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(54) **SMART COVER FOR SENSING A SIGNAL AND METHOD TO OPERATE THE SMART COVER**

(57) Smart cover for sensing a signal, the smart cover comprising a preferably conducting sheet of fabric or leather arranged to cover a seat, a handle and/or a steering device particularly of a vehicle, and a sensor matrix printed on the sheet and comprising several sensor elements, wherein each of the sensor elements is arranged for sensing or detecting one or more of an electrical signal sent out by a body of a human occupant, an outline of the body, and a body dimension.

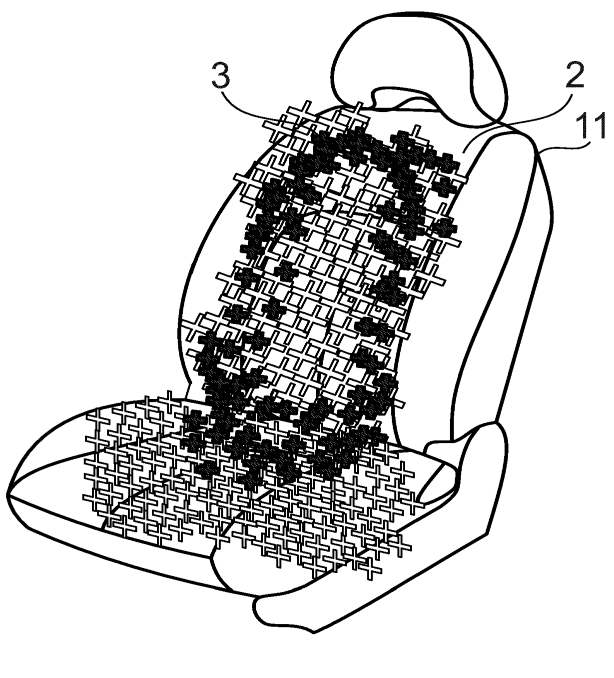


Fig. 3b

EP 3 888 538 A1

## Description

**[0001]** The present invention relates to a smart cover for sensing a signal and to a method to operate the smart cover. The invention is described with respect to an automobile having a seat and a steering device but may be advantageously used with any other chair or with gym equipment having a seat and a handle or in hospitals & clinics.

**[0002]** Some vehicles have one or more seats, a steering device and at least one safety system which aims to increase driver and passenger safety. Some of these safety systems should function better if they could use data referring to the driver or passenger (occupant).

**[0003]** It is an objective of the present invention to provide more safety to the occupant of a vehicle.

**[0004]** The object is achieved by a smart cover according to claim 1 and by a method to operate the smart cover (second aspect).

**[0005]** The smart cover according to the first aspect is arranged for sensing a signal. The smart cover comprises a preferably conducting sheet of fabric or leather arranged to cover a seat, a handle and/or a steering device particularly of a vehicle, and a sensor matrix printed on the sheet and comprising several sensor elements. Each of the sensor elements is arranged for sensing or detecting one or more of an electrical signal sent out by a body of a human occupant, an outline of the body, and a body dimension.

**[0006]** The method according to the second aspect is suitable to operate a smart cover. The method comprises the following steps:

> S2 sensing or detecting by sensor elements (4) one or more of an electrical signal sent out by a body of a human occupant, an outline of the body, and a body dimension, wherein the sensor elements are arranged in a sensor matrix of the smart cover, which sensor matrix is printed on a preferably conductive sheet of fabric or leather of the smart cover, wherein the sheet is arranged to cover a seat or a steering device of a vehicle, particularly to detect the presence of the occupant and/or to provide occupant presence information,
> further comprising one or both of the following steps
> S3 estimating the physique of the occupant based on the signals received by the sensor elements, and providing respective anthropometric data, and/or
> S6 obtaining a physiologic parameter of the occupant, such as ECG, GSR, EEG (evaluated physiologic parameter) or temperature, based on the signals received by the sensor elements.

**[0007]** Health Monitoring of driver or occupants in vehicle or automotive environment has been the trend for a long time. The usual ways to get access to the health of the occupants is to one, connect and synchronize activity trackers; two, connect ambulatory health monitoring systems, and three, use of bio vital acquiring sensors within the vehicle.

**[0008]** Although the best and easiest way to access the health is the third option, the sensors used for this application need to be placed on the location of body that is the target location of sensor. For e.g. blood pulse volume/rate can be acquired from finger tips, ear lobes or centre in the back of torso. Hence there is a need to identify and recognize the target locations on which the sensor can read the required information.

**[0009]** The invention permits to detect the physique, a seating position of the occupant and/or continuous monitoring of one of the occupant's physiologic parameters, such as heart activity. Thereby, a safety system can adapt to the detected physique of the occupant. There is no need for the occupant to key in data prior to driving or riding the vehicle. In case of an undesirable physiologic parameter a safety system or comfort system could adapt based on the physiologic parameter, at least a warning could be given to the occupant.

**[0010]** The invention helps to ensure that the safety systems depended on occupant or driver health work effectively for every seating position, contour and kind.

**[0011]** The body dimension can relate to one or more of armpit, crotch, shoulders, neck waist, chest, hips.

**[0012]** Within the concept of the present invention, physiologic parameters are particularly the heart's beats per minute, heart rate variability, blood pressure, blood oxygen saturation, breathing cycles per minute, the tidal volume per breathing cycle and characteristic values in an ECG.

**[0013]** Preferred embodiments given below may be combined advantageously, unless stated otherwise.

**[0014]** The sensor matrix of an embodiment is made with capacitive sensor elements. Each of the capacitive sensor elements can comprise two electrodes which are isolated from each other and which are printed on the sheet. The occupant can serve to increase the capacitance C of the capacitive sensor element including the two isolated electrodes. The printed electrodes can have a rounded or essentially rectangular shape or the shape of a cross. The two printed electrodes belonging to the same capacitive sensor element need not be immediately adjacent to each other. One of the capacitive sensor elements can form temporarily, when the electronic control unit described below relates a first and a second of the printed electrodes temporarily.

**[0015]** In case the sensor matrix is of the capacitive technology, the EEG and ECG measurements are feasible with increased resolution of these capacitive sensors. A derived combination of sensors in the matrix according to the anthropometric data/information leads to accurate EEG and ECG information. With processing these signals can provide hear rate, heart rate variability and insights on cardiac abnormalities. Additionally, for PPG (blood volume/rate), blood glucose etc. the sensing technology specific to these bio vitals are aligned, rotated or moved and activated with respect to the detected contour. The EEG signals are processed and analysed along with ECG signal characteristics to estimate the mental health like stress, distraction, drowsiness etc. and emotional health like mood, frustration, road rash etc.

**[0016]** The sensor matrix can be of any technology that can individually sense the body touch / contact to establish the outline contour with local extreme points (minimum and maximum vertical and horizontal coordinates). Optical, capacitive and force sensitive resistors are possible.

**[0017]** The sensing technology used for sensor matrix can/not be utilized for sensing the physiological signals. In case of capacitive sensors, additionally ECG, GSR and EEG signals can be acquired. In case of optical and piezo sensors, PPG signals can be acquired.

**[0018]** The sensor matrix of another embodiment is arranged to detect the occupant's physique, based on the signals received by the sensor elements, and is arranged to provide an electrically generated profile or anthropometric data based on the signals received by the sensor elements, particularly to a safety system of a vehicle.

**[0019]** In an embodiment, a first group of sensor elements is positioned and can be activated to detect electric heart signals of the occupant. The smart cover can indicate to a safety system whether the occupant is overloaded or stressed or tired.

**[0020]** The sensor matrix can be of any technology that can individually sense the body touch / contact to establish the outline contour with local extreme points (minimum and maximum vertical and horizontal coordinates). Optical, capacitive and force sensitive resistors are possible.

**[0021]** The sensing technology used for sensor matrix can/not be utilized for sensing the physiological signals. In case of capacitive, additionally ECG, GSR and EEG signals can be acquired. In case of optical and piezo, PPG signals can be acquired.

**[0022]** The sheet of another embodiment is arranged to cover a handle or steering device. Some of the sensor elements are positioned and arranged to detect or provide a dual electrode ECG from the occupant's fingers placed on the handle or steering device. Signals from the fingers of the right & left hand placed on the handle or steering device can be used advantageously for the dual electrode ECG.

**[0023]** The sheet of a further embodiment is arranged to cover the seat particularly of a vehicle or gym equipment. Some of the sensor elements can be positioned and arranged to detect or provide a 12 electrode ECG after/by estimating the location of exact electrode positions from the electrically generated profile or anthropometric data.

**[0024]** According to an embodiment, the smart cover has an electronic control unit arranged to process signals from the sensor elements into anthropometric data and/or a physiologic parameter of the occupant. The control unit can be arranged to provide the anthropometric data and/or the physiologic parameter to an adaptive safety system, a predictive safety system and/or to a comfort system particularly of a vehicle. The control unit can have an independent power supply unit providing power also to the sensor matrix. The control unit can be arranged to process the signals from the sensor elements into one of evaluated physiologic parameters ECG, GSR and EEG. The control unit may employ an array for storing signals of several sensor elements at different points in time. The smart cover's electronic control unit can be arranged for wireless communication with a superordinate control unit e.g. of a vehicle.

**[0025]** A preferred vehicle has a smart cover as explained above and a safety system, preferably an adaptive passive safety system. The smart cover can be connected with the safety system to provide it with anthropometric data and/or a physiologic parameter of the occupant. The safety system can be arranged to operate based on the anthropometric data and/or the physiologic parameter. The vehicle can have a comfort system and/or a predictive safety system, each arranged to operate based on the anthropometric data and/or the physiologic parameter. The smart cover can have the control unit which begins to operate once the vehicle's ignition is switched on. The vehicle can be an automobile, lorry, locomotive, bicycle, motorcycle, ship or airplane. The smart cover can be part of a seat cover.

**[0026]** The smart cover can be used with gym equipment having a seat and/or a handle bar. The smart cover can cover the handle bar such that the hands of a user can touch sensor elements of the sensor matrix. The electronic control unit of the smart cover can be supplied with power by the gym equipment. The electronic control unit of the smart cover can be connected with the gym equipment such that a load on the user can be varied depending on a physiologic parameter of the user, particularly to avoid an overload. The electronic control unit can be connected with the gym equipment such that a member of the gym equipment can be positioned depending on the anthropometric data. This can also serve to avoid an accident.

**[0027]** The smart cover can be part of a chair at home or in an office or part of an arm chair. The smart cover can be used in hospitals & clinics. When the smart cover is part of a bed or pillow sheet or forms a bed or pillow sheet, a patient or an elderly person can be monitored. A physiologic parameter of the patient/person can be derived from the signals from the capacitive sensor elements. Movements of the patient/person can be detected based on changes of the signals from the capacitive sensor elements. If a physiologic parameter develops undesirably, then a countermeasure can be initiated or at least a warning can be given.

**[0028]** The system can facilitate a subject and his/her position independent physiology, health and state monitoring of the occupant in an automotive environment. The system facilitates use of sensors interconnected as a matrix embedded or printed as electronics on seat cover and steering wheel cover. As an occupant is seated, his contour outline is sensed using the sensor matrix and related anthropometric information is gained. For ECG and EEG, the same sensors/sensing technology is applicable, hence gets activated on the location estimated from the contour in the sensor matrix. The sensors can be also exclusive, independent of sensor matrix (for e.g. glucose, blood pulse etc.) and are additionally activated based on the contour detected.

**[0029]** An embodiment of the method comprises the step of activating/switching on the smart cover (S1), particularly when switching on an ignition device of a vehicle or when activating a piece of gym equipment. This can help to save energy and/or to relieve the occupant/user from keying in data.

**[0030]** Another embodiment of the method includes activating or adjusting an adaptive passive safety system of the vehicle based on the anthropometric data of step S3 (S4). This can help to increase occupant safety.

**[0031]** A further embodiment of the method also includes the following steps:

S5 increasing the sensitivity of at least one of the sensor elements,
S6' obtaining the physiologic parameter of the occupant, such as ECG, GSR, EEG (evaluated physiologic parameter) or temperature, based on the signals received by the sensor elements, using the at least one sensor element of step S5.

**[0032]** An embodiment of the method involves activating a predictive safety system and/or a comfort system based on the physiologic parameter of step S6 or step S6' (S7). A further embodiment includes a step of
S8 monitoring changes over time of at least one physiologic parameter of the occupant.

**[0033]** To this end, two subsequent signals of the same sensor element can be compared. It may be useful to compare a signal of one of the sensor elements at a first point in time with the signal of the same sensor element at a second point in time, wherein $\Delta t \geq N$ minutes and N is a natural number or positive integer greater than 0. The control unit of the smart cover may employ an array for storing signals of several sensor elements at different points in time. When comparing signals of the same sensor at different points in time, the control unit may access the array.

**[0034]** Another embodiment includes the step of
S9 monitoring changes over time of the electrically generated profile or anthropometric data of the occupant.

**[0035]** To this end, two subsequent signals of the same sensor element can be compared. It may be useful to compare a signal of one of the sensor elements at a first point in time with the signal of the same sensor element at a second point in time, wherein $\Delta t \geq N$ minutes and N is a natural number or positive integer greater than 0. A changing electrically generated profile or "changing anthropometric data" may indicate that the posture of the occupant changes indicating discomfort, pain or fatigue.

**[0036]** One of the smart covers explained above can advantageously be operated as follows:

S11 switching one or more sensors of the sensor matrix individually, preferably adapting one or more switched sensors,
S12 acquiring signals from the sensor matrix, preferably converting the acquired signals into digital and/or filtering the acquired signals (processed signals),
S13 communicating or transferring acquired or processed signals to an electronic control unit,
S14 determining minimum and maximum extreme points from the transfer to data by the control unit,
S15 identifying a contour of a body engaging with the sensor matrix,
S16 estimating anthropometric data referring to the body,
S17 estimating a sensing area for physiological signals referring to the body,
S18 deciding or selecting sensors to be activated and preparing instruction for configuring these sensors based on the estimated sensing area,
S19 communicating or transferring the instructions prepared during step S18 to a physiology sensor unit,
S20 activating sensors of the sensor matrix with the instruction of steps S18, S19,
S21 acquiring signals by the activated sensors,
S22 verifying the accuracy of the acquired physiology signals and verifying signal characteristics,
S23 returning the verified physiology signals to the control unit.

**[0037]** Further details and advantages are apparent to the skilled person from the following exemplary embodiment.

Figure 1 schematically shows a smart cover 1 which covers an independent car seat 11. The smart cover has a fabric sheet 2 on which a sensor matrix 3a, 3b is printed. The smart cover's sheet can be sewn to other cuttings to be a part of the same seat cover. The sensor matrix has several capacitive sensor elements 4a to 4d. The smart cover can have electronic control unit receiving and processing the sensor signals into anthropometric data and/or a physiologic parameter relating to the occupant. The electronic control unit of the smart cover can provide the anthropometric data and/or the physiologic parameter to a safety system of the independent car. Further, the electronic control unit can begin to operate when the ignition of the car is switched on.

Figure 2 shows how an exemplary smart cover can be operated.

**[0038]** The smart cover can be switched on when switching on an ignition device of the vehicle having the smart cover (S1). Step S2 is performed including sensing or detecting an electrical signal sent out by a body of a human occupant by sensor elements arranged in a sensor matrix of the smart cover, which sensor matrix is printed on a preferably conductive sheet of fabric or leather of the smart cover, wherein the sheet is arranged to cover a seat or a steering device of a vehicle. Thereby, the occupant is detected and occupant presence information 23 can be provided.

**[0039]** Afterwards, one or both of the following steps are executed:

> S3 estimating the physique of the occupant based on the signals received by the sensor elements, and providing respective anthropometric data 21, and/or S6 obtaining a physiologic parameter 22 of the occupant, such as ECG, GSR, EEG (evaluated physiologic parameter) or temperature 24, based on the signals received by the sensor elements.

**[0040]** The smart cover can provide a safety system of a vehicle with anthropometric data 21 (obtained by S3) an/or a physiologic parameter (obtained by S6) referring to the occupant. An adaptive passive safety system of a vehicle can be activated or adjusted based on the anthropometric data obtained by step S3 (S4).

**[0041]** The smart cover can be operated such that the sensitivity of at least one of the sensor elements is increased (S5). During step S5, a first group of sensor elements can be activated to detect electric heart signals of the occupant. Using the at least one sensor element of step S5, the physiologic parameter of the occupant, such as ECG, GSR, EEG or temperature, can be obtained based on the signals received by the sensor elements (S6').

**[0042]** A predictive safety system and/or a comfort system can be activated (S7) based on the physiologic parameter of step S6 or step S6'.

**[0043]** As shown by Figure 3a, several capacitive sensor elements 4a, 4b of a sensor matrix 3 are shown schematically. Each of the capacitive sensor elements 4a, 4b includes two electrodes (cross shaped, marked black) which are electrically isolated from each other. Each of the electrodes may have an individual electrical contact for connecting with an electronic control unit of the smart cover. Further capacitive sensor elements of the sensor matrix and the sheet, on which the sensor matrix is printed, are not shown. Two of the electrodes may form a capacitive sensor element, temporarily.

**[0044]** Figure 3b schematically shows a car seat 11 having the exemplary smart cover 1. The smart cover comprises the sensor matrix as is shown in Figure 3a. The sensors are each shown in a cross shape but they can have any other shape. The smart cover is part of the car seat as its sheet 2 is sewn to other cuttings to form the seat cover. Some of the capacitive sensor elements are shown in red/dark while others are shown in a lighter colour. Signals of the capacitive sensor elements shown in red/dark can be read and interpreted to provide anthropometric data, occupant presence information and the position of the occupant on the seat.

**[0045]** Figure 4 shows how an exemplary control unit processes signals/data and how it may cooperate with an exemplary sensor matrix and an exemplary physiology sensor unit, as a block diagram.

**[0046]** In the exemplary sensor matrix, individual sensors can be switched and may be adapted to their respective purpose (S11). Signals from the sensor matrix can be received by an acquisition unit (S12) which passes on acquired signals to a communication interface. The acquired signals may be converted into digital signals and/or can be filtered into processed signals (S12). The sensor unit's communication interface serves to transfer the signals/data to the control unit (S13). The sensor unit can have a receiver and a transmitter for communicating with the control unit.

**[0047]** The exemplary control unit is arranged to determine minimum and maximum extreme points (S14). These extreme points can be used for contour identification (S15), anthropometric data estimation (S16) and physiological signal sensing area estimation (S17). Based on the physiological signal sensing area estimation, sensor activation can be decided and sensor configuration can be instructed by the control unit (S18). The control unit can communicate the instructions to the exemplary physiology sensor unit (S19).

**[0048]** Based on these instructions, sensors are activated by the exemplary physiology sensor unit (S20). Afterwards, signal acquisition occurs by the activated sensors (S21). The accuracy and characteristics of the acquired data can be verified by the exemplary physiology sensor unit (evaluation) (S22). The evaluation can be fed to a sensor matrix control unit and/or to the exemplary control unit (S23). The feedback can be used in the control unit for decisions on sensor activation and instructions for sensor configuration.

**Reference signs**

**[0049]**

| | |
|---|---|
| 1 | smart cover |
| 2 | sheet of fabric or leather |
| 3 | sensor matrix |
| 4 | sensor element |
| 11 | independent car seat |
| 21 | anthropometric data of occupant |
| 22 | physiologic parameter of occupant |
| 23 | occupant presence information |
| 24 | evaluated physiologic parameter, such as ECG, GSR, EEG |

## Claims

1. Smart cover (1) for sensing a signal, the smart cover comprising a preferably conducting sheet (2) of fabric or leather arranged to cover a seat, a handle and/or a steering device particularly of a vehicle, and a sensor matrix (3) printed on the sheet and comprising several sensor elements (4), wherein each of the sensor elements is arranged for sensing or detecting one or more of an electrical signal sent out by a body of a human occupant, an outline of the body, and a body dimension.

2. Smart cover (1) according to claim 1, **characterised in that** the sensor matrix is made with capacitive sensor elements (4).

3. Smart cover (1) according to one of the preceding claims, **characterised in that** the sensor matrix (3) is arranged to detect the occupant's physique, and is arranged to provide an electrically generated profile or anthropometric data (21), based on the signals received by the sensor elements (4).

4. Smart cover (1) according to one of the preceding claims, **characterised in that** a first group of sensor elements is positioned and can be activated to detect electric heart signals of the occupant.

5. Smart cover (1) according to one of the preceding claims, **characterised in that** the sheet (2) is arranged to cover the handle or the steering device, and **in that** some of the sensor elements (4) are positioned and arranged to detect or provide a dual electrode ECG from the occupant's fingers placed on the handle or steering device, particularly from the fingers of the right & left hand placed on the handle or steering device.

6. Smart cover (1) according to one of claims 2 to 4, **characterised in that** the sheet is arranged to cover the seat, and **in that** some of the sensor elements (4) are positioned and arranged to detect or provide a 12 electrode ECG by estimating the location of exact electrode positions from the electrically generated profile or anthropometric data.

7. Smart cover (1) according to one of the preceding claims, **characterised by** an electronic control unit arranged to process signals from the sensor elements (4) into anthropometric data (21), the physiologic parameter (22) and/or an ECG, GSR or EEG (24) (evaluated physiologic parameter) of the occupant.

8. Vehicle having a smart cover (1) according to one of the preceding claims and a safety system, **characterised in that** the smart cover (1) is connected with the safety system to provide anthropometric data (21) and/or a physiologic parameter (22) of the occupant to the safety system, preferably **characterised in that** the safety system is arranged to operate based on the anthropometric data and/or the physiologic parameter.

9. System **characterised by** a smart cover according to one of claims 1 to 7 and a piece of gym equipment having a seat and/or a handle, the smart cover (1) being arranged to cover the seat or handle.

10. Method for operating a smart cover (1), particularly according to one of the preceding claims, the method comprising the steps:

    S2 sensing or detecting by sensor elements (4) one or more of an electrical signal sent out by a body of a human occupant, an outline of the body, and a body dimension, wherein the sensor elements (4) are arranged in a sensor matrix (3) of the smart cover (1), which sensor matrix is printed on a preferably conductive sheet (2) of fabric or leather of the smart cover, wherein the sheet is arranged to cover a seat, handle or a steering device particularly of a vehicle, particularly to detect the presence of the occupant and/or to provide occupant presence information (21),
    further comprising
    S3 estimating the physique of the occupant based on the signals received by the sensor elements (4), and providing respective anthropometric data (21), and/or
    S6 obtaining a physiologic parameter (22) of the occupant, such as ECG, GSR, EEG or temperature (24), based on the signals received by the sensor elements (4).

11. Method according to claim 10, **characterised by** the following step S1 activating the smart cover (1), particularly when switching on an ignition device of a vehicle.

12. Method according to one of claims 10, 11, **characterised by** step S4 activating or adjusting an adaptive passive safety system of a vehicle based on the anthropometric data of step S3.

13. Method according to one of claims 10 to 12, **characterised by** steps

    S5 increasing the sensitivity of at least one of the sensor elements,
    S6' obtaining the physiologic parameter of the occupant, such as ECG, GSR, EEG or temperature, based on the signals received by the sensor elements, using the at least one sensor el-

ement of step S5.

**14.** Method according to one of claims 10 to 13, **characterised by** step
S7 activating a predictive safety system and/or a comfort system based on the physiologic parameter of step S6 or step S6'.

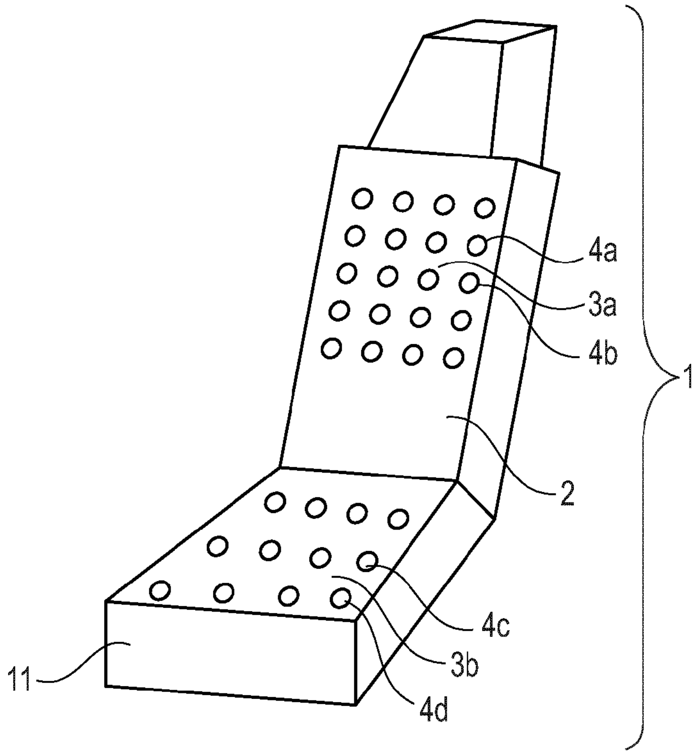


Fig. 1

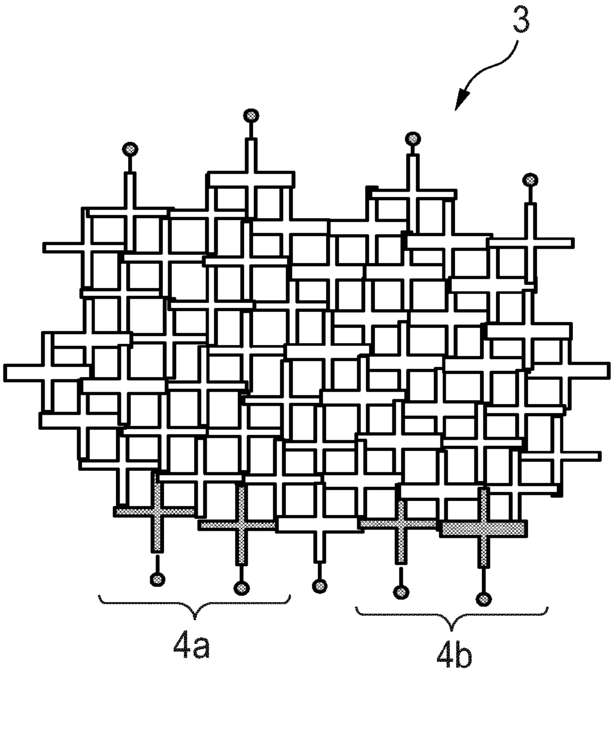


Fig. 3a

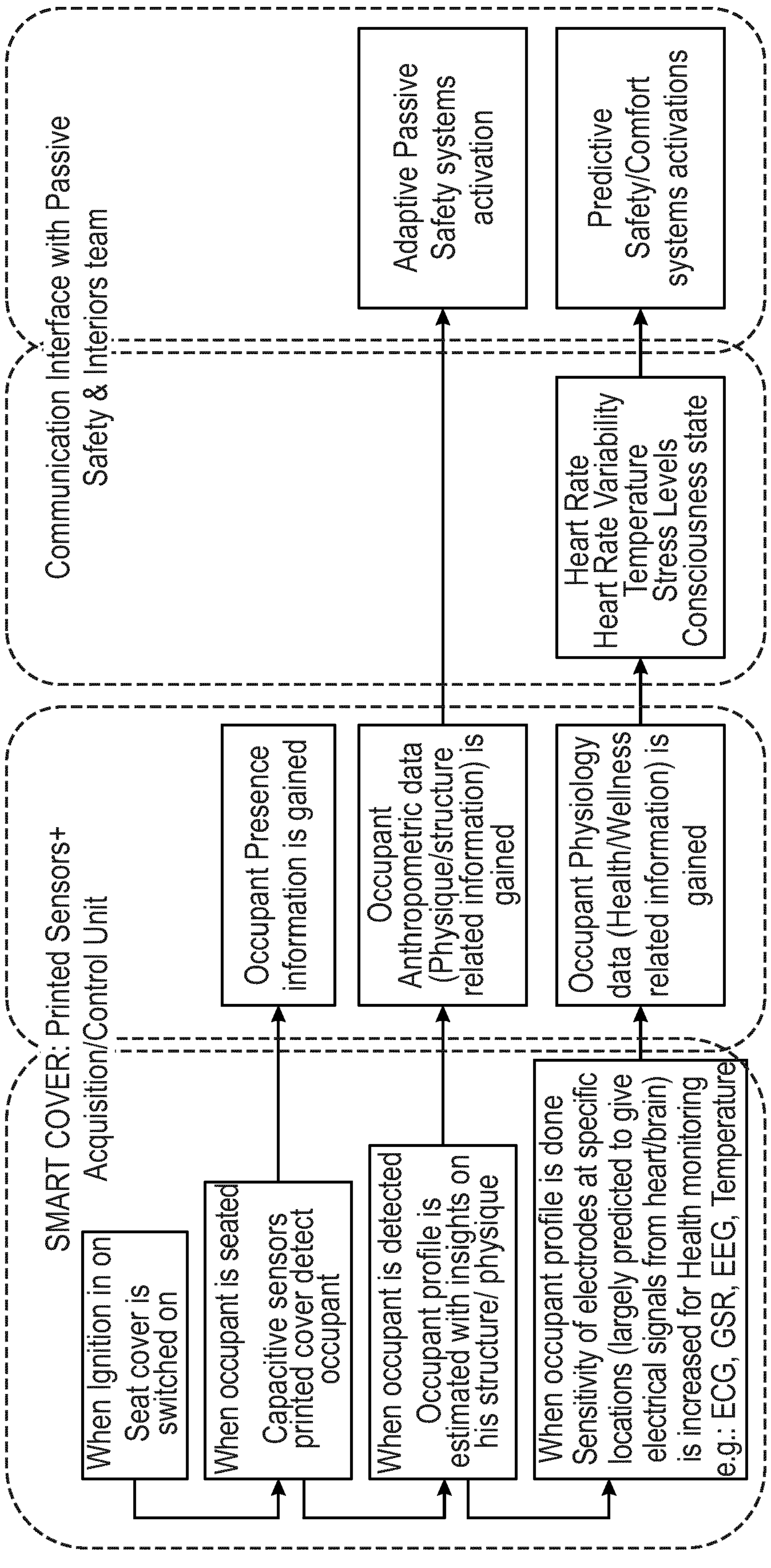
SMART COVER: Printed Sensors+ Acquisition/Control Unit
Communication Interface with Passive Safety & Interiors team
When Ignition in on Seat cover is switched on
When occupant is seated Capacitive sensors printed cover detect occupant
When occupant is detected Occupant profile is estimated with insights on his structure/ physique
When occupant profile is done Sensitivity of electrodes at specific locations (largely predicted to give electrical signals from heart/brain) is increased for Health monitoring e.g.: ECG, GSR, EEG, Temperature
Occupant Presence information is gained
Occupant Anthropometric data (Physique/structure related information) is gained
Occupant Physiology data (Health/Wellness related information) is gained
Heart Rate Heart Rate Variability Temperature Stress Levels Consciousness state
Adaptive Passive Safety systems activation
Predictive Safety/Comfort systems activations

Fig. 2

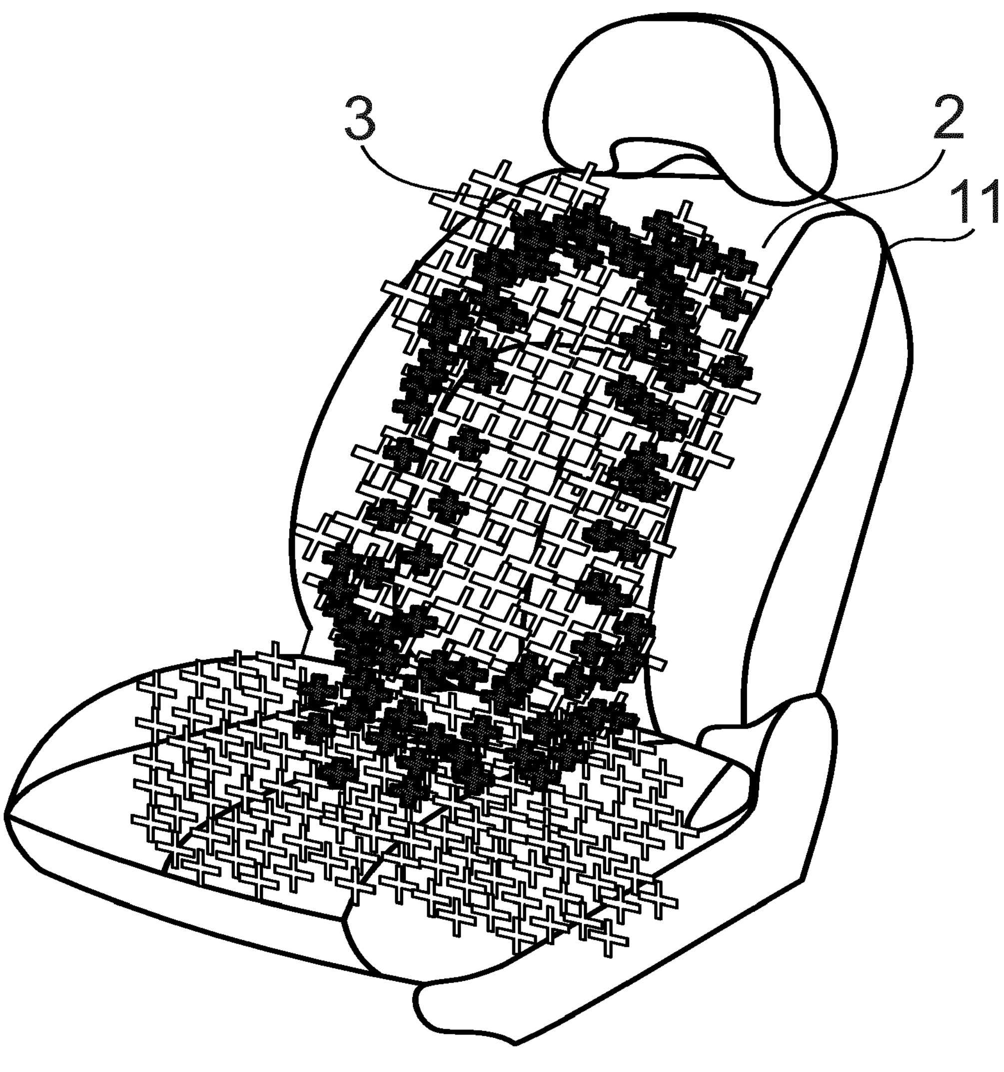


Fig. 3b

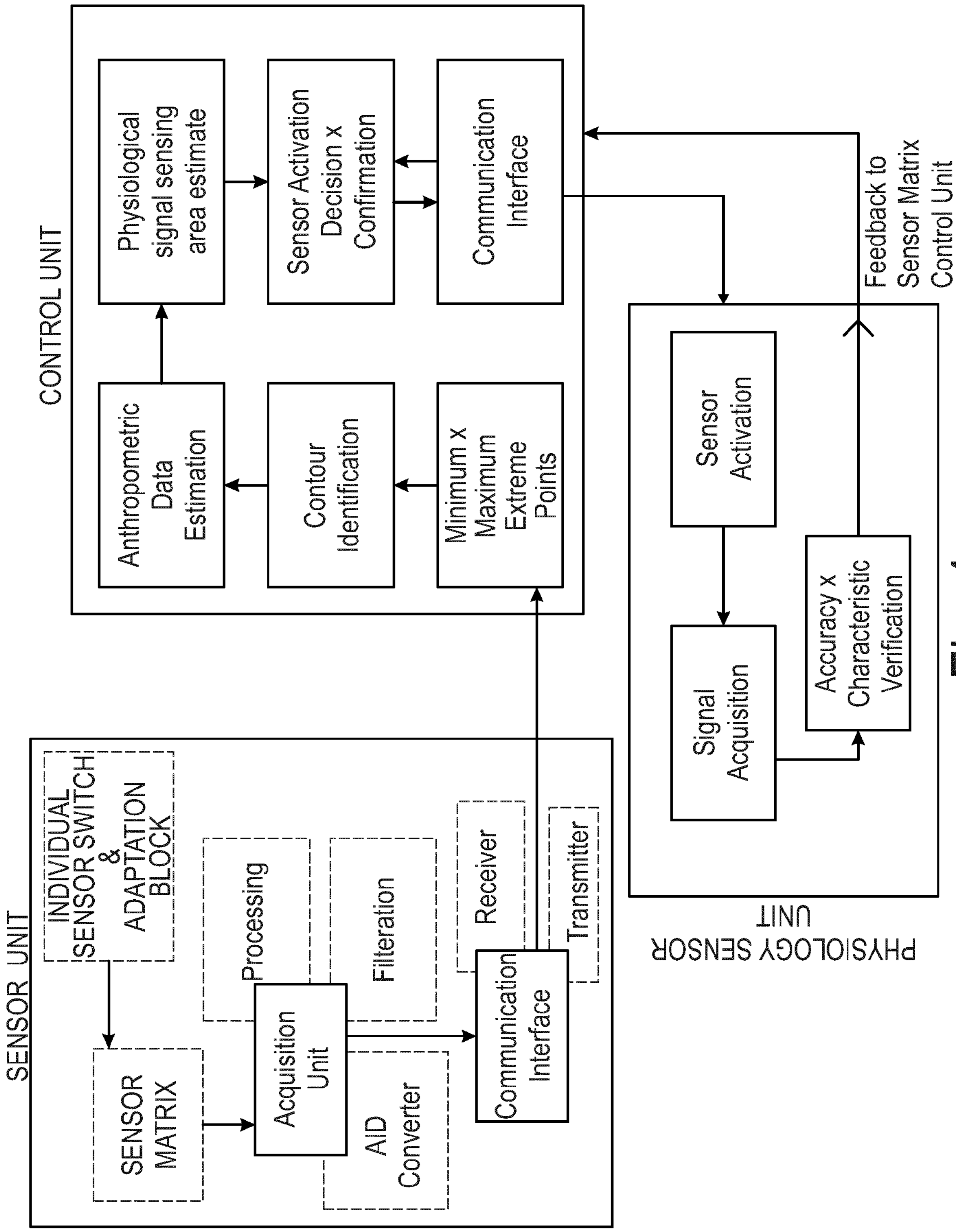
CONTROL UNIT
Physiological signal sensing area estimate
Sensor Activation Decision x Confirmation
Communication Interface
Anthropometric Data Estimation
Contour Identification
Minimum x Maximum Extreme Points
Feedback to Sensor Matrix Control Unit
PHYSIOLOGY SENSOR UNIT
Sensor Activation
Signal Acquisition
Accuracy x Characteristic Verification
SENSOR UNIT
INDIVIDUAL SENSOR SWITCH & ADAPTATION BLOCK
SENSOR MATRIX
Processing
Filteration
Acquisition Unit
AID Converter
Receiver
Transmitter
Communication Interface

Fig. 4

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# EUROPEAN SEARCH REPORT

Application Number
EP 20 16 7546

## 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 | US 10 299 520 B1 (SHAFFER BENJAMIN A [US] ET AL) 28 May 2019 (2019-05-28)<br>* column 1, line 33 - column 2, line 3 *<br>* column 2, line 43 - line 64 *<br>* column 4, line 7 - line 33 *<br>* column 7, line 14 - line 47 *<br>* column 12, line 23 - line 43 *<br>* figures 1-12 *<br>----- | 1-14 | INV.<br>A61B5/021<br>A61B5/024<br>A61B5/04<br>A61B5/00 |
| X | US 2019/381860 A1 (CREDO GRACE [US] ET AL) 19 December 2019 (2019-12-19)<br>* paragraph [0018] - paragraph [0053] *<br>* figures 1-11 *<br>----- | 1-14 | |
| X | US 2014/361871 A1 (SILVA HUGO HUMBERTO PLÁCIDO DA [PT] ET AL)<br>11 December 2014 (2014-12-11)<br>* paragraph [0024] - paragraph [0031] *<br>* paragraphs [0055], [0056] *<br>* figures 2,3 *<br>----- | 1-14 | |
| X | US 2016/200220 A1 (SUGIYAMA SHINJI [JP]) 14 July 2016 (2016-07-14)<br>* paragraph [0008] - paragraph [0031] *<br>* figures 1-7 *<br>----- | 1-14 | TECHNICAL FIELDS SEARCHED (IPC)<br>A61B |
| X | US 2016/278709 A1 (RIDAO GRANADO MIGUEL [ES] ET AL) 29 September 2016 (2016-09-29)<br>* the whole document *<br>----- | 1-14 | |
| A | US 2007/156031 A1 (SULLIVAN PATRICK K [US] ET AL) 5 July 2007 (2007-07-05)<br>* paragraph [0009] - paragraph [0027] *<br>* paragraphs [0058], [0059] *<br>* figure 6 *<br>----- | 1-14 | |

The present search report has been drawn up for all claims

1

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Berlin | 3 September 2020 | Abraham, Volkhard |

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

EPO FORM 1503 03.82 (P04C01)

## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 20 16 7546

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
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