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Transportable fatigue level evaluation system and related evaluation method

Abstract

A transportable system of evaluation of a level of fatigue of at least one operator. The system includes a case, a camera configured to acquire images of the face of an operator, a sensor configured to measure a heart rate of the operator, a calculator, and a human-machine interaction device. The calculator is configured to receive the images acquired from the camera and the measurement of the heart rate from the sensor, and configured to process the images and the measurement to calculate a level of fatigue of the operator. The human-machine interaction device is configured to transmit an alert if the calculated level of fatigue is greater than a predefined threshold. The calculator and the human-machine interaction device are at least partially integrated into the case. The camera and the sensor are integrated or apt to be stowed in the case.

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Background/Summary

REFERENCE TO RELATED APPLICATION

[0001] This application is a U.S. non-provisional application claiming the benefit of French Patent Application No. 24 01396 filed on Feb. 13, 2024, the contents of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD OF THE INVENTION

[0002] The present invention relates to a transportable system for objectively evaluating a level of fatigue of at least one operator.

[0003] The present invention relates to the field of objective evaluation of level of fatigue, particularly of operators in a professional context.

BACKGROUND OF THE INVENTION

[0004] In some professions, the level of fatigue of operators is a fundamental issue, in particular when the operator's profession is to make decisions that could put his/her life or the lives of others at risk.

[0005] It is known that an advanced level of fatigue impairs brain performance, in particular the reaction time and the quality of the decisions taken.

[0006] Thereby, when an operator is tired, the quality of the decisions taken is impaired.

[0007] Furthermore, in a context of advanced fatigue, the operator is likely to doze off or even fall asleep, thereby making him/her unfit for the tasks incumbent on him/her.

[0008] More particularly, in the aeronautical field, the task of the flying crew, and in particular the pilot(s), is to ensure the safety of passengers and their transport to their destination point.

[0009] In airlines, management systems for managing the risk relating to fatigue, also known as the Fatigue Risk Management System (FRMS), have been implemented. Such systems are based on declarative questionnaires on the level of fatigue, associated with a biomathematic model predicting the evolution of fatigue during a flight. The purpose of such systems is to predict phases of drowsiness during a flight.

[0010] However, such systems are highly subjective as are limited by the operator's declarations before the flight. Thereby, there is a strong bias associated with the state the operator finds himself in when giving his declaration. For example, the state is strongly influenced by his food consumption, stress level or excitement at the time he makes his statement.

[0011] Moreover, it is not wise to ask the operator to make a declaration again during their work, since the interruption would risk de-concentrating him and could lead to risks for them or for the passengers.

[0012] There is thus a need for a system of non-interruptive and more objective evaluation of fatigue, that eliminates any declarative bias and serves to measure the fatigue of an operator without diverting him from his work.

SUMMARY OF THE INVENTION

[0013] To this end, the present invention relates to a transportable system for evaluating a level of fatigue of at least one operator, the system including: [0014] a case; [0015] a camera configured to acquire images of an operator's face; [0016] a sensor configured to measure an operator's heart rate; [0017] a calculator configured for: [0018] receiving, from the camera, the acquired images of the operator's face, [0019] receiving, from the sensor, a measurement of the operator's heart rate, and

[0020] processing the received images and measurement to calculate a level of fatigue of the operator; and [0021] a human-machine interaction device configured to send an alert to the operator and/or to an administrator if the calculated level of fatigue is greater than a predefined threshold;

the calculator and the human-machine interaction device being at least partially integrated into the case. [0022] the camera and the sensor being integrated or suitable for being stowed in the case.

[0023] The heart rate sensor and camera allow the acquisition of data representative of the level of fatigue of the operator without the need for the operator to distract themselves from their current task.

[0024] Furthermore, the fact that the sensor, camera, calculator and human-machine interaction device are integrated or suitable for being integrated into the case makes the system easily transportable and thus makes possible an evaluation of the level of fatigue: before, during and/or after an operator's mission.

[0025] According to other particular embodiments of the invention, the system includes one or a plurality of the following features, taken individually or according to all technically possible combinations: [0026] the sensor configured to measure the heart rate is a bracelet configured to be positioned around the operator's wrist to measure their heart rate; [0027] the camera is apt to acquire images of the face of at least one operator who is located at a distance of between 30 and 130 cm from the case, and according to an angular travel defined about an optical axis of the camera, at least equal to 30°; [0028] the case includes first and second shells movable between an open position and a closed position, [0029] the first shell defining a first compartment suitable for storing the camera and a zone for receiving the sensor, [0030] the sensor being removable from the receiver zone; [0031] the first shell defines a surface for being at least partially in contact against the second shell when the first and second shells are in the closed position, [0032] the camera defining an optical axis having an elevation angle with respect to the surface comprised between 30° and 40°, and a positioning angle about an axis perpendicular to the surface comprised between 55° and 65°; [0033] the case further includes a power supply configured to supply electrical energy to the camera, the heart rate sensor, the calculator and a human-machine interaction device; [0034] the calculator is configured to determine facial markers of the operator from the acquired images and, furthermore, to calculate the level of fatigue of the operator from the determined facial markers; [0035] the system includes a plurality of heart rate sensors, each of which is suitable for measuring the heart rate of a respective operator, [0036] the system further including one amongst: [0037] a plurality of cameras each configured to acquire images of a face of a respective operator, and [0038] a single camera configured to acquire images of a face of each of a plurality of operators, [0039] the calculator being configured to calculate a level of fatigue of each operator from the measurement of the heart rate of the operator and the acquired images of the operator's face; and [0040] the human-machine interaction device includes a display screen and/or a loudspeaker, and optionally a vibrator integrated into the sensor, [0041] furthermore, the human-machine interaction device is configured to indicate to the operator when the image acquisition and the heart rate measurement have been completed, [0042] preferably, the human-machine interaction device being further configured to acquire data relating to the or to each operator, also preferably, the human-machine interaction device being configured to signal to the operator if he leaves the field of view of the camera and/or if the operator's eyes leave the field of view of the camera.

[0043] A further subject matter of the invention relates to a method for evaluating the level of fatigue of an operator, the method being implemented by such a transportable system and including: [0044] acquisition of a plurality of images of the operator's face, [0045] measurement of the operator's heart rate so as to obtain a measurement of the heart rate, [0046] processing the acquired images and the heart rate measurement so as to calculate the level of fatigue of the operator, and [0047] if the level of fatigue is above a predefined threshold, transmission of an alert to the operator and/or to an administrator.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0048] The system according to the invention and the embodiments thereof will be better understood upon reading the following description, given only as a non-limiting example, and made with reference to the enclosed drawings, wherein:
[0049] FIG. **1** is a schematic representation of a transportable system of evaluation of a level of fatigue according to a first embodiment of the invention;
[0050] FIG. **2** is a detailed schematic representation of the camera of the system shown in FIG. **1**;
[0051] FIG. **3** is a sectional schematic representation of the system shown in FIG. **1**;
[0052] FIG. **4** is a flowchart of a method of evaluation of level of fatigue; and
[0053] FIG. **5** is a schematic representation of a transportable system of evaluation of a level of fatigue according to a second embodiment of the invention.
DETAILED DESCRIPTION OF THE INVENTION
[0054] With reference to FIG. **1**, a transportable system **10** of evaluation of a level of fatigue of at least one operator, is described.
[0055] System **10** includes a case **12**, a camera **14**, a sensor **16**, a calculator **18**, a human-machine interaction device **40** and optionally a power supply **22** shown in FIG. **3**, and an array antenna **24**, visible in FIG. **3**.
[0056] Calculator **18**, human-machine interaction device **40** and optionally power supply **22**, and array antenna **24** are integrated into case **12**. Camera **14** and sensor **16** are integrated or suitable for being stowed in case **12**.
[0057] Case **12** is intended to be placed on a surface, called a support surface, such as a table or a dashboard of a cockpit.
[0058] Case **12** preferentially includes a first shell **26** and a second shell **28** that may be moved between an open position and a closed position.
[0059] Preferably, case **12** includes means **29** forming a pivot making the first shell **26** and the second shell **28** rigidly attached with one of the respective edges thereof and making same movable with respect to one another.
[0060] Also preferentially, case **12** further includes means for locking first **26** and second **28** shells in the closed position.
[0061] Furthermore, case **12** advantageously includes on one of the shells **26**, **28** thereof, a handle **32** for transporting the case when shells **26**, **28** are in the closed position.
[0062] The means of locking are preferably positioned on both sides of handle **32** on the same edge.
[0063] The dimensions of case **12** are, e.g. such that the case satisfies the dimensional requirements of a cabin luggage. For example, case **12** has dimensions less than 55×35×25 centimeters. Advantageously, case **12** is in the form of a suitcase.
[0064] First shell **26** has a substantially parallelepipedal shape defining a not-shown surface apt to be in contact with the support surface, and a surface **33**, called the opposite surface, opposite the not-shown surface. Opposite surface **33** is substantially rectangular and defines a first direction of extension X and a second direction of extension Y perpendicular to each other.
[0065] Opposite surface **33** is intended to be at least partially in contact with second shell **28** when first shell **26** and second shell **28** are in the closed position.
[0066] The first direction of extension X is substantially parallel to the edge of first shell **26** having the means forming a pivot **29** with second shell **28**, the second direction of extension Y being substantially perpendicular to said edge.
[0067] First shell **26** preferably defines a first compartment **34** apt to store camera **14**.
[0068] Optionally, first shell **26** is apt to receive sensor **16** on opposite surface **33**. First shell **26**

then preferably defines a receiving zone including an orifice **36** for passage of a charging cable, also called a charger, of sensor **16** when same rests on opposite surface **33**, as shown in FIG. **1**.

[0069] Preferentially, first shell **26** further defines a second compartment **38** suitable for at least partially storing human-machine interaction device **40**, and optionally a third compartment **39** suitable for at least partially storing power supply **22**, preferentially a cable of the power supply (not shown).

[0070] According to an example not shown, human-machine interaction device **40** and calculator **18** are made of the same element. In other words, a single physical unit includes human-machine interaction device **40** and calculator **18**.

[0071] Advantageously, first shell **26** further defines a ventilation **20** formed by ventilation holes **42** extending through opposite surface **33**, to ensure the ventilation of elements integrated into the shell, under the surface **33**. The elements are described hereinafter.

[0072] As will be described hereinafter, sensor **16** is preferably removable from shell **26**. In the embodiment shown in FIG. **1**, camera **14** and human-machine interaction device **40** are not removable from first compartment **34** and from second compartment **38**, respectively.

[0073] First compartment **34**, second compartment **38**, and third compartment **39** as well as orifice **36** are, e.g., formed in opposite surface **33**.

[0074] Camera **14** is configured, e.g., to acquire images of a face of the operator positioned close to case **12**.

[0075] In the embodiment shown in FIG. **1**, camera **14** is fixed with respect to case **12**, i.e., integrated into first compartment **34** and not removable from compartment **34**.

[0076] The camera **14** defines an optical axis O.

[0077] As shown in FIG. **2** illustrating camera **14** in detail, a reference frame centered on camera **14** is defined by a first axis X**1** extending along the first direction X and by a second axis Y**1** extending along the second direction Y. In the frame of reference, optical axis O forms a positioning angle α with first axis X**1**. The positioning angle α is preferentially comprised between 55° and 65°.

[0078] It should be understood that positioning angle α is an angle about an axis (not shown) perpendicular to opposite surface **33**.

[0079] Optical axis O forms an elevation angle β with respect to opposite surface **33**, between 30° and 40°.

[0080] In FIG. **2**, the coordinate system X**1**, Y**1** is shown in dashed lines and the projections of optical axis O on the coordinate system are shown in chain-dotted lines.

[0081] The values of positioning angle α, of elevation angle β and of an angular travel Δ enable camera **14** to acquire images of the face of the operator even if the operator is not positioned facing case **12**. Thereby, the operator is free to perform other tasks while camera **14** acquires images of their face.

[0082] Furthermore, and again with reference to FIG. **1**, camera **14** is apt to acquire images of the face of an operator which is located at a distance between 30 cm and 130 cm from case **12**, and according to angular travel **4**, defined about optical axis O, at least equal to 30°.Preferably, angular travel Δ is equal to plus or minus 20° along a plane parallel to opposite surface **33**, i.e., horizontally, and plus or minus 15° along a plane perpendicular to opposite surface **33**, i.e., vertically.

[0083] Optionally, camera **14** is an infrared camera.

[0084] According to an example not shown, illuminators, e.g., infrared LEDs, are arranged close to camera **14** to illuminate the operator during acquisition of images by camera **14**. It is thereby possible to use the images of the operator's face even in dark environments.

[0085] Sensor **16** is configured to measure the heart rate of an operator.

[0086] For example, and as illustrated in FIG. **1**, sensor **16** is a bracelet configured to be positioned around a wrist of the operator to measure their heart rate.

[0087] Sensor **16** is suitable for resting on opposite surface **33**. For example, sensor **16** has a dial comprising the electronic circuitry intended to carry out measurements.
[0088] To hold sensor **16** in place when same rests on opposite surface **33** in the closed position, second shell **28** preferably includes an extruded portion **50** protruding from second shell **28** and intended to be in contact with sensor **16** in the closed position. Preferentially, when sensor **16** has a dial, extruded portion **50** defines a recess **52**, one dimension of which corresponds to a diameter of the dial, so as to cooperate with sensor **16** in the closed position.
[0089] Extruded portion **50** is, e.g., a foam.
[0090] It should then be understood that, when sensor **16** rests on opposite surface **33**, the bracelet thereof extends along the first direction of elongation X.
[0091] For example, sensor **16** is configured to measure the heart rate of the operator by photoplethysmography, called PPG. The technique is known per se.
[0092] Alternatively, sensor **16** is configured to carry out the measurement on the basis of an analysis of the electrical response between sensor **16** and the wrist of the operator, or by analysis of radar signals propagating along the wrist of the operator.
[0093] As an optional addition, sensor **16** is configured to additionally measure other physiological parameters of the operator, such as blood pressure, oxygen saturation, sweating, level of dehydration.
[0094] For oxygen saturation, e.g., in a known manner, sensor **16** is configured, e.g., to transmit, toward of the skin of the operator, and to receive, a light signal including at least two wavelengths. A first wavelength corresponds to a wavelength absorbed by saturated red blood cells, and a second wavelength corresponds to a wavelength absorbed by unsaturated red blood cells.
[0095] In the present example, sensor **16** is configured to determine the oxygen saturation of the operator by comparing light intensity received at each of the two wavelengths.
[0096] Preferentially, the cable of a charger (not shown), such as an induction charger or a direct contact charger, configured to recharge sensor **16** when it is positioned on opposite surface **33**, extends through orifice **36**.
[0097] With reference to FIG. **3** representing a sectional view of first shell **26** along a sectional plane perpendicular to the second direction of elongation Y, first shell **26** preferably integrates, under opposite surface **33**, calculator **18**, a part of power supply **22**, and array antenna **24**.
[0098] Calculator **18** is configured to receive, from camera **14**, the acquired images of the operator's face. To this end, calculator **18** is, e.g., connected to camera **14** via a wire link (not shown).
[0099] Calculator **18** is also configured to receive, from sensor **16**, the measurement of the heart rate, e.g., via a wireless connection passing through array antenna **24** as such connected to calculator **18**.
[0100] Calculator **18** is also configured to process images from camera **14** and the measurement received, i.e., the data from sensor **16**, to calculate a level of fatigue of the operator.
[0101] The level of fatigue is, e.g., a score given on a scale of 20 or of 100.
[0102] To this end, calculator **18** is preferably configured to determine facial markers of the operator. Facial markers are points of interest located on the face and from which different features are suitable for being extracted. As examples, the features are: statistics of yawning, opening of eyes, direction of the gaze and of the head, frequency of eye blinking, etc.
[0103] Furthermore, calculator **18** is preferably configured to calculate the level of fatigue of the operator from the determined facial markers.
[0104] For example, calculator **18** is configured to extract the features of the facial markers, e.g. using a technique such as same presented in patent applications FR 3133534 and FR 3133691.
[0105] Calculator **18** is then configured to supply such features, as well as the measurement, i.e. the data from the sensor **16**, to an artificial intelligence model trained beforehand from a labeled set of data, in order to determine the level of fatigue of the operator.

[0106] For example, the artificial intelligence model is a neural network.
[0107] The neural network includes an ordered succession of neuron layers, each of which takes the inputs thereof from the outputs of the preceding layer.
[0108] More precisely, each layer includes neurons taking the inputs thereof from the outputs of the neurons of the preceding layer, or from the input variables for the first layer.
[0109] Each neuron is also associated with an operation, i.e. a type of treatment, to be performed by said neuron within the corresponding processing layer.
[0110] Each layer is linked to the other layers by a plurality of synapses. A synaptic weight is associated with each synapse, and each synapse forms a link between two neurons. Each synaptic weight is preferentially a real number that may take positive as well as negative values. In certain cases, each synaptic weight is a complex number.
[0111] Each neuron is apt to perform a weighted sum of the value(s) received from the neurons of the preceding layer, each value then being multiplied by the respective synaptic weight of each synapse, or link between the neuron and the neurons of the preceding layer, then to apply an activation function, typically a non-linear function, to the weighted sum, and to deliver at the output of the neuron, more particularly to the neurons of the next layer which are connected thereto, the value resulting from the application of the activation function. The activation function is used for introducing a non-linearity in the processing performed by each neuron. The sigmoid function, the hyperbolic tangent function, the Heaviside function, the Rectified Linear Unit (ReLU), and the softmax function, are examples of activation functions.
[0112] As an optional addition, each neuron is also apt to apply, in addition, a multiplicative factor, also called bias, to the output of the activation function, and the value delivered at the output of the neuron is then the product of the bias value and of the value derived from the activation function. Calculator **18** is then configured to communicate to the operator the level of fatigue via the human-machine interaction device, as will be described hereinafter.
[0113] As a variant, calculator **18** is configured to transmit the calculated level of fatigue to a device external to system **10** via array antenna **24**, intended for an administrator.
[0114] As may be seen in FIG. **1**, human-machine interaction device **40** includes, e.g., a display screen, such as a touch screen, and optionally a loudspeaker (not shown).
[0115] The loudspeaker is, e.g., located below ventilation holes **42**.
[0116] Alternatively, the display screen includes a non-touch screen **40** and a keyboard (not shown).
[0117] As an optional supplement, human-machine interaction device **40** is also partially integrated into sensor **16**, e.g., in the form of a vibrator (not shown).
[0118] Human-machine interaction device **40** is configured to send an alert to the operator and/or to an administrator if the calculated level of fatigue is greater than a predefined threshold.
[0119] To this end, if the recipient of the alert is the operator of system **10**, the alert is, e.g., a message displayed on touch screen **40** or a sound signal emitted by the loudspeaker.
[0120] If the recipient of the alert is an administrator, the alert is, e.g., transmitted via array antenna **24**.
[0121] As an optional supplement, human-machine interaction device **40** is configured to acquire data relating to the operator or to each operator, such as their gender, age, height, weight, or others.
[0122] Furthermore, human-machine interaction device **40** is preferably configured to indicate to the operator when the image acquisition and the heart rate measurement have been completed.
[0123] To this end, preferably, the vibrator integrated in sensor **16** is configured to vibrate when acquisition of images and measurement of the heart rate are completed.
[0124] Preferably, human-machine interaction device **40** is configured to signal to the operator if he leaves the field of view of camera **14** during acquisition of images, more particularly, if his eyes leave the field of view of camera **14**. The field of view of camera **14** is preferably defined by positioning angle α, elevation angle β and angular travel Δ.

[0125] As an example, the eyes of the operator may leave the field of vision if the operator turns or inclines his head or if the operator moves and is no longer in front of camera **14**.
[0126] Advantageously, in order to perform such a signaling to the operator, the vibrator integrated into sensor **16** is configured to vibrate.
[0127] Power supply **22** is suitable for supplying electrical energy to camera **14**, to sensor **16**, to calculator **18**, and to human-machine interaction device **40**. For example, power supply **22** includes a cable suitable for connection to a power distribution plug.
[0128] In a variant, power supply **22** is a battery.
[0129] Array antenna **24** is suitable for being connected to a local network system, e.g., via a Wi-Fi™ or Bluetooth™ protocol, or a global network system via a cellular protocol 4G or 5G. Array antenna **24** is capable of transferring data between calculator **18** and an external system (not shown), such as the level of fatigue determined by calculator **18**.
[0130] Optionally, array antenna **24** is also apt to communicate with sensor **16** so that calculator **18** receives measurements of the heart rate.
[0131] Operation of system **10** will now be described with reference to FIG. **4**, illustrating a flowchart of a method of evaluation of a level of fatigue of an operator. The method is used, e.g., before, during or after a flight.
[0132] Initially, the operator opens case **12** and takes hold of sensor **16**. Optionally, if power supply **22** includes a power cable, the operator connects the cable to a power distribution plug.
[0133] If sensor **16** is a bracelet, the operator positions same around his wrist.
[0134] The operator positions case **12** so as to be in the field of view of camera **14**. It should be then understood that case **12** is not directly in front of the operator but slightly offset to the side so as not to clutter the zone in front of the operator so that he can perform different tasks, even while his level of fatigue is evaluated.
[0135] Preferentially, the operator identifies himself on system **10**. To this end, identification of the operator is carried out, e.g., via a code entered manually by the operator on human-machine interaction device **40**, or by reading a code via NFC or a QR code read by camera **14**.
[0136] The method includes an acquisition operation **110**, during which camera **14** acquires a plurality of images of the face of the operator.
[0137] Preferably, during acquisition operation **110**, if the operator and/or his eyes leave the field of view of the camera, defined by: positioning angle α, elevation angle β and angular travel Δ, human-machine interaction device **40** signals that the operator leaves the field of view of camera **14**, e.g., by vibrating the vibrator integrated in sensor **16**, or alternatively by emitting a sound or by displaying a message.
[0138] The method further includes an operation **120** of measuring the heart rate of the operator in order to obtain a measure of his heart rate, preferably by sensor **16**.
[0139] Preferably, acquisition operation **110** and measurement operation **120** are implemented simultaneously.
[0140] The method further includes an operation **130** of processing the acquired images and of measurement of the heart rate to calculate the level of fatigue of the operator.
[0141] As explained hereinabove, preferentially, calculator **18** determines the facial markers of the operator. Calculator **18** then extracts the features of the facial markers and supplies the features and the measurement to the artificial intelligence model trained beforehand to determine the level of fatigue.
[0142] The method then includes, if the level of fatigue is greater than a predefined threshold, an operation **140** of transmission of an alert to the operator and/or to an administrator, as explained hereinabove.
[0143] A second embodiment will now be described with reference to FIG. **5**.
[0144] The common elements between the first and second embodiments keep the reference numbers thereof. Only the distinct elements have a reference incremented by the value 200.

[0145] The second embodiment will be described only by the differences thereof with the first embodiment so that each feature that is not described is identical to the corresponding feature in the first embodiment.
[0146] In the second embodiment, transportable system **210** is more compact than transportable system **10** of the first embodiment.
[0147] In the second embodiment, first compartment **234** is contiguous with second compartment **238**.
[0148] According to the example illustrated in FIG. **5**, first compartment **234** and second compartment **238** are, e.g., common. In other words, according to such example, there is no physical delimitation between first compartment **234** and second compartment **238**.
[0149] In the second embodiment, first compartment **234** should be understood substantially along the first X and the second Y directions.
[0150] In the second embodiment, optical axis O of camera **14** is, in projection onto opposite surface **33** substantially aligned with the second direction of elongation Y, in an opposite direction. In other words, positioning angle α has a value substantially equal to 90°.
[0151] In the second embodiment, the receiver zone of sensor **16** preferably defines three orifices **236** rather than a single orifice in the first embodiment. Two of the three orifices are then preferably slots, e.g., parallel to each other and optionally extending along the first direction of elongation X. Each of the two orifices **236** is intended to receive a lug of the bracelet of sensor **16** for the stowage thereof in the closed position. Third orifice **36**, not shown in FIG. **5**, is intended for passage of the cable of the charger of sensor **16**.
[0152] In FIG. **5**, only two of the three orifices **236** are visible.
[0153] Preferably, second shell **28** further includes extruded portion **250**. However, in the second embodiment, extruded portion **250** preferably has no set-back and is in contact with sensor **16** only via the dial of the latter, when same is present, in the closed position.
[0154] In the second embodiment, ventilation holes **42** extend over a zone on opposite surface **33** smaller than in the first embodiment. The loudspeaker is optionally placed under ventilation holes **42**.
[0155] In the second embodiment, the means of locking are positioned on edges of first shell **26** and second shell **28** substantially perpendicular to the edge including handle **32** and same including the pivot-forming means. The pivot-forming means are not represented in FIG. **5**.
[0156] Thereby, system **210** according to the second embodiment is more compact than system **10** according to the first embodiment, which enhances even more the transportable aspect of system **210**.
[0157] The operation of system **210** according to the second embodiment is similar to the operation of the system **10** according to the first embodiment. Thereby, system **210** according to the second embodiment is suitable for implementing the method of evaluation of the level of fatigue described hereinabove.
[0158] In the second embodiment, optical axis O of camera **14** is such that the operator is placed in front of the case during the image acquisition. However, the compactness of system **210** according to the second embodiment makes it possible not to clutter up the space in front of the operator.
[0159] Alternatively, camera **14** is oriented toward the right-hand or left-hand side of system **10**, so that the system may be placed on the left or on the right, respectively, of the operator while pointing camera **14** toward the operator.
[0160] Variants of systems **10** and **210** will now be described wherein the system is configured to simultaneously evaluate the level of fatigue of a plurality of operators. The variants are compatible with systems **10** and **210** according to the first and second embodiments.
[0161] In the variants, systems **10** and **210** include a plurality of sensors **16**. Preferably, first case **26** then includes a plurality of orifices **236**, or triplet of orifices **236**.
[0162] According to a first variant, systems **10** and **210** further include a plurality of cameras **16**,

each configured to acquire images of a face of a respective operator.
[0163] According to a second variant, systems **10** and **210** include a single camera configured to acquire images of a face of each of a plurality of operators.
[0164] In the variants, calculator **18** is configured to calculate a level of fatigue of each operator from the measurement of the heart rate of the operator and the acquired images of the face of the operator, as explained hereinabove for each operator.
[0165] According to the variants, systems **10** and **210** are suitable for implementing the method for evaluating the level of fatigue described hereinabove, for each operator.
[0166] Systems **10** and **210** according to the invention serve to evaluate the fatigue of the operator without distracting them from their work and by dispensing with the declarative bias.
[0167] Furthermore, systems **10** and **210** enable an evaluation of the level of fatigue that is objective and non-intrusive since the operator is completely passive during the evaluation.
[0168] Furthermore, the fact that systems **10** and **210** are transportable makes the use thereof particularly easy and possible in multiple situations.

Claims

1. A transportable system for evaluating a level of fatigue of an operator, comprising: a case; a camera acquiring images of a face of the operator; a sensor measuring a heart rate of the operator; a calculator receiving, from said camera, the acquired images of the operator's face, receiving, from said sensor, a measurement of the operator's heart rate, and processing the received images and measurement to calculate a level of fatigue of the operator; and a human-machine interaction device configured to send an alert to the operator and/or to an administrator if the calculated level of fatigue is greater than a predefined threshold, wherein said calculator and said human-machine interaction device are at least partially integrated into said case, and wherein said camera and said sensor are integrated or arranged to be stowed in said case.
2. The system according to claim 1, wherein said sensor comprises a bracelet configured to be positioned around a wrist of the operator to measure his heart rate.
3. The system according to claim 1, wherein said camera acquires images of the face of at least one operator who is located at a distance between 30 cm and 130 cm from said case, according to an angular travel defined about an optical axis of said camera, at least equal to 30°.
4. The system according to claim 1, wherein said case comprises first and second shells movable between an open position and a closed position, the first shell defining a first compartment suitable for storing said camera and a receiver zone of said sensor, said sensor being removable from the receiver area.
5. The system according to claim 4, wherein said first shell defines a surface for being at least partially in contact with said second shell when said first and second shells are in the closed position, said camera defining an optical axis having an elevation angle with respect to the surface between 30° and 40°, and a positioning angle about an axis perpendicular to the surface between 55° and 65°.
6. The system according to claim 1, wherein said case further comprises a power supply configured to supply electrical power to said camera, said sensor, said calculator, and said human-machine interaction device.
7. The system according to claim 1, wherein said calculator determines facial markers of the operator from the acquired images and calculates the level of fatigue of the operator from the determined facial markers.
8. The system according to claim 1, comprising: a plurality of heart rate sensors, each measuring the heart rate of a respective operator; and either a plurality of cameras each acquiring images of a face of a respective operator, or a single camera acquiring images of a face of each of a plurality of operators, wherein said calculator calculates a level of fatigue of each operator from the

measurement of the heart rate of the operator and from the acquired images of the face of the operator.

9. The system according to claim 1, wherein said human-machine interaction device comprises a display and/or a loudspeaker, and wherein said human-machine interaction device indicates to the operator when the image acquisition and the heart rate measurement have been completed.

10. The system according to claim 9 wherein said human-machine interaction device comprises a vibrator integrated into said sensor.

11. The system according to claim 9 wherein said human-machine interaction device acquires data relating to the operator.

12. The system according to claim 9 wherein said human-machine interaction device signals to the operator if he leaves the field of view of said camera and/or if his eyes leave the field of view of said camera.

13. A method of evaluating a level of fatigue of an operator, the method being carried out by a transportable system according to claim 1 and comprising: acquiring a plurality of images of the operator's face, measuring the operator's heart rate; processing the acquired images and the heart rate measurement to calculate the level of fatigue of the operator; and if the level of fatigue is above a predefined threshold, transmitting an alert to the operator and/or to an administrator.