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(54) **SYSTEM FOR, AND METHOD OF, SITUATION-RELEVANT ASISTANCE TO INTERACTION WITH THE AID OF AUGMENTED-REALITY TECHNOLOGIES**

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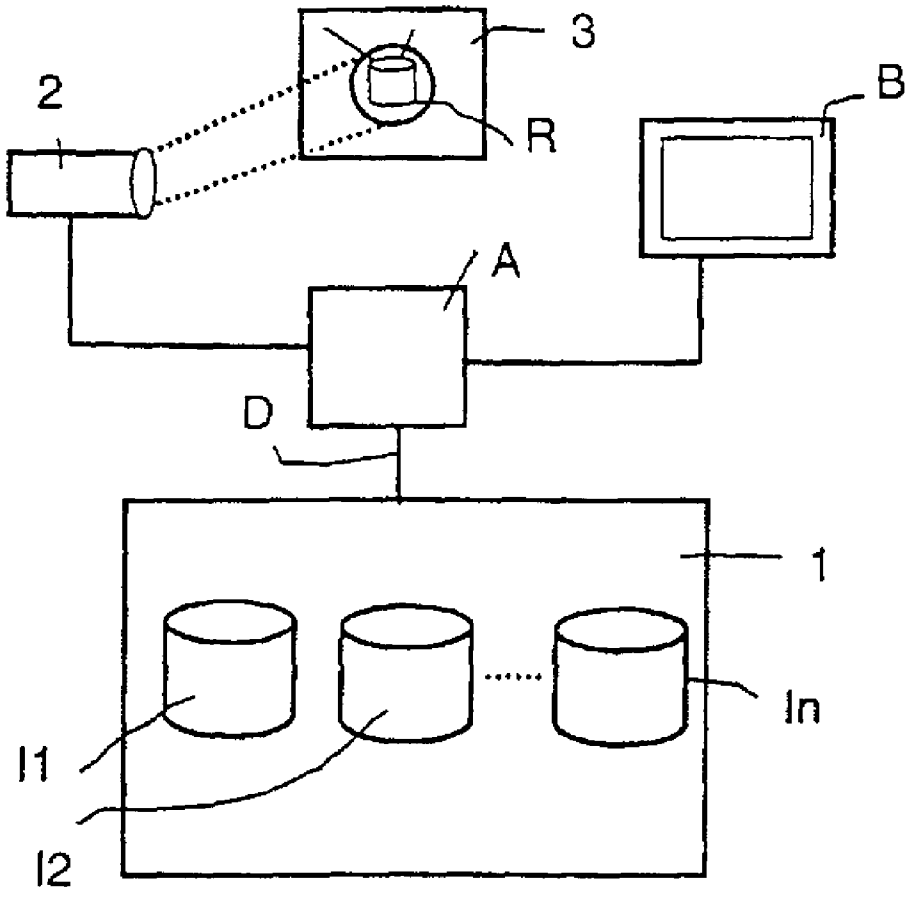
(57) **ABSTRACT**

The invention relates to a system for, and method of, situation-relevant assistance to interaction with the aid of augmented-reality technologies. To achieve optimized assistance, especially when setting up a system, commissioning and right up to the maintenance of systems and processes controlled by means of automation technology it is proposed that a specific operating situation be detected automatically, that the operating situation be analyzed and that information data relevant for the specific analyzed operating situation be automatically selected from static information and be displayed.



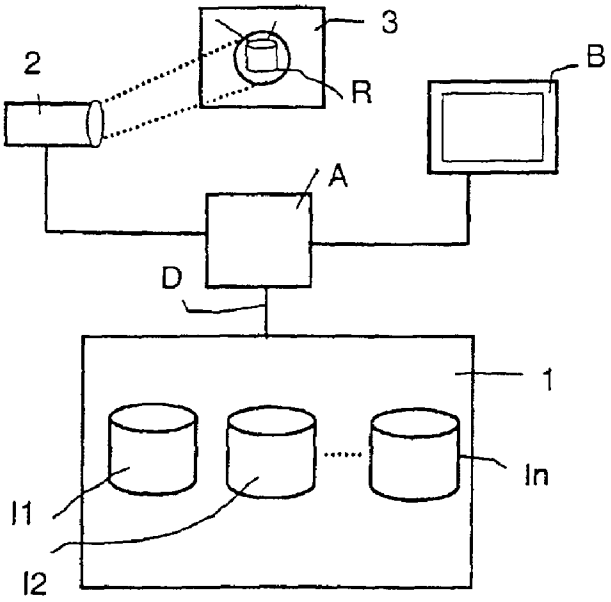


Fig. 1

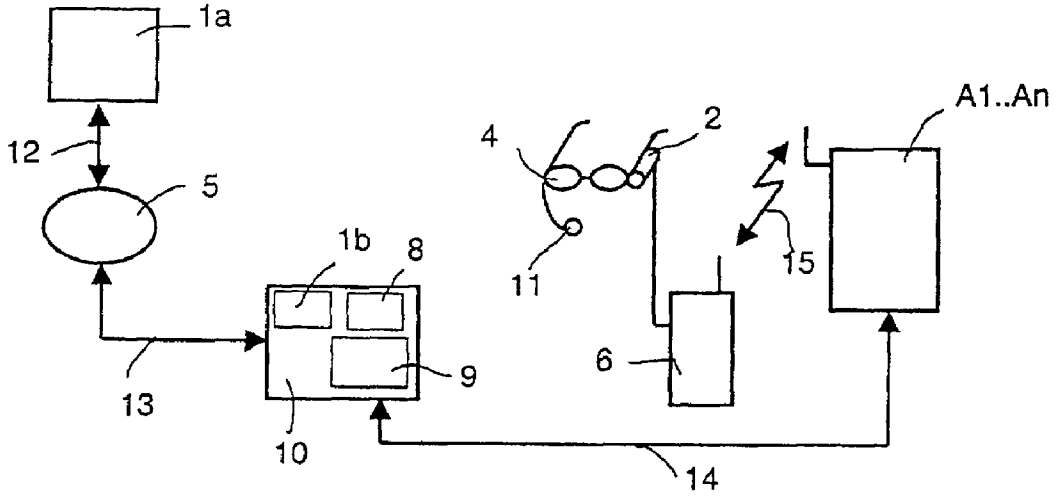


Fig. 2

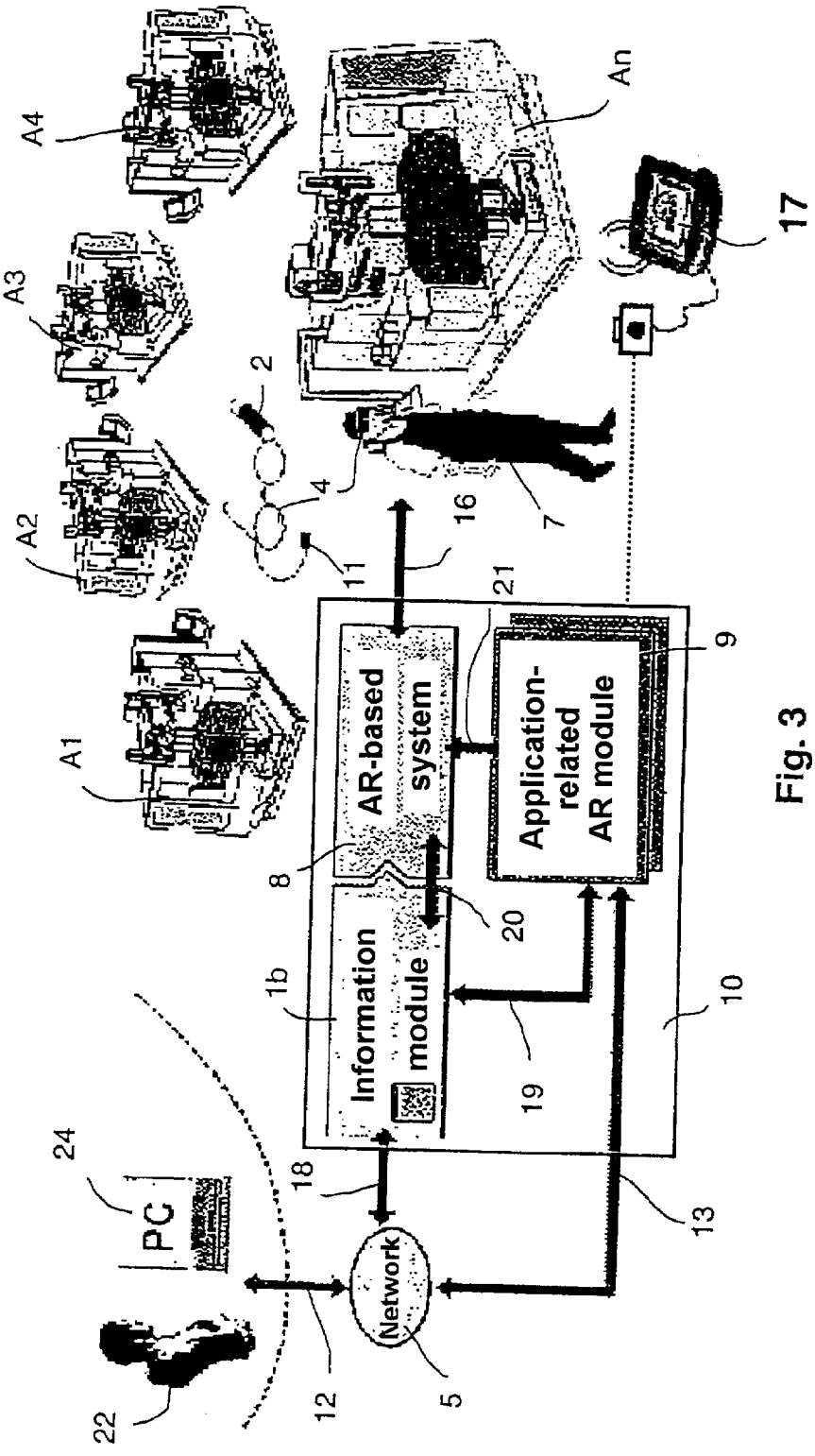

A1
A2
A3
A4
An
17
2
4
7
11
16
21
9
8
20
1b
10
19
18
13
24
PC
22
12
5
Network
AR-based system
Application-related AR module
Information module

Fig. 3

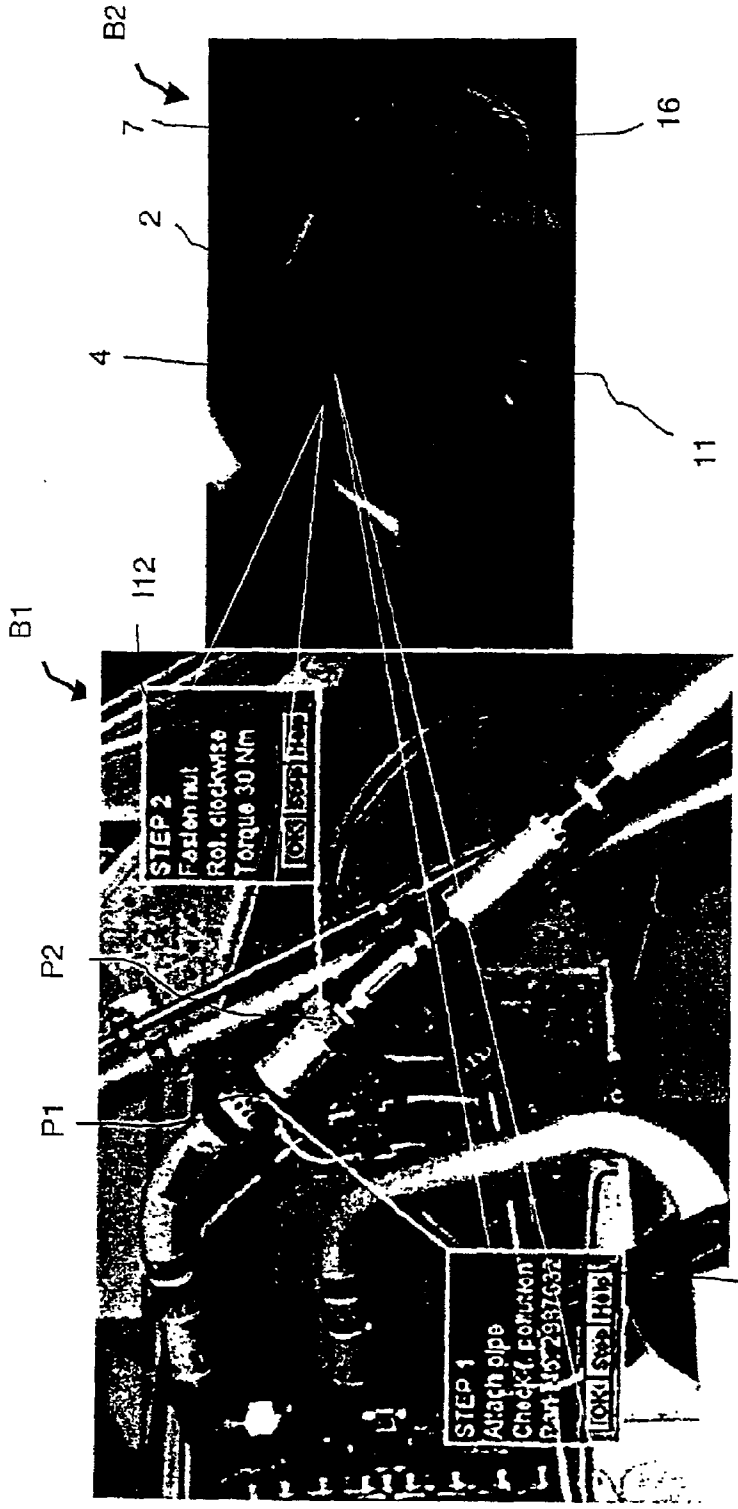

B2
7
16
2
4
11
112
B1
P2
P1
STEP 2
Fasten nut
Rot. clockwise
Torque 30 Nm
STEP 1
Attach pipe
111

Fig. 4

SYSTEM FOR, AND METHOD OF, SITUATION-RELEVANT ASISTANCE TO INTERACTION WITH THE AID OF AUGMENTED-REALITY TECHNOLOGIES

BACKGROUND OF THE INVENTION

[0001] The invention relates to a system for, and a method of, documentation processing, particularly for engineering and industrial applications.

[0002] Such a system and method are used, for example, in the field of automation technology, for production machinery and machine tools, in diagnostic/service support systems, and for complex components, equipment and systems such as, for example, vehicles and industrial machinery and plants.

[0003] GB 2 327 289 discloses a job aiding apparatus which, by means of a display, simultaneously visualizes instructions on the job to be carried out and information on the results of this job for the benefit of a conveyor belt operator. The job results are detected by the operator by means of measuring means or by entering a specific part number, and the job process is recorded by cameras.

[0004] The object of the invention to specify a system and a method which, in specific operational situations, permits rapid and reliable access to relevant documentation data.

[0005] This object is achieved by a system for documentation processing for situation-relevant assistance to interaction between a user and an engineering apparatus, particularly for engineering and industrial applications, comprising storage means for storing documentation data and comprising acquisition means designed as an image recording device for acquiring real information, comprising access means for accessing the documentation data and comprising analysis means for evaluating the real information and for selecting the stored documentation data as a function of the real information.

[0006] This object is achieved by a system for documentation processing for situation-relevant assistance to interaction between a user and an engineering apparatus, particularly for engineering and industrial applications, comprising storage means for storing documentation data and comprising acquisition means designed as an image recording device for acquiring real information, comprising access means for accessing the documentation data and comprising analysis means for evaluating the real information and for selecting the stored documentation data as a function of the real information.

[0007] The documentation data can, for example, be data compiled and collected while a plant, an automation technology-controlled system or a process was set up, and/or documentation data maintained and, when necessary, updated according to predefinable criteria during operation of a plant or an automation system. These documentation data can be stored on storage means which are stored both locally, i.e. at the site of the specific application, or alternatively at any other site, for example the site of the respective manufacturers of the individual plant components. With the aid of the acquisition means, the real information is acquired, for example from an image content, and is analyzed via the analysis means, thereby enabling the real objects to be associated with the object data stored in the documentation data. On the basis of the real information data, for example in the form of a detected object, the additional object data contained in the documentation data are then selected, particularly in an automatic manner, and are made available in situ, for example for service purposes. This enables situation-relevant, rapid access to the data specifically required.

[0008] Advantageous refinements consist in the documentation data being static and/or dynamic information data. Examples of such static information include technical data from manuals, exploded views, maintenance instructions, etc. Examples of dynamic information include process values such as temperature, pressure, signals, etc.

[0009] Rapid, situation-relevant access to the documentation data is further assisted by the feature that the acquisition means and/or the visualizing means being designed as data goggles.

[0010] The invention is described and explained below in more detail with reference to the specific embodiments depicted in the Figures, in which:

[0011] **FIG. 1** shows a block diagram of an exemplary embodiment of a documentation processing system;

[0012] **FIG. 2** shows a block diagram of an exemplary embodiment of a documentation processing system;

[0013] **FIG. 3** shows a further block diagram of an exemplary embodiment of a documentation processing system; and

[0014] **FIG. 4** shows a specific application for situation-relevant access to documentation data.

[0015] **FIG. 1** shows a schematic depiction of a system for documentation processing making use of augmented-reality techniques. The system consists of analysis means A to which acquisition means **2** and visualization means B are connected. Via a data link D, the analysis means A can be coupled to storage means **1**. The storage means **1** contain information Il..In as documentation data. The acquisition means **2** serve for acquiring real information R of a process **3**, for example an automation system or a system or process controlled by means of automation technology.

[0016] **FIG. 1** constitutes the basic structure of a system for a situation-relevant documentation processing for engineering and industrial applications. With the aid of the acquisition means **2**, for example a video camera, real information of the engineering and industrial application **3** is acquired and is analyzed and evaluated with the aid of the analysis means A, for example the digital image processing means. Analysis of the real information R with the aid of the analysis means A is performed, for example, by individual objects, i.e. individual components of an automation system or an industrial application, being detected. Said detection can be effected, for example, in the form of additional information applied to the real objects, for example in the form of bar code stickers, or by comparing the image information with reference data stored in the analysis means A and/or the documentation data **1**. After a desired object corresponding to the real information R has been found, the documentation data Il..In are displayed to a user, either automatically and/or under the user's interactive control, with the aid of the visualization means B. These documentation data Il..In form additional information for situation-

relevant assistance with the repair, with maintenance etc. Depending on the real information the documentation data required in each case are presented in accordance with the given situation. The documentation data Il..In can, for this purpose, either be stored in situ, for example on a data processing device, or at remote locations, being accessed in this case, for example, via an Internet link.

[0017] **FIG. 2** shows a schematic depiction of a documentation processing system for situation-relevant assistance to interaction between a user and automation apparatuses Al..An. The user, not explicitly shown in **FIG. 2**, is equipped with mobile equipment **4**, **6**. The mobile equipment **4**, **6** includes data goggles **4** fitted with a video camera **2** and a microphone **11**. The data goggles are linked to a device for communication without the use of wires, for example a radio transceiver **6**, which can communicate with the automation system Al..An via a radio interface **15**. The automation system Al..An can be linked, via a data link **14**, to an augmented-reality system **10**, hereinafter also abbreviated as AR system. The AR system includes an information module **1***b* for storing or accessing information data, an AR base module **8** and an AR application module **9**. The AR system **10** can be linked to the Internet **5** via a data link **13**, with optional access to further storage data and documentation data la via an Internet link **12** shown by way of example.

[0018] The user who is equipped with the data goggles **4** and the mobile radio transceiver **7** is able to move freely within the plant Al..An for maintenance and service purposes. For example, if maintenance of, or repair to, a particular subcomponent of plants Al..An has to be carried out, appropriate access to the relevant documentation data **1***a*, **1***b* is established with the aid of the camera **2** of the data goggles **4**, optionally controlled by speech commands detected by the microphone **11**. To do this, a data link to plant Al..An or with an appropriate radio transceiver unit is set up via the radio interface **15**, and the data transmitted to the AR system **10**. Within the AR system, the data obtained from the user are analyzed in accordance with the situation, and information data **1***a*, **1***b* are accessed automatically or in a manner controlled interactively by the user. The relevant documentation data **1***a*, **1***b* obtained are transmitted via the data links **14**, **15** to the transceiver **6**, with the overall result that an analysis is carried out on the basis of the operational situation detected, said analysis forming the basis for the selection of data from the available static information. This results in a situationally appropriate, object-oriented or component-oriented selection of relevant knowledge from the most up-to-date data sources **1***a*, **1***b*. Information is displayed with the aid of the visualization component used in each case, for example a handheld PC or data goggles. AR-based technologies are referred to. The operator in situ is therefore provided only with the information he needs. This information is always up-to-date. The service technician therefore does not suffer from information overload from a "100-page manual", for example.

[0019] **FIG. 3** shows a further specific application of a documentation processing system for service and maintenance. The system consists of an augmented-reality system **10** which comprises an information module **1***b* for storing information data, an AR base system **8** and an AR application module **9**. The AR system **10** can be linked to the Internet **5** via connecting lines **13**, **18**. Thence a link is possible, via an exemplary data link **12**, to a remote PC **16** with a remote expert **22**. Linkage between the individual modules of the AR system **10** is effected via links **19**, **20**, **21**. The user communication between a user **7** and the AR system is effected via interfaces **8**, **23**. To this end, the AR system can be linked to a transceiver which enables bidirectional data communication between the AR system **10** and the user **7** via data goggles **4**, either directly via the interface **8** or via a radio transceiver **17**, located in the vicinity of the user **7**, via an interface **23**. The link **23** can be implemented via a separate data link or via the mains as a "power-line" modem. As well as a display device disposed in the vicinity of the eye pieces, the data goggles **4** comprise an image acquisition device **2** in the form of a camera and a microphone **11**. With the aid of the data goggles **4**, the user **7** can move round the plants Al..An and carry out service or maintenance activities.

[0020] With the aid of the data goggles **4** and the corresponding radio transceivers, e.g. the radio transceiver **17** worn by personnel directly on the body, it is possible to achieve preventive functionality: the initial step is the detection of the respective operational situation, for example by the camera **2** or via localization by the personnel **7**. On the basis of the operational situation detected, a selection of data from the plant Al..An undergoing maintenance is made in the AR system. The fundamental advantage of the system depicted in **FIG. 3** is that this system assists the cooperation of the individual single functionalities in an application-relevant manner: i.e. firstly a specific operational situation is detected automatically, and this operational situation is then analyzed, the aspects relevant at that point being determined automatically from the most up-to-date available static information in conjunction with the dynamic data acquired instantaneously. As a result, for example, assembly suggestions are correlated with current process data. As a result, personnel **7** are provided with a situationally appropriate display of the relevant information, for example by a superposed visualization of the respective data in such a way that the real operational situation in the field of view of the personnel is expanded by the information acquired. As a result, personnel **7** are very rapidly put in the position of being able to act, thereby ensuring the requisite machine operating times.

[0021] Assistance to the maintenance technician **7** in situ can also be provided via the remote expert **22** and the knowledge **16** available at the location of the remote expert **22**.

[0022] **FIG. 4** shows a specific application of situation-relevant access to documentation data. **FIG. 4** shows a first monitor region B1 which shows a plant component. Shown in the right-hand monitor region B2 is a user **7** who, for example, is looking at an individual plant component. The user **7** is equipped with data goggles **4** which comprise a camera **2** as an acquisition means. Additionally disposed on the data goggles **4** are a microphone **11** and a loudspeaker **16**. The left-hand monitor region B1 shows a view of conduits which can be viewed with the data goggles shown in window B2. Marked in the left-hand monitor region B1 are two points P1, P2 which each represent two image details viewed with the aid of the data goggles **4**. After the first point P1 has been viewed, i.e. after the conduit disposed at or near point P1 has been viewed, additional information is visualized for the user **7** in the data goggles **4**. This additional information **11** consists of documentation data

which, regarding the first point P1, include operational instructions for this pipe section and, regarding point P2, comprise the installation instruction to be implemented in a second step. The installation instruction in this case consists of the user **7** being informed of the torque and the sense of rotation of the screwed joint of point P2 via visualization of the additional data **112**. The user **7** is therefore very quickly provided with situationally appropriate instructions for the object being viewed. If an intelligent tool is used which is able to detect the torque applied at any given moment, it is also possible for the user to be told, on the basis of the current torque, to increase or reduce the torque as required.

[**0023**] Below, background information is provided to the field of application of the invention: this involves an application-oriented requirement analysis and development of AR-based systems to support operational processes being developed, production and service of complex engineering products and plants in fabrication and process technology, and for service support systems as with motor vehicles, or for maintaining any industrial equipment.

[**0024**] Augmented reality, AR in brief, is a novel type of man-machine interaction of major potential for supporting industrial operational processes. With this technology, the field of view of the observer is enriched with computer-generated virtual objects, which means that intuitive use can be made of product or process information. In addition to the extremely simple interaction, the deployment of portable computers opens up AR application fields involving high mobility requirements, for example if process, measured or simulation data are linked to the real object.

[**0025**] The situation of German industry is characterized by increasing customer requirements in terms of individuality and quality of products and by the development processes taking substantially less time. Especially in developing, producing and servicing complex industrial products and plants it is possible, by means of innovative solutions to man-machine interaction, both to achieve jumps in efficiency and productivity and to design the work so as to enhance competence and training, by the users' need for knowledge and information being supported in a situationally appropriate manner on the basis of data available in any case.

[**0026**] Augmented reality is a technology with numerous innovative fields of application:

[**0027**] In development, for example, a "mixed mock-up" approach based on a mixed-virtual environment can result in a distinct acceleration of the early phases of development. Compared with immersive "virtual reality" (VR) solutions, the user is at a substantial advantage in that the haptic properties can be depicted faithfully with the aid of a real model, whereas aspects of visual perception, e.g. for display variants, can be manipulated in a virtual manner. In addition, there is a major potential for user-oriented validation of computer-assisted models, e.g. for component verification or in crash tests.

[**0028**] In flexible production it is possible, inter alia, to considerably facilitate the process of setting up machinery for qualified skilled operators by displaying, e.g. via mobile AR components, mixed-virtual clamping situations directly in the field of view. Fabrication planning and fabrication control appropriate to the skilled worker in the workshop is facilitated if information regarding the respective order status is perceived directly in situ in connection with the corresponding products. This also applies to fitting, with the option of presenting the individual procedural steps to the fitter in a mixed-virtual manner even in the training phase. In this connection it is possible, e.g. by comparing real fitting procedures with results of simulations, to achieve comprehensive optimizations which both improve the quality of operation scheduling and simplify and accelerate the fitting process in the critical start-up phase.

[**0029**] Finally, regarding service, conventional technologies are by now barely adequate for supporting and documenting the complex diagnostic and repair procedures. Since, however, these processes in many fields are in any case planned on the basis of digital data, AR technologies provide the option of adopting the information sources for maintenance purposes and of explaining the dismantling process to an engineer, e.g. in the data goggles, via the superposition with real objects. Regarding cooperative operation, the AR-assisted "remote eye" permits a distributed problem solution by virtue of a remote expert communicating across global distances with the member of staff in situ. This case is particularly relevant for the predominantly medium-sized machine tool manufacturers. Because of globalization, they are forced to set up production sites for their customers worldwide. Neither, however, is the presence of subsidiaries in all the important markets achievable on economic grounds, nor is it possible to dispense with the profound knowledge of experienced service staff of the parent company with respect to the increasingly more complex plants.

[**0030**] The special feature of man-machine interaction in augmented reality is the very simple and intuitive communication with the computer, supplemented, for example, by multimode interaction techniques such as speech processing or gesture recognition. The use of portable computer units in addition enables entirely novel mobile utilization scenarios, with the option of requesting the specific data at any time via a wireless network. Novel visualization techniques permit direct annotation, e.g. of measured data or simulation data, to the real object or into the real environment. In conjunction with distributed applications, a number of users are able to operate in a real environment with the aid of a shared database (shared augmented environments) or to cooperate with AR support in different environments.

[**0031**] Augmented reality has been the subject of intense research only in the last few years. Consequently, only a few applications exist, either on the national or the international level, usually in the form of scientific prototypes in research establishments.

[**0032**] U.S.A.: As with many novel technologies, the potential uses of augmented reality were first tapped in North America. Examples include cockpit design or maintenance of mechatronic equipment. The aircraft manufacturer Boeing has already carried out initial field trials using AR technology in the assembly field. The upshot is that in this hi-tech area too the U.S.A. occupy a key position, potentially making them technological leaders.

[0033] Japan: Various AR developments are being pushed in Japan, e.g. for mixed-virtual building design, telepresence or "cyber-shopping". The nucleus is formed by the Mixed Reality Systems Laboratory founded in 1997, which is supported jointly as a center of competence by science and by commerce and industry. Particular stimuli in the consumer goods field are likely in the future from the Japanese home electronics industry.

[0034] Europe: So far, only very few research groups have been active in Europe in the AR field. One group at the University of Vienna is working on approaches to mixed-real visualization. The IGD group, as part of the ACTS project CICC, which has now come to an end, has developed initial applications for the building industry and a scientific prototype for staff training in car manufacturing.

[0035] The invention in particular should be seen in the specific context of the fields of application "production machinery and machine tools" (NC-controlled, automation-technology processes) and "diagnostics/service support systems for complex engineering components/equipment/systems" (e.g. vehicles, but also industrial machinery and plants).

[0036] To sum up, the invention therefore relates to a system for, and method of, situation-relevant assistance to interaction with the aid of augmented-reality technologies. To achieve optimized assistance, especially with setting up a system, commissioning and right up to the maintenance of systems and processes controlled by means of automation technology it is proposed that a specific operating situation be detected automatically, that the operating situation be analyzed and that information data relevant for the specific analyzed operating situation be automatically selected from static information and be displayed.

We claim:

1. A system for documentation processing for situation-relevant assistance to interaction between a user and an engineering apparatus particularly for engineering and industrial applications, comprising storage means for storing documentation data and comprising acquisition means designed as an image recording device for acquiring real information comprising access means for accessing the documentation data and comprising analysis means for evaluating the real information and for selecting the stored documentation data as a function of the real information.

2. The system according to claim 1, wherein the documentation data are static and dynamic information data.

3. The system according to claim 1, wherein the analysis means for evaluating the real information are provided in such a way that a deployment context, in particular an object of the documentation data is determined from the real information, and in that the system includes visualization means for visualizing the documentation data.

4. The system according to claim 1, wherein the acquisition means are user-controlled.

5. The system according to claim 3, wherein the visualization means are designed as display devices disposed in the vicinity of eyepieces of data goggles, in that the acquisition means provided is an image acquisition device disposed on the data goggles, and in that a microphone disposed on the data goggles is provided to detect speech commands.

6. A method of documentation processing for situation-relevant assistance to interaction between a user and an engineering apparatus particularly for engineering and industrial applications, wherein documentation data are stored and real information is acquired by means of acquisition means designed as an image recording device, wherein the documentation data are accessed in such a way that the real information is analyzed and the stored documentation data are selected as a function of the real information.

7. The system according to claim 6, wherein the documentation data are static and dynamic information data.

8. The system according to claim 6, wherein a deployment context, in particular an object of the documentation data is determined from the real information, and in that the documentation data determined are visualized via visualization means.

9. The system according to claim 6, wherein the acquisition means are user-controlled.

10. The system according to claim 8, wherein the visualization means are designed as display devices disposed in the vicinity of eyepieces of data goggles, in that the acquisition means provided is an image acquisition device disposed on the data goggles, and in that a microphone disposed on the data goggles is provided to detect speech commands.

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