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(54) Workspace-monitoring system and method for automatic surveillance of safety-critical workspaces

(57) A workspace-monitoring system (10, 50, 51) for automatic surveillance of at least one person working in a safety-critical workspace (12) is disclosed. The system comprises a person-monitoring system (52), which comprises a person-identification device (54) for capturing person-related data (82); and an image-data-capturing device (18, 66) for capturing image data (84) of the person in the safety-critical workspace (12); and at least one computing device (60), which is configured for the analysis and the evaluation of the person-related data (82) and of the image data (84) and for changing the state of at least one person-safety-signal (87) depending on the person-related data (82) and on the image data (84), The system comprises furthermore one system-monitoring system (58) for self-monitoring the functionality of the workspace-monitoring system (10, 50, 51), which is configured for changing the state of at least one system-safety-signal (91) depending on an unexpected malfunction of the workspace-monitoring system (10, 50, 51). At least one alerting device (72) is also included, which is activated in case of a relevant state of the person-safety-signal (87) and/or the system-safety-signal (91). The invention includes also a Method for automatic monitoring of a person in a safety-critical workspace (12), with the above mentioned workspace-monitoring system (10, 50, 51) according to the introduced invention.

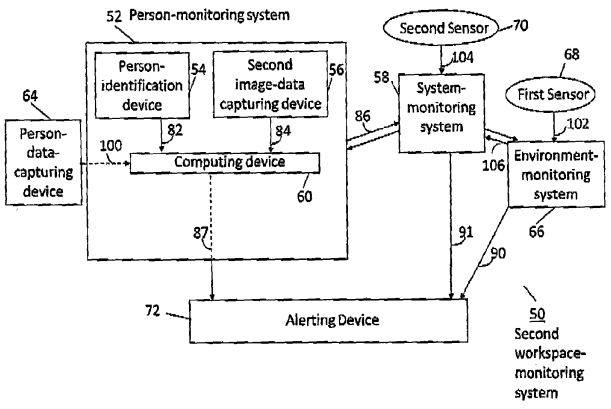

Fig. 2

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Description

[0001] The invention relates to a workspace-monitoring system and a method for automatic surveillance of persons working in a safety-critical workspace.

[0002] Service and repair operations often have to be done in safety-critical or confined workspaces. In industrial plants these are often places where workspace is limited, for example in large pipes, paper mills, tunnels, manholes or caves. A diameter between 1m and 10m is typical. These places have often only one entrance and are furthermore poorly illuminated. Despite these bad working conditions craftsmen have to repair all kind of physical devices in these places.

[0003] Therefore extra safety procedures are required to protect these persons from danger or at least to be able to rescue them immediately in case of an injury. A common method in the prior art is to place a door watch person at the door, or other entrance point, to provide safety to the person working in the safety-critical workspace.

[0004] In an emergency case the door watch person calls for help and shows the ambulance where to find the injured person. As the person working in the safety-critical workspace is blocking the view it is often impossible for the door watch person to know what went wrong and massive paperwork is needed to document the accident.

[0005] For the automatic surveillance of persons different tracking technology, motion and posture sensors and 3D-scanners are available. It is known that for the detection of human movements the products Microsoft™ Kinect is for example available.

[0006] Known drawbacks of the state of the art are described in the following. The door watch person is not able to see behind the injured person. In case of emergency it is often difficult to find out what happened and how the person can be rescued. A door watch person first has to inform other people about the accident. Afterwards the door watch person often leaves the place to rescue the injured person without knowing in detail what went wrong. In case of an accident even the door watch person might be harmed while trying to help the injured person, for example in case of a toxic gas release.

[0007] As known, today's tracking technology is not able to recognize an abnormal position or movement of the working person and to trigger an alarm automatically.

[0008] The objective of this invention is to provide a possibility for an improved surveillance of persons working in a safety-critical workspace.

[0009] This object is accomplished according to the present invention by a workspace-monitoring system for automatic surveillance of persons working in a safety-critical workspace.

[0010] The system comprises a person-monitoring system, which comprises a person-identification device for capturing person-related data and an image-data-capturing device for capturing image data of the person in the safety-critical workspace. Furthermore the person-monitoring system comprises at least one computing device, which is configured for the analysis and the evaluation of the person-related data and of the image data. Additionally it is configured for changing the state of at least one person-safety-signal. The person-safety-signal is depending on the person-related data and on the image data. Moreover, one system-monitoring system is provided for self-monitoring the functionality of the workspace-monitoring system and is prepared and configured for changing the state of at least one system-safety-signal. The system-safety-signal is depending on an unexpected malfunction of the workspace-monitoring system. Furthermore, the workspace-monitoring system comprises at least one alerting device, which is activated in case of a relevant state of the person-safety-signal and/or the system-safety-signal.

[0011] In contrast to the state of the art, a person in a safety-critical workspace can be surveyed automatically by the invented workspace-monitoring system. Before a person is allowed to enter the workspace the person-related data is captured by the person-identification device of the workspace-monitoring system. Figure 4 discloses an overview of the several subsystems listed in a table and of the signals which may be generated by each device and which is a relevant state for each signal.

[0012] Person-related data could be for example data and information which relates to the person who enters the safety-critical workspace at which time, in particular information concerning diseases and physical condition like for example diabetes, heart diseases, cancer, hypertension, multiple sclerosis, pregnancy, allergies or the like, and/or data and information which relate to the size, the weight, the age, the gender, the body-temperature and/or the average body-movement-speed of the person- who enters the safety-critical workspace. This data is captured directly before the person enters the confined workspace, in particular by manual input and/or access to a database or data storage provided with said information.

[0013] Another possibility is to safe the data on a chip beforehand. It is then compulsory for each person to declare its identity by the chip before entering the workspace. By capturing the entrance time of the person, an alarm signal is triggered when the person does not leave the workspace in a predefined time.

[0014] The simplest way of recognizing who enters when the workspace is to provide a keypad. Every person who wants to enter has to hand in its name and its further person-related-data.

[0015] The image data capturing device captures image-data of the safety-critical workspace and/or the person before the person enters the confined workspace. After the person has entered the safety-critical workspace and starts working in it, the image data capturing device captures continuously image-data of the person working in it and/or of the workspace.

[0016] The captured data is analyzed and evaluated by the computing device and at least one person-safety

signal is generated by this data. According to the table of Figure 4 the person-safety signal corresponds exemplary to one of the states "Person is fine'', "Person is in an emergency case", "Workspace is fine for the person" or "Workspace is dangerous for the person". The workspace behind the person can be made visible while the person is still in the workspace and therefore blocking the view for a human door watch. This is done by analyzing the captured data. The picture which is made before the person enters the workspace is compared with the picture which is made with the person in the workspace. By comparing both pictures the workspace behind the person is made visible while the person is still in the workspace and therefore blocking the view for a human door watch.

[0017] In case of emergency a person-safety-relevant-signal is sent out by the computing device via a wireless communication channel, for example to a control center, a handheld device or any other further alarm device. To figure out the best way to rescue the person, it is useful to know the actual workspace of the person and the actual workspace behind the person.

[0018] As known, in the state of the art this could neither be figured out by a surveillance camera, nor by a tracking technology system nor by a human door watch person.

[0019] The position of the person can be determined by an image-capturing device, preferably a 3D-image capturing device. The position and the coordinates of the person are determined by analyzing the image data. As these data are further processed and transmitted to a further alerting device rescue operations can be better coordinated.

[0020] The workspace-monitoring system can self-monitor its own functionality as it comprises the system-monitoring system. According to the table of Figure 4 several system-monitoring signals may be generated which carry the message if one of the subsystems for example the person-monitoring system, the signal processing device, an environment-monitoring system is fine or in a malfunction. If the whole system, or a crucial subsystem, is not working properly any more it is shutting down after sending a malfunction message to prevent sending confusing information to further alerting device.

[0021] For the case that the workspace-monitoring system or any subsystems are not working properly any more, a system-monitoring signal is generated. This signal is for example activating a loudspeaker or an alarm light bulb to inform the person in the workspace that he is no longer protected by the system. Then the person has to leave the workspace immediately. Additionally the signal can exemplarily activate a message to inform a control center or a supervisor and/or to initiate a safety functionality of the control center, for example a shut-down of a process and/or opening of doors and/or turn on lights or the like.

[0022] Said workplace-monitoring system is therefore not only capable of replacing a human door watch person, but it is additional capable of providing pictures of the safety-critical workspace before and after the person entered it. To guarantee safe surveillance of the person in the safety-critical workspace, it is foreseen that the system provides furthermore self-checking functions.

[0023] The image-data-capturing device can be a usual camera, preferably with additional lighting to illuminate the often dark workspace. It is advantageously that the image-data-capturing device is configured for capturing image data of at least two persons. The image data of the at least two person can be assigned safely to one person.

[0024] By capturing person-related data before entering the workspace, the sensitivity of the workspace monitoring system is adapted to different persons. The system captures predefined image sections of a person. These predefined image sections are then compared to already saved and / or previously captured image sections. An image section could be for example the head, the wrist or any other part which is seldom covered by clothing and could be easily further processed by image-data processing.

[0025] Hence the system is adaptable to the characteristics of different persons, for example the weight, the body temperature and/or the speed of body movement. For example, if a person who moved very slowly before becomes unconscious, the system is less sensitive compared to a person who moved very fast before. The body-movement-speed is determined by comparing the distance of predefined body points, e.g. the head or the wrist by pictures which are made in a predefined time span.

[0026] According to a preferred embodiment the workspace-monitoring system comprises also a signal-processing device, which is configured for changing the state of at least one alarm signal for activating the at least one alerting device, whereas the state of the alarm signal is at least depending on the state of the person-safety signal and the state of the system-safety signal.

[0027] In case of a malfunction of the workspace-monitoring system, the signal-processing device generates a signal which differs from the one generated in case of emergency. For example in case of emergency an alarm bulb is triggered to attract attention of other person nearby. Whereas in case of a malfunction of the workspace-monitoring system for example the person in the safety-critical workspace is compulsory warned to come out and a control station is informed to repair the workspace-monitoring system. In another exemplary configuration different acoustic alarms are sent out for different states of the workspace-monitoring system. Concluding people can distinguish what happened and therefore react reasonably.

[0028] The acoustical warning signal has to be audible in an industry noise surrounded area within a distance of at least 10m. The signal-processing device generates and sends not only visible and acoustical warning signals, but also a signal and/or a message to further safety-relevant devices such as central control stations. From

the central control station further rescue operations are initiated and/or coordinated.

[0029] According to the invention the workspace-monitoring system is configured for capturing image-data of an optical image and/or of a thermal image. The basic information which are gained of the optical image is the position of the person and the speed of body movement. In case of very rapid movements or no movements at all, emergency calls and warnings will be triggered.

[0030] By capturing the thermal image the temperature of the person or the temperature close to the person can be continuously measured. By this, a temperature drop or a temperature rise in a given time-gap can be recognized. For example a drop of the person's body temperature due to a health problem can be captured or a fast rise of the temperature in the workspace due to a fire can be recognized.

[0031] For both cases different warning signals will be generated and sent out by the signal-processing device to initiate coordinated rescue measurements. The warning signal is sent out to a further alerting device, for example a central control station, one or several mobile devices which are used exemplary by a foreman or by persons who are typical working around the workspace. One further configuration is, to send the warning signal directly to a central ambulance control station which can interpret the signal correct.

[0032] In another advantageous embodiment the system comprises a Workspace-monitoring system according to any of the preceding claims, characterized in that it comprises a person-data-capturing device for capturing close-to-person data. Close-to-person data can be the pulse, the body temperature, the body movement speed or any other data of interest. By measuring close-to-person data the measuring uncertainty is narrowed. One possibility of measuring close-to-person data is to attach a sensor directly to the body of the person. A radio connection is exemplary provided for transmitting the close-to-person data to the person-monitoring system.

[0033] Person-triggered data means that the data has to be handed in consciously by the person in a predefined time gap. By this data, it is assured that the person is still conscious.

[0034] A further advantageous embodiment according to the invention is that the person-data-capturing device comprises a gas-concentration-measuring-, a body-temperature-measuring- and/or a dead-man device. The dead-man device asks the person in a predefined time-gap to press a button to make sure that the person is still conscious and alive. The body temperature of the person can be measured directly at the body of the person by a body-temperature-measuring device. If the data-capturing device is in a malfunction, for example due to a not activated dead-man device or due to a difference between the average body-temperature and the measured body temperature an alarm signal is triggered by processing the close-to-person data to the computing device and generating a further signal in the signal-processing device.

[0035] By attaching a gas-concentration-measuring device to the person's body, the gas concentration can be measured very close at the person. As the gas concentration is often differing in various heights, it is advantageously to attach a sensor at the highest point of the person, for example at the head, and another sensor at the lowest point, for example at an ankle or a shoe of the person. In the known state of the art, the gas concentration has to be measured in a predefined time by the person and the person usually has to interpret the measured gas-concentration himself, In the state of the art no automatic signal is sent directly to further person who are out of the workspace.

[0036] In industrial or chemical plants persons often have to work in confined spaces where the gas concentration might be critical. Often the gas concentration could not be measured easily or might change accidently when a person has entered the confined workspace. In case of emergency it happens very often that a rescuer tries to rescue the person without measuring the gas-concentration beforehand. When the rescuer enters the safety-critical workspace he might also collapse without being able to rescue the person. To avoid these dangerous cases a close-to-person signal is generated to inform about the measured gas concentration. Therefore the rescuer will be warned before entering the confined workspace. Additionally a display is exemplary attached at the workspace monitoring system which informs rescuer about the actual gas-concentration before entering the confined workspace.

[0037] The body-temperature-measuring device is advantageously configured in that the temperature of the skin is measured in a range of 0,1 °C by an infrared thermal measuring device. One possible solution for the thermal measuring device is an infrared thermometer which is attached to the skin. In case that the deviation of the temperature is out of a predefined range, an alarm is generated to inform the person in the safety-critical workspace and other people about a possible danger.

[0038] In particular advantageously, the workspace-monitoring system comprises an environment-monitoring system with at least a first sensor for capturing data outside the workspace and for generating at least one environment-monitoring signal in case of danger for the workspace-monitoring system.

[0039] The task of the environment-monitoring system is to monitor the environment close to the workspace-monitoring system and hence to identify any dangers or harmful situations for the workspace-monitoring system itself or for the person in the confined workspace. At least one preferably non-contact distance sensor is used. One possibility is, to configure this sensor swiveling and/or moving to be able to measure two or three dimensional distances. Another exemplary embodiment is to use ultrasonic-, infrared-,microwave- and/or radar sensors.

[0040] In one advantageous development at least one first sensor of the environment-monitoring system is a

position-, an acceleration-, an infrared-, a temperature-, a smoke-, a ultrasonic sensor or a hygroscopic sensor.

[0041] By a position sensor the system can verify that its initial position and its initial orientation is not changed and therefore it is still monitoring the relevant workspace. Due to an acceleration sensor the system will recognize any vibration or shocks. Movements in the near environment, for example up to 20m or more can be recognized by use of an infrared sensor and possible dangers for the system will be figured out beforehand. By a temperature and/or a smoke sensor fire and smoke are detected. The hygroscopic sensor is used for measuring the humidity. The temperature and/or the hygroscopic sensor can be further used to compensate other measurements. The environment is exemplarily monitored by an Ultrasonic sensor or by a combination of an infrared and ultrasonic sensor. Another possibility is to use a PIR sensor (passive infrared sensor) which is very common in use. In case that an actual signal of the before mentioned sensor signals is out of a predefined range at least one alarm signal is generated.

[0042] In a further advantageous embodiment according to the invention, the system-monitoring system comprises at least one second sensor for capturing sensor data outside the safety-critical workspace. The environment is exemplarily monitored by an Ultrasonic sensor or by a combination of infrared and ultrasonic sensor. Another possibility is to use a PIR sensor (passive infrared sensor) which is very common in use.

[0043] According to a preferred embodiment the workspace-monitoring system is characterized in that at least one second sensor of the system-monitoring system is a position sensor, an acceleration sensor, and/or an optical sensor.

[0044] The at least one second sensor is supposed to provide at least partly redundant functions to the at least one first sensor of the environment-monitoring system. The position sensor can be realized as an absolute position sensor or a relative displacement sensor. Possible solutions are linear, angular or multi-axis sensors.

[0045] In addition, the stated object is also achieved by an appropriate method for automatic monitoring of a person in a safety-critical workspace with the workspace-monitoring system according to the invention, comprising the following steps: In a step the person-related data is captured by the person-identification device. In a further step the image-data of a person in the safety-critical workspace is continuously captured by the image-data-capturing device. The person-related data and the image data is continuously analyzed and evaluated by the computing device and data processing device respectively.

[0046] This method provides a safe surveillance of the person in the safety-critical workspace. In case that the image-data-capturing device is not able to capture image data of the person a signal is send out, which carries the message that the person is no longer surveyed by the system. The functionality of the workspace-monitoring system is assured by the system-monitoring system which checks the functionality of the whole workspace-monitoring system.

[0047] In one further advantageously embodiment of the method at least one further signal is generated .and sent out in case of any malfunction or danger, depending at least on the received person-safety signal and on the systemically safety-relevant signal. The message what happened to the system or to the craftsman is also transferred to a further safety-relevant device, as the signal-processing-device takes the input signal into account while processing an output signal. Additionally the message is shown on an output device, in particular a display or touchscreen.

[0048] According to the invention the workspace-monitoring system is continuous monitoring the environment outside the safety-critical workspace and changing the at least one environment-monitoring signal by the environment-monitoring system in case of danger. Therefore it is assured that the workspace-monitoring system recognized dangers beforehand and is able to warn the person in the safety-critical workspace. Furthermore a central control station can be informed. Therefore safe surveillance of the person is guaranteed and approaching dangers are figured out beforehand.

[0049] According to another exemplary embodiment the close-to-person data is continuously captured by the person-data-capturing device. The close-to-person data can be the pulse, the body temperature, the body movement speed or any further data of interest. As the data is continuously captured by the person-data-capturing device one possible embodiment is to transfers the captured data in real time ($t<1$ second) to the computing device. As the close-to-person data is captured directly at the body of the person, the measurement uncertainty is very small. Hence the results are comparably reliable. In conclusion, the close-to-person data is made available to the computing-device quickly and reliable.

[0050] Exemplary embodiments of the present disclosure also provide a method for changing the state of the at least one alerting signal for activating the at least one alerting device by the signal-processing device, wherein the state of the alerting signal is at least depending on the state of the person-safety signal and the state of the system-safety signal. Therefore the alarm signal is depending on the trigger and people can react reasonable. The advantages of this method are discussed in the preceding claims.

[0051] These and further embodiments and improvements of the invention are subject matter of the subclaims.

[0052] By means of an exemplary embodiment shown in the accompanied drawing the invention itself, preferred embodiments and improvements of the invention and specific advantages of the invention shall be explained and illustrated in more detail.

[0053] The drawings disclose in

Fig. 1 an exemplary first workspace-monitoring sys-

tem in front of a workspace,

Fig. 2 an exemplary architecture of a workspace-monitoring system,

Fig. 3 an exemplary architecture of a workspace-monitoring system with a signal-processing device and

Fig. 4 an exemplary table of providable signals.

[0054] In Figure 1 a first exemplary workspace-monitoring system according to the invention in front of a safety-critical workspace 8 is disclosed. In this figure the person 14 is working in a typical safety-critical workspace 12 which is exemplary a confined workspace, in this figure a large pipe. As the safety-critical workspace 12 is very limited, the person 14 has to lie in the pipe. The person 14 is blocking the view to the pipe and to the place where the work is actually done. For surveying the person 14 a workspace-monitoring system 10 is placed near the entrance of the pipe. The workspace-monitoring system 10 comprises typically several single devices. In this figure an exemplary first environment-monitoring system 16, a first image-data-capturing device 18, a first thermal-image-capturing device 20 and a first warning device 22 are depicted.

[0055] The workspace-monitoring system 10 is typically mounted on a stand. One further possible solution, which is not depicted, is to hang up the device at the entrance of the pipe. In the depicted Figure, the workspace-monitoring 10 system is installed in a box. One advantageous embodiment is to paint the box in a glowing warning color that it can be better seen by other person.

[0056] Preferably all measuring devices have to be protected against a temperature impact up to 100°C and more, an impact of high humidity and an impact of gas concentration. This protection can be made by a thermally decoupled system box, exemplarily made of stainless steel. The person-related data, the image data and the close-to-person data are typical continuously saved in this storage device. In case of emergency this data is made available and for example displayed on a not depicted display. Therefore the storage of the computing device has to be protected exemplarily from fire or mechanical shocks. A range of capacity between 100 Megabyte and 2 Terabyte is typically required for the storage device; therefore it is able to save the data of at least one working day.

[0057] In Figure 2 an exemplary architecture of a workspace-monitoring system 50 is disclosed. The technical process as well as the system need to be engineered in order to fulfill the required behavior and specification. As the workspace-monitoring system 50 is very complex, it is divided into several subsystems which may consist of hardware and software components from different suppliers.

[0058] The heart of the workspace-monitoring system 50 is the person-monitoring system 52, which comprises a person-identification device 54, a second image-data-capturing device 56 and a computing device 60. These subsystems capture several kinds of different data, for example person-related data 82, image data 84 and close-to-person data 100. These different kinds of different data are processed to a person-safety signal which is created by the computing device 60.

[0059] Person-related data 82 is captured by the person-identification device 54 before the person enters the safety-critical workspace. These data is then transferred to the computing device 60. Before the person enters the workspace optical and thermal image data is captured of the empty safety-critical workspace and transferred to the computing device 60. In addition the system comprises a person-data-capturing device 64 for capturing close-to-person data 100. Close-to-person data 100 includes the data which is directly measured at the person, for example the body temperature or the gas-concentration. Meanwhile the person is working in the safety-critical workspace image data 84 is captured by the image-data capturing device 56.

[0060] The computing device 60 is configured for analyzing and evaluating the captured data and generates a person-safety signal 87 out of these data, The person-safety signal 87 includes typically the message if the person is still healthy and had no accident. Furthermore the person-safety signal 87 includes the message if the workspace is still uncritical or becomes critical or dangerous.

[0061] Additionally the workspace-monitoring system 50 comprises a system-monitoring system 58 which monitors the person-monitoring system 52 and its subsystems by sending a periodic first system-monitoring signal 86. The system-monitoring system 58 monitors additionally the functionality of an environment-monitoring system 66 by sending a periodic third system system-monitoring signal 106. One further possibility, which is not depicted in the figure, is to monitor the functionality of the alerting device 72 by sending a further periodic signal.

[0062] The system-monitoring system 58 comprises at least one second sensor 70. Typically the respective second sensor 70 can be configured as a position-, acceleration-, or an optical sensor.

[0063] Another typical further use of the at least one second sensor is that the second sensor 70 captures data about the functionality of the system-monitoring system 58. Furthermore the at least one second sensor provides additional safety as it is at least partly redundant with the at least one first sensor 68 of the environment-monitoring system 66. According to Fig. 2 in this exemplary embodiment three second sensors are provided, wherein one second sensor is a position sensor, one second sensor is an acceleration sensor and one second sensor is an optical sensor. The single sensors are partly redundant to the sensors of the environment-monitoring system 58, to provide a higher safety standard.

[0064] The workspace-monitoring system 50 comprises also an environment-monitoring system 66 including at least one first sensor 68. The respective first sensor is exemplary configured as a position-, an acceleration-, an infrared-, a temperature-, a smoke-, an ultrasonic- or an hygroscopic sensor. In the depicted figure the first sensor 68 is implemented as several single sensors, whereas each single sensor is a different sensor. Therefore the environment-monitoring 66 system includes one position-, one acceleration-, one infrared-, one temperature-, one smoke-, one ultrasonic- and one hygroscopic sensor. As the environment-monitoring system 66 possesses very different sensors it is able to identify very different possible dangers.

[0065] Due to several different sensors their signals are processed in combination and/or the signal of the one sensor is used to verify the signal of another sensor. For example, the signal of the acceleration sensor is depending on the signal of the position sensor. If the position of the environment-monitoring system 66 changes it also has to be accelerated and therefore both the position- and the acceleration sensor have to generate signals,

[0066] The environment-monitoring system 66 is not necessarily included in the person-monitoring system 52 and can even physically be separated. Therefore it can be placed to a position where the environment is optimally monitored.

[0067] In case of emergency or malfunction the alerting device 72 generates typically an alarm signal depending on its received input signal. At least three different kind of signals are typically transferred to the alerting device 72. The person-safety signal 87 comprises typically different states about the person and about the workspace, typically one of the following states: "Person is fine" or "Person is in an emergency state" and one of the following states "Workspace is fine for the person" or "Workspace is dangerous for the person".

[0068] Additionally the alerting device 72 receives exemplary the system-safety signal 91 from the system-monitoring system 58. The system safety signal 91 comprises typically different states about the person-monitoring system 52 and about the environment-monitoring system 66. The state of the signal is typical "Person-monitoring system is fine" or "Person-monitoring system is in a malfunction" and one of the following states "Environment-monitoring system is fine" or "Environment-manitoring system is in a malfunction". Additionally the system-monitoring system 58 checks its own functionality and transfers the state of its own functionality by means of the system-safety signal 91.

[0069] Figure 3 is similar to Figure 2 but also shows a signal-processing device 62. The signal-processing device 62 receives exemplary the person-safety signal 87, the environment-monitoring signal 90 and the system-safety signal 91. The signal-processing device 61 is a smart device which processes the received signals and generates an alarm signal 92, which is depending on the received signals. Hence the signals which are generated by the sub-systems are gathered by the signal processing device 62. The signal-processing device is typically configured for analyzing and assessing the received signals and generating an output signal depending on the received signal. In case of an emergency case a signal is generated which triggers a further signal that the attention of other people. For example a signal that switches on an alarm bulb or a serene. Whereas if one of the subsystems is not working properly or is in a malfunction and has to be repaired, an Email or a Short Message can exemplarily be sent to inform a supervisor.

[0070] In Figure 4 a table is presented which shows or lists the different devices of the workspace-monitoring system, the typically signals which are generated by these devices and the typical information of these signals. The person-data-capturing device for example creates the close to person data which comprises typical information about the person. For example this signal includes information about the pulse, the body temperature, the body movement speed or any other data of interest of the person.

[0071] The present invention also comprises any combination of preferred embodiments as well as individual features and developments provided they do not exclude each other.

List of References

[0072]

8	First workspace-monitoring system with workspace
10	First workspace-monitoring system
12	Safety-critical workspace
14	Person
16	First environment-monitoring system
18	First image-data-capturing device
20	First thermal-image,capturing device
22	First warning device
50	Second workspace-monitoring system
51	Third workspace-monitoring system
52	Person-monitoring system
54	Person-identification device
56	Second image-data-capturing device
58	System-monitoring system
60	Computing device
62	Signal-processing device
64	Person-data-capturing device
66	Second environment-monitoring system
68	First sensor
70	Second sensor
72	Alerting Device
82	Person-related data
84	image data
86	First system-monitoring signal
87	Person-safety-signal

88 Second system-monitoring signal
90 Environment-monitoring signal
91 System-safety-signal
92 Alarm Signal

100 Close-to-person data
102 First sensor signal
104 Second sensor signal
106 Third system-monitoring signal

120 Table

Claims

1. Workspace-monitoring system (10, 50, 51) for automatic surveillance of at least one person working in a safety-critical workspace (12) wherein the system comprises:

a person-monitoring system (52) comprising

- a person-identification device (54) for capturing person-related data (82);
- and an image-data-capturing device (18, 56) for capturing image data (84) of the person in the safety-critical workspace (12);
- and at least one computing device (60), which is configured for
  - the analysis and the evaluation of the person-related data (82) and of the image data (84) and for
  - changing the state of at least one person-safety-signal (87) depending on the person-related data (82) and on the image data (84);
- and one system-monitoring system (58) for self-monitoring the functionality of the workspace-monitoring system (10, 50, 51), which is configured for changing the state of at least one system-safety-signal (91) depending on an unexpected malfunction of the workspace-monitoring system (10, 50, 51);
- and at least one alerting device (72), which is activated in case of a relevant state of the person-safety-signal (87) and/or the system-safety-signal (91).

2. Workspace-monitoring system according to claim 1, **characterized in that** it comprises also a signal-processing device (62), which is configured for changing the state of at least one alarm signal (92) for activating the at least one alerting device (72), whereas the state of the alarm signal (92) is at least depending on the state of the person-safety signal (87) and the state of the system-safety signal (91).

3. Workspace-monitoring system according to claim 1 or 2, **characterized in that** the image-capturing device (56) is configured for capturing the image data (84) of an optical image and/or of a thermal image.

4. Workspace-monitaring system according to any of the preceding claims, **characterized in that** it comprises a person-data-capturing device (64) for capturing close-to-person data (100)

5. Workspace-monitoring system according to claim 4, **characterized in that** the person-data-capturing device (64) comprises a gas-concentration-measuring-, a body-temperature-measuring- and/or a deadman device.

6. Workspace-monitoring system according to any of the preceding claims, **characterized in that** it comprises also an environment-monitoring system (66) with at least a first sensor (68) for capturing data outside the workspace and for generating at least one environment-monitoring signal (90) in case of danger for the workspace-monitoring system (10, 50, 51).

7. Workspace-monitoring system according to claim 6, **characterized in that** at least one first sensor (68) of the environment-monitoring system (66) is a position-, an acceleration-, an infrared-, a temperature-, a smoke-, a ultrasonic -, or a hygroscopic sensor.

8. Workspace-monitoring system according to any of the preceding claims, **characterized in that** the system-monitoring system (58) comprises at least one second sensor (70) for capturing sensor data outside the safety-critical workspace (12).

9. Workspace-monitoring system according to claim 8, **characterized in that** the second sensor (70) of the system-monitoring system (58) is a position-, an acceleration-, or an optical sensor.

10. Method for automatic monitoring of a person in a safety-critical workspace (12), with the workspace-monitoring system (10, 50, 51) according to one of the claims 1 to 9, comprising the following steps:

- capturing person-related data (82) by the person-identification device (52);
- continuous capturing the image-data (84) of a person in the safety-critical workspace (12) by the image-data-capturing device (18,56);
- continuous analyzing and evaluating the person-related data (82) and the image-data (84) by the computing device (60);

■ changing the state of at least one person-safety-signal (87) depending on the person-related data (82) and on the image data (84) by the computing device (60) in case of danger;

■ continuous self-monitoring of the functionality of the workspace-monitoring system (10, 50, 51) and changing the state of the at least one system-safety-signal (91) depending on an unexpected malfunction of the workspace-monitoring system (10, 50, 51) by the system-monitoring system (58);

■ activating the at least one alerting device (72) in case of a relevant state of the person-safety-signal (87) and/or the system-safety-signal (91).

11. Method according to claim 10, comprising the following additional step:

- Continuous monitoring the environment outside the safety-critical workspace (12) and changing the at least one environment-monitoring signal (90) by the environment-monitoring system in case of danger.

12. Method according to claim 10 or 11, comprising the following additional step:

- continuous capturing the close-to-person data (100) by the person-data-capturing device (64) and changing the state of at least one close-to-person data (100) in case of danger.

13. Method according to one of claim 10 to 12, comprising the following additional step:

- Changing the state of the at least one alerting signal (92) for activating the at least one alerting device (72) by the signal-processing device (62), whereas the state of the alerting signal (92) is at least depending on the state of the person-safety signal (87) and the state of the system-safety signal (9

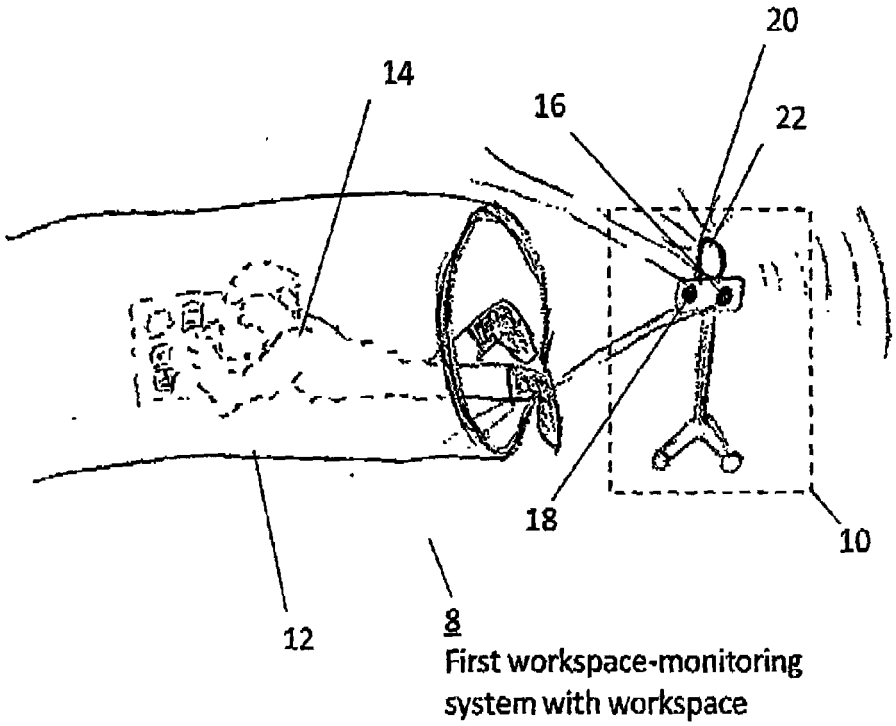

20
14
16
22
18
10
12
8
First workspace-monitoring system with workspace

Fig. 1

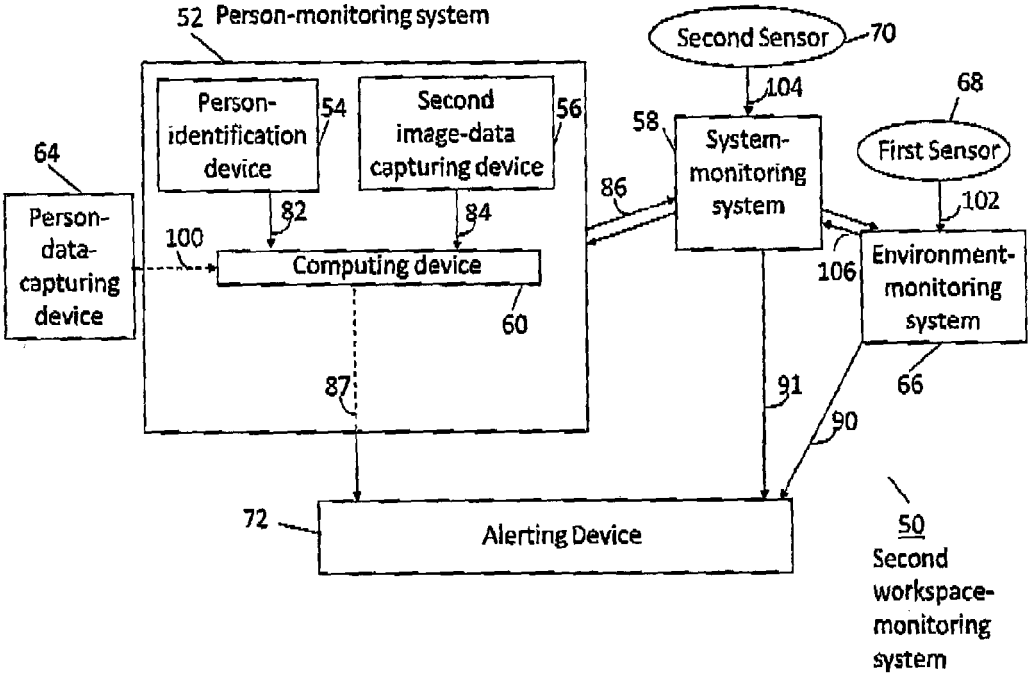
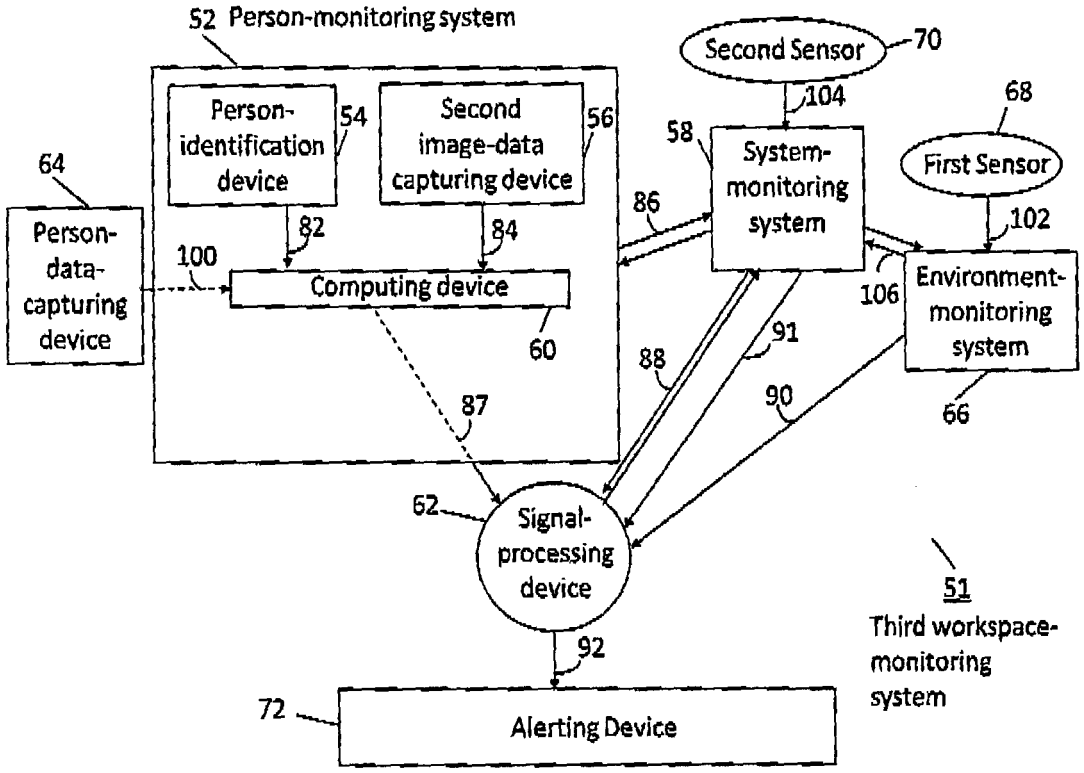

52 Person-monitoring system
Second Sensor
70
104
68
Person-identification device
54
Second image-data capturing device
56
58
System-monitoring system
First Sensor
64
86
102
Person-data-capturing device
82
84
100
Computing device
106
Environment-monitoring system
60
87
91
66
90
72
Alerting Device
50
Second workspace-monitoring system

Fig. 2


52 Person-monitoring system
Second Sensor
70
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Person-identification device
54
Second image-data capturing device
56
58
System-monitoring system
First Sensor
64
86
102
Person-data-capturing device
82
84
100
Computing device
106
Environment-monitoring system
60
88
91
87
90
66
62
Signal-processing device
51
Third workspace-monitoring system
92
72
Alerting Device

Fig. 3

Device/System	Typically generated Signal/Data	Typical Information of the Signal/Data
Person-data-capturing device	close to person data	- the pulse, - the body temperature, - the body movement speed - or any other data of interest
Person-identification device	Person-related data	- Who enters the workspace - Entrance/Exit Time of the person
Second image-data capturing device	Image data	- Captured Image data and/or thermal data of the person and/or of the workspace before the person entered the workspace and/or meanwhile the person is working in the workspace
Computing device	Person-safety signal	- Person is fine - Person is in an emergency case - Workspace is fine for the person - Workspace is dangerous for the person
System-monitoring system	First system-monitoring signal	- Person-monitoring system is fine - Person-monitoring system is in a malfunction
	Second system-monitoring signal	- Signal-processing device is fine - Signal-processing device is in a malfunction
	Third system-monitoring signal	- Environment-monitoring system is fine - Environment-monitoring system is in a malfunction
Environment-monitoring system	Environment-monitoring signal	- Environment is in normal condition - Environment is dangerous for the person

120 Table

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 12 00 7101

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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