur.

[0020] Preferably, said delirium determination unit is configured to determine a delirium type indicator from the duration of high or low movement counts and/or from the duration, intensity, type, location and/or occurrence of delirium-typical motion events, said delirium type indicator indicating the type of delirium including hyperactive delirium, hypoactive delirium and mixed hyperactive and hypoactive delirium. The different motor subtypes are based on differences in motoric behavior. More knowledge about the subtype gives the opportunity to adjust the care for the patient. Currently it is not possible to detect the different subtypes of delirium in a continuous objective manner. Amongst others the amount of activity and speed of activity can give an indication about subtype of delirium. Additionally, classification of movement types beyond activity count and speed may give beneficial information.

[0021] Even more preferably, said delirium determination unit is configured to determine the delirium type indicator to indicate hyperactive delirium if the accumulated duration of hyperactive periods in a first time interval exceeds a first duration threshold and to determine the delirium type indicator to indicate hypoactive delirium if the accumulated duration of hypoactive periods in said first time interval exceeds a second duration threshold. In this context a hyperactive period is defined here as a period longer than a second time interval where the movement count (= activity count) exceeds a first movement count threshold. A hypoactive period is defined here as a period longer than a second time interval where the movement count falls below a second movement count threshold.

[0022] Advantageously, said delirium determination unit is configured to determine the delirium score to indicate non-delirium if there is a substantial difference of movement counts between day and night time and/or if the movement counts in a predetermined time interval are between a third and fourth movement count threshold. Said third and fourth movement count thresholds are preferably identical to the first and second, respectively, movement count thresholds. This embodiment provides for a higher accuracy of the delirium detection.

[0023] According to a preferred embodiment said monitoring unit is configured to continuously or at regular intervals obtain image data of the patient, in particular to obtain video data of the patient by use of a (conventional or infrared) video camera. Preferably, the same equipment as typically used in video actigraphy is used here. To monitor the patient also in darkness, an infrared camera, such as a near-infrared (NIR) camera or one or more image sensors is used in combination with NIR illumination.

[0024] Still further, in an embodiment the monitoring system further comprises an information determination unit for determining additional information about the patient from said image data and/or said detected motion events, said additional information including one or more of a mean activity of the patient in a predetermined time interval, detected motion patterns, motion events of predetermined parts of the patient's body and changes and/or trends of the patient's activity. Thus, in addition to the determined delirium score further information may be extracted from the obtained image data which might give an even better picture of the state of the patient to a nurse or a doctor. This additional information can be easily obtained from the obtained image data with the acquisition of additional image data.

[0025] In another embodiment said delirium determination unit is configured to determine said delirium score by additionally using additional physiological information about the patient, in particular EEG data and/or skin conductance data of the patient. The additional physiological information is obtained, simultaneously or in advance to the acquisition of the image data, by further equipment / hardware which may or may not part of the proposed monitoring system. For instance, in a preferred embodiment a physiological data acquisition unit is provided for acquiring additional physiological information about the patient, in particular EEG data and/or skin conductance data of the patient. Such a data acquisition unit may be a conventional unit for measuring EEG data of patients and/or a conventional skin conductance measurement unit (e.g. a NeXus Skin Conductance Sensor as e.g. currently described at http://www.mindmedia.nl/CMS/en/products/sensors/item/166-nx-gsrld.html and a NeXus EEG Sensor as e.g. currently described art http://www.mindmedia.nl/CMS/en/products/sensors/item/167-nx-exg2b.html).

[0026] The additional physiological information further increases the accuracy of the delirium detection and may be used to exclude motion that does not indicate or is not useful to evaluate for detecting delirium. For example, motoric alterations due to Parkinson disease can be excluded by means of EEG which can be used for detecting that a patient suffers from Parkinson disease.

[0027] For instance, in an embodiment said delirium determination unit is configured to compare said additional physiological information about the patient with reference physiological information indicative for delirium, in particular to compare EEG data and/or skin conductance data of the patient with typical patterns of EEG data and/or skin conductance data indicative for delirium. Preferably, said reference physiological information indicative for delirium is stored in a storage unit, such as a hard disc of a computer or a central storage, e.g. of a data management system as often provided in a hospital. Said reference physiological information may include typical patterns of EEG data and/or skin conductance data indicative for delirium. Thus, by this comparison the additional physiological information can be easily used to exclude motion that does not indicate or is not useful to evaluate for detecting delirium.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter. In the following drawings

Fig. 1 shows a first embodiment of a monitoring system according to the present invention,

Fig. 2 shows a second embodiment of a monitoring system according to the present invention,

Fig. 3 shows a diagram illustrating information about a patient obtained by an embodiment of the proposed monitoring system, and

Fig. 4 shows a third embodiment of a monitoring system according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0029] Fig. 1 shows a block diagram of a first embodiment of a monitoring system 1 according to the present

invention. The monitoring system 1 comprises a monitoring unit 10 for obtaining image data 30 of the patient over time. Said monitoring unit 10 comprises, for instance, one or more image sensors or cameras for acquiring image data 30 (e.g. a new image at certain time intervals, for instance every second, or continuous video data). Further, the monitoring system 1 comprises an image analysis unit 12 for detecting motion events of the patient from the obtained image data, an evaluation unit 14 for classifying the detected motion events into delirium-typical motion events and non-delirium-typical motion events, and a delirium determination unit 16 for determining a delirium score 32 from the duration, intensity, type, location and/or occurrence of delirium-typical motion events, said delirium score indicating the likelihood and/or strength of delirium of the patient.

[0030] In an embodiment said image analysis unit 12, said evaluation unit 14 and said delirium determination unit 16 are implemented on a common processor 5, as indicated by the dashed box. Said processor 5 may implement each of said units 12, 14, 16 by a separate processing unit. Alternatively, in another embodiment several processors or a computer are used for implementing said units 12, 14, 16.

[0031] The proposed monitoring system enables a (semi-)automated, continuous and objective delirium detection, not only once but at regular intervals or continuously, as required e.g. for ICU patients. Movements of selected or all parts of the body can be monitored to provide an accurate determination of the delirium score 32 which is a simple measure for indicating the strength of delirium so that an alarm can be issued if a certain threshold is exceeded by the delirium score.

[0032] Another embodiment of a monitoring system 2 according to the present invention is schematically illustrated in Fig. 2. In this embodiment the monitoring system is installed in a hospital in which one or more (or all) patient rooms 50 are equipped with at least one camera 20 (representing said monitoring unit 10). The cameras 20 are mounted in such a manner that the whole body of a patient (not shown, but only the patient bed 52) is in picture. The video data 30 obtained by the camera 20 is transmitted to a computational system 6 (representing the processor 5) where the video data is analyzed. The activity is extracted real-time from the video data by the image analysis unit 12 and magnitude of activity, location of activity, type of activity (i.e. movement pattern) and/or time are stored. The video data 30, in particular detected motion events, is further analyzed by the evaluation unit 14 on typical patterns indicative for delirium, repetition of patterns, increase/decrease of activity, and/or speed of motion. Preferably, high and/or low movement counts of detected motion events are determined as well by the evaluation unit 14, said (high or low) movement counts indicating the intensity of motions of the patient. In addition the duration of high or low movement counts is determined for the determined movement counts.

[0033] The duration of high or low movement counts and/or the duration, intensity, type, location and/or occurrence of delirium-typical motion events are used by the delirium determination unit 16 to determine the delirium score. Preferably, both the duration of high or low movement counts and the duration, intensity, type, location and/or occurrence of delirium-typical motion events are used for this purpose, which provides a higher accuracy and reliability of the determined delirium score.

[0034] All this data can be calculated for the whole body or selected parts of the body such as the arms. Based on the different measures obtained from the video data and eventually other relevant information the delirium score is calculated.

[0035] The amount of activity and speed of activity is preferably used in addition to classify the subtype of delirium (hypoactive, hyperactive, mixed) and, preferably, to generate and output a corresponding delirium type indicator 34. Hyperactive delirium is detected if the accumulated duration of hyperactive periods in a first time interval exceeds a first duration threshold. Hypoactive delirium is detected if the accumulated duration of hypoactive periods in said first time interval exceeds a second duration threshold. Mixed delirium is detected if there is a shift between hypo- and hyperactivity. Non-delirium is detected if there is a substantial difference of movement counts between day and night time and/or if the movement counts in a predetermined time interval are between a third and fourth movement count threshold (which are preferably identical to the first and second threshold, respectively). Thus, generally, the delirium type indicator is determined from the duration of high or low movement counts and/or the duration, intensity, type, location and/or occurrence of delirium-typical motion events.

[0036] In an embodiment, the reference could be the activity of a non-delirious patient. If μ denotes the average movement count (= activity count) of a non-delirious patient during e.g. 24 hours (which is an example for the first time interval), then for example the first movement count threshold can be defined as $\mu + \sigma$, where σ denotes the standard deviation, and the second movement count threshold can be defined as $\mu - \sigma$. An example for the second time interval could be 5 minutes.

[0037] Similarly, the mentioned duration thresholds can be defined as follows:

If d1 denotes the accumulated duration of all hyperactive periods of a non-delirious patient during e.g. 24 hours (= first time interval), then the first duration threshold can for example be defined as 2 * d1 (i.e. at least twice the duration a non-delirious patient has). If d2 denotes the accumulated duration of all hypoactive periods of a non-delirious patient during e.g. 24 hours (= first time interval), then the second duration threshold can for example be defined as 2 * d2.

[0038] Thus, a person can be judged as being a delirious patient if he/she shows a pronounced hyperactive behavior, a pronounced hypoactive behavior and/or significantly often delirium-typical movements.

[0039] The generated data, in particular the delirium score, is displayed on a bedside patient monitor 54 and/or a nurse monitor 56, preferably included in an overall overview of all patients that can be assessed at the nursing station 58. Based on thresholds set by the clinical staff an alarm can be given when the delirium score exceeds predefined thresholds.

[0040] Preferably, in this embodiment (but also in other embodiments), besides the delirium score clinical staff can access different parameters to have better insight in the patient condition. For this purpose an information determination unit 18 is provided for determining additional information 36 about the patient from said image data and/or said detected motion events. Fig. 3 shows an example of additional information data which can be assessed, the additional information data particularly including one or more of mean activity during the last 24 hours, mean speed of activity, current activity, but also patterns and how often these were repeated in the last 24 hours. The 24 hours analysis can also be adjusted to smaller or larger timeframes depending on the input of the clinical staff.

[0041] As shown in Fig. 3 the motion estimation is performed returning motion vectors (arrows in upper right image). The different motion within the body is well visible in different arrows of different orientation and length.

[0042] Still another embodiment of a monitoring system 3 according to the present invention is schematically shown in Fig. 4. In this embodiment relevant information from tests such as delirium prediction scores (e.g. PRE-DELIRIC score (as described in Van den Boogaard, M., Pickers, P., et al., PRE-DELIRIC, PREdiction of DELIRium in ICu patients; development and validation of a delirium prediction model for intensive care patients (2010), Proceedings of the European delirium Association, 5th scientific congress on delirium), CAM-ICU (Confusion Assessment Method - ICU) test results 38 can be filled and are input to the delirium determination unit 16 to calculate the delirium score 32. Said test results 38 are preferably stored in a separate storage unit 20.

[0043] Still further, in this embodiment the monitoring system 3 is further extended with EEG measurements 40. An association between clinical symptoms of delirium and changes in the spectral EEG is a consistent finding. EEG gives the possibility to measure real-time changes in brain functioning. Complementary information of EEG measurements can give more accurate information about the patient condition and a more precise delirium score. The EEG data 40 can be used to rule out changes in motoric behavior due to other diseases such as Parkinson or Epilepsy. Said EEG 40 may be pre-acquired and also stored in the storage unit 20. Alternatively, they may be acquired online by an EEG unit 22.

[0044] Similarly, in still another embodiment additional physiological information about the patient other than (or in addition to) EEG data may be used for determination of the delirium score 32. Particularly, skin conductance data 42 of the patient can be used to advantage for this purpose. Said skin conductance data 42 may also be stored in the storage unit 20 or may be acquired online by a skin conductance measurement unit 24.

[0045] Other additional physiological information that could be added for determining the delirium score may include vital signs, such as information about the heart rate, blood pressure, respiration rate. Such information may also be obtained from an analysis of the obtained image, e.g. using a known PPG (photo-plethysmography) algorithm. Alternatively, such information can be obtained by use of additional conventional equipment.

[0046] Preferably, in the delirium determination unit 16 said additional physiological information 40, 42 about the patient is compared with reference physiological information (e.g. stored also in the storage unit 20) indicative for delirium, in particular to compare EEG data and/or skin conductance data of the patient with typical patterns of EEG data and/or skin conductance data indicative for delirium. The result is preferably used to identify movement patterns which are not indicating delirium and can therefore be excluded from the determination of the delirium score. The use of such additional physiological information thus increases the accuracy and reliability of the delirium score determination.

[0047] In summary, the proposed monitoring system and method provides a simple, non-obtrusive, accurate and reliable way of determining the intensity of delirium of a patient. Preferred embodiments enable the determination of the type of delirium as well as additional information about the patient. The image data, particularly video data, obtained and evaluated according to the present invention also provides the possibility to analyze the types of movements in more detail to further increase the detection and classification of delirium. The invention is, however, not only able to return an activity count over time or a delirium score, but does further allow for a more distinguished analysis (e.g. location of hands, classifying the type of hand movement ...) depending on the desired application.

[0048] The proposed monitoring system and method can preferably be applied in all kinds of patient monitoring systems, as clinical decision support for delirium, in intensive care units, in general wards and in assisted living facilities.

[0049] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims.

[0050] In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single element or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures

are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

[0051] A computer program may be stored/distributed on a suitable non-transitory medium, such as an optical storage medium or a solid-state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems.

[0052] Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. Monitoring system (1, 2, 3) for automated monitoring of a patient and detecting delirium of the patient, comprising:

   - a monitoring unit (10) for obtaining image data (30) of the patient over time,
   - an image analysis unit (12) for detecting motion events of the patient from the obtained image data (30),
   - an evaluation unit (14) for classifying the detected motion events into delirium-typical motion events and non-delirium-typical motion events, wherein said evaluation unit (14) is configured to determine high and/or low movement counts indicating the intensity of detected motion events, and
   - a delirium determination unit (16) for determining a delirium score (32) from the duration of high or low movement counts and the duration, intensity, type, location and/or occurrence of delirium-typical motion events, said delirium score (32) indicating the likelihood and/or strength of delirium of the patient.

2. Monitoring system as claimed in claim 1, wherein said delirium determination unit (16) is configured to indicate a higher likelihood and/or higher strength of delirium of the patient the longer, more intense and/or more often delirium-typical motion events occur.

3. Monitoring system as claimed in claim 1, wherein said delirium determination unit (16) is configured to determine a delirium type indicator (34) from the duration of high or low movement counts and/or from the duration, intensity, type, location and/or occurrence of delirium-typical motion events, said delirium type indicator indicating the type of delirium including hyperactive delirium, hypoactive delirium and mixed hyperactive and hypoactive delirium.

4. Monitoring system as claimed in claim 3, wherein said delirium determination unit (16) is configured to determine the delirium type indicator to indicate hyperactive delirium if the accumulated duration of hyperactive periods in a first time interval exceeds a first duration threshold and to determine the delirium type indicator to indicate hypoactive delirium if the accumulated duration of hypoactive periods in said first time interval exceeds a second duration threshold.

5. Monitoring system as claimed in claim 1, wherein said delirium determination unit (16) is configured to determine the delirium score to indicate non-delirium if there is a substantial difference of movement counts between day and night time and/or if the movement counts in a predetermined time interval are between a third and fourth movement count threshold.

6. Monitoring system as claimed in claim 1, wherein said monitoring unit (10) is configured to continuously or at regular intervals obtain image data (30) of the patient, in particular to obtain video data of the patient by use of a video camera.

7. Monitoring system as claimed in claim 1, further comprising an information determination unit (18) for determining additional information (36) about the patient from said image data (30) and/or said detected motion events, said additional information (36) including one or more of a mean activity of the patient in a predetermined time interval, detected motion patterns, motion events of predetermined parts of the patient's body and changes and/or trends of the patient's activity.

8. Monitoring system as claimed in claim 1, wherein said delirium determination unit (16) is configured to determine said delirium score (32) by additionally using additional physiological information (38, 40, 42) about the patient, in particular EEG data and/or skin conductance data of the patient.

9. Monitoring system as claimed in claim 8, wherein said delirium determination unit (16) is configured to compare said additional physiological information (38, 40, 42) about the patient with reference physiological information indicative for delirium, in particular to compare EEG data and/or skin conductance data of the patient with typical patterns of EEG data and/or skin conductance data indicative for delirium.

10. Monitoring system as claimed in claim 9, further comprising a storage unit (20) for storing said reference physiological information indicative for delirium, in particular typical patterns of EEG data and/or skin conductance data indicative for delirium.

11. Monitoring system as claimed in claim 8, further comprising a physiological data acquisition unit (22, 24) for acquiring additional physiological information about the patient, in particular EEG data and/or skin conductance data of the patient.

12. Method for automated monitoring of a patient, comprising:

- obtaining image data (30) of the patient over time,
- detecting motion events of the patient from the obtained image data (30),
- determining high and/or low movement counts indicating the intensity of detected motion events,
- classifying the detected motion events into delirium-typical motion events and non-delirium-typical motion events, and
- determining a delirium score (32) from the duration of high or low movement counts and the duration, intensity, type, location and/or occurrence of delirium-typical motion events, said delirium score (32) indicating the likelihood and/or strength of delirium of the patient.

13. Processor (5, 6) for use in an automated monitoring system for monitoring a patient, said processor comprising:

- a first processing unit (12) for detecting motion events of the patient from image data (30) obtained over time from the patient,
- a second processing unit (14) for classifying the detected motion events into delirium-typical motion events and non-delirium-typical motion events and for determining high and/or low movement counts indicating the intensity of detected motion events, and
- a third processing unit (16) for determining a delirium score (32) from the duration of high or low movement counts and the duration, intensity, type, location and/or occurrence of delirium-typical motion events, said delirium score (32) indicating the likelihood and/or strength of delirium of the patient.

14. Processing method for use in an automated monitoring system for monitoring a patient, said processing method comprising:

- a first processing step for detecting motion events of the patient from image data (30) obtained over time from the patient,
- a second processing step for classifying the detected motion events into delirium-typical motion events and non-delirium-typical motion events and for determining high and/or low movement counts indicating the intensity of detected motion events, and
- a third processing step for determining a delirium score (32) from the duration of high or low movement counts and the duration, intensity, type, location and/or occurrence of delirium-typical motion events, said delirium score (32) indicating the likelihood and/or strength of delirium of the patient.

15. Computer program comprising program code means for causing a computer to carry out the steps of the processing method as claimed in claim 14 when said computer program is carried out on the computer.

Patentansprüche

1. Überwachungssystem (1, 2, 3) zur automatischen Überwachung eines Patienten und zur Erkennung eines Deliriums des Patienten, umfassend:

- eine Überwachungseinheit (10) zum Erhalten von Bilddaten (30) des Patienten im Laufe der Zeit,
- eine Bildanalyseseinheit (12) zur Erkennung von Bewegungsereignissen des Patienten von den erhaltenen Bilddaten (30),
- eine Auswerteeinheit (14) zur Klassifizierung der erkannten Bewegungsereignisse in Bewegungsereignisse, die typisch für Delirium sind und in Bewegungsereignisse, die nicht typisch für Delirium sind, wobei die Auswerteeinheit (14) konfiguriert ist, um hohe und/oder geringe Bewegungszahlen zu bestimmen, die die Intensität von erkannten Bewegungsereignissen anzeigt, und
- eine Deliriumbestimmungseinheit (16) zur Bestimmung eines Deliriumstands (32) von der Dauer der hohen und geringen Bewegungszahlen und von der Dauer, Intensität, Art, Stelle und/oder des Auftretens von Bewegungsereignissen, die typisch für Delirium sind, wobei der Deliriumstand (32) die Wahrscheinlichkeit und/oder die Stärke des Deliriums des Patienten anzeigt.

2. Überwachungssystem nach Anspruch 1, wobei die Deliriumbestimmungseinheit (16) konfiguriert ist, um eine höhere Wahrscheinlichkeit und/oder höhere Stärke des Patienten anzuzeigen, umso länger, intensitiver und/oder häufiger Bewegungsereignisse auftreten, die typisch für Delirium sind.

3. Überwachungssystem nach Anspruch 1, wobei die Deliriumbestimmungseinheit (16) konfiguriert ist, um einen Deliriumsartanzeiger (34) von der Dauer der hohen oder geringen Bewegungszahlen

und/oder von der Dauer, Intensität, Art, Stelle und/oder des Auftretens von Bewegungsereignissen, die typisch für Delirium sind, zu bestimmen, wobei der Deliriumsartanzeiger die Art des Deliriums anzeigt, einschließlich hyperaktives Delirium, vermindertes Delirium und gemischtes hyperaktives und vermindertes Delirium.

4. Überwachungssystem nach Anspruch 3, wobei die Deliriumbestimmungseinheit (16) konfiguriert ist, um den Deliriumsartanzeiger zu bestimmen, um hyperaktives Delirium anzuzeigen, wenn die angesammelte Dauer von hyperaktiven Perioden in einem ersten Zeitintervall eine erste Dauerschwelle überschreitet, und um den Deliriumsartanzeiger zu bestimmen, um hyperaktives Delirium anzuzeigen, wenn die angesammelte Dauer von hyperaktiven Perioden in dem ersten Zeitintervall eine zweite Dauerschwelle überschreitet.

5. Überwachungssystem nach Anspruch 1, wobei die Deliriumbestimmungseinheit (16) konfiguriert ist, um die Deliriumzahl zu bestimmen, um Nicht-Delirium anzuzeigen, wenn ein wesentlicher Unterschied von Bewegungszahlen zwischen Tag- und Nachtzeit besteht und/oder wenn die Bewegungszahlen in einem vorbestimmten Zeitintervall zwischen einer dritten und vierten Bewegungszahlschwelle liegen.

6. Überwachungssystem nach Anspruch 1, wobei die Überwachungseinheit (10) konfiguriert ist, um Bilddaten (30) des Patienten kontinuierlich oder in regelmäßigen Abständen zu erhalten, insbesonders um Videodaten des Patienten durch Benutzung einer Videokamera zu erhalten.

7. Überwachungssystem nach Anspruch 1, ferner umfassend eine Informationsbestimmungseinheit (18) zur Bestimmung von zusätzlichen Informationen (36) über den Patienten von den Bilddaten (30) und/oder den erkannten Bewegungsereignissen, wobei die zusätzlichen Informationen (36) eine oder mehrere einer mittleren Aktivität des Patienten in einem vorbestimmten Zeitintervall einschließen, erkannte Bewegungsmuster, Bewegungsereignisse von vorbestimmten Teilen des Körpers des Patienten, und Änderungen und/oder Trends der Aktivität des Patienten.

8. Überwachungssystem nach Anspruch 1, wobei die Deliriumbestimmungseinheit (16) konfiguriert ist, um den Deliriumstand (32) durch zusätzliches Benutzen von zusätzlichen physiologischen Informationen (38, 40, 42) des Patienten zu bestimmen, insbesonders EEG-Daten und/oder Hautleitfähigkeitsdaten des Patienten.

9. Überwachungssystem nach Anspruch 8, wobei die Deliriumbestimmungseinheit (16) konfiguriert ist, um die zusätzlichen physiologischen Informationen (38, 40, 42) des Patienten mit physiologischen Referenzinformationen zu vergleichen, die Delirium anzeigen, insbesonders um EEG-Daten und/oder Hautleitfähigkeitsdaten des Patienten mit typischen Mustern von EEG-Daten und/oder Hautleitfähigkeitsdaten zu vergleichen, die Delirium anzeigen.

10. Überwachungssystem nach Anspruch 8, ferner umfassend eine Speichereinheit (20) zur Speicherung der physiologischen Referenzinformationen, die Delirium anzeigen, insbesonders typische Muster von EEG-Daten und/oder Hautleitfähigkeitsdaten, die Delirium anzeigen.

11. Überwachungssystem nach Anspruch 8, ferner umfassend eine physiologische Datenerfassungseinheit (22, 24) zur Erfassung von zusätzlichen physiologischen Informationen des Patienten, insbesonders EEG-Daten und/oder Hautleitfähigkeitsdaten des Patienten.

12. Verfahren zur automatischen Überwachung eines Patienten, umfassend:

- Erhalten von Bilddaten (30) des Patienten im Laufe der Zeit,
- Erkennen von Bewegungsereignissen des Patienten von den erhaltenen Bilddaten (30)
- Bestimmen von hohen und/oder geringen Bewegungszahlen, die die Intensität von erkannten Bewegungsereignissen anzeigen,
- Klassifizieren der erkannten Bewegungsereignisse in Bewegungsereignisse, die typisch für Delirium sind und in Bewegungsereignisse, die nicht typisch für Delirium sind, und
- Bestimmen eines Deliriumstands (32) von der Dauer der hohen und geringen Bewegungszahlen und von der Dauer, Intensität, Art, Stelle und/oder des Auftretens von Bewegungsereignissen, die typisch für Delirium sind, wobei der Deliriumstand (32) die Wahrscheinlichkeit und/oder die Stärke des Deliriums des Patienten anzeigt.

13. Verarbeitungsgerät (5, 6) zur Benutzung in einem automatischen Überwachungssystem zur Überwachung eines Patienten, das Verarbeitungsgerät umfassend:

- eine erste Verarbeitungseinheit (12) zur Erkennung von Bewegungsereignissen des Patienten von Bilddaten (30), die im Laufe der Zeit von dem Patienten erhalten werden,
- eine zweite Verarbeitungseinheit (14) zur Klas-

sifizierung der erkannten Bewegungsereignisse in Bewegungsereignisse, die typisch für Delirium sind und in Bewegungsereignisse, die nicht typisch für Delirium sind, und zur Bestimmung von hohen und geringen Bewegungszahlen, die die Intensität von erkannten Bewegungsereignissen anzeigen, und

- eine dritte Verarbeitungseinheit (16) zur Bestimmung eines Deliriumstands (32) von der Dauer der hohen und geringen Bewegungszahlen und von der Dauer, Intensität, Art, Stelle und/oder des Auftretens von Bewegungsereignissen, die typisch für Delirium sind, wobei der Deliriumstand (32) die Wahrscheinlichkeit und/oder die Stärke des Deliriums des Patienten anzeigt.

14. Verarbeitungsverfahren zur Benutzung in einem automatischen Überwachungssystem zur Überwachung eines Patienten, das Verarbeitungsverfahren umfassend:

- einen ersten Verarbeitungsschritt zur Erkennung von Bewegungsereignissen des Patienten von Bilddaten (30), die im Laufe der Zeit von dem Patienten erhalten werden,
- einen zweiten Verarbeitungsschritt zur Klassifizierung der erkannten Bewegungsereignisse in Bewegungsereignisse, die typisch für Delirium sind und in Bewegungsereignisse, die nicht typisch für Delirium sind, und zur Bestimmung von hohen und/oder geringen Bewegungszahlen, die die Intensität der erkannten Bewegungsereignissen anzeigen, und
- einen dritten Verarbeitungsschritt zur Bestimmung eines Deliriumstands (32) von der Dauer der hohen und geringen Bewegungszahlen und von der Dauer, Intensität, Art, Stelle und/oder des Auftretens von Bewegungsereignissen, die typisch für Delirium sind, wobei der Deliriumstand (32) die Wahrscheinlichkeit und/oder die Stärke des Deliriums des Patienten anzeigt.

15. Computerprogramm umfassend Programmcodemittel, um zu verursachen, dass ein Computer die Schritte des Verarbeitungsverfahrens nach Anspruch 14 durchführt, wenn das Computerprogramm auf dem Computer durchgeführt wird.

Revendications

1. Système de surveillance (1, 2, 3) pour la surveillance automatisée d'un patient et la détection du délire du patient, comprenant :

- une unité de surveillance (10) pour obtenir des données d'image (30) du patient au fil du temps,
- une unité d'analyse d'images (12) pour détecter les événements de mouvements du patient à partir des données d'image obtenues (30),
- une unité d'évaluation (14) pour classer les événements de mouvement détectés en événements de mouvement typiques du délire et en événements de mouvements non typiques du délire, dans lequel ladite unité d'évaluation (14) est configurée pour déterminer des décomptes de mouvements hauts et/ou bas indiquant l'intensité des événements de mouvements détectés, et
- Une unité de détermination de délire (16) pour déterminer un score de délire (32) à partir de la durée des décomptes de mouvement hauts ou bas et de la durée, de l'intensité, du type, de l'emplacement et/ou de la survenue d'événements de mouvement typiques du délire, ledit score de délire (32) indiquant la probabilité et/ou la force du délire du patient.

2. Système de surveillance selon la revendication 1, dans lequel ladite unité de détermination de délire (16) est configurée pour indiquer une probabilité supérieure et/ou une force supérieure du délire du patient, selon que les événements de mouvement typiques du délire se produisent plus longtemps, plus intensément et/ou plus souvent.

3. Système de surveillance selon la revendication 1, dans lequel ladite unité de détermination de délire (16) est configurée pour déterminer un indicateur de type de délire (34) à partir de la durée des décomptes de mouvement hauts ou bas et/ou à partir de la durée, de l'intensité, du type, de l'emplacement et/ou de la survenue des événements de mouvement typiques du délire, ledit indicateur de type de délire indiquant le type de délire incluant le délire hyperactif, le délire hypoactif et le délire mixte hyperactif et hypoactif.

4. Système de surveillance selon la revendication 3, dans lequel ladite unité de détermination de délire (16) est configurée pour déterminer l'indicateur de type de délire afin d'indiquer un délire hyperactif si la durée cumulée des périodes hyperactives dans un premier intervalle de temps dépasse un premier seuil de durée et pour déterminer l'indicateur de type de délire afin d'indiquer un délire hypoactif si la durée cumulée de périodes hypoactives dans ledit premier intervalle de temps dépasse un second seuil de durée.

5. Système de surveillance selon la revendication 1, dans lequel ladite unité de détermination de délire (16) est configurée pour déterminer le score de délire afin d'indiquer une absence de délire s'il existe une différence substantielle de décomptes de mouve-

ment entre le jour et la nuit et/ou si les décomptes de mouvement dans un intervalle de temps prédéterminé sont entre un troisième et un quatrième seuils de décomptes de mouvement.

6. Système de surveillance selon la revendication 1, dans lequel ladite unité de surveillance (10) est configurée pour obtenir continuellement ou à intervalles réguliers des données d'image (30) du patient, en particulier pour obtenir des données vidéo du patient, en utilisant une caméra vidéo.

7. Système de surveillance selon la revendication 1, comprenant en outre une unité de détermination d'informations (18) pour déterminer des informations supplémentaires (36) concernant le patient à partir desdites données d'image (30) et/ou desdits événements de mouvement détectés, lesdites informations supplémentaires (36) incluant une ou plusieurs des activités moyennes du patient dans un intervalle de temps prédéterminé, des motifs de mouvement détectés, des événements de mouvement de parties prédéterminés du corps du patient et des changements et/ou tendances dans l'activité du patient.

8. Système de surveillance selon la revendication 1, dans lequel ladite unité de détermination de délire (16) est configurée pour déterminer ledit score de délire (32) en utilisant en outre des informations physiologiques supplémentaires (38, 40, 42) concernant le patient, en particulier les données d'EEG et/ou les données de conductance de la peau du patient.

9. Système de surveillance selon la revendication 8, dans lequel ladite unité de détermination de délire (16) est configurée pour comparer lesdites informations physiologiques supplémentaires (38, 40, 42) concernant le patient avec des informations physiologiques de référence pour le délire, en particulier, pour comparer les données EEG et/ou les données de conductance de la peau du patient avec des motifs typiques des données EEG et/ou des données de conductance de la peau, indicatives du délire.

10. Système de surveillance selon la revendication 9, comprenant en outre une unité de stockage (20) pour stocker lesdites informations physiologiques de référence indicatives du délire, en particulier des motifs particuliers de données EEG et/ou des données de conductance de la peau indicatives du délire.

11. Système de surveillance selon la revendication 8, comprenant en outre une unité d'acquisition des données physiologiques (22, 24) pour acquérir des informations physiologiques supplémentaires sur le patient, en particulier des données EEG et/ou des données de conductance de la peau du patient.

12. Procédé de surveillance automatisée d'un patient, comprenant :

- l'obtention de données d'image (30) du patient au fil du temps,
- la détection d'événements de mouvement du patient à partir des données d'image obtenues (30),
- la détermination de décomptes de mouvement hauts et/ou bas indiquant l'intensité des événements de mouvements détectés,
- le classement des événements de mouvement détectés en événements de mouvement typiques du délire et en événements de mouvement non typiques du délire, et
- La détermination d'un score de délire (32) à partir de la durée des décomptes de mouvement hauts ou bas et de la durée, de l'intensité, du type, de l'emplacement et/ou de la survenue des événements de mouvement typiques du délire, ledit score de délire (32) indiquant la probabilité et/ou la force du délire du patient.

13. Processeur (5, 6) pour utilisation dans un système de surveillance automatisé pour surveiller un patient, ledit processeur comprenant :

- une première unité de traitement (12) pour détecter les événements de mouvement du patient à partir de données d'images (30) obtenues au fil du temps auprès du patient,
- une deuxième unité de traitement (14) pour classer les événements de mouvement détectés en événements de mouvement typiques du délire et en événements de mouvements non typiques du délire et pour déterminer les décomptes de mouvement hauts et/ou bas indiquant l'intensité des événements de mouvements détectés, et
- une troisième unité de traitement (16) pour déterminer un score de délire (32) à partir de la durée des décomptes de mouvement hauts ou bas et de la durée, de l'intensité, du type, de l'emplacement et/ou de la survenue d'événements de mouvement typiques du délire, ledit score de délire (32) indiquant la probabilité et/ou la force du délire du patient.

14. Procédé de traitement pour utilisation dans un système de surveillance automatisé pour surveiller un patient, ledit procédé de traitement comprenant :

- une première étape de traitement pour détecter les événements de mouvement du patient à partir de données d'image (30) obtenues au fil du temps auprès du patient,
- une deuxième étape de traitement pour classer les événements de mouvement détectés en

événements de mouvement typiques du délire et en événements de mouvement non typiques du délire et pour déterminer des décomptes de mouvement haut et/ou bas, indiquant l'intensité des événements de mouvement détectés, et
- une troisième étape de traitement pour déterminer un score de délire (32) à partir de la durée des décomptes de mouvement hauts ou bas, et de la durée, de l'intensité, du type, de l'emplacement et/ou de la survenue d'événements de mouvement typiques du délire, ledit score de délire (32) indiquant la probabilité et/ou la force du délire du patient.

15. Programme informatique comprenant des moyens de code de programme pour qu'un ordinateur effectue les étapes du procédé de traitement selon la revendication 14 quand ledit programme informatique est exécuté sur l'ordinateur.

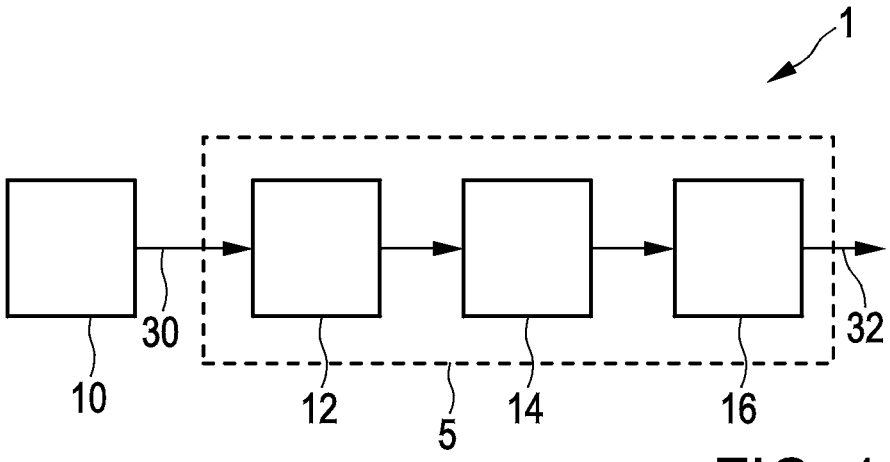

FIG. 1

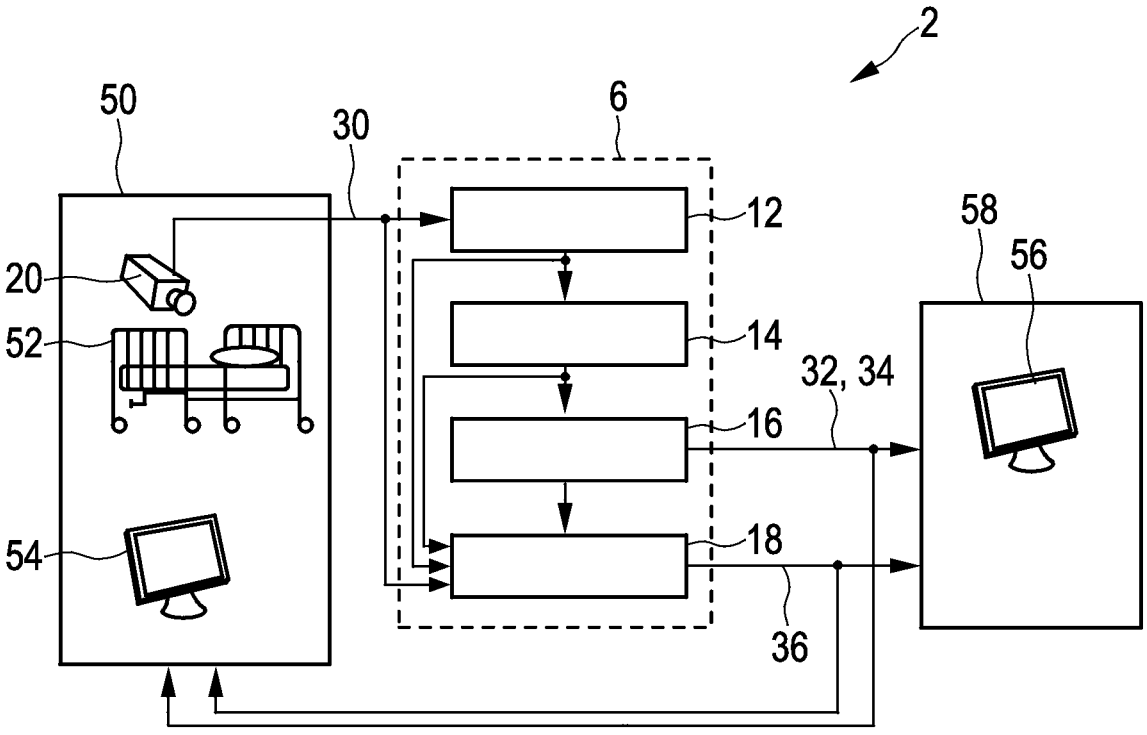

FIG. 2

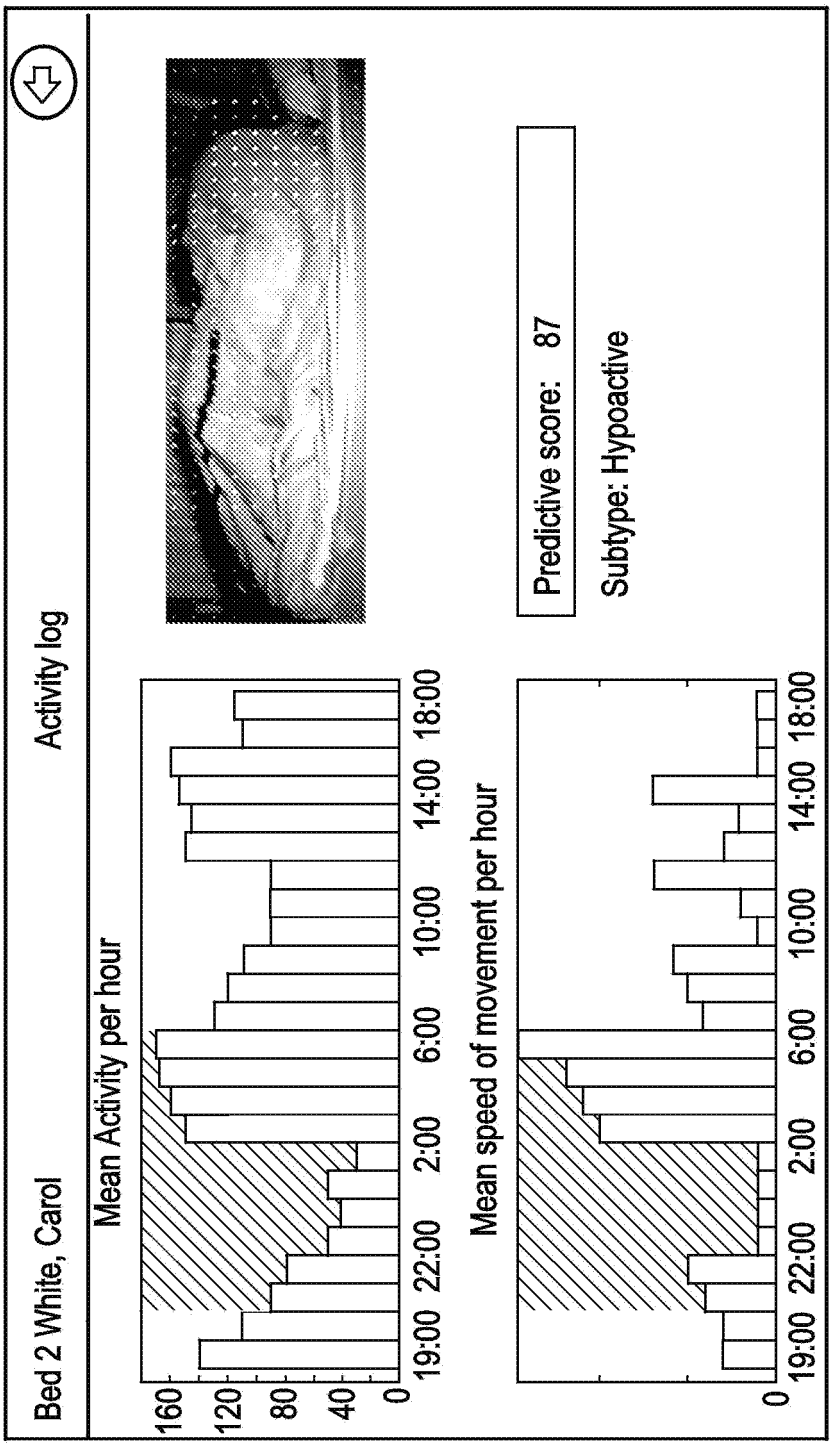
Bed 2 White, Carol
Activity log
Mean Activity per hour
160
120
80
40
0
19:00
22:00
2:00
6:00
10:00
14:00
18:00
Mean speed of movement per hour
0
19:00
22:00
2:00
6:00
10:00
14:00
18:00
Predictive score: 87
Subtype: Hypoactive

FIG. 3

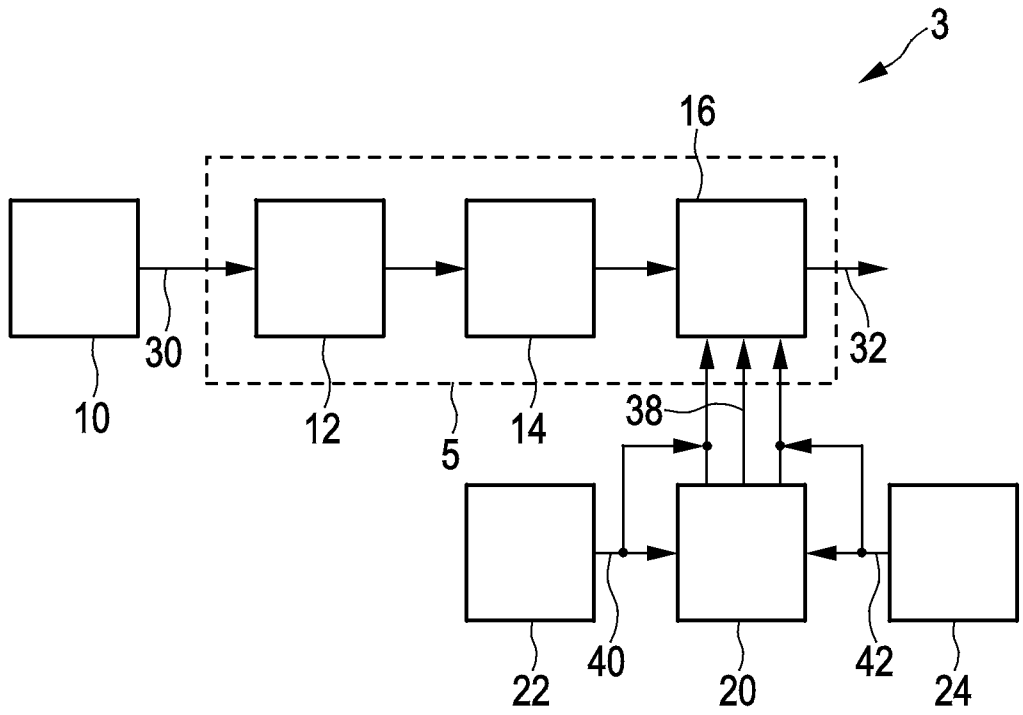

FIG. 4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20100049095 A **[0008]**
- US 6049281 A **[0009]**

Non-patent literature cited in the description

- **HEINRICH, A. ; VAN VUGT, H.** A new video actigraphy method for non-contact analysis of body movement during sleep. *European Sleep Research Society ESRS, Journal on Sleep Research,* 2010, vol. 19 (2 **[0006]**
- **VAN DEN BOOGAARD, M. ; PICCKERS, P. et al.** PRE-DELIRIC, PREdiction of DELIRium in ICu patients; development and validation of a delirium prediction model for intensive care patients. *Proceedings of the European delirium Association, 5th scientific congress on delirium,* 2010 **[0042]**

专利名称(译)	用于监测患者和检测患者谵妄的监测系统		
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申请(专利权)人(译)	皇家飞利浦N.V.		
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代理机构(译)	STEFFEN，THOMAS		
优先权	61/544321 2011-10-07 US		
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摘要(译)

本发明涉及一种监测系统（1,2,3）和相应的监测方法，用于监测患者并以不显眼的方式检测患者的谵妄，而不需要体上传感器。所提出的监测系统包括用于随时间获得患者的图像数据（30）的监测单元（10），用于从获得的图像数据（30）检测患者的运动事件的图像分析单元（12），评估单元（14）用于将检测到的运动事件分类为谵妄典型运动事件和非谵妄典型运动事件，以及谵妄确定单元（16），用于根据持续时间，强度，类型，位置和确定谵妄评分（32）。 /或发生谵妄典型的运动事件，所述谵妄评分（32）表示患者谵妄的可能性和/或强度。