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LE GOUVERNEMENT
DU GRAND-DUCHÉ DE LUXEMBOURG
Ministère de l'Économie

11

N° de publication :

93285

12

BREVET D'INVENTION

B1

21

N° de dépôt: 93285

51

Int. Cl.:
A61B 5/11, G08B 13/10, G08B 21/04

22

Date de dépôt: 31/10/2016

30

Priorité:

72

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43

Date de mise à disposition du public: 29/05/2018

74

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47

Date de délivrance: 29/05/2018

73

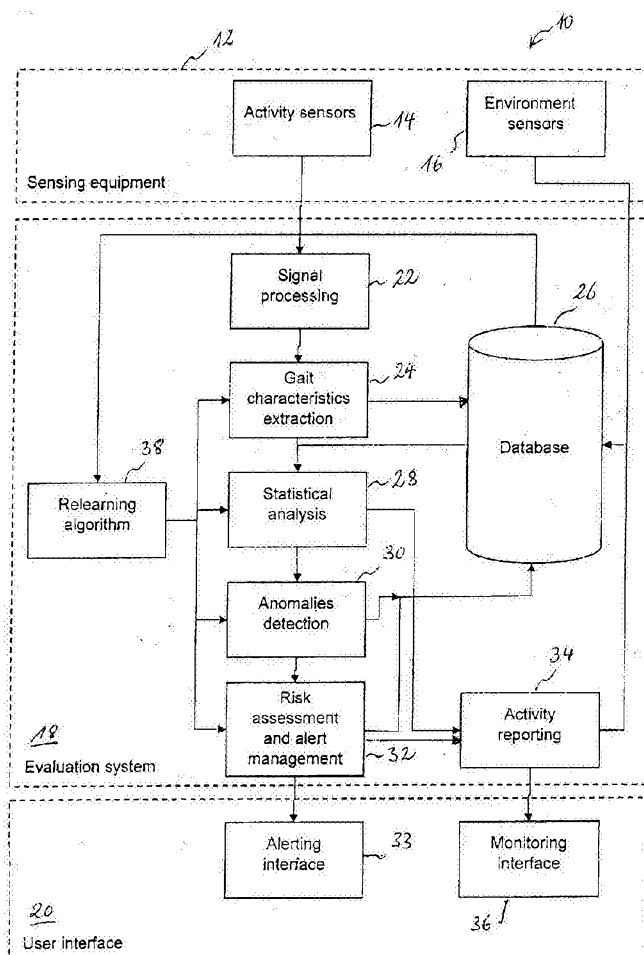
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Behavior monitoring system and method.

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Abstract: A behavior monitoring system for monitoring the behavior of a person in a building comprises: o walking activity sensors integrated in or concealed by permanently installed finishing work on the building, the walking activity sensors configured for producing a measurement signal indicating when the person is walking on a walk-on-able surface of a flooring that is part of the finishing work; and o an evaluation system connected to the walking activity sensors so as to receive the measurement signal for processing. The evaluation system is configured to extract gait characteristics from the measurement signal, to log at least part of the gait characteristics in a database, and to identify development trends in the logged gait characteristics indicative of evolution of the person's behavior. The evaluation system may also generate electronic reports on the person's behavior, the electronic reports including notice of any suspected evolution of the person's behavior. 93285



DESCRIPTION**BEHAVIOR MONITORING SYSTEM AND METHOD****Field of the Invention**

[0001] The invention generally relates to a behavior monitoring system, especially, but not exclusively, for monitoring persons in their indoor living environment, e.g., in their apartment or in their private rooms within an assisted living facility (retirement home, nursing home or hospital), while preserving, as much as possible, the monitored persons' autonomy and privacy.

Background of the Invention

[0002] EP 2 263 217 discloses an object tracking system, comprising a dense sensor field in the floor. The object tracking system detects sensor activations and links an object to each activation. It further produces event information describing events for immediate or later use. The system detects events according the conditions defined for them, on the basis of sensor observations. The conditions can relate to the essence of the objects, e.g. to the strength of the observations linked to the object, to the size and/or shape of the object, to a temporal change of essence and to movement. The system can be used e.g. for detecting the falling, the getting out of bed, the arrival in a space or the exit from it of a person by tracking an object with the dense sensor field, and for producing event information about the treatment or safety of the person for delivering to the person providing care.

[0003] US 8 138 882 discloses an electronic multi-touch floor covering that has numerous sensors arranged in a dense two-dimensional array to identify shapes. The electronic multi-touch floor covering identifies the shape of an object that is in contact with the surface of the electronic multi-touch floor covering. An entity record is then retrieved from a data store, such as a database, with the retrieved entity record corresponding to the identified shape. Actions are then retrieved from a second data store with the actions corresponding to the retrieved entity record. The retrieved actions are then executed by the computer system. For instance, if the system detects that the family dog has entered an area that is "off-limits" for it, a notification to the owner can be dispatched in order to have the dog removed from the off-limits location.

[0004] WO 2016/083294 A1 discloses a monitoring system comprising a floor covering with a sheet-type pressure sensor and a sensor control unit. The latter includes an ADC for providing a digital raw signal, a microcontroller configured to carry out data extraction by signal processing of the digital raw signal and generating a digital processed signal having a lower digital bandwidth than the digital raw signal, and a communications module connected to or integrated within the microcontroller so as to receive the digital processed signal. The communications module is configured to establish data communication with one or more database servers and to transmit the extracted data to the one or more database servers. The monitoring system of WO 2016/083294 A1 is configured to detect events such as falls, walking activity starts, walking activity ends, entries into the monitored room and exits from the monitored room. The detected events are used by the system to detect emergency situations, such as, e.g., unauthorized leaves, unauthorized intrusions, falls, sudden health degradations, etc., based on a short-time analysis of the extracted data. Creeping health degradations may also be detected long-time analysis of the extracted data.

[0005] It has been found, on the one hand, that the event-based detection of health degradations as described in WO 2016/083294 A1 works well in case of emergency situations such as falls. On the other hand, it was noted that an approach to the detection of creeping health degradations more refined than that of WO 2016/083294 A1 would be desirable.

Summary of the Invention

[0006] A first aspect of the invention relates to a behavior monitoring system for monitoring the behavior of a person in a building. The system comprises:

- walking activity sensors integrated in or concealed by permanently installed finishing work on the building, the walking activity sensors configured for producing a measurement signal indicating when the person is walking on a walk-on-able surface of a flooring that is part of the finishing work; and
- an evaluation system connected to the walking activity sensors so as to receive the measurement signal for processing.

The evaluation system is configured to extract gait characteristics from the measurement signal, to log at least part of the gait characteristics in a database, to

identify development trends in the logged gait characteristics indicative of evolution of the person's behavior. Preferably, the evaluation system is further configured to generate electronic reports on the person's behavior. The electronic reports may, in particular, include notice of any behavior evolution suspected indicative of degradation of the person's well-being. In the present document, "well-being" is intended to have the same meaning as "health".

[0007] As used herein, the term "finishing work" may include, further to flooring, skirting, plaster, corner moulding and/or ceiling.

[0008] The evaluation system takes the role of a gait analyzer with data logging functionality. As used herein, the term "gait characteristics" designates parameters describing the gait of the person(s) being monitored. Gait characteristics may include, for instance: frequency of steps, stride length, walking speed (centre of gravity speed), ground reaction force for each of the person's feet, weight balance (centre of gravity position) and foot strike pattern variability. According to an embodiment, the evaluation system extracts and logs at least two of the above-mentioned parameters.

[0009] Gait analysis enables a significantly more precise detection of health degradations, especially those caused by dementia and Parkinson's disease. As regards Parkinson's disease, it is known that abnormal gait, typically characterized by small shuffling steps, may be a symptom of that disease ("Parkinsonian gait"). However, the severity of the symptom depends on the subject and may vary over the day, which may make it difficult for the physician to recognize the symptom and make the correct diagnosis. As will be appreciated, the behavior monitoring system according to the first aspect of the invention gives unprecedented access to a vast collection of gait-related data, which may facilitate diagnosis and make it more reliable.

[0010] According to an embodiment of the behavior monitoring system, the evaluation system is configured to extract the gait characteristics from the measurement signal in real-time or near real-time by carrying out signal conditioning and on-the-fly feature calculation. As used herein, "signal conditioning" includes analog-to-digital conversion (unless the walking activity sensors deliver themselves a digital signal) and noise suppression (filtering). Feature calculation takes the digitized measurement signal and builds derived values (features) intended to summarize the relevant content of the signal. In the present case, the calculated features include the gait characteristics.

[0011] Preferably, the evaluation system is configured to digitally link any suspected evolution of the person's behavior to those among the logged gait characteristics responsible for the development trend identified as indicative of the suspected evolution. Such digital linking may include, for instance, tagging a recorded suspected evolution and/or the responsible values of the gait characteristics with metadata or attributes. The purpose of the digital linking is of course that the data being the cause of a suspected evolution can be identified, retrieved and verified more easily. Preferably, the evaluation system is configured to render the data deemed to be responsible for a suspected evolution accessible for inspection by the user (e.g. a physician). To achieve this, the evaluation system may e.g. provide a user interface capable of querying the database containing the logged gait characteristics based upon the metadata or attributes. For instance, the metadata or attributes could comprise a search string or the parameters of a search string that allows the database management system to retrieve the desired data.

[0012] According to an embodiment, at least part of the walking activity sensors are integrated in or arranged under the flooring. Additionally or alternatively, at least part of the walking activity sensors may be integrated in or arranged behind a skirting.

[0013] The walking activity sensors could be based upon sensors selected from the group consisting of impact sensors, pressure sensors, vibration sensors, capacitive sensors, piezoelectric sensors, piezoelectret sensors, piezoresistive sensors, infrared sensors, opto-electronic sensors. Other sensing principles are not, however, excluded.

[0014] According to an embodiment, the behavior monitoring system further comprises environment sensors for sensing environmental conditions in the rooms in which the walking activity sensors are arranged. The environment sensors are in this case connected to the evaluation system and the evaluation system is configured to contextualize the logged gait characteristics using the environmental conditions sensed by the environment sensors. As will be appreciated, contextualization of the gait characteristics allows detection as well as mitigation of environmental influences. In the context of this document, "contextualization" means to associate the gait characteristics with the environmental conditions prevailing at the time the gait characteristics were detected. How the association is implemented in practice depends on the structure chosen for the database. Timestamp and location information may e.g. be suitable for establishing that relationship, i.e. environmental data and gait

characteristics recorded at (approximately) the same time and (approximately) the same location are known to belong together.

[0015] Preferably, the evaluation system is configured to identify the development trends in the logged gait characteristics indicative of evolution of the person's behavior using the contextualized logged gait characteristics. For instance, the use of contextualized gait characteristics could allow filtering out data recorded in exceptional environmental conditions (e.g. abnormally high temperatures in summer), reducing seasonal effects or taking specific events into account (e.g. clock change in autumn or spring).

[0016] According to an embodiment, the environment sensors comprise one or more of the following: luminosity sensors, humidity sensors, temperature sensors, gas sensors (e.g. CO₂-sensors), fire detectors (or smoke sensors), door sensors (e.g. dry contact sensors) and presence sensors (e.g. infrared presence sensors). Preferably, the environment sensors are also integrated in or concealed by the finishing work of the building. Any suitable sensing technology may be used for each of these sensors.

[0017] The building may be any kind of residential building, e.g. a single-family house, an apartment building, a retirement home, a nursing home or a hospital. The present invention may be especially useful for monitoring, in the least disturbing manner, the inhabitants of a retirement home or a nursing home while respecting their privacy as much as possible. In that sense, the behavior monitoring system may be qualified as minimally intrusive.

[0018] According to an embodiment, the evaluation system is further configured for detecting anomalies in the extracted gait characteristics indicative of emergencies (e.g. a fall of the monitored person, or a suffering, etc.) and raising an alarm in case of such detection.

[0019] The evaluation system may comprise a computer or a network of computers, in particular, one or more database servers for logging the collected data. The evaluation system may also comprise client computers for visualization of the gait characteristics and the reports issued by the system.

[0020] If the walking activity sensors output analog signals, the evaluation system also comprises one or more analog-to-digital converters (ADCs). The ADCs are preferably configured to sample the analog measurement signals at a sampling rate

(f_s) comprised in the range from 50 Hz to 1 kHz, more preferably in the range from 50 Hz to 500 Hz and yet more preferably in the range from 100 Hz to 200 Hz. The resolution of the ADC is preferably at least 8 bits ($2^8 = 256$ quantization levels), more preferably at least 16 bits (2^{16} quantization levels) and yet more preferably at least 32 bits (2^{32} quantization levels) or even higher (e.g. 64 bits).

[0021] The evaluation system preferably comprises a buffer memory for buffering the digital measurement signal as received from the walking activity sensors. The buffer memory preferably implements a FIFO (first in first out) buffer, e.g. a cyclic buffer. When the capacity of the FIFO buffer is reached (i.e. when the buffer is full), insertion of a new sample of the digital measurement signal into the FIFO buffer is accompanied with deletion of the oldest sample of the digital measurement signal from the FIFO buffer. The content of the FIFO buffer thus changes at the sampling rate (i.e. the frequency at which new samples of the measurement signal are provided). Preferably, the evaluation system comprises a signal processor configured to extract the gait characteristics from the entire content of the FIFO buffer, e.g. using a classifier or other suitable feature extraction method. The signal processor preferably carries out these steps at the sampling rate ($f_s = 1/T_s$), i.e. each time the FIFO buffer is updated, new values of the gait characteristics are calculated. Alternatively, the signal processor may carry out these steps at a lesser rate. With N being the size of the FIFO buffer (i.e. the maximum number of samples it may contain) and f_{proc} the extraction rate of the gait characteristics, one has the relationship:

$$f_{proc} = f_s/n, \text{ with } n = 1, 2, 3, \dots, N.$$

The signal processor recalculates the gait characteristics each time n new samples have entered the FIFO buffer. Between each calculation, $N-n$ samples in the FIFO buffer remain unchanged, which means that the calculations are performed on a "sliding window". With $n = N$, the contents of two subsequent windows are disjoint, but n may also be chosen such that there is a non-zero overlap between the contents of two subsequent windows, i.e. $n < N$.

[0022] A further aspect of the invention relates to a method for monitoring the behavior of a person in a building, comprising:

- o producing a measurement signal using activity sensors integrated in or concealed by permanently installed finishing work on the building, the

measurement signal indicating when the person is walking on a walk-on-able surface of a permanent flooring that is part of the finishing work;

- conveying the measurement signal to an evaluation system for processing;
- processing the measurement signal using the evaluation system, the processing including:
- extracting gait characteristics from the measurement signal;
- logging at least part of the gait characteristics in a database; and
- identifying patterns in the logged gait characteristics indicative of evolution of the behavior of the person.

[0023] The method for monitoring the behavior may further include generating electronic reports on the person's behavior, the electronic reports including notice of any suspected evolution of the person's behavior, e.g. behavior changes attributed to health degradations.

[0024] Preferably, the gait characteristics are extracted from the measurement signal in real-time or near real-time by signal conditioning and on-the-fly feature calculation.

[0025] Preferably also, any suspected evolution of the person's behavior is digitally linked to those among the logged gait characteristics responsible for the development trend identified as indicative of the suspected evolution.

[0026] According to an embodiment, the method further comprises:

- sensing environmental conditions in the rooms in which the walking activity sensors are arranged
- contextualizing the logged gait characteristics using the sensed environmental conditions.

[0027] Preferably, identification of the development trends in the logged gait characteristics indicative of evolution of the person's behavior is achieved on the basis of the contextualized logged gait characteristics.

[0028] A noteworthy advantage of the present invention resides in the fact that the monitored person or the person in the monitored room is not required to wear a wearable device (for measuring pulse, respiratory rate and/or other parameters). This greatly reduces the perceived impact on the monitored person's life and thus

contributes to the minimally intrusive character of the system. According to preferred embodiments of the invention, the monitoring system thus does not comprise any such wearable device. It should be noted however, that it is not excluded to use the present monitoring system in combination with one or more other monitoring systems in case
5 a closer and/or more advanced (medical) monitoring of the person is intended or necessary. More specifically, the present monitoring system does not aim at replacing medical vital signs monitoring systems but at offering a monitoring solution especially (but not exclusively) for situations where permanent medical monitoring of vital signs is not necessary but monitoring the person's activity is desirable. It will be appreciated
10 that the system according to the invention bridges that gap in a relatively non-intrusive manner with regard to the monitored person's private life.

[0029] In contrast to systems that rely on worn devices, and which thus require a minimum amount of the monitored person's ability and willingness to collaborate, the monitoring system according to the invention requires no specific education of the
15 persons to be monitored. It happens quite often that patients refuse to wear a monitoring device. The reasons for refusal may be discomfort or fear from being stigmatised as a person having to be monitored. Experience shows that it may be even more difficult to encourage a person to carry a wearable device when the person feels healthy. In that respect, the present invention thus greatly simplifies the caregivers'
20 task.

Brief Description of the Drawings

[0030] By way of example, preferred, non-limiting embodiments of the invention will now be described in detail with reference to the accompanying drawings, in which:

Fig. 1: is a schematic view of the functional blocks of a behavior monitoring system
25 according to a preferred embodiment of the invention;

Fig. 2: is a schematic view of a walking activity sensor arranged under permanently installed decorative flooring; and

Fig. 3: is a schematic drawing illustrating a possible way of connecting walking activity sensors and environmental sensors to an evaluation system.

Detailed Description of Preferred Embodiments

[0031] Fig. 1 schematically shows a behavior monitoring system 10 according to a preferred embodiment of the invention. Behavior monitoring system 10 comprises three main sub-parts, i.e., the sensing equipment 12, including the sensor hardware such as activity sensors 14 and environment sensors 16, an evaluation system 18 with several functional modules and a user interface 20.

[0032] The evaluation system 18 receives the measurement signal from the activity sensors 14 for processing. If the activity sensors 14 deliver an analog measurement signal to the evaluation system, initial signal processing 22 includes analog-to-digital conversion; otherwise, analog-to-digital conversion is achieved internally in the activity sensors and the measurement signal is received by the evaluation system as a digital signal. Signal processing 22 may include filtering and smoothing operations. The digital samples are then stored at least temporarily in a memory that functions as a FIFO buffer with a size of N samples (see also Fig. 3).

[0033] Gait characteristics extraction module 24 uses the FIFO buffer to produce a so-called feature vector, whose vector components correspond to the various gait characteristics that are analyzed. Gait characteristics are computed anew each time a specified number n of samples have been admitted to the buffer and the oldest n samples have been removed from it, thus using the N most recent samples ($n \ll N$).

[0034] For the purpose of illustration, f_s may e.g. be selected in the range from 100 to 1000 Hz and N in the range from 100 to 10000. Preferably N and f_s are chosen such that N/f_s (i.e. the time interval represented by the FIFO buffer) is comprised in the range from 5 to 40 s, more preferably in the range from 5 to 20 s. n may e.g. be chosen such that n/f_s amounts to about 0.5 s. Each one of the features (gait characteristics) quantifies a specific gait-related property of the N most recent samples and is obtained at runtime through application of a corresponding formula.

[0035] The gait characteristics are logged in a database 26. The same happens with the data collected by the environment sensors 16, which serve to contextualize the gait characteristics. A statistical analysis module 26 evaluates the development trends in the different gait characteristics. The statistics are computed not only on the basis of the live data but also taking the logged data in the database 26 into account: development trends are preferably obtained by the analysis of data in a time window

having a duration of more than 5 minutes, e.g. a few hours or one day (24 hours). Long-term development trends may e.g. be observed over periods of several days, weeks, months or even years of data if such long-time observations are available.

[0036] It should be noted that gait characteristics extraction may be part of a feature extraction step that provides other features not directly related to gait. For instance, the feature extraction step could produce supplementary features indicative of a fall of the monitored person or features indicative of vital signs (e.g. heart rate, respiration rate, etc.)

[0037] A module termed "anomalies detection module" scrutinizes the statistics of the features, including the contextualized gait characteristics, but not necessarily only them, for any anomalies. Anomalies may include, for instance, unexpectedly high or low values of a feature, untypically high or low variability of a feature, significant variation of a long-term moving average of a feature, etc. In specific embodiments of the behavior monitoring system, anomalies, may include, e.g.: unusual levels of night activities, more frequent than usual visits to the bathroom and/or the toilet, untypically long stays in the bathroom or restroom, less frequent than usual visits to the kitchen (potential nutrition issue), less frequent than usual visits to the bathroom (potential hygienic issue possibly linked with a loss of autonomy), no or less than usual activity in specific rooms at given times of the day, etc.

[0038] Any anomalies are analyzed in a module in charge of risk assessment and alert management. Module 32 assesses whether the anomalies detected indicate any risk for the health of the person who is being monitored. For instance, if a feature indicative of a fall is unexpectedly high, the module 32 cross-checks with other features and/or data in order to determine whether a fall is likely to have occurred or not. In case the module 32 suspects a fall to have occurred, it triggers an alert, which is dispatched to the user interface with high priority and importance. The alerting interface 33 may comprise, for instance, a caretaking facility's nurse or caregiver call system.

[0039] If the module 32 determines that the gait characteristics have changed significantly over a longer time period (e.g. over several days, weeks or months), an alert of a different type is generated as the anomaly does not require immediate attention of a medical practitioner but should nevertheless be considered as soon as possible. Specifically, in the described embodiment, an anomaly, such as a suspected evolution of the monitored person's behavior, is forwarded to an activity reporting unit

34, in charge of conditioning the statistical data for display by a user. The anomaly relating to the gait characteristics is included into the electronic reports generated by the activity reporting unit 34, e.g. in the form of a record in a warnings window or a pop-up window, which appears when the monitored person's electronic file is opened in the monitoring interface 36. The activity reporting unit 34 also links the suspected evolution of the person's behavior to those among the logged gait characteristics responsible for the development trend identified as indicative of the suspected evolution. The behavior evolution could be due to a degradation of the monitored person's well-being (health). Depending on how the linking is achieved, the user (medical practitioner) could e.g. click on a button or hyperlink associated with the anomaly notice for direct visualization of graphics illustrating the history of the gait characteristics and the nature of the anomaly detected. Preferably, the monitoring interface is configured in such a way that the medical can validate, rate, comment and/or complement any suspected evolution notified to them. Also preferably, the evaluation system may be integrated into a patient file management system, wherein all data relevant to the monitored person are stored (dietary information, medication information, results of medical analyses or examinations, etc.) In that way, the evaluation system could take medical data into account for contextualization of the gait characteristics. This could allow gaining objective data on whether a medical treatment is effective and to the benefit of the monitored person. For instance, it would be easier for a medical practitioner to determine whether a newly prescribed medicament against insomnia reduces night-time activities without having to rely solely on the patient's declarations.

[0040] The database 26 stores not only the gait characteristics and the data of the environment sensors but also the anomalies, the statistical data and any feedback from the medical practitioners. The content of the database may be used to feed a relearning algorithm 38. Relearning algorithm 38 may implement, for instance, an ensemble learning technique. Relearning algorithm 38 may influence the way the gait characteristics are extracted, the statistics are computed, the anomalies are detected and the risk assessment is carried out by tuning the operating parameters of the corresponding functional blocks.

[0041] Fig. 2 illustrates how walking activity sensors can be integrated in a floor covering. In the illustrated embodiment, the walking activity sensors are sheet-type pressure sensors 40 arranged under a resilient polymer-based floor covering 42. The

construction of the floor covering is best illustrated in Fig. 2. The sheet-type pressure sensor 40 is affixed to the floor pavement 44 with a first adhesive layer 46. The resilient floor covering 42 is affixed on the top surface of the sheet-type pressure sensor 40 with a second adhesive layer 48. Also shown in Fig. 2 is a skirting 50, which may
5 comprise additional walking activity sensors (e.g. vibration sensors or infrared light sensors with a field of view limited to a height range from floor level to a few (e.g. up to 20) centimeters above the floor). The skirting may serve to accommodate further sensors, such as environment sensors (e.g. CO₂ sensors, temperature sensors, humidity sensors, etc.)

10 [0042] Fig. 3 schematically illustrates how walking activity sensors 14 and environment sensors 16 can be connected to the evaluation system 18. Only a few components of the evaluation system are shown. In the illustrated embodiment, the walking activity sensors are sheet-type pressure sensors 40 using ferroelectret polymer films for generating an analog measurement signal but other sensors may be
15 used alternatively or in addition. The analog measurement signal is filtered and, if necessary, amplified in an analog signal conditioning stage before conversion by analog-to-digital converters (ADCs) 54. The digital measurement signals are fed to the evaluation system 18, which stores the raw data in a raw data memory 56. This repository of raw data may be organized as a simple file system.

20 [0043] The digital measurement signals are also fed into different buffers 58 and then processed by a microprocessor 60, which extracts the gait characteristics and, possibly, other features, from the measurement signals. The microprocessor 60 further comprises or is connected to a communication module 62 for connection to one or more networks (e.g. Ethernet, WiFi™ (IEEE 802.11™ standard), DECT (Digital
25 Enhanced Cordless Telecommunications) and/or a building automation system interface, etc.) The communication module 62 may, in particular, be in charge of communicating with one or more user interfaces and/or the database wherein the extracted gait characteristics are stored.

[0044] Environment sensors 16 are connected to the evaluation system in such a way
30 that the microprocessor 60 may use the data on the environmental conditions for contextualization of the gait characteristics. With regard to the embodiment of Fig. 3, it is assumed that the environment sensors 16 provide a digital output, which can be treated as such by the microprocessor 60. However, this is not a limitation of the

system, as a suitable ADC may be used in case the environment sensors should produce an analog output.

[0045] While specific embodiments have been described herein in detail, those skilled in the art will appreciate that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. Accordingly, the particular arrangements disclosed are meant to be illustrative only and not limiting as to the scope of the invention, which is to be given the full breadth of the appended claims and any and all equivalents thereof.

Revendications

1. Un système de surveillance de comportement pour surveiller le comportement d'une personne dans un bâtiment, comprenant des capteurs de marche intégrés dans ou cachés par un travail de finition permanent du bâtiment, les capteurs de marche étant configurés pour produire un signal de mesure indiquant quand la personne marche sur une surface de marche d'un revêtement de sol qui fait partie du travail de finition; et un système d'évaluation connecté aux capteurs de marche de telle façon à recevoir un signal de mesure pour traitement, le système d'évaluation étant configuré pour extraire des caractéristiques de démarche du signal de mesure, de consigner au moins une partie des caractéristiques de démarche dans une base de données, d'identifier des tendances d'évolution dans les caractéristiques de démarche consignées indicatives de l'évolution du comportement de la personne.
2. Le système de surveillance de comportement tel que revendiqué à la revendication 1, dans lequel le système d'évaluation est, en plus, configuré pour générer des rapports électroniques sur le comportement de la personne, lesdits rapports électroniques incluant une notification d'une quelconque évolution présumée du comportement de la personne.
3. Le système de surveillance de comportement tel que revendiqué aux revendications 1 ou 2, dans lequel le système d'évaluation est configuré pour extraire les caractéristiques de démarche du signal de mesure en temps réel ou proche du temps réel en réalisant un conditionnement du signal et un calcul de caractéristiques à la volée.
4. Le système de surveillance de comportement tel que revendiqué à l'une quelconque des revendications 1 à 3, dans lequel le système d'évaluation est configuré pour lier digitalement une quelconque évolution présumée du comportement de la personne aux caractéristiques de démarche consignées responsables de la tendance d'évolution identifiée comme indicative de l'évolution présumée.

5. Le système de surveillance de comportement tel que revendiqué à l'une quelconque des revendications 1 à 4, dans lequel le travail de finition inclut en plus des plinthes, du plâtre, des moulures d'angle et/ou un plafond.
6. Le système de surveillance de comportement tel que revendiqué à l'une
5 quelconque des revendications 1 à 5, dans lequel au moins une partie des capteurs de marche sont intégrés dans ou arrangés sous ledit revêtement de sol.
7. Le système de surveillance de comportement tel que revendiqué à l'une quelconque des revendications 1 à 6, dans lequel au moins une partie des capteurs de marche sont intégrés dans ou arrangés derrière des plinthes.
- 10 8. Le système de surveillance de comportement tel que revendiqué à l'une quelconque des revendications 1 à 7, dans lequel lesdits capteurs de marche sont basés sur des capteurs sélectionnés dans le groupe consistant en : des capteurs d'impact, des capteurs de pression, des capteurs de vibration, des capteurs capacitifs, des capteurs piézoélectriques, des capteurs piézoélectrets,
15 des capteurs piézorésistifs, des capteurs infrarouges, des capteurs optoélectroniques.
9. Le système de surveillance de comportement tel que revendiqué à l'une quelconque des revendications 1 à 8, dans lequel les caractéristiques de démarche comprennent au moins deux des éléments suivants: la fréquence des
20 pas, la longueur des pas, la vitesse de marche, la force de réaction du sol pour chacun des pieds de la personne, la répartition de la masse, la variabilité du profil des pas.
10. Le système de surveillance de comportement tel que revendiqué à l'une quelconque des revendications 1 à 9, comprenant en plus des capteurs
25 environnementaux pour capter les conditions environnementales dans les salles dans lesquelles les capteurs de marche sont arrangés, dans lequel les capteurs environnementaux sont connectés au système d'évaluation et dans lequel le système d'évaluation est configuré pour contextualiser les caractéristiques de démarche consignées en utilisant les conditions environnementales captées par
30 les capteurs environnementaux.
11. Le système de surveillance de comportement tel que revendiqué à la revendication 10, dans lequel le système d'évaluation est configuré pour identifier

les tendances d'évolution dans les caractéristiques de démarche consignées indicatives de l'évolution du comportement de la personne en utilisant les caractéristiques de démarche consignées et contextualisées.

5 12. Le système de surveillance de comportement tel que revendiqué aux revendications 10 ou 11, dans lequel les capteurs environnementaux comprennent un ou plusieurs des éléments suivants: capteurs de luminosité, capteurs d'humidité, capteurs de température, capteurs de gaz, capteurs de feu, capteurs de portes et capteurs de présence.

10 13. Le système de surveillance de comportement tel que revendiqué à l'une quelconque des revendications 1 à 12, dans lequel le bâtiment est une maison unifamiliale, un bâtiment à appartements, une maison de repos, une maison de soins ou un hôpital.

15 14. Le système de surveillance de comportement tel que revendiqué à l'une quelconque des revendications 1 à 13, dans lequel l'évolution du comportement de la personne est due à la dégradation du bien-être de la personne, par exemple dû à une démence et/ou à la maladie de Parkinson.

20 15. Le système de surveillance de comportement tel que revendiqué à la revendication 14, dans lequel le système d'évaluation est en plus configuré pour détecter des anomalies dans les caractéristiques de démarche extraites indicatives d'urgences et déclencher une alarme dans le cas d'une telle détection.

16. Un procédé pour surveiller le comportement d'une personne dans un bâtiment, comprenant:

25 la production d'un signal de mesure utilisant des capteurs d'activité intégrés dans ou cachés par un travail de finition permanent du bâtiment, le signal de mesure indiquant quand la personne marche sur une surface de marche d'un revêtement de sol permanent qui fait partie du travail de finition;

la transmission du signal de mesure à un système d'évaluation pour traitement; le traitement du signal de mesure en utilisant le système d'évaluation, le traitement incluant:

30 l'extraction des caractéristiques de démarche du signal de mesure;
la consignation d'au moins une partie des caractéristiques de démarche dans une base de données; and

l'identification de motifs dans les caractéristiques de démarche consignées indicatives de l'évolution du comportement de la personne.

17. Le procédé tel que revendiqué à la revendication 16, incluant la génération de rapports électroniques sur le comportement de la personne, les rapports électroniques incluant la notification d'une quelconque évolution présumée du comportement de la personne, par exemple une quelconque évolution présumée indicative de la dégradation du bien-être de la personne.
18. Le procédé tel que revendiqué à la revendication 17, dans lequel les caractéristiques de démarche sont extraites du signal de mesure en temps réel ou proche du temps réel en réalisant un conditionnement du signal et un calcul de caractéristiques à la volée.
19. Le procédé tel que revendiqué à l'une quelconque des revendications 16 à 18, dans lequel une évolution présumée quelconque du comportement de la personne est liée numériquement aux caractéristiques de démarche consignées responsables de la tendance d'évolution identifiée comme indicative de l'évolution présumée.
20. Le procédé tel que revendiqué à l'une quelconque des revendications 16 à 19, dans lequel lesdites caractéristiques de démarche comprennent au moins deux des éléments suivants: la fréquence des pas, la longueur des pas, la vitesse de marche (vitesse du centre de gravité), la force de réaction du sol pour chacun des pieds de la personne, la répartition de la masse (position du centre de gravité).
21. Le procédé tel que revendiqué à l'une quelconque des revendications 16 à 20, comprenant en plus:
 - la détection des conditions environnementales dans les salles dans lesquelles les capteurs de marche sont arrangés
 - la contextualisation des caractéristiques de démarche consignées en utilisant les conditions environnementales détectées.
22. Le procédé tel que revendiqué à la revendication 21, dans lequel l'identification des tendances d'évolution dans les caractéristiques de démarche consignées indicatives de l'évolution du comportement de la personne est réalisée sur base des caractéristiques de démarche consignées et contextualisées.

Fig. 1

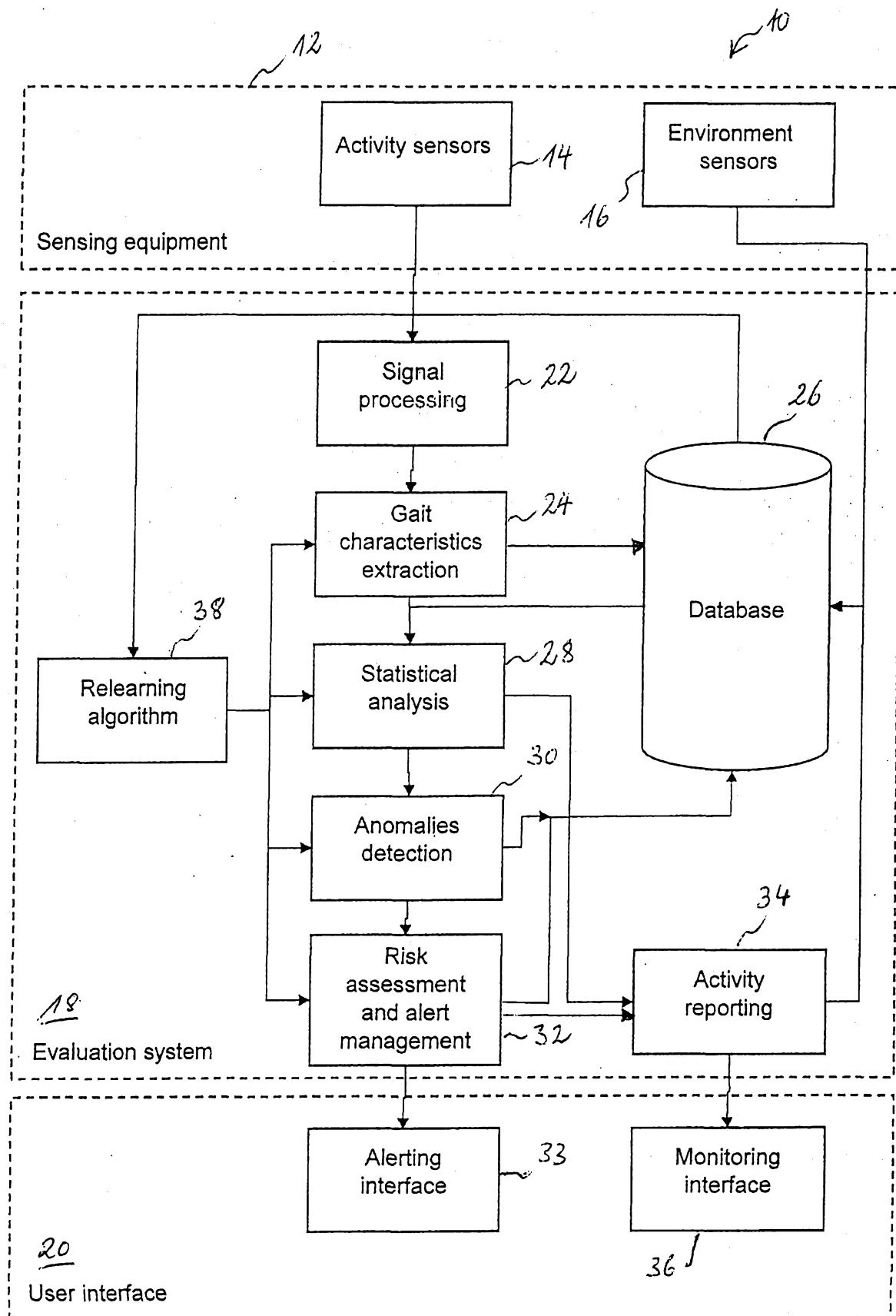


Fig. 2

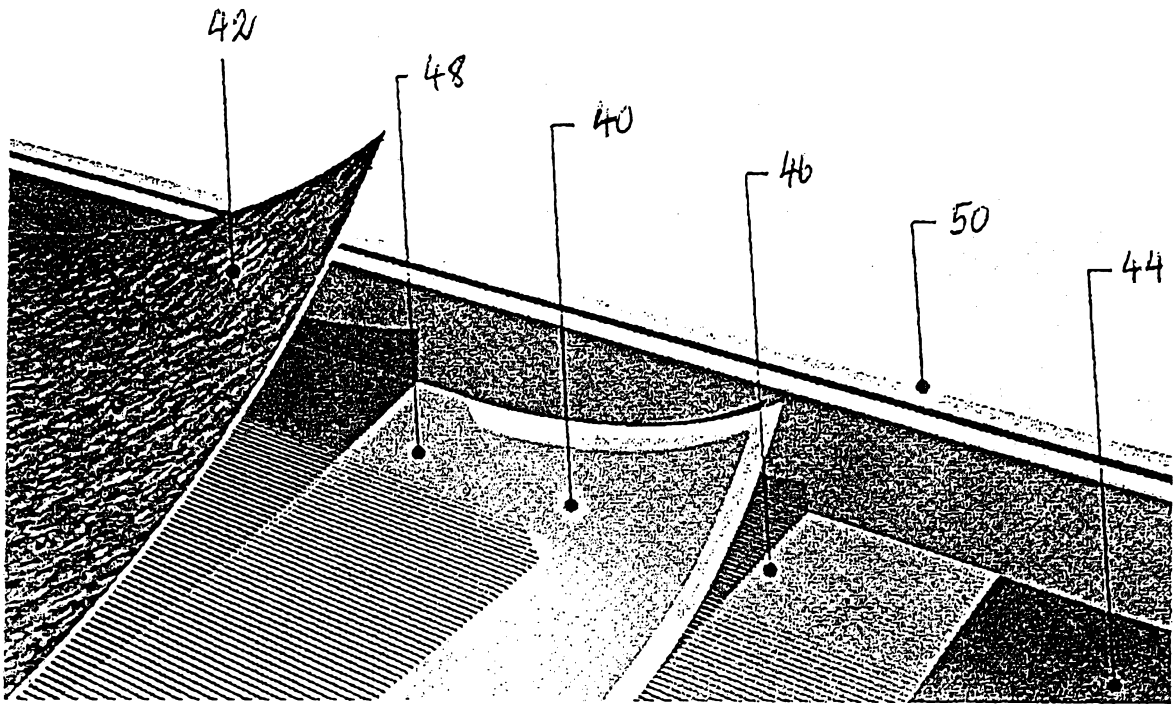
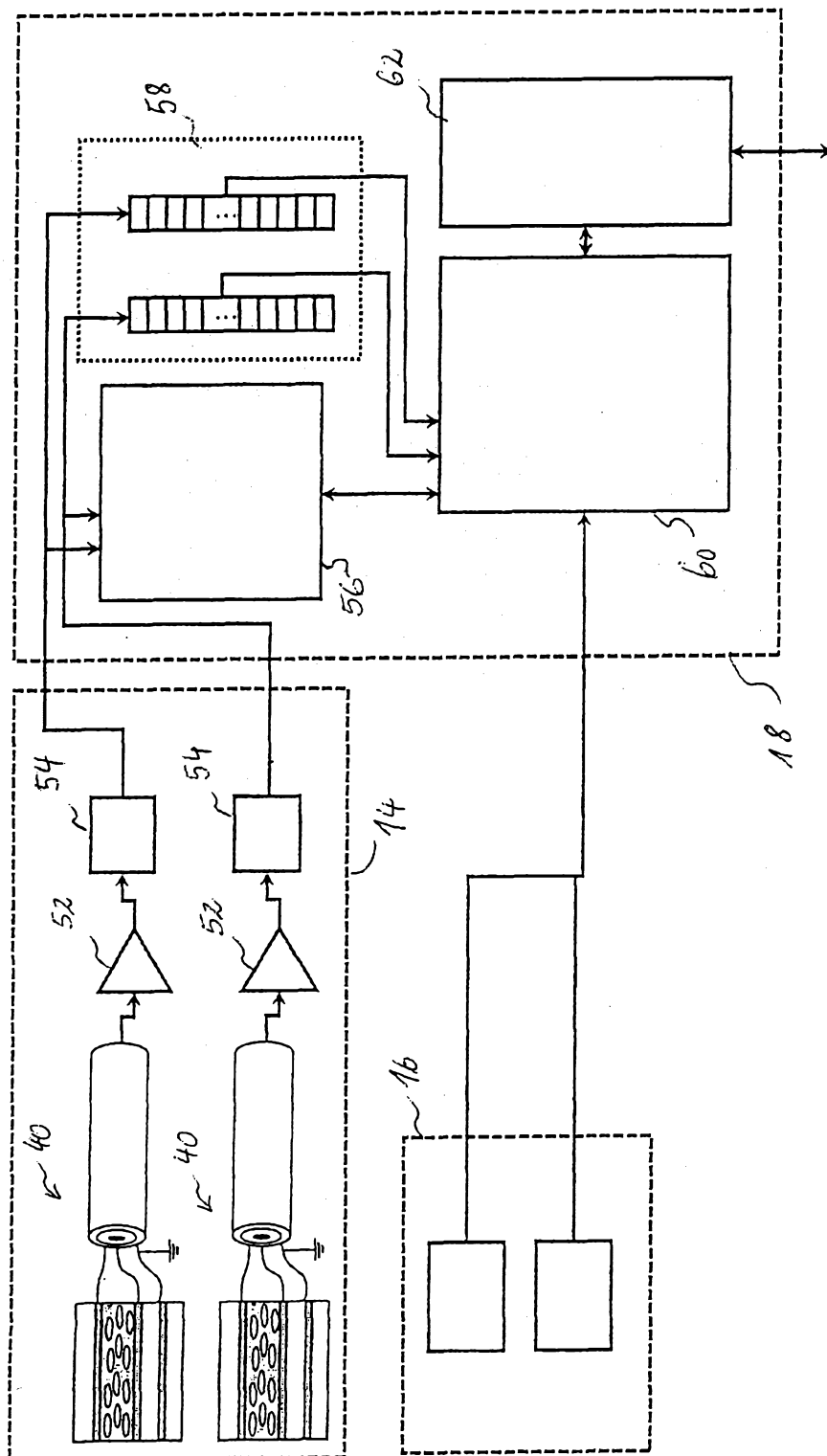


Fig. 3



Abstract

A behavior monitoring system for monitoring the behavior of a person in a building comprises:

- 5 ○ walking activity sensors integrated in or concealed by permanently installed finishing work on the building, the walking activity sensors configured for producing a measurement signal indicating when the person is walking on a walk-on-able surface of a flooring that is part of the finishing work; and
 - an evaluation system connected to the walking activity sensors so as to receive the measurement signal for processing.
- 10 The evaluation system is configured to extract gait characteristics from the measurement signal, to log at least part of the gait characteristics in a database, and to identify development trends in the logged gait characteristics indicative of evolution of the person's behavior. The evaluation system may also generate electronic reports on the person's behavior, the electronic reports including notice of any suspected
- 15 evolution of the person's behavior.



SEARCH REPORT
in accordance with Article 35.1 a)
of the Luxembourg law on patents
dated 20 July 1992

LO 1468
LU 93285

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 10 2012 107412 A1 (REMES JAROMIR [DE]) 28 May 2014 (2014-05-28) * abstract; figures 1,11 * * paragraphs [0002] - [0005], [0030], [0035], [0042], [0057] - [0061], [0064], [0065] *	1-22	INV. A61B5/11 G08B13/10 G08B21/04
X	WO 2016/083294 A1 (TARKETT GDL [LU]) 2 June 2016 (2016-06-02) * abstract; figures 1,4 * * paragraphs [0022] - [0030] *	1,5-8,13	
X	DR A STEINHAGE ET AL: "SensFloor: Ein AAL Sensorsystem für Sicherheit, Homecare und Komfort", AMBIENT ASSISTED LIVING 1.DEUTSCHER KONGRESS MIT AUSSTELLUNG TECHNOLOGIEN - ANWENDUNGEN - MANAGEMENT,, 1 January 2008 (2008-01-01), pages 37-41, XP008185110, * abstract; figures 1,2,4 * * paragraphs [0004], [0005] *	1,16	
X	Christopher McQuarrie: "Top 12 Technology on Mission Impossible 5: Rogue Nation 2015", youtube, 4 August 2015 (2015-08-04), page 1 pp., XP054977538, Retrieved from the Internet: URL:https://www.youtube.com/watch?v=InUm02 gjp7k [retrieved on 2017-07-12] * 3 Minutes 20 seconds - 3 minutes 42 seconds*	1,16	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC) A61B G08B
Date of completion of the search		Examiner	
14 July 2017		Jonsson, P.O.	
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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ISO-FC2284:1993-03-02 (P)X(C)501



SEARCH REPORT
in accordance with Article 35.1 a)
of the Luxembourg law on patents
dated 20 July 1992

LO 1468
LU 93285

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 2 679 743 A1 (TARKETT GDL [LU]) 1 January 2014 (2014-01-01) * abstract *	5-8,13	
A	----- WO 2004/100092 A2 (DATA HEALTH SYSTEM [FR]; BERTAUD JEAN-MICHEL [FR]; FACHE JEAN-LOUIS [F]) 18 November 2004 (2004-11-18) * abstract; figures 1-4 * * page 32, line 3 - page 36, line 16 *	1-22	
A	----- MIIKA VALTONEN ET AL: "TileTrack: Capacitive human tracking using floor tiles", PERVASIVE COMPUTING AND COMMUNICATIONS, 2009. PERCOM 2009. IEEE INTERNATIONAL CONFERENCE ON, IEEE, PISCATAWAY, NJ, USA, 9 March 2009 (2009-03-09), pages 1-10, XP031453094, ISBN: 978-1-4244-3304-9 * abstract; figure 2 * * paragraphs [0001], [VIII] *	1-22	
			TECHNICAL FIELDS SEARCHED (IPC)
The present search report has been drawn up for all claims			
Date of completion of the search		Examiner	
14 July 2017		Jonsson, P.O.	
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	

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ISO FC22M 1503 03 02 (9/00C55)

**ANNEX TO THE SEARCH REPORT
ON LUXEMBOURG PATENT APPLICATION NO.**

LO 1468
LU 93285

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

14-07-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102012107412 A1	28-05-2014	NONE	
WO 2016083294 A1	02-06-2016	NONE	
EP 2679743 A1	01-01-2014	NONE	
WO 2004100092 A2	18-11-2004	EP 1623397 A2	08-02-2006
		FR 2854713 A1	12-11-2004
		WO 2004100092 A2	18-11-2004



WRITTEN OPINION

File No. LO1468	Filing date (day/month/year) 31.10.2016	Priority date (day/month/year)	Application No. LU93285
International Patent Classification (IPC) INV. A61B5/11 G08B13/10 G08B21/04			
Applicant TARKETT GDL			

This report contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☒ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the application
- ☒ Box No. VIII Certain observations on the application

Form LU237A (Cover Sheet) (January 2007)	Examiner Jonsson, P.O.
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WRITTEN OPINION

Application No.

LU93285

Box No. I Basis of the opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:
 - a. type of material:
 - ☐ a sequence listing
 - ☐ table(s) related to the sequence listing
 - b. format of material:
 - ☐ on paper
 - ☐ in electronic form
 - c. time of filing/furnishing:
 - ☐ contained in the application as filed.
 - ☐ filed together with the application in electronic form.
 - ☐ furnished subsequently.
3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes: Claims	
	No: Claims	1-22
Inventive step	Yes: Claims	
	No: Claims	1-22
Industrial applicability	Yes: Claims	1-22
	No: Claims	

2. Citations and explanations

see separate sheet

WRITTEN OPINION

Application No.
LU93285

Box No. VI Certain documents cited

☐ Certain published documents

☒ Non-written disclosures

see the Search Report

Box No. VIII Certain observations on the application

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

- 1 Reference is made to the following documents:
 - D1 DE 10 2012 107412 A1;
 - D2 WO 2016/083294 A1;
 - D3 DR A STEINHAGE ET AL: "SensFloor: Ein AAL Sensorsystem für Sicherheit, Homecare und Komfort", AMBIENT ASSISTED LIVING 1.DEUTSCHER KONGRESS MIT AUSSTELLUNG TECHNOLOGIEN - ANWENDUNGEN - MANAGEMENT,, 1 January 2008 (2008-01-01), pages 37-41, XP008185110;
 - D4 Christopher McQuarrie: "Top 12 Technology on Mission Impossible 5: Rogue Nation 2015", youtube, 4 August 2015 (2015-08-04), page 1 pp., XP054977538,
Retrieved from the Internet:
URL:<https://www.youtube.com/watch?v=lnUm02gjP7k>
[retrieved on 2017-07-12];
 - D5 EP 2 679 743 A1;
 - D6 WO 2004/100092 A2;
 - D7 MIIKA VALTONEN ET AL: "TileTrack: Capacitive human tracking using floor tiles", PERVASIVE COMPUTING AND COMMUNICATIONS, 2009. PERCOM 2009. IEEE INTERNATIONAL CONFERENCE ON, IEEE, PISCATAWAY, NJ, USA, 9 March 2009 (2009-03-09), pages 1-10, XP031453094, ISBN: 978-1-4244-3304-9.
- 2 The present application does not meet the criteria of patentability, because the subject-matter of claims 1-22 is not new.
 - 2.1 Claim 1:

- 2.1.1 Document D1 discloses (abstract; figures 1,11; paragraphs [0002] - [0005], [0030], [0035], [0042], [0057] - [0061], [0064], [0065]) a behavior monitoring system (see title) for monitoring the behavior of a person in a building (par. 4) comprising:

walking activity sensors (1,1' in fig. 1) integrated in or concealed by permanently installed finishing work on the building (par. 2),

the walking activity sensors configured for producing a measurement signal indicating when the person is walking on a walkon-able surface of a flooring that is part of the finishing work (abstract, lines 1-6 in comb. with par. 2);

and an evaluation system (4) connected to the walking activity sensors so as to receive the measurement signal for processing (7-9),

the evaluation system being configured to extract gait characteristics from the measurement signal (par. 41, 42, 57), to log at least part of the gait characteristics in a database (par. 64), to identify development trends in the logged gait characteristics indicative of evolution of the person's behaviour (par. 57, two last lines).

- 2.1.2 Also document D2 discloses (abstract; figures 1,4; paragraphs [0022], [0025] - [0027], [0030]) all the features of claim 1. In shortform

A behavior monitoring system in a building (fig. 1, title) comprising

walking activity sensors (16) integrated in or concealed by permanently installed finishing work on the building (ab. lines 1-2); and

an evaluation system to extract gait characteristics from the measurement signal and to log at least part of the gait characteristics (par. 30).

- 2.1.3 Finally also document D3 discloses (abstract; figures 1,2,4; paragraphs [0004], [0005]) a behavior monitoring system in a building (anstract) comprising

walking activity sensors integrated in or concealed by permanently installed finishing work on the building (fig. 2); and

an evaluation system to extract gait characteristics from the measurement signal and to log at least part of the gait characteristics (bild 1,4; par. 4).

2.2 Claim 16:

Claim 16 claims a method containing method steps corresponding to the system features of claim 1. Since the documents D1-D3 are computer implemented behavior monitoring systems (see document D1, fig. 1 and 6; document D2 par. 29; document D3 par. 3), it follows that claim 16 lack novelty over documents D1-D3 mutatis mutandis.

2.3 Dependent claims 2-15 and 17-22 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of novelty. In detail:

2.3.1 Claims 2 and 17:

See document D1, par. 64;

2.3.2 Claims 3 and 18:

See document D1, par. 42;

2.3.3 Claims 4 and 19:

See document D1, par. 65;

2.3.4 Claims 5-7:

See document D1, par. 2 and 30;

See document D2, abstract;

2.3.5 Claim 8:

See document D1, abstract;

See document D2, par. 27;

2.3.6 Claims 9 and 20:

See document D1, par. 58;

2.3.7 Claims 10, 12 and 21:

See document D1, par. 69 and 71;

2.3.8 Claims 11 and 22:

See document D1, par. 57;

2.3.9 Claim 13:

See document D1, par. 4;

See document D2, fig. 4;

2.3.10 Claim 14:

See document D1, par. 61;

2.3.11 Claim 15:

See document D1, par. 42 and 49;

- 3 Furthermore, although not relevant to the claims in their current form in view of the objection to lack of novelty above, the following is pointed out:
 - 3.1 In view of document D5 it would not be considered to involve an inventive step to amend the claims so as to direct the sensor to be hidden behind a skirting. It is well known in the art to hide things behind the skirtings in a building (kables for instance) and given the objective problem to mount the sensors for a behaviour monitoring system hidden away in a building where it is not possible to put the sensors below the flooring, the skilled person would know about the use of skirtings for this purpose and implement this without involving any inventive activity.
 - 3.2 In view of document D6 (abstract; figures 1-4; page 32, line 3 - page 36, line 16) it would not be considered to involve an inventive step to specify the further details of the analysis of movements, trembling or gait characteristics of a patient for diagnosis of behavioural related diseases. There is a host of documents describing these analysis techniques for mobile applications where the analysis is mostly done in a central processing facility. The skilled person would be able to benefit from, and have knowledge about all this techniques. Please also note that document D6 involves a similar type of cyclic memory for the measurement data as in the current application.
 - 3.3 Finally, in view of document D7 (abstract; figure 2; paragraphs [000I], [VIII]) it would not be considered to involve an inventive step to provide further details of the sensors themselves, or their integration into a floor material. Such techniques are well known in the art and the skilled person would know how to further adapt the sensor to the specific conditions of the building where the monitoring system is to be included.

Re Item VI

- 4 Non-written disclosures

Kind of non-written disclosure	Date of non-written disclosure (day/month/year)	Date of written disclosure referring to non-written disclosure (day/month/year)
Internet Video Clip	04/08/20154	07/12/2017

Re Item VIII

Certain observations on the application

- 5 Claims 10, 11 and 14 do not meet the requirement of clarity because the matter for which protection is sought is not clearly defined. These claims attempts to define the subject-matter in terms of the result to be achieved, which merely amounts to a statement of the underlying problem, without providing the technical features necessary for achieving this result.

Regarding claims 10 and 11 the feature that (emphasis added)

"the evaluation system *is configured to contextualize the logged gait characteristics* using the environmental conditions sensed by the environment sensors",

or the feature that

"the evaluation system *is configured to identify the development trends* in the logged gait characteristics *indicative of evolution of the person's behavior* using the contextualized logged gait characteristics"

merely amounts to describing the goal, without disclosing, in terms of **technical features**, the features necessary to obtain said desirable goal.

Regarding claim 14 it is not clear from the claim, or even from the description, how the behavior monitoring system claimed can ascertain that (emphasis added:

"evolution of the person's behavior *is due to a degradation of the person's well being*, e.g. to dementia and/or to Parkinson's disease.

- 6 This appears to be nothing more than a mere postulate rather than a definition of the system in terms of technical features.