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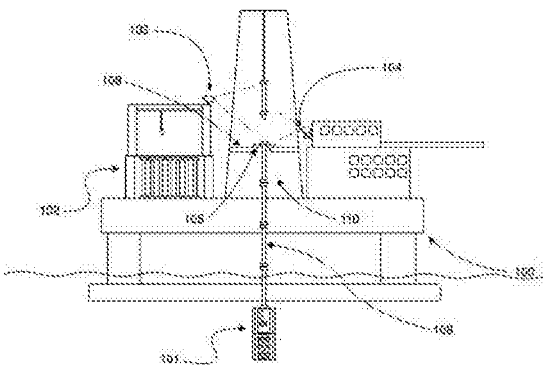
(54) Title **MONITORING AND AUDIT SYSTEM AND METHOD**

(57) Abstract

A system for monitoring and managing a plurality of elements of drilling or well control equipment positionable on a mobile drilling unit (100) is described. The drilling or well control equipment (203) is configured to be assembled during the process of drilling or workover of a new or existing oil or gas well. The system comprises at least one camera (103, 104, 105, 106, 107) arranged on the mobile drilling unit (100), the at least one camera (103, 104, 105, 106, 107) being positioned so that a visual identification of each element of the drilling or well control equipment (203) can be performed by the at least one camera (103, 104, 105, 106, 107) when the drilling or well control equipment (203) is deployed or retrieved. The camera (103, 104, 105, 106, 107) is operationally coupled to a computer system (202, 401, 501) for storing and/or processing data received from the camera (103, 104, 105, 106, 107) in order to uniquely identify and monitor the elements of the drilling or well control equipment (303) which have been retrieved or deployed.



MONITORING AND AUDIT SYSTEM AND METHOD

TECHNICAL FIELD OF THE INVENTION

This invention is related to systems and methods for identifying, monitoring and managing drilling or well control equipment relating to drilling or workover of new or existing oil and gas wells. It also relates to the generation of audit logs recording the usage of drilling and well control equipment.

BACKGROUND OF THE INVENTION

This invention relates to drilling and well control equipment used for drilling or workover on new or existing oil and gas wells offshore, which includes, but is not limited to, the following components:

- Marine Blow Out Preventer (BOP)
- Well Intervention BOP Including Well Control Package (WCP) And Lower Riser Package (LRP)
- Drilling Risers (DR)
- Workover Risers (WOR)
- Lower Marine Riser Package (LMRP) And Emergency Disconnect Package (EDP)
- Surface Flow Tree (SFT)
- Pressure Control Head and Stuffing Box
- Back Pressure Check Valve
- Kill And Choke Lines (Including Supply and Return Lines) With Manifold and Valves
- Drill Pipes
- Tools Connected to a Drill String
- Drill Bits
- Workover Wirelines and Tools

- Casings

Drilling risers are used during offshore oil and gas exploration to serve as a temporary conduit between a mobile offshore drilling unit (MODU) and a Blow Out Preventer (BOP) resting on the well head at the sea bed. Drilling risers are used on a majority of all MODUs during offshore oil and gas exploration. While this specification describes the invention with respect to MODUs, because it has particular significance for equipment which is subject to sea currents and movements associated with a waterbourne vessel, the invention extends to any form of drilling unit.

A drilling riser comprises several drilling riser joints that are connected together. A riser joint, in turn, comprises a main pipe, usually with a length between 75 and 90 feet (approximately 22.5 and 27.5 m), and in many cases with an inner diameter of 16 or 21 inch (approximately 405 or 535 mm), with connectors in each end. Alongside the main pipe there may be auxiliary lines such as hydraulic lines, high pressure choke and kill lines for circulating fluids to the BOP and usually also power and control lines for subsea equipment.

Many drilling riser joints have flotation collars (buoyancy) in order to reduce their submerged weight. Drilling riser joints with flotation collars are designed for a specific water depth range and may be visually marked with a corresponding color coding.

Drilling riser joints without flotation collars are sometimes referred to as slick joints, bare joints or naked joints. Slick joints that have a length different to the standard length are usually called pup joints, and are used in order to assemble a riser string whose length corresponds to the depth between the MODU and sea bed.

In addition, other components may have a more specific role in a riser string, for instance, a diverter whose purpose is to close the flow path and direct well flow from the riser to other equipment. Another example is a telescopic joint which consists of two barrels sliding in and out of each other in order to compensate for MODU heave movements. Flex joints are another type of specialized joints and are located both on the upper and lower part of the riser string, the main purpose of which is to compensate for bending moments due to lateral movements as well as roll and pitch movements of the MODU.

Other types of joints may or may not be a part of a riser string, and serve a special purpose such as instrumented riser joints which can provide sensor feedback from the riser string, for instance strain measurements or measurement of the gravity field allowing to provide a real image of the riser configuration underwater. Another example is fill-up valves, which are special joints that enable the riser annulus to be opened to the sea to prevent riser pipe collapse due to differential pressure between the inside and outside of the riser.

A complete riser string comprises all of the riser elements that are needed to build a complete conduit from the MODU to the well head. It will normally comprise a minimum of the following components; a diverter, an upper flex joint, a telescopic joint, a number of riser joints with or without buoyancy, pup joints, a lower flex joint, a lower marine riser package (LMRP) and a blow out preventer (BOP).

A drilling riser is deployed into the sea from a MODU joint by joint through a moon pool. For every additional joint that is to be attached, the so far assembled riser string is hung off in a spider while the new riser joint is being prepared and lifted into place by a crane. When the new joint is securely connected to the rest of the string, the spider will release and the load of the riser string is transferred to the crane, which then lowers the riser string through the spider, which again closes, thus enabling yet another joint to be connected. At the final stages of a riser string deployment the riser load is transferred to a tensioning system, which provides tension to avoid the riser collapsing due to its own weight.

Once a riser string is connected to a well head and properly secured on the MODU, a drill string can be lowered through the riser. Segments of two or more drill pipes are then assembled together and placed in a pipe rack ready to be deployed. The drill string segments, with a drill bit at the end, are assembled together and lowered into the riser. Once the drill string reaches solid ground, drilling can commence. The riser will then act as a means to circulate drill mud, which enables the removal of cuttings and pressure control of the drilled well.

Workover risers are open-water risers designed for installation, completion and intervention of subsea oil or gas wells.

Contrary to drilling risers, which have a low pressure inside its riser, workover riser systems utilize a surface flow tree on the MODU and thus maintain a high pressure throughout the riser.

While drilling risers mainly are used during exploration of new oil or gas fields, workover risers are mostly used during workover operations on existing oil or gas fields. They are primarily intended to retain well pressure control while facilitating the passage of tools in order to perform various tasks on the existing wells.

Workover risers usually have between a 5 and 8 inch (approximately 125 and 200 mm) bore size and do not use flex joints in the upper and lower part as used for the drilling riser. Instead, stress joints are used whose purpose is to withhold bending moment induced from movements of the vessel.

A workover riser typically comprises of the following components:

- Workover Bop
- Emergency Disconnect Package
- Retainer Valve(s) To Retain the Fluid Contents of the Riser During an Emergency Disconnect
- Stress Joints
- Workover Riser Joints
- Lubricator Valve(s)
- Telescopic Joint
- Surface Flow Tree
- Tension Joint with Corresponding Tension Frame

Drilling risers and workover risers, hereby referred to as drilling and well control equipment, are mission critical and need to be inspected and (re)certified during their lifespan to ensure safe operation and compliance with regulations. General maintenance of well control equipment is performed periodically both offshore as well as onshore. Full re-certifications, however, need to be performed at certain intervals in certified onshore workshops, carried out by qualified and trained technicians and approved by class societies.

Class societies, operators, rig owners and local authorities, amongst others, are all involved in determining the frequency and extent of maintenance and certification, however in many cases well control equipment manufacturer's maintenance recommendations will serve as a basis for the determinations. Some manufacturers recommend that the equipment is re-certified every 4-5 years while class societies normally have a 5-year re-certification requirement. On many occasions, no reliable records showing actual time in operation for the equipment are kept and maintained, leading to re-certification every fifth calendar year, in contrast to the requirement for re-certification after five years operational time. When a 5-year re-certification scheme is followed, typically 20% of the equipment is shipped onshore to be re-certified every year, with no consideration taken to the actual usage of this equipment.

The logistics involved with onshore maintenance and re-classification is complicated as in many cases it involves transporting equipment to offshore supply bases, from where the equipment is further transported to certified workshops. After the equipment has been maintained, checked and inspected, it needs to be shipped back offshore again.

Re-certification of well control equipment involves several steps and can for instance involve some or all of the following work to be performed:

- Disassembly
- Sand Blasting
- Ultrasonic Shear Wave Inspection and Dye Penetrant Inspection
- Welding repairs
- Riser Line Seals Removal, Inspection and Replacement
- Dimensional Inspection
- Riser Collars, Thrust Collars and Plates Inspection

- Coatings Inspection
- Riser Buoyancy Inspection
- Hydraulic, Choke and Kill Lines Inspection and Maintenance.
- Painting and Coating
- Reassembly
- Pressure Testing
- Quality Assurance and Quality Control
- Documentation

As the practice of following a strictly periodic (calendar based) maintenance is costly and logistic intensive, the inventors have identified a need for a system that can keep track of the usage of the drilling or well control equipment used during the process of drilling and workover of new or existing oil or gas wells. A need is identified for a system that will allow drilling and well control equipment owners to practice *usage based maintenance* or *condition based maintenance*, in contrast to periodic maintenance, meaning that the extent and frequency of maintenance and re-classification may be determined by taking actual equipment usage history into consideration.

The inventors further recognize that the need identified, in addition to drilling risers and workover risers, also applies for other drilling and well control equipment that is deployed or retrieved from a MODU, such as, but not limited to, drill pipes, drill bits, tools and casings.

Various initiatives using sensors for keeping track of equipment usage have been tried out by the industry. One of the most common methods is using radio frequency identification tags (RFID). RFID tags can be read by a mobile handheld device or a reader built into existing equipment on, or close to, the drill floor.

One challenge with RFID is that the tracked equipment has to be modified in order for the RFID tags to be installed. Further, by using handheld devices for reading the tags, there is a risk that scanning can be neglected or otherwise prone to human error. By having an RFID reader incorporated in or close to the drill floor, for instance in the spider, automatic readings can be achieved, however installing and maintaining electronic components in such harsh and hazardous environments has proven to be challenging. In addition, a single RFID signal does not allow the system to define whether the drilling or well control equipment is moving downwards, or upwards.

SUMMARY OF THE INVENTION

The inventors have identified a need for tracking and logging usage of drilling or well control equipment in a cost effective and reliable manner.

Viewed from a first aspect, the present invention can be seen to provide a system for monitoring and managing a plurality of elements of drilling or well control equipment positionable on a drilling unit, said drilling or well control equipment being configured to be assembled during the process of drilling or workover of a new or existing oil or gas well, characterised in that the system comprises at least one camera arranged on the mobile drilling unit, said at least one camera being positioned so that a visual identification of each element of the drilling or well control equipment can be performed by the at least one camera when the drilling or well control equipment is deployed or retrieved, said at least one camera being operationally coupled to a computer system for storing and/or processing data received from said at least one camera in order to uniquely identify and monitor the elements of the drilling or well control equipment that have been retrieved or deployed.

The system proposes utilizing digital or analog video or images from one or more cameras installed on a rig, for example a MODU. The camera(s) will provide a continuous flow of imagery data, for example as a data stream, to be stored on a computer storage device, for example a hard disk drive, a solid state memory or a cloud-based storage resource, collectively referred to as a storage medium, that can be later retrieved from the storage medium and processed at any time later by the system proposed. In case of an analog video stream, the video may be digitized using an analog to digital video converter before being stored on a computer device or storage medium and later processed by the system proposed.

The camera(s) can be connected to the system using industry standard cables, for example Ethernet TCP/IP connections or dedicated USB cables, or they might be connected to the system wirelessly or in any other way. The camera(s) can be located at a distance far away from where the drilling or well control equipment is being tracked and thus avoid the need for electrical or sensitive equipment in critical and exposed areas, such as the drill floor area or moon pool area. The cameras can also be positioned above the drill floor area or moon pool area, preferably observing the assembly and disassembly of the drilling and well control equipment from above the level of a spider from which a riser system or drill string is suspended during deployment and retrieval of the equipment. With appropriate camera lenses and features such as image stabilization the camera(s) could be located as far as 200 meters away from the equipment being recorded, but preferably at less than 100 m, or even less than 50 m. In any event, in contrast to the RFID readers, they can be a safe working distance away from the harsh and hazardous environment of the drill floor.

The digital video can be split into single images, which may be compressed in order to optimize storage size requirements by reducing unnecessary and redundant data.

The system will use software algorithms for computer vision and image recognition in order to extract key information from the imagery data. The key information can be for example visual characters such as text, numbers or symbols, or the key information can be object features, physical dimensions, colour or pattern information. Based on the key information extracted, the system will further be able to uniquely identify individual elements of the drilling or well control equipment being presented in the imagery data.

By processing and analyzing images sequentially in the time domain, the system will be able to track the moving direction of the equipment. This can be done by locating specific elements in the imagery data and comparing that location with the previous imagery data element location. This enables the possibility to keep track of whether the drilling or well control equipment is being deployed or being retrieved.

One of the disadvantages of using traditional sensor based technology, such as RFID, for tracking drilling and well control equipment is the lack of auditability, for instance by class societies and authorities which may be responsible to control that the equipment is being maintained in the correct and timely manner. For example, providing an auditor with data from sensors showing that a component has been in operation for a certain number of days is not unquestionable because it could, for example, be that the sensors performing the monitoring were shut off or malfunctioned for a period of time. By using imagery data, one could store all of the data generated by the camera(s) onboard the drilling unit even when the equipment is not being used and thus prove that the equipment was only deployed in that specific time span that has been logged. It will also be possible to provide an auditor a full visual representation of the equipment that was deployed, thus allowing a manual inspection of the recognition results.

The resulting audit log may comprise an audit log recording at least the usage of each of a plurality of elements of drilling and well control equipment deployed and retrieved over a period of 12 months, more preferably over at least three years, and more preferably over five years or more. The audit log is preferably of a form which is able to satisfy drilling and well control equipment certification requirements. For example, preferably the audit log provides a continuous log over this period. Preferably it is also able to give information concerning the operational condition of the equipment.

Another key advantage by using camera technology is the possibility of performing visual inspection for damages or wear and tear of the drilling or well control equipment remotely. Visual inspection is performed, in many cases, as a manual task, either when the drilling or well control equipment is deployed or retrieved, or at other times. By having access to imagery data, one can automate this inspection process or perform the inspection remotely at any time after usage. The imagery data may have been captured with one or several cameras with special properties or features, for example special lenses or optical filters. The delayed processing of data can, for example, add filters, remove noise or utilize any other digital image processing algorithms or techniques to improve the recognition and information extraction from the imagery data. The imagery data may also provide a resource or archive that can be used and accessed, for example, with filters to provide data on the drilling and well control equipment. This might help in an after-the-event analysis of the equipment if there has been an equipment failure of some form. It may be determined whether, and to what extent, defects or other observable conditions were previously present. Combining this analysis with previous operational history of the failing component can allow for even more advanced analysis and ultimately information that may be valuable, for instance, in order to implement further precautious measures or to improve design of new equipment.

Viewed from a second aspect the present invention can be seen to provide a method for monitoring and managing of a plurality of elements of drilling or well control equipment positionable on a drilling unit said drilling or well control equipment being configured to be assembled during the process of drilling or workover of new or existing oil or gas well, characterised in that for each element of drilling or well control equipment being assembled the method comprises the following steps:

receiving imagery data of the drilling or well control equipment from at least one camera installed on the mobile drilling unit;

storing the imagery data together with a timestamp into an imagery data storage;

processing identification information from the imagery data in order to uniquely identify elements of the drilling or well control equipment;

matching the identification information with an inventory list stored in a drilling or well control equipment data storage; and

storing identification information for each element of the drilling or well control equipment with matching identification information in said inventory list in a result storage.

Viewed from a third aspect, the present invention can be seen to provide an audit log system for generating an audit log recording deployment and retrieval of drilling or well control equipment that is assembled and dissassembled on a drilling unit, the audit log system comprising a computer system that is programmed to analyse a received data stream of imagery data taken from one or more cameras provided on the drilling unit arranged to record in the imagery data the deployment and retrieval of the drilling or well control equipment, the computer system comprising:

a data storage section for storing the imagery data and generated audit logs; and

a data processing part for analysing the imagery data,

wherein the computer system is configured to:

analyse the imagery data to identify elements of the drilling or well control equipment being deployed or retrieved through image recognition performed on the imagery data;

determine usage for each of a plurality of the elements;

generate usage data logging periods of usage for each of the plurality of elements; and

output an audit log of the usage data for each of a plurality of elements of the drilling or well control equipment for certification purposes.

The audit log system may be automated to determine usage for each of the plurality of elements from the imagery data automatically.

Viewed from a fourth aspect, the present invention can be seen to provide a method of generating an audit log recording deployment and retrieval of drilling or well control equipment that is assembled and dissassembled on a drilling unit, using an audit log system comprising a computer system, the method comprising:

receiving in the computer system a data stream of imagery data taken from one or more cameras provided on the drilling unit that are arranged to record in the imagery data the deployment and retrieval of the drilling or well control equipment;

analysing the imagery data to identify elements of the drilling or well control equipment being deployed or retrieved through image recognition performed on the imagery data;

determining usage for each of a plurality of the elements;

generating usage data logging periods of usage for each of the plurality of elements; and

outputing an audit log of the usage data for each of a plurality of elements of the drilling or well control equipment for certification purposes.

Viewed from a fifth aspect, the present invention can be seen to provide a computer program product comprising software instructions that when run on a computer system generate an audit log recording deployment and retrieval of drilling or well control equipment that has been assembled and dissassembled on a drilling unit, by:

receiving in the computer system a data stream of imagery data taken from one or more cameras provided on the drilling unit that are arranged to record in the imagery data the deployment and retrieval of the drilling or well control equipment;

analysing the imagery data to identify elements of the drilling or well control equipment being deployed or retrieved through image recognition performed on the imagery data;

determining usage for each of a plurality of the elements;

generating usage data logging periods of usage for each of the plurality of elements; and

outputing an audit log of the usage data for each of a plurality of elements of the drilling or well control equipment for certification purposes.

The audit log produced by the system may allow owners of such drilling and well control equipment to switch from strict periodic maintenance over to usage or condition based maintentance (for example, based on equipment time in operation). Maintaining equipment based on its actual condition will allow for longer time intervals between re-certifications.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be explained in detail by way of example only and with reference to the accompanying drawings, in which:

Fig. 1A shows a perspective view of a mobile offshore drilling unit which is in the process of deploying drilling or well control equipment. The figure shows two cameras that are capable of capturing imagery data of the well control equipment being lowered into the sea;

Fig.1B shows another embodiment of the invention with possible alternative locations of camera or cameras to be used for tracking of the drilling or well control equipment. Although Fig. 1A shows cameras located with free line of sight into the drill floor area, it is also possible to locate cameras, for example, in the moon pool area or in the riser storage area;

Fig. 2 shows a camera with its connection to a computer able to process the imagery data. It also shows the drilling and well control equipment to be tracked, in this case a riser joint;

Fig 3 shows a first embodiment of the data flow in the computer software program;

Fig 4 shows a first embodiment of the MODU computer connected to an onshore based computer or server;

Fig 5 shows a second embodiment of the MODU computer connected to a cloud based virtual server;

Fig 6 shows a second alternative embodiment of the data flow in the computer system managing and processing the imagery data; and

Fig 7 shows a third alternative embodiment of the data flow in the computer system managing and processing the imagery data.

DETAILED DESCRIPTION OF THE INVENTION

A first embodiment of the system for monitoring a riser joint deployed in the sea is shown in figure 1A.

The terms *well control equipment* or *drilling equipment* are hereinafter used with respect to specific embodiments where an element of the equipment is a riser or part of a drillstring; however, the terms *well control equipment, drilling equipment* and *element* must be interpreted broadly in the context of this specification. The element could also be other drilling or well control equipment such as any of the equipment itemised in the background of invention section.

Fig 1A shows a mobile offshore drilling unit (MODU) 100 in a perspective view. The MODU is in the process of deploying a riser system 109 with a blow out preventer stack (BOP stack) 101 attached at the lower part of the riser system 109. The riser system 109 comprises a plurality of riser joints 203 connected together and extending towards the seabed. In the figure, the riser system 109 is shown hanging in a spider 105 located in a drill floor area 108 and a new riser joint 203 is in the process of being lowered and assembled with a plurality of riser joints to the riser system 109. The riser system 109 is extending through a moonpool area 110. The moonpool area 110 is defined as the area below the drill floor giving access to the water below. A riser storage area 102 is located on the deck of the MODU. The riser storage area 102 comprises a plurality of stored riser joints 203 which may be moved into the drill floor area 108 and connected to the riser system 109.

The riser storage area 102 and the process of deploying, retrieving and connecting the riser joints 203 together in the riser system are known per se.

Fig. 1A shows a camera 103 located on top of the riser storage area 102 and a camera 104 installed on a building structure on the MODU. Possible locations for the cameras 103, 104 are any location onboard the entire MODU where they can provide imagery data into the proposed system, but will typically be located 5 to 80 meters away from the objects being recorded, preferably 10 to 50 meters, though they may be located as far as 100 meters, 200 meters, or even further away. Although the cameras usually installed onboard a MODU are standard CCTV cameras, it is understood that the camera technology utilized for obtaining imagery data also could involve other types of camera technologies, such as cameras able to detect information not visible to the human eye, for example, infrared energy or any other spectrum.

The imagery data could for instance contain a tag number, text or a symbol 204, etc., that is marked on the drilling or well control equipment (203) or any other characteristics that could uniquely identify each of the drilling or well control equipment (203) such as object features, physical dimensions or pattern information. The imagery data could include colour coding applied to the elements to indicate a working level. The imagery data may also contain qualitative information on the equipment, such as for example integrity, corrosion, bulks or minor, as well as major, defects and other observable conditions.

Fig 1B shows other examples of locations of the cameras 106, 107 that can provide imagery data. A camera 106 is in this embodiment located outside the moon pool area 110 and another camera 107 is located in the riser storage area 102.

Camera 103, 104, 105, 106, 107 can be located in several different locations to provide multiple sources of imagery data. Possible locations can be, but are not limited to the drill floor 108, moon pool area 110 and riser storage area 102. While one imagery data stream from a single camera 103, 104, 105, 106, 107 might be sufficient, the system proposed may also be designed to utilize several independent imagery data streams in order to get a full and redundant overview of all drilling or well control equipment 203 being lowered into and retrieved from the sea.

Utilizing cameras 103, 104, 105, 106, 107 both above and below the drill floor, enables imagery data not only of the riser deployment, but also deployment of other equipment such as the BOP stack 101.

Further, reliability and robustness of the proposed system is enhanced by simultaneously capturing several independent imagery data streams, thus reducing the risk of insufficient or corrupt data, which, for instance, may be caused by issues such as temporarily covered camera line of sight or malfunctioning hardware components.

Fig 2 shows a physical connection 201 between one camera 103, 104, 105, 106, 107 and the computer 202 in the proposed system. The camera 103, 104, 105, 106, 107 has direct line of sight to the equipment being tracked, in this case a riser joint 203.

A majority of MODU’s have numerous CCTV-cameras 200 already installed onboard that are used for, for instance, surveillance of critical tasks and ongoing operations. A common way to distribute imagery data from these cameras is over TCP/IP through Ethernet cables in existing data networks onboard the MODUs. In addition to being able to connect to proprietary camera systems, the proposed system may also be able to connect to the same data networks to receive imagery data. The proposed system may be designed to handle several different physical camera connections or camera bus technologies, such as, but not limited to, industry standard Ethernet, USB, Firewire or it might even be able to handle wireless connections.

The imagery data received in the computer 202, which may also be a PC, PLC, server, virtual computer or similar, is stored on a local storage medium, on a storage medium on-shore, or in a cloud service. The imagery data can be processed in real time from the imagery data provided by the camera(s) or it can be processed by fetching data from storage at a later stage. It may also be processed in several steps, such as for example a near real-time pre-processing to identify the riser joint, and a later processing to identify possible rust, bulks etc. The processing of the imagery data can include but is not limited to using computer vision technology and algorithms for optical character recognition, feature detection, and object detection and extraction.

Fig. 3 shows the data flow of the computer software program for the system shown in figure 2. In this embodiment, the reception, processing and storage of the data is performed by the local computer 202 arranged on the MODU.

The imagery data 300 is received in the computer 202 on which a program 302 executes a number of operations. The imagery data 300 is received in a first step 303, pre-processed, compressed if it is desired to reduce unnecessary and redundant data in order to optimize storage and/or satisfy transmission requirements, and stored in a second step 304. The imagery data 300 is further stored together with a timestamp 311 (date and time provided by a clock 310) in an image storage 308, which for example can be a database. The time stamp 311 may make it possible to determine exactly the time domain in which the drilling or well control equipment 203 was in the cameras field of view.

Where an imagery data stream is being received from more than one camera, the embedded time stamps 311 can be used to synchronise the data and the usage data sourced therefrom. The plurality of cameras can use a common clock 310 to set their respective time stamps 311.

In addition, other information than time stamp 311 may also be stored in the image storage 308. This information may for example be related to which camera the imagery data originates from or the physical location of the camera. This will make it possible to select imagery data for image processing either from a specific time period or from one specific camera.

Image processing 305 is performed with software algorithms for computer vision and image recognition in order to extract identification information from the imagery data 300. The image processing/computer vision function 305 can process imagery data either directly from the pre-processing, compression and storage function 304, or it can fetch imagery data from the image storage 308 at a later stage. The image storage 308 may, for example be a database, a file structure on a hard disk or any other organized collection of data stored in a physical medium. The identification information can be for example visual characters such as text, numbers or symbols. The identification information may also be object features, physical dimensions, colour or pattern information in addition to the visual identification marks.

Based on the identification information extracted, the system may further be able to uniquely identify 306 the drilling equipment 203 being presented in the imagery data 300 by comparing and matching the identified characteristics with data stored in the riser data storage 309. When the imagery data 300 is being processed the result of this identification process may be matched towards a predefined inventory list in the equipment data storage 309, where all identifiable drilling or well control equipment is stored. For example, if the computer vision algorithms detect a serial number string within the imagery data, that serial number string may be pre-configured in the equipment data storage where links between configured components and the number strings are stored. When a match is found, the imagery data, an equipment identification number, direction and time stamp will be stored in a database for later reference.

By processing and analyzing images sequentially in the time domain, the system may be able to track the direction of equipment. This can be done by locating specific elements of the drilling and well control equipment in the imagery data and comparing that location with the previous imagery data element location. This enables the possibility to identify whether the drilling or well control equipment 203 is being lowered or raised, hence identifying whether the drilling or well control equipment 203 is being deployed or retrieved.

The riser data storage 309 may store for example an identification number for a given piece of equipment (an “element” of the drilling or well control equipment), the time and date of its deployment and retrieval, its usage, but also all other characteristics of that equipment: size, colour, date of fabrication, or any other relevant data related to the tracked equipment. The system may also update a record of the life used up or life remaining based on fatigue lifetime or other lifetime property based on corrosion, operational stresses in axial or circumferential directions, e.g., through weight on the riser section or torque, or through current-induced vibrations, measured through appropriate sensors matched to the imagery data through a time stamp or the like.

Fig. 4 shows possible embodiment of a MODU 400. A local computer 401 is arranged on the MODU 400. The local computer 401 is connected to a remote computer 404 on an onshore base 403. The connection 402 can be a standard internet connection delivered through satellite communication or other wireless communication protocol 402.

Fig. 5 shows another possible embodiment of a MODU 500 where the MODU having a local computer 501 is connected to a remote virtual server 503 located in a cloud based infrastructure center 504. The connection 502 can be a standard internet connection delivered through satellite communication or other wireless communication protocol 502 similar to that described in figure 4.

Fig. 6 shows a second alternative embodiment of the computer software program for the system shown in figure 2. The computer 602 located on the MODU 401, 501 is receiving imagery data 601 in a computer program 603. The computer program 603 is handling the reception of the data 604 and sends the data to a pre-processing, compression and storage function 605. This may, for example, include splitting of video frames to single images, removal of duplicated data in the imagery data or using compression algorithms to optimize storage requirements. This function stores the image in a local database 607 for later retrieval and distribution in the image distribution function 606. The image distribution can be real time or delayed depending on status of the onshore connection and the operator's needs. The imagery data is preferably stored together with a timestamp in the local image storage so that it is possible to determine exactly in which time domain the drilling equipment 203 was in the camera's 103, 104, 105, 106, 107 field of view.

When the MODU has a valid connection, the image distribution function 606 distributes images to an onshore facility 405, 504 with a dedicated computer or server 609, but this can also be a cloud based virtual server infrastructure 404, 504 as described in relation to figure 4 and 5. The program 610 running on the onshore facility 404, 504 handles the reception of imagery data 611 from the image distribution on the MODU. The images are received and sent to a function for image processing 612, which involves utilizing computer vision algorithms to detect text or symbols or object features, or any combination of these to identify unique features of this component. The result from the image processing may be stored in an onshore local database 614 and sent to an equipment identification and usage tracking function 613. This function will, based on the computer vision result, identify the element of drilling or well control equipment 203 from the imagery data and store the usage data in the onshore data storage 614 which is equivalent to the offshore equipment data storage 309. The system may log the amount of fatigue lifetime used or remaining for each of the elements. Other relevant information extracted from the computer vision result may also be stored in the onshore data storage. This could be for example information relating to physical attributes or appearance of the riser. For reference purposes or for third party validation of the computer vision results, one could also store the original imagery data in the data storage and link it to the audit log data.

Fig. 7 shows a third alternative embodiment of the computer software program for the system shown in figure 2. The computer 700 located on the MODU 700 may in this situation only handle the most necessary parts of the imagery data reception and distribution, while all processing, storage and equipment identity matching may then occur on an onshore computer located onshore or in a cloud facility. The imagery data is received by the computer 702 on the MODU 700 which may have a program 703 that may handle the reception 704 and distribution 705 of imagery data. In case of no connection to an onshore facility 706 the image distribution function may buffer imagery data in a data buffer section until connection is re-established. As long as the MODU has a connection to an onshore facility the computer software program 708 running on a dedicated server or a cloud based virtual server 707 may receive the imagery data in the reception function 709. This function may further send the imagery data to a pre-processing, compression and storage function 710. This step could, for example, include splitting of video frames to single images, removal of duplicated data in the imagery data or using compression algorithms to optimize storage requirements. This function may store the imagery data in a data storage 713 that could be a database or any other computer based storage facility. The image processing, computer vision algorithms function 711 may further handle the analysis of the imagery data to extract unique identification information from the data. This function may receive imagery data directly from the pre-processing, compression and data storage function 710 or it could receive data from the data storage 713 at a later stage. The computer vision algorithms function 711 may also detect image anomalies or other possible conditions or defects, for instance corrosion or bulks and generate a message in a dedicated field in the database. After the identification information is extracted from the imagery data, this information may be sent to an equipment identification and usage tracking function 712. This function may compare the results from the image processing, computer vision algorithms function 711 with pre-configured data of all the available components that may be tracked. When a match is found, the imagery data, an equipment identification number, direction and time stamp, and any other further information deduced from the imagery data or fed from ancillary sensors, may be stored in a database for later reference.

The stored imagery data can provide a continuous historical record of an area of the drilling unit, for example, the operations of the drill floor over a broad period of time. This is in contrast to the spike of information provided by an RFID reader when it records a tag passing before it. The imagery data can provide a valuable resource or archive for other information that later becomes helpful to the operation and management of the drilling unit.

There are several advantages of utilizing imagery data for tracking drilling or well control equipment compared to more traditional industrial sensors, like for example RFID. One advantage is that it is possible to document that the drilling or well control equipment was not in use for a specific time period. For time periods where the drilling equipment is not deployed the imagery data could still be stored in the data storage to show that no equipment was in the water. When using other systems, like for instance RFID, it is possible that the system could have malfunctioned for a time period, or that the tracking system was powered off during deployment and retrieval of the drilling equipment. Another likely failure of an RFID system is the loss of one or more RFID tags. It is also possible for an RFID tag attached to a specific element to malfunction, or for a new part on the MODU not to be tagged with an RFID tag. An RFID system alone would not be able to detect this. By contrast, by utilizing imagery data the system could be so configured that it would provide a message when a specific part (element) was not recognized. The imagery data enables processing and storing of a continuous data flow regardless of whether an element of drilling or well control equipment is passing close to a sensor or not, thus being able to document the usage more effectively and accurately. Another advantage is that the imagery data provides a resource from which more information can be extracted than simply the identification of a drilling or well control equipment part. One could for example detect corrosion, bulks or other conditions of defects.

While the present invention has been described with reference to an MODU, as mentioned above, the invention can be used with any form of drilling unit. It can, for example, be used on onshore and/or permanent drilling units.

The following clauses do also set out features of the invention which may or may not be presently claimed in this application, but which may form the basis for future amendment or a divisional application.

1. An audit log system for generating an audit log recording deployment and retriival of drilling or well control equipment that is assembled and dissassembled on a drilling unit, the audit log system comprising a computer system that is programmed to analyse a received data stream of imagery data taken from one or more cameras provided on the drilling unit arranged to record in the imagery data the deployment and retrieval of the drilling or well control equipment, the computer system comprising:

a data storage section for storing the imagery data and generated audit logs; and

a data processing part for analysing the imagery data,

wherein the computer system is configured to:

analyse the imagery data to identify elements of the drilling or well control equipment being deployed or retrieved through image recognition performed on the imagery data;

determine usage for each of a plurality of the elements;

generate usage data logging periods of usage for each of the plurality of elements; and

output an audit log of the usage data for each of a plurality of elements of the drilling or well control equipment for certification purposes.

2. An audit log system according to clause 1, wherein the computer system also records a condition of each element and records the condition with the usage data for each of the plurality of elements.

3. An audit log system according to clauses 1 or 2, wherein the computer system also records a value indicating an amount of fatigue life used or a value indicating an amount of fatigue life remaining for each of the plurality of elements of the drilling or well control equipment.

4. An audit log system according to clauses 1, 2 or 3, wherein the data storage section comprises a hard disk drive, solid state memory, cloud-based storage.

5. An audit log system according to any one of clauses 1 to 4, wherein the audit log system comprises one or more cameras arranged on a drilling unit and directed towards the drilling or well control equipment and arranged to feed a data stream of imagery data to the computer system.

6. An audit log system according to any of clauses 1 to 5, wherein the data stream is a continuous video stream.

7. An audit log system according to any of clauses 1 to 6, wherein the elements of drilling and well control equipment comprises at least one of riser sections, drill pipes, drill bits, tools, casings.

8. A method of generating an audit log recording deployment and retrieval of drilling or well control equipment that is assembled and dissassembled on a drilling unit, using an audit log system comprising a computer system, the method comprising:

receiving in the computer system a data stream of imagery data taken from one or more cameras provided on the drilling unit that are arranged to record in the imagery data the deployment and retrieval of the drilling or well control equipment;

analysing the imagery data to identify elements of the drilling or well control equipment being deployed or retrieved through image recognition performed on the imagery data;

determining usage for each of a plurality of the elements;

generating usage data logging periods of usage for each of the plurality of elements; and

outputing an audit log of the usage data for each of a plurality of elements of the drilling or well control equipment for certification purposes.

9. A method according to clause 8, wherein the imagery data is stored locally on the drilling unit after the step of receiving the data stream and before the step of analysing the imagery data, the imagery data is transmitted to a section of the computer system which is remote from the drilling unit.

10. A method according to clause 9, wherein the imagery data is preprocessed and compressed prior to being transmitted to the section of the computer system which is remote from the drilling unit.

Although illustrative embodiments of the invention have been disclosed in detail herein, with reference to the accompanying drawings, it is understood that the invention is not limited to the precise embodiments shown and that various changes and modifications can be affected therein by one skilled in the art without departing from the scope of the invention defined by the appended claims and their equivalents.

CLAIMS

1. A system for monitoring and managing a plurality of elements of drilling or well control equipment positionable on a drilling unit (100), said drilling or well control equipment (203) being configured to be assembled during the process of drilling or workover of a new or existing oil or gas well, characterised in that the system comprises at least one camera (103, 104, 105, 106, 107) arranged on the mobile drilling unit (100), said at least one camera (103, 104, 105, 106, 107) being positioned so that a visual identification of each element of the drilling or well control equipment (203) can be performed by the at least one camera (103, 104, 105, 106, 107) when the drilling or well control equipment (203) is deployed or retrieved, said at least one camera (103, 104, 105, 106, 107) being operationally coupled to a computer system (202, 401, 501) for storing and/or processing data received from said at least one camera (103, 104, 105, 106, 107) in order to uniquely identify and monitor the elements of the drilling or well control equipment (303) that have been retrieved or deployed.

2. A system according to claim 1 wherein the elements of the drilling or well control equipment to be identified and monitored comprises elements of a riser or drill string, more preferably riser joints (203) or sections of a drill string.

3. A system according to claim 1 or 2 wherein the visual identification of the well control equipment comprises a serial code of numbers or symbols 204.

4. A system according to any one of claims 1-3, wherein the at least one camera (103, 104, 105, 106, 107) is positioned at a level above a spider which is used to suspend the assembled drilling and well control equipment in order to capture in the imagery data the assembly and disassembly of the equipment as it is being deployed and retrieved.

5. A system according to any one of claims 1-4, wherein the system is configured to process and analyse the imagery data to determine usage of each element of the drilling or well control equipment and to store a record of that usage.

6. A system according to any one of claims 1-5, wherein the system is configured to process and analyse sequential images in a time domain to determine a moving direction of the equipment, storing a record of whether the drilling and well control equipment is being deployed or retrieved.

7. A system according to any one of claims 1-6, wherein the system is configured to process and analyse the imagery data to assess the condition of each of the elements of drilling or well control equipment.

8. A system according to any one of claims 1-7, wherein the system is configured to process and analyse the imagery data to recognise a colour coding applied to an element of drilling or well control equipment and assess that the element has been used at an appropriate depth.

9. A system according to any one of claims 1-8, wherein the system is configured to generate an audit log providing details of usage and/or condition of each element of the drilling and well control equipment over a period of time, preferably a continuous period of 5 years or more.

10. A method for monitoring and managing of a plurality of elements of drilling or well control equipment (203) positionable on a drilling unit (100) said drilling or well control equipment (203) being configured to be assembled during the process of drilling or workover of new or existing oil or gas well, characterised in that for each element of drilling or well control equipment (203) being assembled the method comprises the following steps:

receiving imagery data of the drilling or well control equipment (203) from at least one camera (103, 104, 105, 106, 107) installed on the mobile drilling unit (100);

storing the imagery data together with a timestamp into an imagery data storage (308, 607);

processing identification information from the imagery data in order to uniquely identify elements of the drilling or well control equipment;

matching the identification information with an inventory list stored in a drilling or well control equipment data storage (309,614); and

storing identification information for each element of the drilling or well control equipment (203) with matching identification information in said inventory list in a result storage (307, 613).

11. A method according to claim 10, wherein said steps are performed by a computer located on the drilling unit, preferably a mobile drilling unit (100).

12. A method according to claim 10 or 11, wherein the method includes a step of preprocessing and compressing the imagery data retrieved from the at least one camera (103, 104, 105, 106, 107) between the steps of receiving imagery data and storing the imagery data.

13. A method according to claim 10,11 or 12, wherein said steps of receiving imagery data and storing the imagery data are performed by a local computer (401, 501) on the drilling unit (100) and said steps of processing, matching and storing identification information are performed by a computer or server (404, 504) arranged remote from the drilling unit (100).

14. A computer program product comprising software instructions that when run on a computer system generate an audit log recording deployment and retrieval of drilling or well control equipment that has been assembled and dissassembled on a drilling unit, by:

receiving in the computer system a data stream of imagery data taken from one or more cameras provided on the drilling unit that are arranged to record in the imagery data the deployment and retrieval of the drilling or well control equipment;

analysing the imagery data to identify elements of the drilling or well control equipment being deployed or retrieved through image recognition performed on the imagery data;

determining usage for each of a plurality of the elements;

generating usage data logging periods of usage for each of the plurality of elements; and outputing an audit log of the usage data for each of a plurality of elements of the drilling or well control equipment for certification purposes.

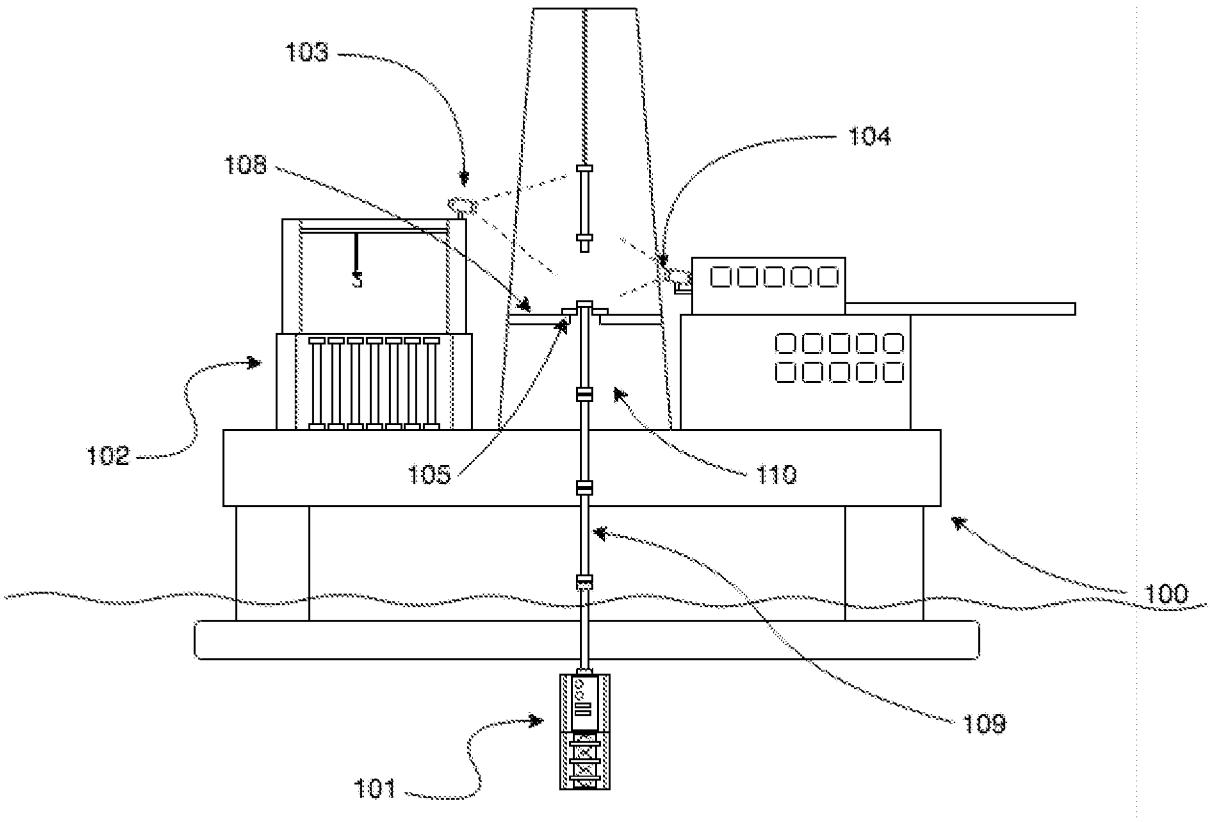


Fig. 1A

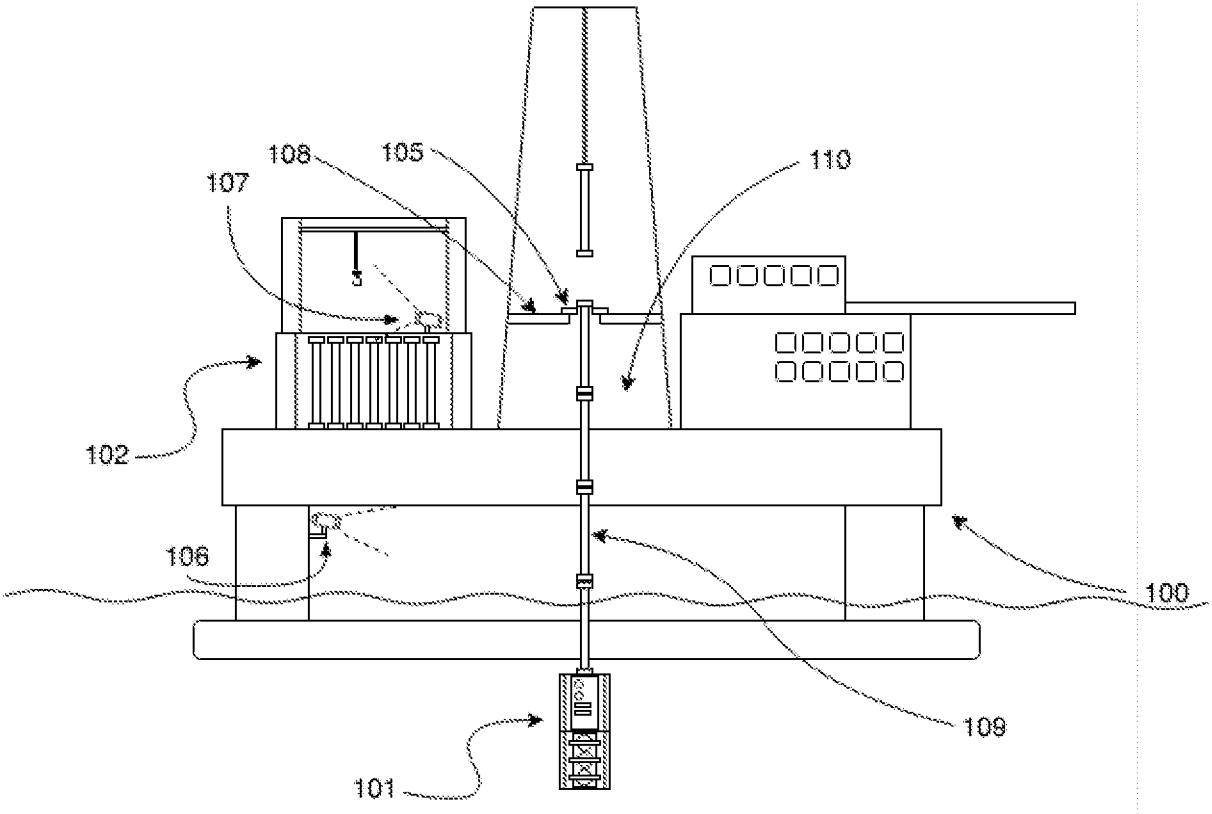


Fig. 1B

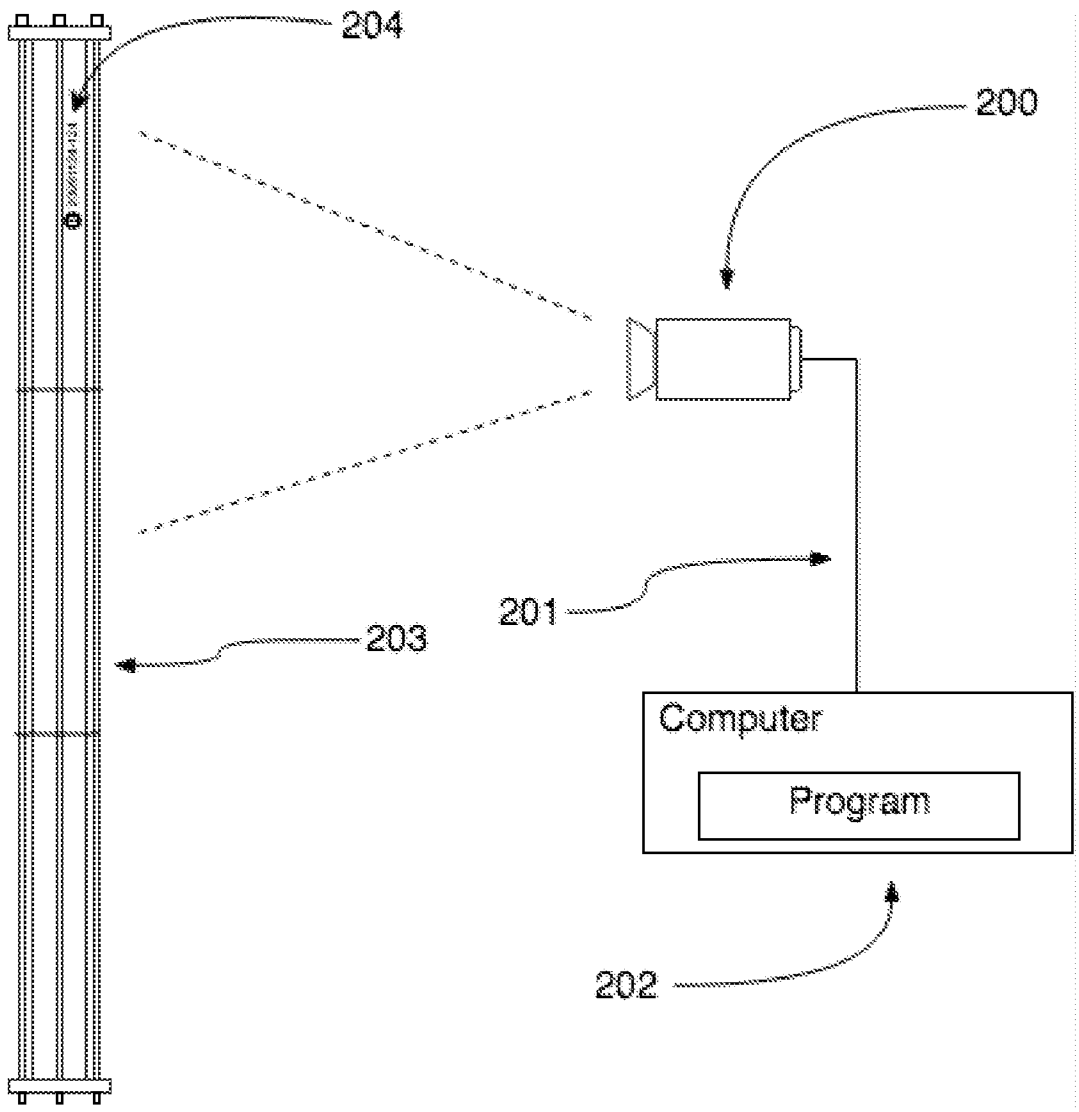
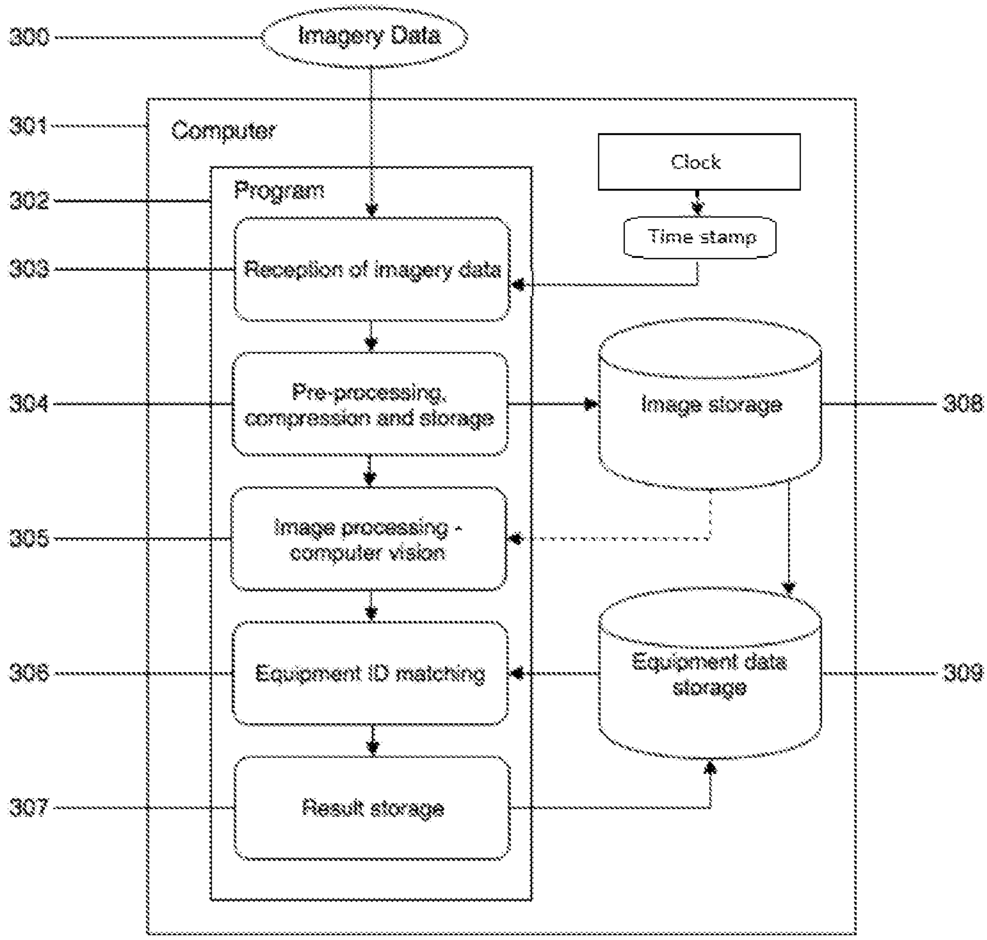


Fig. 2



300
Imagery Data
301
Computer
302
Program
Clock
Time stamp
303
Reception of imagery data
304
Pre-processing, compression and storage
Image storage
308
305
Image processing - computer vision
306
Equipment ID matching
Equipment data storage
309
307
Result storage

Fig. 3

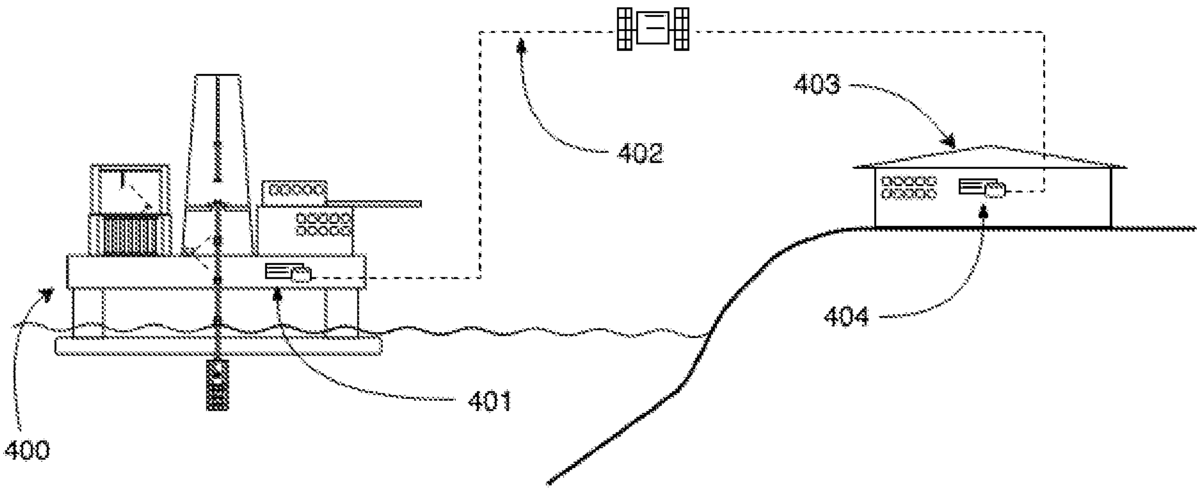


Fig. 4

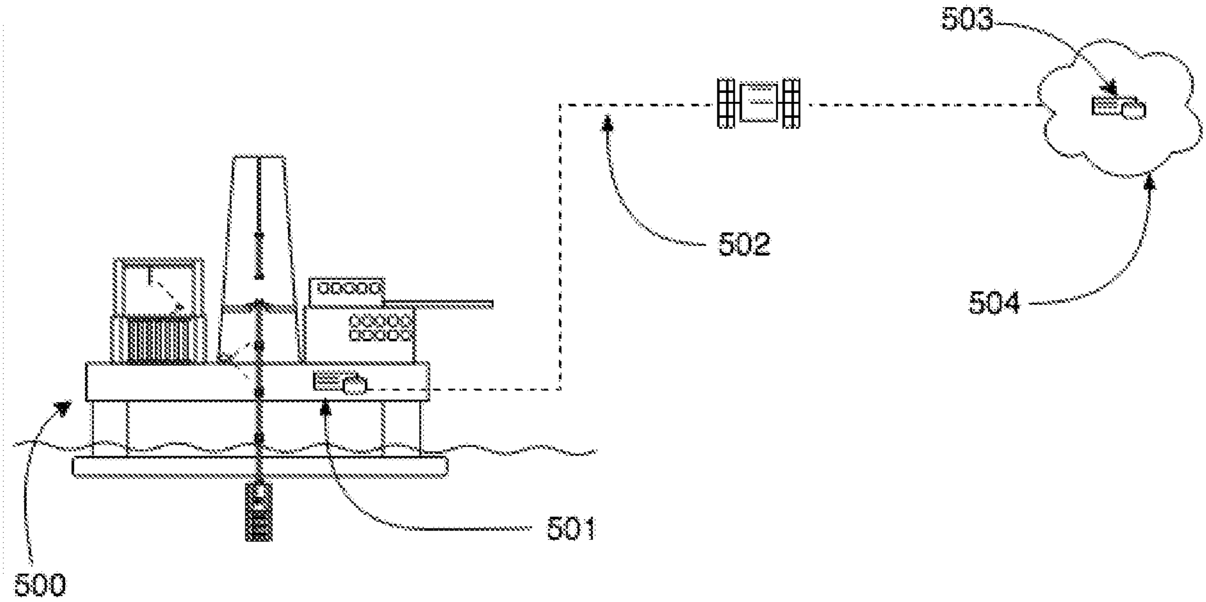


Fig. 5

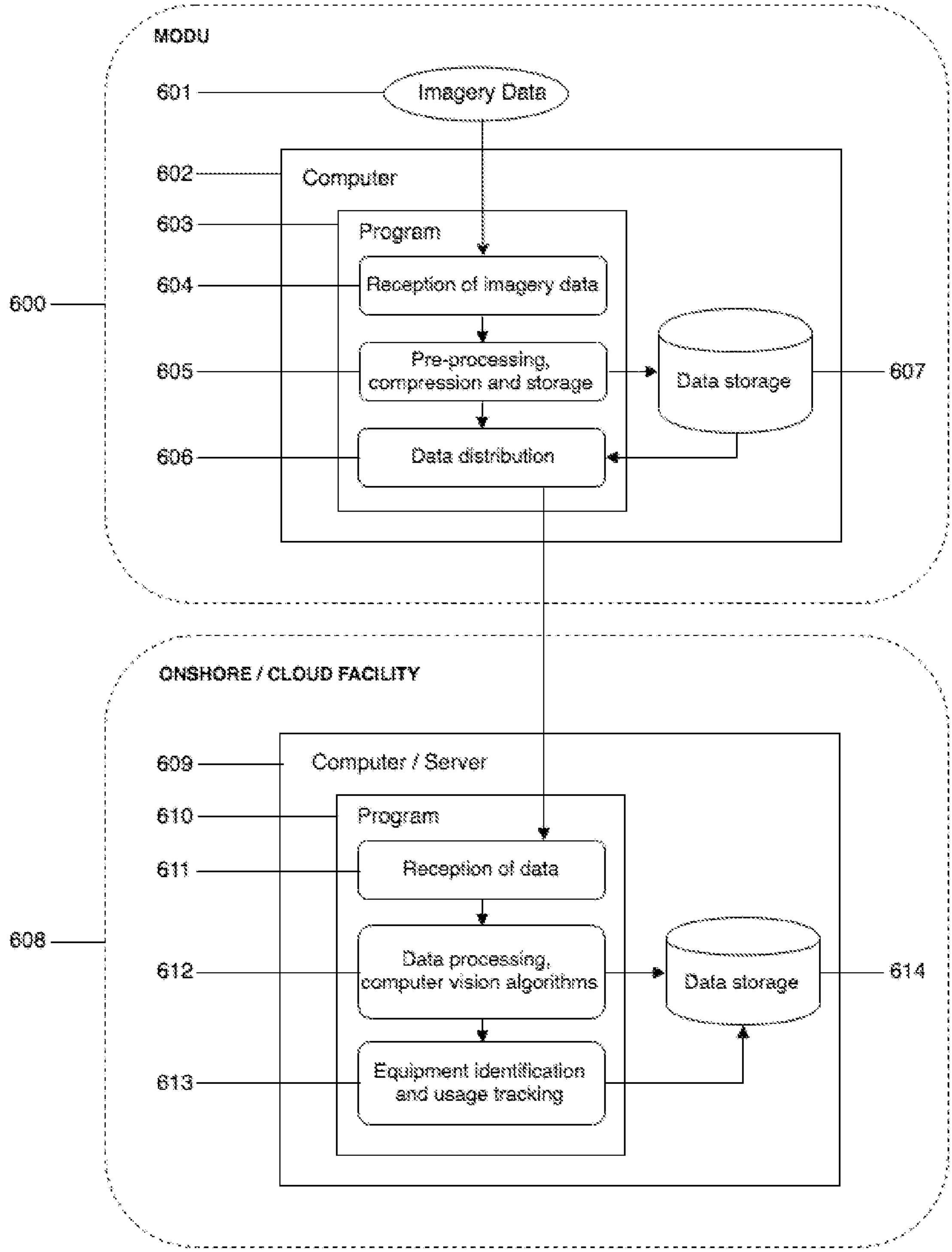

MODU
601
Imagery Data
602
Computer
603
Program
604
Reception of imagery data
600
605
Pre-processing, compression and storage
Data storage
607
606
Data distribution
ONSHORE / CLOUD FACILITY
609
Computer / Server
610
Program
611
Reception of data
608
612
Data processing, computer vision algorithms
Data storage
614
613
Equipment identification and usage tracking

Fig. 6

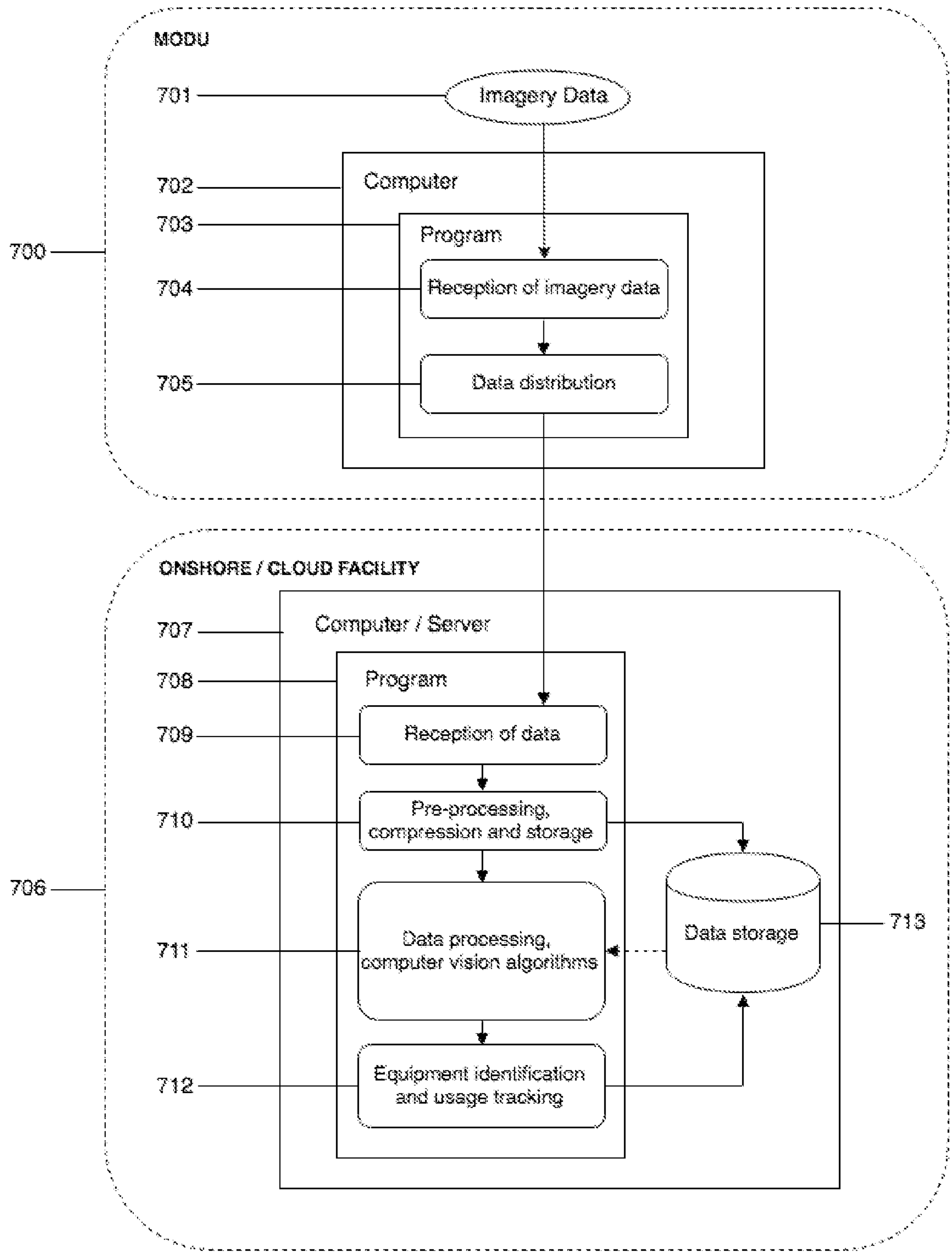

MODU
701
Imagery Data
702
Computer
703
Program
700
704
Reception of imagery data
705
Data distribution
ONSHORE / CLOUD FACILITY
707
Computer / Server
708
Program
709
Reception of data
710
Pre-processing, compression and storage
706
713
Data storage
711
Data processing, computer vision algorithms
712
Equipment identification and usage tracking

Fig. 7