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Description

[0001] The invention relates to the support of work on formwork and scaffoldings, such as assembly, construction, deconstruction and disassembly, by means of sensor-based monitoring.

Prior art

[0002] Formwork and scaffoldings are often composed of standard building elements and prefabricated elements that are provided by a modular system. In this way, formwork and scaffoldings may be produced quickly. After using the formwork or scaffolding, the material may be reused as desired. One example of a modular system from which formwork may be produced is known from WO 2005/040 525 A1.

[0003] The more extensive the range of such a modular system is, the greater the number of possible ways of making errors when putting the formwork or the scaffolding together. Such errors, such as assembling building elements that do not technically match, may only be inherently prevented to a limited extent, for example by special structures that mechanically block incorrect assembly being attached or integrally molded to building elements. Whoever wishes to work with the modular system thus has to learn how to use it correctly. Particularly for temporary workers and other only temporary employees, the learning effort may be disproportionately high in relation to the intended duration of employment.

[0004] WO 2020/201 559 A1 discloses a method for automatically assessing a building process and for checking that trades are being carried out according to specifications.

[0005] EP 3 779 875 A1 discloses a method for measuring building elements on a building site for erecting or taking down a building on the basis of optical measurement and projection data.

[0006] CN 108 845 663 A discloses another method for supporting the erection of buildings and facilities, in which the nominal state to be achieved is combined with images of the building site by augmented reality and the actual state reached is simultaneously calibrated.

Problem and solution

[0007] The problem addressed by the present invention is therefore to support work on scaffoldings, in particular the assembly, construction, deconstruction and disassembly, using sensor-based monitoring such that error may be corrected as early as possible and the adverse effects of these errors may therefore be kept as low as possible.

[0008] According to the invention, this problem is solved by a method according to the main claim. Additional advantageous embodiments may be found in the dependent claims, which refer back to said main claim.

Disclosure of the invention

[0009] Within the context of the invention, a computer-implemented method for supporting work on formwork and/or scaffolding has been developed. This work may in particular include the assembly, construction, deconstruction and disassembly of the formwork or the scaffolding, for example.

[0010] In the method, physical measurement data are firstly obtained. Here, "obtained" especially means that the sensor-based recording and processing, which will be explained in more detail in the following, may be carried out at different points and/or by different entities, too. The measurement data may therefore be recorded on a building site, for example, and evaluated in a Cloud "as a Service" by an external service provider in order to obtain the result of the evaluation as quickly as possible.

[0011] The physical measurement data are dependent on an actual action carried out by a worker as part of their work either on the building site or anywhere else the formwork or scaffolding is located. This means that a change to the actual action is reflected in a significant change in the physical measurement data and may therefore be evaluated from the physical measurement data.

[0012] For example, different actions thus cause different noises and may therefore be differentiated from one another using audio recordings from the region where the worker is working. Different-sized wrenches also have different mechanical dimensions, for example, and therefore they sound different when they come into contact with other objects or are handled in some other way. Physical measurement data may thus be used to determine what the worker is doing and what tools and equipment they are using.

[0013] In this case, the physical measurement data are not always uniquely assigned to actions carried out by the worker. If all that may be heard on an audio recording is the fact that a specific wrench is being used to tighten a bolt, for example, this does not make it possible to conclude exactly what bolt this is. However, it has to be a bolt that is within "earshot" of the microphone and the size of the bolt also has to at least be approximately as large as the wrench.

[0014] This example shows that a plurality of actual actions may also be plausible for an observation obtained by measurement. One or more actual actions for which the physical measurement data are plausible is/are therefore determined during the method.

[0015] Furthermore, one or more nominal actions is/are determined that, starting from the present state of the work, lead further toward completion of the work. For example, when assembling and constructing formwork or scaffolding, those actions that, starting from the current assembly state of the formwork or the scaffolding, lead further toward completion of the formwork or scaffolding may be nominal actions. Conversely, during deconstruction and disassembly, those actions that, starting from the current disassembly state, lead further toward complete deconstruction or complete disassembly may be nominal actions. In this case, the present state of the work, for example the assembly or disassembly state, may be recorded in whichever way using sensors. For example, the present state of the work may almost be "integrated" from previously uniquely identified actual actions successively carried out by the worker.

[0016] Any criteria to be preset may be used to measure which actions lead further toward completing the work, such as completing the formwork or the scaffolding, starting from the present state of the work, for example the current assembly state. Therefore, a specific assembly state as such may establish at which points it is currently even mechanically possible to add additional elements, for example. Which elements may be attached at these points and which connecting and fixing elements are to be used therefor may be predetermined in the form of additional technical rules. At this point, any prior knowledge of assemblies that belong together may also be used. If, for example, an assembly consists of two building elements connected by connecting means and the two building elements are already provided, a logical next nominal action is then to add the connecting means and thereby complete the assembly.

[0017] If a planned model of the formwork to be constructed or the scaffolding to be constructed is provided, those actions that bring about progress when implementing the formwork or the scaffolding according to the present model may in particular be classed as leading further toward completion. Such actions may therefore be nominal actions. However, the addition of another element which, despite being mechanically suitable for the current assembly state, is not provided according to the model, for example, does not make a contribution to progress. Instead, this part may even have to be taken down later on so that the entire formwork or the scaffolding may be implemented according to the model. The model may be a three-dimensional model that is planned beforehand and/or a "Building Information Model," BIM model, for example.

[0018] A check is made to see the extent to which deviations requiring correction exist between the actual actions and the nominal actions according to at least one preset criterion. This criterion may in particular be a measure of the extent to which the deviation influences the intended technical function of the formwork or scaffolding or may even damage building elements or equipment, for example. If, for example, too small connection elements are used to connect building elements, this may cause the building elements to be movable relative to one another with an undesirable amount of play. It is possible that the connection elements do not withstand the strain from the formwork or the scaffolding during operation either. If, for example, too large a wrench is used to tighten hexagonal nuts, the force does not act on the edges of the hexagonal nuts as intended but on the corners, and the nuts will be damaged.

[0019] In response to the fact that deviations requiring correction exist, information regarding the deviations and/or regarding the one or more nominal actions is output to the worker. In this way, the worker is able to promptly correct the error before continuing work on the formwork or the scaffolding.

[0020] The fact that human workers make mistakes and sometimes also reach for the wrong building element or wrong connection element, for example, is unavoidable. It became known that prompt correction of this error saves a considerable amount of working time, especially when assembling formwork and scaffoldings. Formwork and scaffoldings are mechanical structures, the building elements of which are quite literally built on one another to a particularly large extent. If, therefore, the wrong building element is used at one point for example and this error is only detected later on, there may already be additional building elements supported thereon. It is then impossible to simply remove the incorrect building element and replace it with the correct building element, since the rest of the structure may then collapse. In the extreme case, it may be necessary to remove everything that has been assembled after the time of the error until the incorrect building element is eventually released and may be replaced.

[0021] Furthermore, in particular prompt feedback regarding assembly errors has a learning effect for the worker. Not only will this person correct a specific assembly error or prevent it to some extent, but the same errors will ideally also be prevented in the future. Ultimately, the effect of sensor-based monitoring thus also extends to spatial regions and time frames that are not directly covered by this monitoring process.

[0022] The same applies to disassembly and deconstruction. Here, errors may cause an element essential for stability to be removed too early and the stability to no longer be provided, for example.

[0023] Physical measurement data may be provided by at least one sensor, which is carried by the worker when working. Such a sensor is closest to the actions performed by the worker and may therefore record measurement data that allow for a particularly accurate identification of the actual actions. The physical measurement data are then provided by one or more sensors that are connected to at least one glove of the worker and react to the worker’s hand movements. This in particular allows for the identification of what object the worker is reaching for each time and the orientation in which they are holding it, for example. It is therefore also possible to identify that although the worker has reached for the correct building element, they are building around it incorrectly, for example. Actions may also be checked in regions that may not be seen by cameras, for example. If, for example, the worker reaches into a narrow space between building elements of formwork and uses a locking element to lock the building elements with respect to one another, hand movements may be used to monitor whether the locking element has been correctly operated and locked in position. Furthermore, checking the hand movements produces a considerably smaller volume of data than camera surveillance, does not require any specific lighting conditions and is considerably less likely to breach data protection laws.

[0024] Alternatively or in combination therewith, physical measurement data may be provided by at least one acoustic sensor, which monitors the region where the worker is working. Such a sensor does not have to be carried by the worker but may also be stationary and monitor a larger spatial region. The evaluation is not limited to technically generated noise. Therefore, a noise that indicates a particularly large amount of exertion by the worker may indicate that the worker is currently forcibly “squeezing together” two building elements that do not actually match, for example.

[0025] In another particularly advantageous embodiment, physical measurement data that are obtained characterize the position of the worker in the plane or in space. For example, the position of the worker may be tracked using inertial navigation and/or radio-based navigation. In this way, it is in particular possible to check whether the worker is carrying out their actions at the correct point within a building site or whether they are working in the wrong place or in a potentially unsafe environment, for example.

[0026] In another particularly advantageous embodiment, physical measurement data are provided by at least one sensor that is arranged on a piece of equipment or at an access to a piece of equipment and reacts to a completed or attempted operation of the equipment. It is therefore possible to record when the worker is about to use a specific tool, for example. If, for example, specific bolts are tightened using a torque wrench and the worker instead reaches for a conventional wrench without torque limitation, this error that would subsequently not be visually seen from the formwork or the scaffolding, may be corrected right from the beginning. A range of bolts or other connection elements sorted into drawers or other compartments may also be monitored with respect to which drawer or which compartment is open, for example. If the building elements currently to be connected are connected using M8 bolts and the worker instead opens the drawer containing the M6 bolts, for example, they may be directly advised of the error.

[0027] As previously mentioned, at least one nominal action may advantageously be determined by comparing the present state of the work with a partially or completely planned model for the formwork or the scaffolding. There are usually only a few sensible nominal actions starting from a specific present state of the work and a specific planned model, which actions make it possible to keep pushing forward with the implementation of the formwork or the scaffolding according to the planned model.

[0028] Alternatively or in combination therewith, at least one nominal action may be determined by comparing the present state of the work, for example an assembly state of the formwork or the scaffolding, with a catalogue of technical rules for a modular system from which the formwork or scaffolding is assembled, for example. Such rules may stipulate that specific combinations of building elements may only be formed using specific types of fixing elements, that a minimum number of these fixing elements is required and/or that spacings between two fixing elements may not exceed a preset size, for example. The rules may apply not only to assembly and construction but also to disassembly and deconstruction. This may guarantee that the stability is also always provided even during disassembly and deconstruction, for example. The more this type of prior knowledge is used, the more the number of sensible nominal actions in a specific situation during the work may be limited.

[0029] Examples of deviations requiring correction are, as previously mentioned, the following actions by the worker:

- the use of an incorrect building element of the formwork or scaffolding or the attempt to do so;
- the use of an incorrect mutual connection element and/or fixing element for building elements of the formwork or the scaffolding or the attempt to do so;
- the placing of a building element, connection element and/or fixing element in the wrong position or the attempt to do so; and
- the non-conventional use of a tool or a different piece of equipment.

[0030] The use of incorrect building elements, connection elements or fixing elements and placing them in the wrong position are typical errors made by workers who are not familiar with the specific building site or the specific modular system. In particular, the assembly and disassembly of formwork and scaffoldings is often carried out by workers working on several different building sites. This encourages confusion, for example from the worker remembering a first fixing element from a first building site and also using this on a second building site even though the modular system used there requires a different fixing elements.

[0031] The non-conventional use of a tool or other equipment does not necessarily have to be caused by confusion or a lack of knowledge. Instead, such actual actions are especially often consciously carried out by experienced staff but not identified as an error. Therefore, at first glance it may be a “bright” idea to carry out work using a tool that is not intended therefor, since it may then be done quicker, for example. Said staff then appear to be smarter than the plan. In this case, failure is often made to recognize that there are perfectly tangible technical reasons as to precisely why a specific tool is provided for carrying out the work. For example, whoever does not know that a specific bolt connection on the scaffolding is particularly dynamically loaded when using the scaffolding shall not recognize the need to use the torque wrench to tighten this bolt connection. Instead, a conventional open-end wrench that is closer to hand is used and the bolt connection becomes the weak spot within the static behavior of the scaffolding.

[0032] In another particularly advantageous embodiment, at least one nominal action is determined for at least one actual action of the worker, which nominal action, with respect to its technical function within the context of the formwork or the scaffolding, may take the place of the actual action. This nominal action is outputted to the worker. Instead of only detecting and reporting an error while working, a proposal for remedying it may therefore then simultaneously also be made. In this case, a plurality of nominal actions that appear to be sensible in the current context may also be proposed by all means. If a list of several proposals is presented to a person skilled in the art, it is often still clear to said person which nominal action they should take in place of the actual action claimed to be incorrect, especially in conjunction with an existing plan.

[0033] However, a nominal action, for which confusion with the actual action is most plausible, may also be selected from a plurality of nominal actions and output to the worker, for example. As previously mentioned, confusions are a particularly frequent cause of assembly errors.

[0034] The information relating to the nominal action may in particular be outputted to the worker using an augmented reality device, for example. In this connection, augmented reality means in particular that the worker may simultaneously see both the output information as well as their environment. A mixed reality environment is then also referred to. The worker may then associate the displayed information with the current situation particularly effectively and carry out the correct nominal action more quickly as a whole.

[0035] For this purpose, for example in response to the worker reaching for the wrong building element, connection element or fastening element, an image of a building element, connection element or fixing element that, according to a nominal action, may take the place of the wrong element may in particular be displayed via the augmented reality device. The correct element is then found particularly quickly.

[0036] One or more actual actions for which the physical measurement data are plausible may in particular be determined, at least in part, using a trained machine learning model, for example. This machine learning module may in particular comprise or be an artificial neural network, ANN.

[0037] Such a machine learning module may in particular contain a function, the behavior of which is characterized by settable parameters. Said module is characterized by a great ability to generalize. This means that, after training with a limited number of situations that have a sufficient degree of variability with respect to one another, the module is also able to apply the acquired knowledge to several situations that were not the subject matter of the training.

[0038] This is particularly advantageous for the detection of actual actions from physical measurement data, in particular from the sources mentioned previously by way of example. If the same actual action is repeated several times under circumstances that are otherwise the same, no two time series shall be exactly the same for physical measurement data in which this actual action is embodied. If, for example, the gloves of the worker are provided with force and/or positional sensors, time series that are qualitatively similar in some ways but still differ from one another are produced for forces and positions each time a bolt is tightened using a wrench. Furthermore, audio recordings recorded at a building site or in an industrial facility may contain a mixture of different noises, for example. Machine learning modules are suitable for breaking such mixtures down into their noise components. Therefore, popular classification algorithms are designed to specify for each of a plurality of the possible category (for example: actual actions here) the level of confidence the inputted audio recording belongs to the particular category. The same levels of confidence for different actual actions, for example for moving a building element and tightening a bolt, may then indicate that a first worker is currently moving a building element and a second worker is simultaneously tightening the bolt at a different point, for example.

[0039] The information relating to deviations requiring correction obtained during the method may in particular be collected and subsequently further evaluated in order to better understand the work process during assembly, construction, deconstruction and disassembly, for example. It is in particular possible to determine which actions are usually performed without errors and for which actions errors accumulate, for example. Such knowledge may then in turn lead to product improvements, for example of modular systems for formwork and scaffoldings.

[0040] As mentioned at the outset, it is not feasible for example in an extensive modular system to mechanically secure the building elements against any fundamentally possible incorrect assembly. If, however, it turns out that a specific error is repeatedly made when assembling two building elements, it may be sensible to provide the building elements with structures that prevent this assembly error from the outset.

[0041] As previously explained, it is particularly advantageous to detect hand movements made by a worker using a special glove. Therefore, a glove for detecting hand movements of a worker is also disclosed here. This glove comprises a plurality of sensors, each of which registers measurement signals. The measurement signals are dependent on

- a tilting movement of the particular sensor in space, and/or
- an acceleration of the particular sensor, and/or
- an exertion of force on the particular sensor.

[0042] Depending on the number of sensors and the level of detail of the measurement signals in particular different actual actions carried out by the worker and different objects picked up by the worker may be differentiated from one another in this way.

[0043] At least one sensor is particularly advantageously arranged on each finger of the glove and on the palm of the glove. This makes it easier to assign the measurement signals to different actual signals and objects. As previously mentioned, it may be important for example to distinguish between two connection elements that could be confused with one another on account of their similarity and only one of which is the correct one.

[0044] The method will be implemented by a computer and is embodied in software for this purpose, for example. Therefore, the invention also relates to one or more computer programs comprising machine-readable instructions which, when executed on one or more computers, cause the one or more computers to carry out one of the described methods.

[0045] The invention likewise also relates to a machine-readable data carrier and/or download product comprising the one or more computer programs. A download product is a digital product, which may be transmitted via a data network, i.e. may be downloaded by a user of the data network, and may be offered for sale in an online shop for immediate download, for example.

<u>Special part of the description</u>

[0046] The subject matter of the invention will be explained in the following on the basis of drawings without the subject matter of the invention being limited thereto, in which:

Fig. 1: shows an embodiment of the method 100;

Fig. 2: shows example assembly situations comprising possible ways of monitoring; and

Fig. 3: shows an example glove 4b for a worker 4 comprising sensors 4a.

[0047] Fig. 1 is a schematic flow diagram of one embodiment of the method 100. In step 110, physical measurement data 2 are obtained, which depend on actual actions 3 that a worker 4 carries out as part of the work on formwork 1a or scaffolding 1b. In step 120, one or more actual actions 3 are determined, for which the physical measurement data 2 are plausible. In step 130, one or more nominal actions 5 are determined, which, starting from the present state of the work, lead further toward the completion of the work on the formwork 1a or scaffolding 1b. In this case, in particular the actual actions 3 may be taken into consideration, for example, for example in order to almost "integrate" the present state of the work from a series of actual actions 3 identified. However, this is not necessarily required.

[0048] In step 140 a check is made to see the extent to which there exist deviations 7 requiring correction between the actual actions 3 and the nominal actions 5 according to at least one present criterion 6. If necessary, in step 150 information relating to the deviations 7 and/or relating to the one or more nominal actions 5 is output to the worker 4.

[0049] Different possible ways of obtaining the physical measurement data 2 are explained in box 110 by way of example.

[0050] According to block 111, the measurement data 2 are provided by at least one sensor 4a recorded, which is carried by the worker 4 while at work. According to block 111a, this sensor 4a may be connected to a glove 4b of the worker 4 for example and react to the worker's hand movements.

[0051] According to block 112, measurement data 2 are provided by an acoustic sensor 8a, which monitors the region where the worker 4 is working.

[0052] According to block 113, in addition to blocks 111a and/or 112, at least some of the measurement data 2 obtained characterizes the position 4c of the worker 4 in the plane or in space.

[0053] According to block 114, in addition to blocks 111a and/or 112, measurement data 4 may be provided by at least one sensor 8b, which is arranged on a piece of equipment 9 or at an access to a piece of equipment 9. This sensor 8b reacts to a completed or attempted operation of the piece of equipment 9.

[0054] Box 120 shows that, according to block 121, the one or more actual actions 3 may be determined using a trained machine learning module, at least in part.

[0055] Box 130 shows different possible ways of determining nominal actions 5 by way of example.

[0056] According to block 131, at least one nominal action 5 may be determined by comparing the present state of the work with a partially or completely planned model 1c for the formwork 1a or scaffolding 1b.

[0057] According to block 132, at least one nominal action 5 may be determined by comparing the present state of the work with a catalogue 1d of technical rules. These technical rules relate to a modular system from which the formwork 1a or the scaffolding 1b is assembled.

[0058] According to block 133, at least one nominal action 5 is determined for at least one actual action of the worker, which nominal action, with respect to a technical function within the context of the formwork 1a or scaffolding 1b, may take the place of the actual action 3. Insofar as a deviation 7 requiring correction is determined in step 140, this nominal action 5 is output to the worker 4 in block 152. In this case, according to block 133a, one nominal action 5 may in particular be selected from a plurality of possible nominal actions 5 for which confusion with the actual action 3 is most plausible, for example.

[0059] Box 150 shows by way of example a few possible ways of how the worker 4 may be informed of the deviation 7 requiring correction and/or of the nominal action 5.

[0060] According to block 151, an augmented reality device such as augmented reality glasses may be used for the outputting process. The concept of the worker 4 being able to see both the output information and their environment simultaneously in this case may be achieved in whichever way. Therefore, the information output may be projected onto an at least partially transparent surface, for example, through which the worker 4 may see the environment. However, an image of the environment may also be taken by a camera for example and may be combined with the information to be output in order to form an overall image that is then output to the worker 4.

[0061] In this case, according to block 151a, in response to the worker 4 reaching for the wrong building element 10, connection element or fastening element, an image of a building element 10, connection element or fixing element that, according to a nominal action 5, may take the place of the wrong element, may in particular be displayed by means of the augmented reality device, for example.

[0062] According to block 152, as mentioned previously, a nominal action 5 that may occur in place of the actual action 3 may be output to the worker 4.

[0063] Fig. 2 shows an example assembly situation in which the method 100 may be used. A worker 4 carries out work on formwork 1a and/or scaffolding 1b and handles building elements 10 each time here. In this case, their position 4c may be monitored.

[0064] The region in which the worker 4 is working may be acoustically monitored using a microphone 8a in this case in order to draw conclusions about the actual actions 3 performed from the audio signal obtained using said microphone. Alternatively or in combination therewith, a piece of equipment 9, here a tool, may be provided with a sensor 8b for this purpose, which registers when the piece of equipment 9 is handled. It is then possible to identify when the worker 4 is about to use the equipment 9 for an unsuitable purpose, for example.

[0065] Fig. 3 shows another possible way of using sensors to record measurement data 2, from which conclusions may be made regarding actual actions 3. A glove 4b for the worker is provided with sensors 4a on the fingers and on the palm. These sensors register hand movements of the worker 4. The sensors 4a may therefore measure tilting movements in space and/or accelerations, for example. Alternatively or in combination therewith, they may react to pressure, for example. Therefore, it is possible to identify what the worker 4 is currently doing with their hands.

List of reference signs

[0066]

1a	formwork
1b	scaffolding
1c	planned model of the formwork 1a or the scaffolding 1b
1d	catalogue containing technical rules
2	physical measurement data, depend on actual actions 3
3	actual actions of the worker 4
4	worker
4a	sensor, carried by worker 4 when working
4b	glove for worker 4
4c	position of the worker 4 in the plane or in space
5	nominal action that leads toward completion
6	criterion for correction requirement
7	deviation between actual actions 3 and nominal actions 5
8a	acoustic sensor

8b	sensor for equipment 9 or access thereto
9	equipment
10	building element for formwork 1a or scaffolding 1b
100	method for supporting the work
110	obtaining physical measurement data 2
111	use of data 2 from a sensor 4a that is carried
111a	use of data 2 from a sensor 4a on the glove 4b
112	use of data 2 from an acoustic sensor 8a
113	use of data 2 that characterize the position 4c of the worker 4
114	use of data 2 from a sensor 8b for a piece of equipment 9
120	determining actual actions 3
121	determining actual actions 3 using machine learning module
130	determining nominal actions 5
131	comparing the status of the work with planned model 1c
132	comparing the status of the work with technical rules 1d
133	determining nominal action 5 that technically replaces actual action 3
133a	determining nominal action 5 for which confusion is plausible
140	checking for deviations 7 requiring correction
150	outputting information to the worker 4
151	outputting using an augmented reality device
151a	displaying a correct element intended to replace the wrong element
152	outputting the nominal action 5 determined in block 133

Patentkrav

1. Computerimplementeret fremgangsmåde (100) til understøttelse af arbejde på en forskalling (1a) og/eller et stillads (1b) med følgende trin:

• fremskaffelse (110) af fysiske måledata (2), der afhænger af en faktisk handling (3), som en arbejder (4) udfører i forbindelse med et arbejde;

• bestemmelse (120) af en eller flere faktiske handlinger (3), som de fysiske måledata (2) er plausible til;

• bestemmelse (130) af en eller flere ønskede handlinger (5), som med udgangspunkt i arbejdets aktuelle status fører yderligere i retning mod færdiggørelse af arbejdet på forskallingen (1a) eller stilladset (1b);

• kontrol af (140), om der efter mindst et forhåndsdefineret kriterium (6) eksisterer afvigelser (7) mellem de faktiske handlinger (3) og de ønskede handlinger (5), som kræver korrigering; og

• udsendelse (150) af information angående afvigelserne (7) og/eller angående den ene eller de flere ønskede handlinger (5), til arbejderen (4) som reaktion på, at der eksisterer afvigelser (7), som kræver korrigering,

hvor fysiske måledata

• stammer (111) fra mindst en sensor (4a), som bæres af arbejderen (4) under arbejdet, hvor den eller de sensorer (4a) er forbundet (111a) med mindst en handske (4b) på arbejderen (4) og reagerer på arbejderens (4) håndbevægelser, og/eller

• stammer (112) fra mindst en akustisk sensor (8a), som overvåger området, i hvilket arbejderen (4) er aktiv.

2. Fremgangsmåde (100) ifølge krav 1, hvor fysiske måledata (2) karakteriserer (113) arbejderens (4) position (4c) i planet eller rummet.

3. Fremgangsmåde (100) ifølge et af kravene 1 til 2, hvor fysiske måledata (2) stammer (114) fra mindst en sensor (8b), som er anbragt på et driftsmiddel (9) eller på en tilgang til et driftsmiddel (9) og reagerer på en afsluttet eller forsøgt håndtering af driftsmidlet (9).

4. Fremgangsmåde (100) ifølge et af kravene 1 til 3, hvor der bestemmes (131) mindst en ønsket handling (5) ved sammenligning af den aktuelle status af arbejdet med en delvis eller fuldstændig planlagt model (1c) af forskallingen (1a) eller stilladset (1b).

5. Fremgangsmåde (100) ifølge et af kravene 1 til 4, hvor der bestemmes (132) mindst en ønsket handling (5) ved sammenligning af den aktuelle status af arbejdet med et katalog (1d) af tekniske regler for et modulsystem, ud fra hvilket forskallingen (1a) eller stilladset (1b) monteres.

6. Fremgangsmåde (100) ifølge et af kravene 1 til 5, hvor afvigelsen (7), der kræver korrigering, omfatter en eller flere af følgende handlinger fra arbejderen (4):

- brug af et forkert byggeelement (10) af forskallingen (1a) eller stilladset (1b), eller forsøg herpå;
- brug af et forkert forbindelseselement og/eller fastgørelsesmiddel til byggeelementer (10) af forskallingen (1a) eller stilladset (1b) mellem hinanden, eller forsøg herpå;
- placering af et byggeelement (10), forbindelseselement og/eller fastgørelsesmiddel i en forkert position, eller forsøg herpå;
- ikke-korrekt brug af et værktøj eller et andet driftsmiddel (9).

7. Fremgangsmåde (100) ifølge et af kravene 1 til 6, hvor der til mindst en faktisk handling (3) af arbejderen (4) bestemmes (133) mindst en ønsket handling (5), som hvad angår sin tekniske funktion inden for rammerne af forskallingen (1a) eller stilladset (1b) kan erstatte den faktiske handling (3), og hvor denne ønskede handling (5) udsendes (152) til arbejderen (4).

8. Fremgangsmåde (100) ifølge krav 7, hvor der blandt flere ønskede handlinger (5) udvælges (133a) en ønsket handling (5), hvor en forveksling med den faktiske handling (3) er mest plausibel.

9. Fremgangsmåde (100) ifølge et af kravene 1 til 8, hvor informationen udsendes (151) til arbejderen (4) med en augmented reality-enhed, sådan at arbejderen (4) kan se både denne information og sine omgivelser samtidig.

10. Fremgangsmåde (100) ifølge krav 9, hvor der som reaktion på, at arbejderen (4) tager fat i et forkert byggeelement (10), forbindelseselement eller fastgørelseselement, via augmented reality-enheden vises (151a) et byggeelement (10), forbindelseselement eller fastgørelseselement, som kan erstatte det forkerte element i overensstemmelse med en ønsket handling (5).

11. Fremgangsmåde (100) ifølge et af kravene 1 til 10, hvor bestemmelsen (120) af den ene eller de flere faktiske handlinger (3) i det mindste delvist foregår (121) med et trænet machine learning-modul.

12. Et eller flere computerprogrammer indeholdende maskinlæsbare instruktioner, som, når de udføres på en eller flere computere (100), får den ene eller de flere computere til at udføre en fremgangsmåde ifølge et af kravene 1 til 11.

13. Maskinlæsbart databærende medie og/eller downloadprodukt med det ene computerprogram eller de flere computerprogrammer ifølge krav 12.

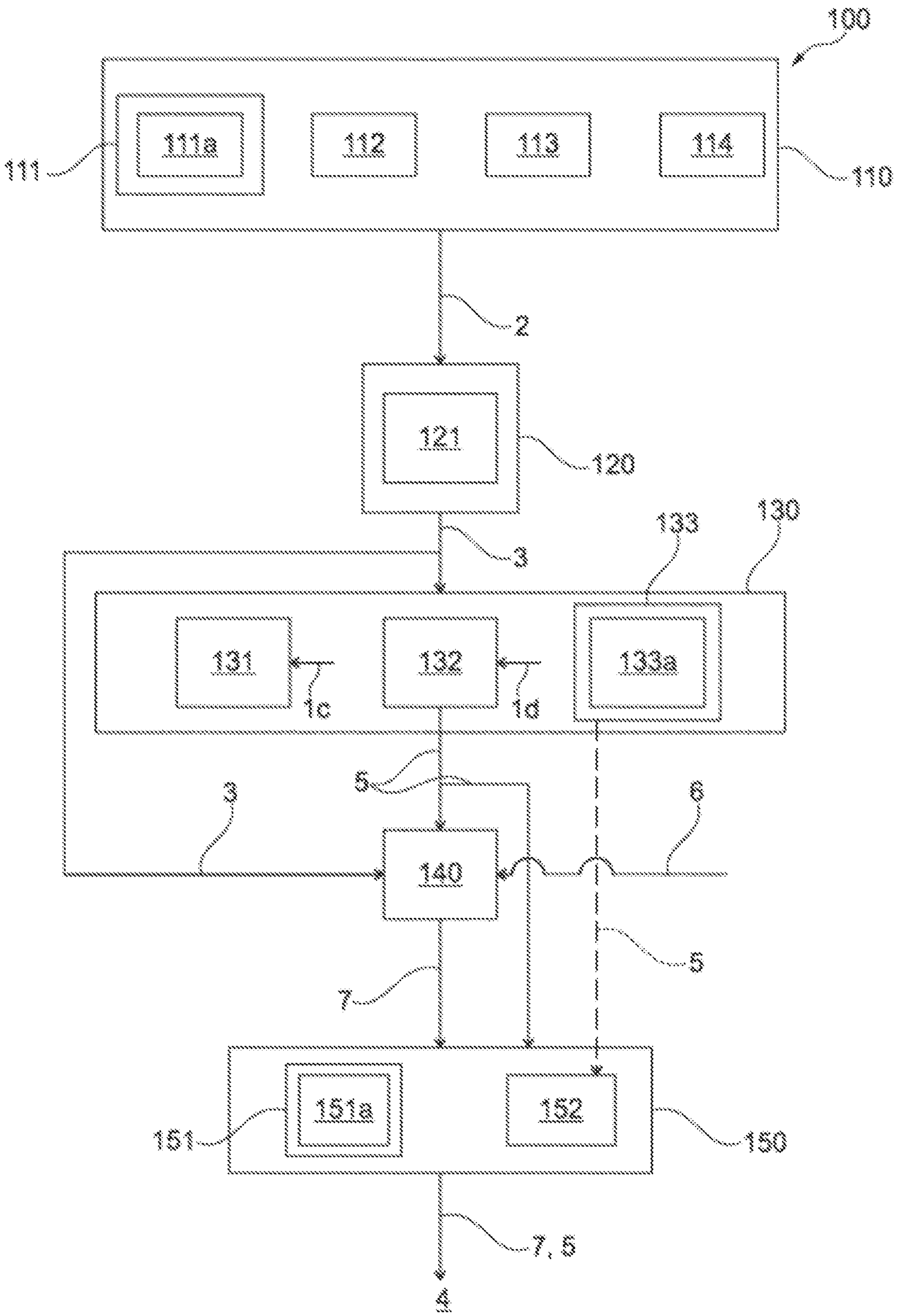
100
111a
112
113
114
111
110
2
121
120
3
133
130
131
132
133a
1c
1d
5
3
6
140
5
7
151a
152
151
150
7, 5
4

Fig. 1

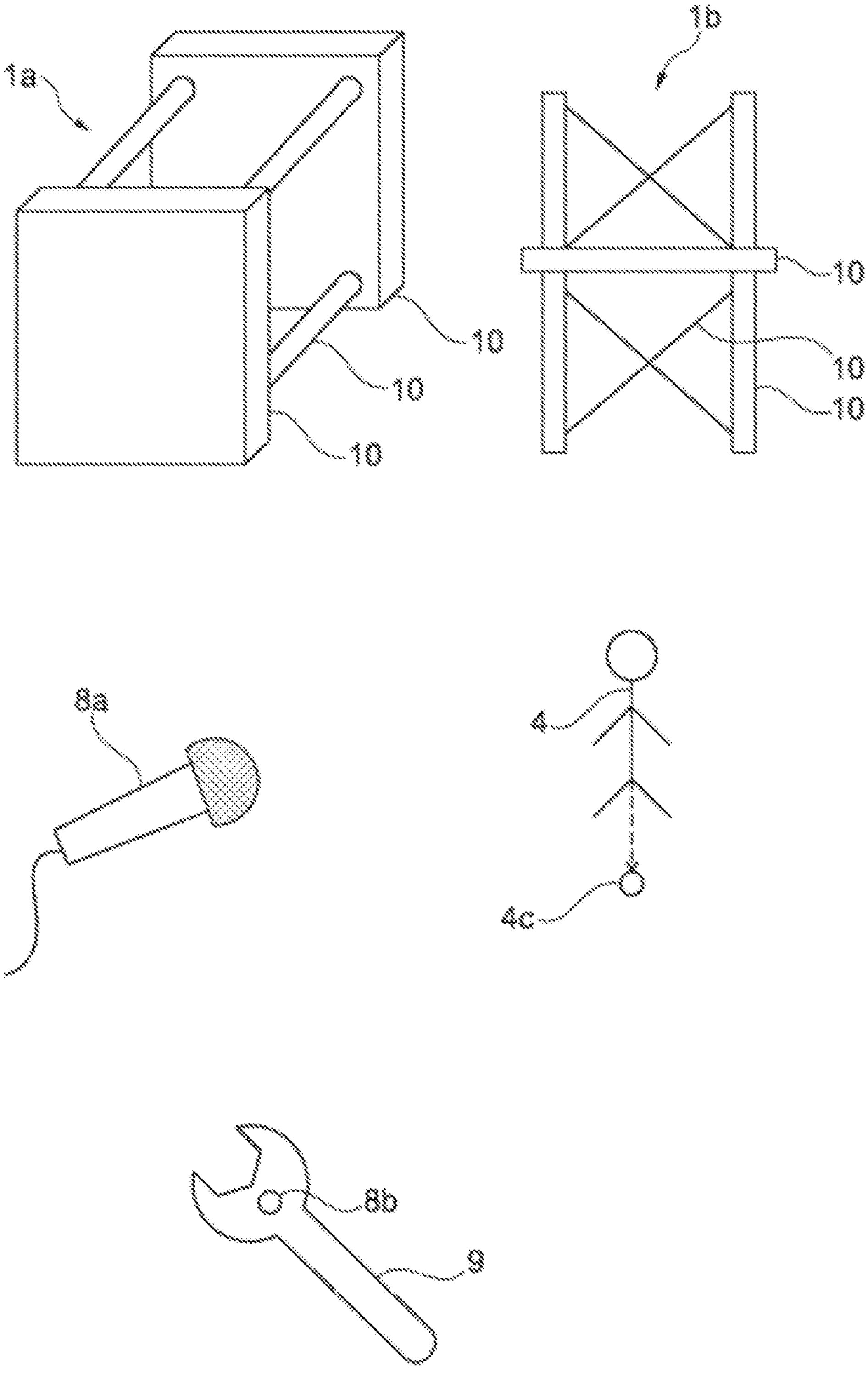

Fig. 2

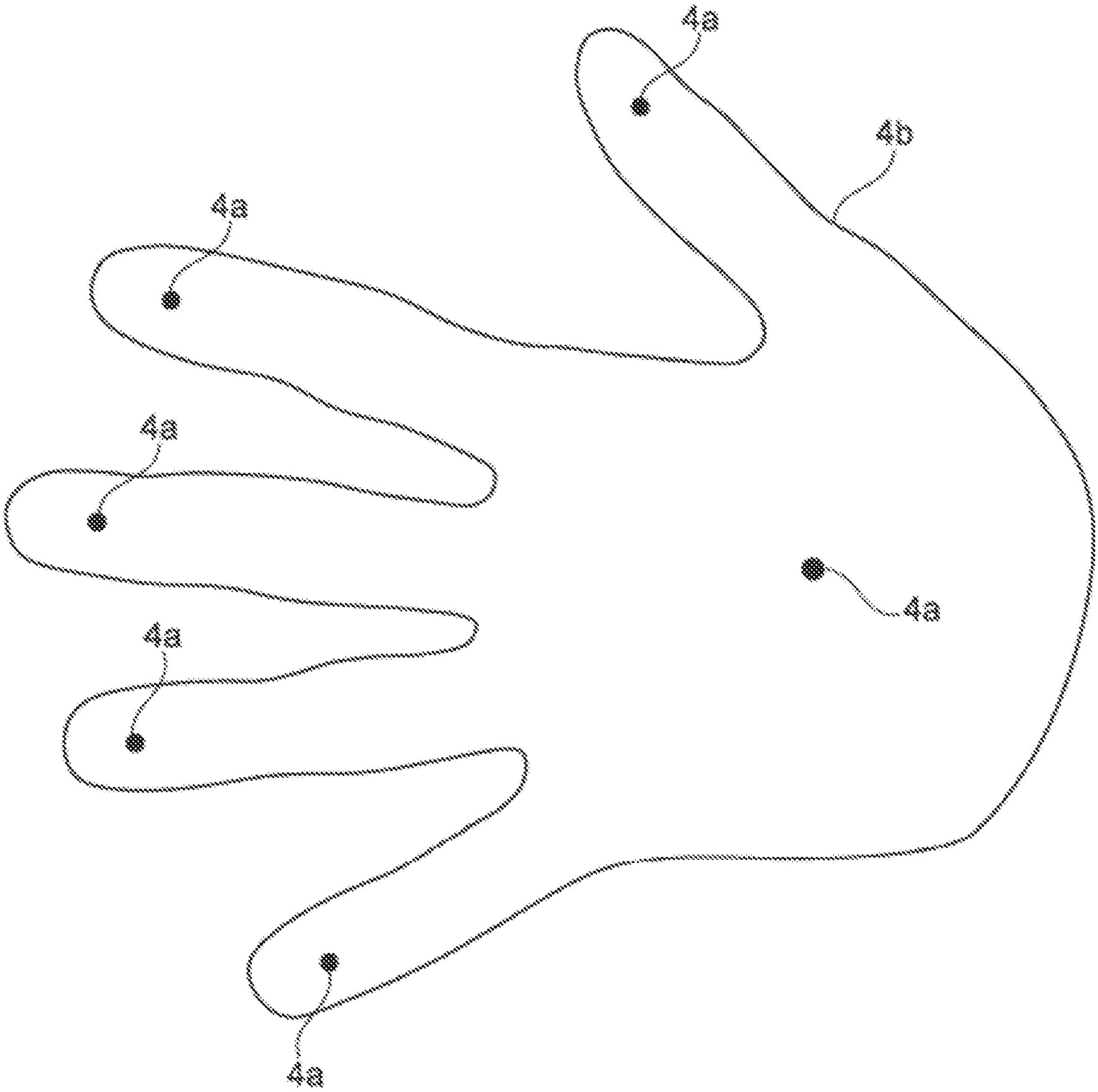

Fig. 3