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(54) **Title:** INSTRUMENTATION IDENTIFICATION AND RE-ORDERING SYSTEM

(57) **Abstract:** A method and system for automated verification of receipt, identification, and/or storage of surgical instruments. The system includes at least one image capture device that is structured to capture a captured data set of one or more surgical instruments. The captured data set may include at least an image of one or more surgical instruments, among other data. A control system may compare the captured data set to one or more of a plurality of reference data sets to identify one or more discrepancies, including the absence of a surgical instrument(s) in the captured data set. The system further includes a management system that is adapted to receive an identifier from the control system that corresponds to the discrepancies identified by the control system. Further, the management system is adapted to use the identifier to determine a course of action for the one or more surgical instruments.



INSTRUMENTATION IDENTIFICATION AND RE-ORDERING SYSTEM

BACKGROUND

[0001] Embodiments of the present invention generally relate to accounting for the location of surgical instruments. More particularly, but not exclusively, embodiments of the present invention relate to a system and method for automated verification of receipt, identification, and/or storage of surgical instruments.

[0002] Various types of surgical instruments, tools, equipment, and materials (collectively “surgical instruments”) may be utilized in different types of surgical procedures. Upon completion of such surgical procedures in at least some operating rooms of certain hospitals, the instrumentation utilized during the surgical procedure is often transported to a Central Processing Area (CPA), where staff in the CPA may clean, inspect, repackage, sterilize, and/or discard at least some of the received surgical instruments. Additionally, the staff may also take inventory of the received surgical instruments in an effort to account for the whereabouts of the instruments and/or the availability of certain surgical instruments for subsequent surgical procedures.

[0003] Use and/or reliance on a CPA may present a number of challenges. For example, the CPA staff may consist of employees who lack the knowledge and/or training to identify the various types of surgical instruments received in the CPA or which are used in the various types of surgical procedures performed in the operating room. Thus, in at least certain instances, the CPA staff may be unaware of what instruments the CPA staff has received, and/or are unable to recognize the particular instrumentation that the CPA should have, but did not, receive following a particular type of surgical procedure. Further, a number of surgical procedures can occur before the CPA staff recognizes that a surgical instrument(s) may be missing. For example, following surgery, the CPA staff often receives surgical instruments in a disorganized fashion, and subsequently cleans the instruments, determines where the instruments are to be stored, and then returns the surgical instruments to the appropriate storage and/or sterilization location(s). Additionally, it is not uncommon for surgical instrument sets to be returned to the operating room or a vendor. The consequences of such procedures and practices can delay the recognition that one or more surgical instruments from the operating room are missing and/or are unavailable

for subsequent procedures, which may thereby delay other surgeries until the missing instruments can be located or replacement instruments can be delivered.

[0004] A prior attempt to assist in accounting for the surgical instruments received by the CPA following a surgical procedure has been to provide CPA staff with a text listing of all of the instruments that were to be present during that particular surgical procedure. In some situations, a laminate card having a picture of the sterilization case with all of the instrumentation present during the surgery may also be made available to CPA staff. Another manner of accounting for surgical instruments that may be received in the CPA uses two-dimensional representations of the instruments, such as outlines and/or colour silhouettes, at locations at which the surgical instruments may be stored, such as, for example, in the bottom of a sterilization case. Another approach utilizes interactive software in which a CPA staff member may identify if an instrument is “available,” “missing,” or “other”. According to such an approach, enlarged images and special cleaning and or inspection instructions may be provided to the staff member. Upon completing the assembly of the sterilization case, a final report may be generated that identifies the instruments that are present in the sterilization case, as well as the instruments that are missing from the case, as well and who assembled the case.

[0005] Each of the above-mentioned approaches relies upon a human element to verify that all of the instrumentation is present in the sterilization case. Such reliance upon the human interaction does not eliminate the possibility of error. Indeed, often the same person that assembles the sterilization case is the same one that certifies that the assembled sterilization case is complete. Thus, such approached may suffer from the lack of oversight or double checking of the results of the assembly of the sterilization case.

BRIEF SUMMARY

[0006] There is provided a method comprising capturing a captured data set of one or more surgical instruments, comparing, by a control system, the captured data set with a reference data set, identifying, by the control system, discrepancies between the captured data set and the reference data set, communicating, by an input/output device of a management system, the identified discrepancies between the captured data set and the reference data set, and determining, by the management system, a course of action based on the nature of the identified discrepancies, the course of action comprising at least one of decommissioning the one or more

surgical instruments, locating a replacement surgical instrument, identifying an owner of the one or more surgical instruments, and/or identifying a storage location for the one or more surgical instruments.

[0007] According to some embodiments, capturing the captured data set of the one or more surgical instruments comprises capturing a captured data set of a plurality of surgical instruments included in an assembled storage container, wherein the reference data set identifies a reference set of surgical instruments included in a reference assembled storage container, and wherein identifying the discrepancies between the captured data set and the reference data set comprises identifying an absence of one or more surgical instruments of the plurality of surgical instruments from the captured data set.

[0008] In some embodiments, the method may further comprise identifying an identifier of the one or more surgical instruments, the identifier providing at least one of an indication of a surgical instrument type and/or an identity of the assembled storage container associated with the one or more surgical instrument.

[0009] Identifying the one or more surgical instruments may comprise comparing the captured data set with a plurality of reference data sets that are stored in a database of the control system.

[00010] Identifying the one or more surgical instruments may comprise detecting at least one of a bar code or radio frequency identifier of the one or more surgical instruments.

[00011] In some embodiments, the method may further comprise determining, based on an identified discrepancy between the captured data set and the reference data set, whether the one or more surgical instruments is fit for use in a surgical procedure.

[00012] In some embodiments, the method may further comprise determining that the one or more surgical instruments is owned by a third party, wherein identifying the owner of the one or more surgical instruments is in response to the determination that the one or more surgical instruments is owned by the third party.

[00013] Locating the replacement surgical instrument may comprise at least one of ordering, by the management system, a replacement surgical instrument for the one or more surgical instruments or identifying an instrument storage container containing the missing instrument.

[00014] The method may further comprise determining, by the control system and based on a comparison of the captured data set and the reference data set, whether any of the one or more surgical instruments is damaged.

[00015] In some embodiments, the method may further comprise determining, by the management system and based on an identified discrepancy between the captured data set and the reference data set, the availability of a replacement surgical instrument for the one or more surgical instruments.

[00016] The captured data set may include a plurality of images of the one or more surgical instruments.

[00017] The captured data set and the reference data set may include at least one of a depth value or a distance value relating to the one or more surgical instruments.

[00018] There is also provided a system comprising at least one image capture device structured to capture a captured data set of one or more surgical instruments, the captured data set comprising an image of the one or more surgical instruments, a control system having a plurality of reference data sets, the control system structured to receive the captured data set and identify one or more discrepancies between the captured data set and at least one of the plurality of reference data sets, and a management system adapted to receive an identifier from the control system, the identifier corresponding to the one or more discrepancies identified by the control system, the management system adapted to use the identifier to determine a course of action for the one or more surgical instruments.

[00019] In some embodiments, the one or more surgical instruments may comprise a plurality of surgical instruments stored in an assembled storage container, and at least one of the plurality of reference data sets may indicate a location and an identifier corresponding to the plurality of surgical instruments.

[00020] The control system may comprise a cloud-based server.

[00021] The control system may comprise a first connecting device that is structured to communicate with a second connecting device of the management system.

[00022] In some embodiments, the at least one image capture device may be structured to obtain three-dimensional images of the one or more surgical instruments.

[00023] The at least one image capture device may be structured to obtain a distance of the one or more surgical instruments from a reference point.

[00024] In some embodiments, the management system may be structured to determine a course of action that includes locating a replacement surgical instrument for the one or more surgical instruments from at least one of an inventory of an associated surgical site or a vendor.

[00025] The management system may be structured to determine a course of action that includes at least one of identifying an owner of one or more surgical instruments or determining a storage location for the one or more surgical instruments.

[00026] There is also provided a system comprising at least one processor and at least one memory comprising a plurality of instructions stored thereon that, in response to execution by the at least one processor, causes the system to receive at least one image of a surgical instrument captured by an image capture device, analyze the at least one image to determine a type of the surgical instrument, determine a surgical storage container within which to store the surgical instrument based on the identified type of the surgical instrument, and notify an operator of the system of the surgical storage container.

[00027] In some embodiments, the plurality of instructions, in response to execution by the at least one processor, may further cause the system to receive sensor data different from the least one image, wherein to analyze the at least one image comprises to analyze the at least one image and the sensor data to determine the type of the surgical instrument.

[00028] The sensor data may be indicative of a weight of the surgical instrument.

[00029] In some embodiments, to analyze the at least one image may comprise to compare the at least one image to reference data that identifies possible reference surgical instruments of different types.

[00030] In some embodiments, to determine the surgical storage container within which to store the surgical instrument may comprise to compare the identified type of the surgical instrument to a database that identifies reference surgical instruments included in one or more surgical storage containers.

[00031] There are various advantages of embodiments of the invention described herein. For example, in some embodiments, an operator may utilize the system described herein to identify pairings between surgical instruments and surgical storage containers and thereby determine whether a particular assembled storage container is ready for use by a surgeon.

[00032] Further features and advantages of at least some of the embodiments of the present invention, as well as the structure and operation of various embodiments of the present invention, are described in detail below with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[00033] The description herein makes reference to the accompanying figures wherein like reference numerals refer to like parts throughout the several views.

[00034] Figure 1 illustrates a block diagram of an example of an identification system according to an illustrated embodiment of the present invention.

[00035] Figure 2 illustrates a top view of an assembled storage container that is arranged to contain a plurality of surgical instruments.

[00036] Figures 3A-D illustrate a schematic flow diagram of an exemplary process of operation of a method for automated verification of receipt, storage, and/or re-ordering of surgical instruments according to an illustrated embodiment of the present invention.

[00037] Figure 4 illustrates a schematic flow diagram of an exemplary process of operation of a method for automated identification of a surgical storage container associated with a particular surgical instrument according to an illustrated embodiment of the present invention.

[00038] The foregoing summary, as well as the following detailed description of certain embodiments of the present invention, will be better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, there is shown in the drawings, certain embodiments. It should be understood, however, that the present invention is not limited to the arrangements and instrumentalities shown in the attached drawings.

DETAILED DESCRIPTION OF THE DRAWINGS

[00039] Certain terminology is used in the following description for convenience and is not intended to be limiting. Words such as “upper,” “lower,” “top,” “bottom,” “first,” and “second” designate directions in the drawings to which reference is made. This terminology includes the words specifically noted above, derivatives thereof, and words of similar import. Additionally, the words “a” and “one” are defined as including one or more of the referenced item unless specifically noted. The phrase “at least one of” followed by a list of two or more items, such as “A, B or C,” means any individual one of A, B or C, as well as any combination

thereof. For example, the phrases “at least one of A, B, and C” and “at least one of A, B, or C” can include (A), (B), (C), (A and B), (A and C), (B and C), or (A, B, and C).

[00040] Embodiments of the present invention provide a relatively cost efficient system and method for automated verification of receipt and/or storage of surgical instruments. For example, embodiments of the present invention provide a system and method for automated verification of the completeness of a surgical storage container (e.g., a sterilization tray) having one or more surgical instruments.

[00041] Figure 1 illustrates a block diagram of one example of an identification system 100 according to an illustrated embodiment of the present invention. The identification system 100 may include at least one image capture device 102, a control system 104, and a management system 106. Although only image capture device 102, one control system 104, and one management system 106 are illustratively shown in Figure 1, the identification system 100 may include any number of image capture devices 102, control systems 104, and/or management systems 106 in other embodiments. In some embodiments, one or more of the devices/systems of the identification system 100 may be integrated such that a single device/system performs the functions of multiple devices/systems described herein. For example, in some embodiments, the control system 104 and the management system 106 may be embodied as a single system.

[00042] In the illustrative embodiment, the image capture device 102 is adapted to obtain an image and/or data (referred to as a “captured data set”) of an assembled surgical storage container 108 (e.g., sterilization cases) that may contain one or more surgical instruments 110 and/or obtain a captured data set of one or more surgical instruments individually. The image capture device 102 may be structured to capture at least an image of a variety of different storage containers, including, for example, the assembled surgical storage container 108 that is depicted in Figure 2. Further, in some embodiments, the image capture device 102 may be configured to capture images of surgical instruments 110 themselves (e.g., surgical instruments 110 within a particular surgical storage container 108 or separate from a surgical storage container 108). For example, in some circumstances, the image capture device 102 may capture images of the surgical instruments 110 in groups (or individually) separate from a surgical storage container 108 (e.g., prior to identifying the appropriate surgical storage container 108 and/or placing the surgical instruments 110 in the container 108).

[00043] It should be appreciated that the surgical storage container 108 may be embodied as any container configured to house or hold one or more surgical instruments 110. For example, in various embodiments, the surgical storage container 108 may be embodied as a sterilized surgical tray, a dedicated surgical instrument case, a contaminated surgical instrument storage basin, or another suitable storage container. The surgical storage container 108 may be configured to house a single surgical instrument 110 or a plurality of similar or dissimilar surgical instruments 110. For example, the surgical storage container 108 depicted in Figure 2 is configured to house a variety of different types of surgical instruments 110. Further, the surgical storage containers 108 may have a variety of different shapes, sizes, and configurations. For example, the surgical storage container 108 shown in Figure 2 includes a sidewall 112 that extends upwardly from at least a portion of the periphery of a base wall 114 of the surgical storage container 108. The sidewall 112 may generally define an inner region 116 of the surgical storage container 108 in which the surgical instruments 110 may be stored. Additionally, at least certain storage containers 108 may include one or more projections 118 extending from the base wall 114 that are structured to matingly engage a particular surgical instrument 110 or type of surgical instrument 110. For example, the one or more projections 118 may be spaced apart from other projections 118 in a manner that permits a recess in the projections 118 to receive similarly sized and/or shaped portions of a particular surgical instrument 110, thereby providing an indication of which surgical instrument(s) 110 is to be placed at that particular location. Accordingly, such projections 118 may limit which instruments 110 are to be, or can be, placed at a particular corresponding location in the surgical storage container 108. Such limitations in placement locations for surgical instruments 110 may provide at least a visual indication of whether the surgical storage container 108 is, or is not, missing a particular surgical instrument(s) 110.

[00044] The image capture device(s) 102 may be embodied as any device capable of capturing two dimensional (2D) and/or three dimensional (3D) images of a surgical storage containers 108 and/or surgical instruments 110. A variety of different types of devices may be utilized for the image capture device 102, including, but not limited to, one or more stereoscopic cameras, infrared cameras, laser imaging devices, and/or a laser imaging detection and ranging (LIDAR) devices, among other image capture devices, that are capable of capturing images in two or three dimensions and/or that are capable of sensing distances or depths. For example,

according to certain embodiments, one or more cameras may be utilized to detect the shape(s) of surgical instruments 110, a depth of the surgical instrument 110, and/or the distance the surgical instrument 110 is away from a reference point. According to certain embodiments, the distance away from the reference point may be the distance the surgical instrument 110 is away from the camera or from another location, such as, for example, a location of the surgical storage container 108. According to certain embodiments, the reference point may be a top or base portion of the surgical storage container 108, among other reference points.

[00045] Images and/or other information or data obtained by the image capture device 102 may be communicated to the control system 104. The control system 104 may be adapted to analyze the actual images or data and/or derive data from the captured data set provided by the image capture device(s) 102. Moreover, as discussed below, the control system 104 may be adapted to compare the images or other information provided and/or derived from the captured data set with reference images and/or reference data, referred to as a reference data set, which may be accessed or stored by the control system 104. Thus, according to certain embodiments, the control system 104 may include a memory 120 and a processor 122 sufficient in size and operation to store and manipulate a database and one or more applications or software in accordance with operating logic 123 for analysis and/or comparison of images and data information provided by, or derived from, the image capture devices 102 and reference images and/or data. The memory 120 may be part of, or separate from, the processor 122. Further, the reference data set may be stored in one or more databases of the control system 104 that are part of the memory 120 or otherwise accessible to the processor 122.

[00046] According to certain embodiments, the control system 104 may include one or more servers 121, such as, for example, one or more cloud-based servers and/or one or more servers that are accessible via a web server or web portal, among other servers. Further, the control system 104 may communicate with the image capture device 102 in a variety of different manners, including, for example, over a wide area network (WAN) (e.g. the Internet), a cellular data network, a local area network (LAN), a hard wired connection, or any combination thereof.

[00047] At least some of the results of the analysis and/or comparison of the control system 104 may be provided to the management system 106. The manner of communication between the control system 104 and the management system 106 may be similar to those identified above for the image capture device 102 and the control system 104. The management

system 106 may include a processing device 124, a memory 126, and one or more input/output devices 128. A variety of different types of processing devices 124 may be used for the management system 106, such as, for example, a programmable, dedicated, and/or hardwired state machine, or any combination thereof. The processing device 124 of the management system 106 may further include multiple processors, such as, for example, Arithmetic-Logic Units (ALUs), Central Processing Units (CPUs), Digital Signal Processors (DSPs), or the like. Processing devices 124 with multiple processing units may also utilize distributed, pipelined, and/or parallel processing. The processing device 124 may be dedicated to performance of the operations described herein or may be utilized in one or more additional applications. In the illustrative embodiment, the processing device 124 is of a programmable variety that executes algorithms and processes data in accordance with operating logic 130 as defined by programming instructions (such as software or firmware) stored in the memory 126 of the management system 106. In other embodiments, the operating logic 130 is, additionally or alternatively, at least partially defined by hardwired logic or other hardware. In some embodiments, the processing device 124 is structured similar to the processor 122. The processing device 124 of the management system 106 may include one or more components of any type suitable to process signals received from an input/output device 128 of the management system 106, such as, for example, a keypad, keyboard, touch monitor, microphone, or elsewhere, and to provide desired output signals. Such components may include digital circuitry, analog circuitry, or a combination of both. Further, in some embodiments, the input/output device 128 may include a display that may provide a visual indication of information to a user of the identification system 100.

[00048] The memory 126 of the management system 106 may be included with the processing device 124 and/or coupled to the processing device 124. Further, the memory 126 may be of one or more types, such as a solid-state variety, electromagnetic variety, optical variety, or a combination thereof. Additionally, the memory 126 can be volatile, nonvolatile, or a combination thereof, and some or all of the memory 126 can be of a portable variety, such as a disk, tape, memory stick, cartridge, or the like. In addition, according to certain embodiments, the memory 126 can store data that is manipulated by the operating logic 130 of the processing device 124, such as data representative of signals received from and/or sent to the input/output

device 128 in addition to, or in lieu of, storing programming instructions defining the operating logic 130.

[00049] The memory 126 may or may not be part of the processing device 124. Further, according to certain embodiments, the management system 106 may include one or more connecting devices 132 configured for communication with one or more connecting devices 134 of the control system 104. The connecting devices 132, 134 may communicate in a variety of manners, including, for example, over a wide area network (WAN) (e.g. the Internet), a cellular data network, a local area network (LAN), or any combination thereof.

[00050] According to certain embodiments, the management system 106 may provide a location for a user or operator of the identification system 100 to enter or receive information from the identification system 100. Therefore, according to certain embodiments, the management system 106 may include a computing device, such as, for example, a laptop or desktop computer, or a mobile electronic device, among other computing devices through which the operator or user may receive notifications, such as, for example, whether the assembled surgical storage container 108 is or is not complete, to authorize the ordering of replacement surgical instruments 110, receive notification of storage locations for the surgical storage container 108, among other interactions with the identification system 100. Additionally, according to certain embodiments, the control system 104 may be at a remote location from the management system 106, such as, for example, at a centralized location relative to a number of Central Processing Areas. Alternatively, according to certain embodiments, the control system 104 may be integrated into the management system 106, or vice versa.

[00051] Figures 3A-D illustrate a schematic flow diagram of an exemplary process 300 for automated verification of receipt and/or storage of surgical instruments 110 according to an illustrated embodiment of the present invention. The operations illustrated for all of the processes in the present application are understood to be examples only, and operations may be combined or divided, and added or removed, as well as re-ordered in whole or in part, unless explicitly stated to the contrary.

[00052] Referencing Figure 3A, at step 302, a surgical storage container 108 may be selected for assembly. For example, the surgical storage container 108 may be selected in connection with the CPA staff cleaning, inspecting, repackaging, and/or sterilizing surgical instruments 110 before or following a surgical procedure. The surgical storage container 108

however may be selected at other times, including, for example, but not limited to, in connection with conducting inventory and/or receipt of new surgical instruments 110. At step 304, the surgical storage container 108 may be assembled by placement of the corresponding surgical instrument(s) 110 into the surgical storage container 108. At step 306, a determination is made as to whether the surgical storage container 108 is missing any surgical instruments 110. Such a determination may be made in a number of manners, including, but not limited to, by a visual indication provided by the absence of one or more surgical instruments 110 in particular designated locations in the inner region 116 of the surgical storage container 108, projections 118 in the surgical storage container 108 that are not engaged with a surgical instrument 110, a comparison of the surgical instruments 110 that are in the surgical storage container 108 with a list and/or graphic indication of surgical instruments 110 that are designated for placement in the surgical storage container 108, and/or information provided by radio frequency identifications (RFIDs) or other identifiers or notifications.

[00053] If the determination at step 306 is that no surgical instruments 110 are missing from the assembled surgical storage container 108, then the assembled surgical storage container 108 may be available for at least capturing of a captured data set for the container. For example, according to certain embodiments, the captured data set may be obtained by capturing one or more images by the image capture device 102 at step 308. Alternatively, according to other embodiments, the captured data set may be obtained in other manners, such as, for example, through the use of radio frequency identifiers (RFIDs), bar codes, text recognition, and/or other identifiers. Further, if the determination at step 306 is that one or more surgical instrument(s) 110 are missing from the surgical storage container 108, then at step 310, an attempt may be made to identify the surgical instrument(s) 110 missing from the surgical storage container 108. Additionally, according to certain embodiments, an identification of the missing surgical instrument(s) 110 may be provided to the management system 106 and/or the control system 104. For example, according to certain embodiments, the identification may be provided by an operator of the identification system 100 using the input/output device 128 of the management system 106, such as, for example, a keypad, keyboard, and/or touch screen monitor, among other input/output devices 128. Additionally, in at least some situations, such an identification of the missing surgical instruments 110 may include an attempt to locate the missing surgical instrument(s) 110 and, if located subsequently, placing the previously missing instrument 110 in

the surgical storage container 108 before the assembled surgical storage container 108 is made available for capturing of the captured data set, such as, for example, before the surgical storage container 108 is made available for at least imaging by the image capture device 102 at step 308, or before the missing instruments 110 are identified to the control system 104 and/or the management system 106.

[00054] At step 308, one or more images and/or other information or data for the captured data set regarding the assembled surgical storage container 108 may be obtained. Again, according to certain embodiments, such capturing may be obtained by the image capture device 102 and/or by other techniques, including, for example, the use of radio frequency identifiers (RFIDs). For example, according to certain embodiments, the assembled surgical storage container 108 may be placed at a position at which the image capture device 102 may capture the image(s) or data of the assembled surgical storage container 108. According to such embodiments, the number of captured images taken by the image capture device 102 and/or whether the relative positions of the image capture device 102 and the assembled surgical storage container 108 are adjusted in connection with obtaining the captured data set, as well as the reference data set, may depend, for example, on the shape, size, and/or complexity of the assembled surgical storage container 108 and the associated surgical instruments 110, among other potential considerations.

[00055] For example, the captured data set may include one or more two or three dimensional images of the assembled surgical storage container 108 and/or other information that is captured by the image capture device 102, including the distance the surgical instruments 110 are from a reference point, such as, for example, from the image capture device 102. Additionally, according to certain embodiments, at step 308, the captured data set may be communicated to the control system 104 for comparison with the reference data set(s). According to certain embodiments, step 308 may include providing an indicator that identifies the actual or type of assembled surgical storage container 108. For example, an operator may provide via the input/output device 128 of the management system 106, among other input/output devices, a general identifier that indicates the type of surgical instruments 110 that are to be contained in the assembled surgical storage container 108, and/or a specific identifier, such as, for example, a tray number for the assembled surgical storage container 108. The provided general and/or specific identifiers may be used by the control system 104 to determine

at least the surgical instruments 110 that are to be contained in the assembled surgical storage container 108. According to other embodiments, the assembled surgical storage container 108 may be automatically identified, such as, for example, through the use of a radio frequency identification device, bar code reader, or text recognition (e.g., of a unique identifier written on the container 108). Such identifiers may also be useful in identifying the assembled surgical storage container 108 in other embodiments of the process 300, including confirming that a particular assembled surgical storage container 108 is to be made available for use in an operating room, identifying the assembled surgical storage container 108 as being the intended recipient of a later received replacement surgical instrument 110, and/or confirming the assembled surgical storage container 108 is to be discarded, among other reasons. Alternatively, the assembled surgical storage container 108 may be determined by a comparison of the captured data set with the one or more reference data sets.

[00056] A variety of types of images and/or data may be utilized for the reference data set. For example, according to certain embodiments, the reference data may include one or more generic/stock two or three dimensional images, previously taken images of the particular assembled surgical storage container 108, previously taken images of similar assembled surgical storage containers 108, the overall weight of the assembled surgical storage container 108, the weight of the individual surgical instruments 110, the dimensions of the surgical instruments 110, and/or other suitable reference data. According to certain embodiments, the reference data may also include images or data of individual surgical instruments 110 and/or collections of surgical instruments 110. For example, in some embodiments, the reference data set may include images of surgical instruments 110 that belong to the specific assembled surgical storage container 108 (e.g., the container associated with the captured data). Moreover, the reference data set may contain images and/or data of an assembled surgical storage container 108 that has been verified as to not missing any surgical instruments 110. Further, depending on the particular embodiment, the reference data set may pertain to a particular assembled surgical storage container 108 or surgical instrument(s) 110, or may be utilized generally for a plurality of assembled surgical storage containers 108 and/or surgical instruments 110 of the same type or category.

[00057] The comparison of the captured and reference data set(s) by the control system 104 may reveal differences between the captured and reference data set(s) that provide an

indication of surgical instruments 110 that may be missing or misplaced in the assembled surgical storage container 108 relative to a reference surgical storage container as determined by the reference data set(s). For example, the control system 104 may detect, via at least a comparison of images of the captured and reference data sets, a discrepancy or difference related to a missing surgical instrument 110 in the captured data set. Further, the control system 104 may include information that, using the identified discrepancy or difference, provides the identity of the missing surgical instrument(s) 110, if any, in the assembled surgical storage container 108. For example, in some embodiments, the reference data set may include a location (e.g., a relative location) of each surgical instrument 110 in the assembled surgical storage container 108 and an indication of the identity of the one or more of the surgical instruments 110 at those particular locations in the reference surgical storage container 108. Thus, according to certain embodiments, using such identification information, the control system 104 may be able to both detect the absence of one or more surgical instruments 110 from the assembled surgical storage container 108 and provide an indication of the identity of the missing surgical instruments 110.

[00058] Based on the comparison of the captured data set and the reference data set(s), at step 312 the control system 104 and/or the management system 106 may determine whether the assembled surgical storage container 108 is complete. In the illustrative embodiment, the assembled surgical storage container 108 may be considered to be complete if all of the surgical instruments 110 associated with that particular surgical storage container 108 are included/present (i.e., no surgical instruments 110 are missing). It should be appreciated that, in some circumstances, each surgeon may have a unique procedural profile. That is, various surgeons may perform different procedures and even for a common procedure may utilize different surgical instruments 110. Accordingly, in some embodiments, the particular surgeon scheduled to perform an operation may impact the determination of whether a particular surgical storage container 110 is complete—at least for the purposes of a particular procedure.

[00059] The conclusion of the determination at step 312 may be indicated to a user of the identification system 100 in a number of different manners, including, for example, via an audible and/or visual indication by the control system 104 and/or the management system 106. If the determination is that the assembled surgical storage container 108 is complete such that there are no missing surgical instruments 110, then at step 314 or step 316 (Figure 3D), the assembled surgical storage container 108 may be returned to a storage location or to the vendor

or owner of the assembled surgical storage container 108 depending on the particular circumstances. According to certain embodiments, the particular location, entity, or person that the assembled surgical storage container 108 is to be delivered to may be determined and/or indicated by the control system 104 and/or the management system 106. For example, using information provided by an operator of the identification system 100, by recognition of information from the captured data set, and/or from information automatically provided from the assembled surgical storage container 108, the control system 104 and/or management system 106 may identify the owner and/or storage location of the assembled surgical storage container 108. Thus, if the control system 104 and/or management system 106 determines that the assembled surgical storage container 108 is the property of another party or entity (e.g., a vendor), then at step 314 the management system 106 may provide an indication that the assembled surgical storage container 108 is to be returned to that party/entity. Alternatively, at step 316, the control system and/or management system 106 may provide an indication of a location at which the assembled surgical storage container 108 is to be stored, such as, for example, in an operating room, a surgical instrument storage room, or another suitable location.

[00060] If however at step 312 the control system 104 determines, based on a comparison of the captured data set and the reference data set, that the assembled surgical storage container 108 is incomplete, then at step 318 (Figure 3B), a query is made as to whether any of the surgical instruments 110 that were identified at step 312 as missing from the assembled surgical storage container 108 are different from the surgical instruments 110 that were identified, if any, as missing at step 306. Depending on the particular embodiment, the determination of whether any of the missing surgical instruments 110 identified at step 312 are in addition to those identified at step 306 may be performed by an operator, the control system 104, and/or the management system 106. If additional surgical instruments 110 are identified as missing at step 318, then at step 320 an attempt may be made to locate the additional missing surgical instruments 110. Such an attempt to locate the missing instrument may include identifying other surgical storage containers that may contain the missing instrument(s). Additionally, step 318 may include a notification via an input/output device 128 of the management system 106 of the absence of the missing surgical instruments 110. For example, according to certain embodiments, the management system 106 may include a display or speaker that provides a visual or audible

indication of the missing surgical instrument(s) 110, such as, for example, displaying a message that a particular surgical instrument 110 “is not part of this set.”

[00061] If, at step 322, a determination is made that the additional missing surgical instruments 110 have been located, then the missing surgical instruments 110 may be properly positioned within the assembled surgical storage container 108, and the assembled surgical storage container 108 may again be available for at least imaging by the image capture device 102 at step 308, as described above in reference to Figures 3A and 3B. The process of determining whether surgical instruments 110 are missing from the assembled surgical storage container 108 may then be repeated. If however the determination at step 322 is that the missing surgical instruments 110 have not been located, then the process 300 advances to step 324 of Figure 3D at which the additional missing instruments 110 that were identified at step 318 may be added to a list or grouping of the missing instruments 110 that were previously identified at step 310. According to certain embodiments, in light of the missing surgical instruments 110 that were identified at steps 310 and 318, step 324 may also include verifying what surgical instruments 110 are actually present in the assembled surgical storage container 108. The process may then proceed to step 326, as discussed below.

[00062] If at step 318 it is determined that the missing surgical instruments 110 are the same surgical instruments 110 that were previously identified as missing, such as, for example, identified at step 310, then at step 326 a determination is made as to a course of action to rectify the absence of the missing instruments 110. A number of courses of action may be available, and may be decided with input from the operator of the identification system 100, the control system 104, and/or the management system 106. Further, the action selected may be based on a number of different criteria, including current inventory or the availability of the missing surgical instrument(s) 110 at the surgical location or related entity or location, the ability to order a replacement instrument(s) 110, the cost of the surgical instrument(s) 110, and/or the owner of the surgical instrument 110 or of the assembled surgical storage container 108.

[00063] For example, in response to the decision associated with step 326, one option provided by step 328 is to obtain one or more replacement surgical instrument(s) 110 from available inventory at the surgical location, such as, for example, from stock available at an associated hospital. Thus, according to certain embodiments, step 326 may include an inquiry by the control system 104 or the management system 106 as to whether a replacement for the

missing instrument(s) 110 is available at the surgical site or a related location. If such a replacement is available, then according to certain embodiments, the control system 104 and/or management system 106 may provide a notification to an operator or user of the identification system 100 to obtain the replacement surgical instrument 110 from available stock. Further, according to certain embodiments, such notification may provide a location at which the replacement surgical instrument 110 may be located. Upon attaining the replacement surgical instrument(s) 110 from available stock, the replacement surgical instrument(s) 110 may be positioned in the assembled surgical storage container 108. A determination may then be made at step 330 (Figure 3D) as to whether the assembled surgical storage container 108 is fit for use. For example, a determination may be made as to whether the assembled surgical storage container 108 is still missing other surgical instruments 110, including surgical instruments 110 that have been ordered from a vendor but have not yet been received. The assembled surgical storage container 108 may also not yet be fit for use due to a feature of the assembled surgical storage container 108, including a replacement surgical instrument(s) 110 needing to undergo an additional form of treatment, packaging, and/or sterilization. If the assembled surgical storage container 108 is not fit for use, then at step 332 the assembled surgical storage container 108 may be placed at a holding area, where the assembled surgical storage container 108 may await further processing before being allowed to be available for a subsequent surgical procedure. If, however, a determination is made at step 330 that the assembled surgical storage container 108 is fit for use, then the process 300 may proceed to step 316, wherein the assembled surgical storage container 108 may proceed to be returned to a storage location or to the vendor/owner of the assembled surgical storage container 108. Additionally, according to certain embodiments, upon completion of step 316, a user or operator of the system 100 may input via the input/output device 128 of the management system 106 that assembly and/or storage of the assembled surgical storage container 108 is complete. The control system 104 may then either document that the set was complete, or, in the event surgical instruments 110 are missing, highlight which particular surgical instruments 110 are missing.

[00064] Another option in response to the decision associated with step 326 is to, at step 334, order a replacement surgical instrument 110, such as, for example, a replacement surgical instrument 110 from a vendor. According to certain embodiments, the control system 104 and/or management system 106 may be configured to automatically order the replacement surgical

instrument 110 if certain criteria are satisfied, such as, for example, criteria related to the type and/or cost of the surgical instrument 110 and/or the availability and expected delivery time from the vendor. According to certain embodiments, the control system 104 and/or the management system 106 may require authorization or verification from a user of the system 100 before the order may be placed. Following the placement of the order, at step 310, a determination is made as to whether the assembled surgical storage container 108 is fit for use, which may result in the assembled surgical storage container 108 being returned to a storage location or to the owner of the assembled surgical storage container 108 at step 316 or being placed at a holding area at step 332 as described above.

[00065] Alternatively, in response to the decision associated with step 326, at step 336 a decision may be made to decommission the assembled surgical storage container 108, such as, for example, discard the assembled surgical storage container 108. Decommissioning the assembled surgical storage container 108 may include discarding all or some of the surgical instruments 110 of the assembled surgical storage container 108. A further option in response to the decision associated with step 326 is, at step 338, to order an entire assembled surgical storage container 108, which may include ordering each surgical instrument 110 for the assembled surgical storage container 108. Again, the decision to decommission the assembled surgical storage container 108 at step 336 or to order an assembled surgical storage container 108, such as, for example, from a vendor, may be automatically generated by the control system 104 and/or the management system 106 or may require user permission or authorization. Further, such decisions may be based on whether certain criteria are satisfied, such as, for example, the type of assembled surgical storage container 108, the type of surgical instruments 110 associated with the assembled surgical storage container 108, the cost of the assembled surgical storage container 108, and/or the cost of the associated surgical instruments 110, among other criteria. Alternatively, if the assembled surgical storage container 108 is the property of another entity, such as, for example a vendor, then at step 340 that entity may be notified of the missing surgical instrument 110 before the assembled surgical storage container 108 is returned to that entity at step 314.

[00066] As described above, each surgeon may have a unique procedural profile such that various surgeons may perform different procedures and even for a common procedure may utilize different surgical instruments 110. Accordingly, in some embodiments, the particular

surgeon scheduled to perform an operation may impact the determination of whether a particular surgical storage container 110 is complete—at least for the purposes of a particular procedure. Accordingly, in some embodiments, in determining the course of action at step 326, the system 100 may retrieve data indicative of the specific surgical instruments 110 utilized by the assigned surgeon for the next surgical case and determine whether a missing surgical instrument 110 is intended to be used by the assigned surgeon in that case. If not, in some embodiments, the incomplete assembled surgical storage container 110, although missing one or more surgical instruments 110, may be selected for use in the next surgical case to avoid an unnecessary delay in performing a surgery. It should be appreciated that the surgical case constituting the “next” case may vary depending on the particular circumstances. For example, in some embodiments, the incomplete assembled surgical storage container 110 may be compared to a multitude of scheduled surgical cases. It should further be appreciated that the system 100 may, in addition to selecting the incomplete assembled surgical storage container 110 for use in a subsequent surgical case, perform one or more of the other functions described above. For example, in some embodiments, a replacement surgical instrument 110 may be ordered while the incomplete assembled surgical case 108 is used in surgical cases for which the missing surgical instrument 110 is unnecessary.

[00067] While the process 300 is discussed above with respect to assembled surgical storage containers 108, a similar process may also be utilized to identify particular surgical instruments 110 and/or to identify an associated assembled surgical storage container 108 for those instruments 110. Thus, for example, at step 308, a first data set may contain an image or other data of the surgical instrument 110 that was captured by the image capture device 102. Further, the control system 104 may compare the first data set, which in this instance is based on the presented surgical instrument 110, with reference data sets that are accessible to, or stored by, the control system 104. If a reference data set appears to correspond to the first data set, then the control system 104 may determine that the presented instrument 110 has been identified. The control system 104 may then transmit identification for that surgical instrument 110 to the management system 106, which may display at least some of the identification information for an operator or user of the identification system 100 via the input/output device 128 of the management system 106. For example, the control system 104 may provide to the management system 106 information that identifies the name of the surgical instrument, an association of the

surgical instrument 110 to a potential instrumentation setup, and/or the actual, or category of, surgical instrument storage container(s) 108 to which the surgical instrument 110 belongs, among other information. In some embodiments, a process 400 described below in reference to Figure 4 may be employed by the system 100 to identify assembled surgical storage containers 108 associated with particular surgical instruments 110.

[00068] Further, while the process 300 is discussed above in connection with the assembly of a surgical instrument storage container 108, the process 300 may also be adapted to determine whether any of the surgical instruments 110 that are present or missing from the assembled surgical instrument storage container 108 are damaged or have over extended their life expectancy or usage. For example, according to certain embodiments, the analysis of the first data set by the control system at step 308 may include identifying the particular surgical instruments 110 in the assembled surgical storage container 108 and determining whether any those surgical instruments 110 have exceeded an expiration date or expected life span. Further, according to certain embodiments, the comparison of the captured data set and the reference data set may include identifying potential discrepancies in the size or shape of the surgical instruments 110, with such discrepancies potentially indicating that the surgical instrument 110 has been damaged or is no longer fit for continued use. Additionally, similar to the above discussion regarding ordering replacement surgical instruments 110 at step 334, according to certain embodiments, if a surgical instrument 110 is deemed no longer fit for use, the control system 104 and/or management system 106 may automatically generate an order for a replacement surgical instrument 110 with, or without, authorization of an operator or user of the identification system 100.

[00069] In some circumstances, during an operation, surgical instruments 110 used throughout that operation may be placed into a surgical instrument sterilization basin or other storage container so that the used surgical instruments 110 may be cleaned, sterilized, and/or otherwise processed. Oftentimes, the surgical instruments 110 are placed into the basin and/or retrieved from a sterilizer in an unordered manner such that the corresponding surgical storage container 108 for one or more of the surgical instruments 110 is unknown to the operator or surgical equipment manager tasked with ensuring that each of the sterilized surgical instruments 110 is returned to its proper storage location. As such, the operator is left with one or more

surgical instruments 110 for which to find a proper location, which could be a daunting task, particularly given the similar appearance of many surgical instruments.

[00070] It should be appreciated that, in some embodiments, one or more of the surgical instruments 110 positioned in a surgical storage container 108 in a manner that the surgical instrument(s) 110 may generally be uncaptured in 2D or 3D images. For example, in some circumstances, the surgical storage container 108 may include shelving or otherwise organize the surgical instruments 110 into multiple levels such that one or more of the surgical instruments 110 may be occluded from the field of view of the image capture device 102. In such embodiments, the individual surgical instruments 110 and/or groupings of the surgical instruments 110 may be imaged prior to being occluded. For example, the image capture device 102 may capture one or more images of those surgical instruments 110 as they are (or prior to being) placed into the surgical storage container 108 or a sub-assembly of the surgical storage container 108 (e.g., a stringer of forceps, scissors, hemostats, and/or other suitable surgical instruments 110) so that the system 100 may verify that the instrumentation has been properly imaged.

[00071] Figure 4 illustrates a schematic flow diagram of an exemplary process 400 for automated identification of a surgical storage container 108 associated with a particular surgical instrument 110 according to an illustrated embodiment of the present invention. The operations illustrated for all of the processes in the present application are understood to be examples only, and operations may be combined or divided, and added or removed, as well as re-ordered in whole or in part, unless explicitly stated to the contrary. Depending on the particular embodiment, the features of the process 400 may be implemented by the control system 104 and/or the management system 106.

[00072] Referring to Figure 4, at step 402, a captured set of images and/or sensor data of a surgical instrument 110 are received by the controller system 104 and/or the management system 106. For example, in the illustrative embodiment, an operator may capture one or more 2D or 3D images of the surgical instrument 110 using the image capture device 102. Further, in some embodiments, additional sensor data may be generated based on the surgical instrument 110 including, for example, data indicative of the weight of the surgical instrument 110. It should be appreciated that the particular sensors utilized may vary depending on the particular embodiment and, in some embodiments, may include optical sensors, light sensors, pressure sensors, weight

sensors, communication sensors, and/or other types of sensors that generate data useful in identifying characteristics of the surgical instrument 110. Depending on the particular embodiment, the captured set of images and/or sensor data may be transmitted to a remote computing device (e.g., a cloud-based server) for remote analysis or may be analyzed locally (e.g., on the control system 104 and/or the management system 106).

[00073] At step 404, the captured image(s) and/or sensor data are analyzed to determine the type of surgical instrument 110. As indicated above, depending on the particular embodiment, the captured image(s) and/or sensor data may be analyzed by the control system 104, the management system 106, and/or a remote system (e.g., a cloud-based computing device). In some embodiments, at step 406, the captured image(s) and/or sensor data may be compared to reference data similar to that described above. For example, in some embodiments, a captured image, a processed version of the captured image, and/or data generated based on an analysis of the captured image may be compared to one or more reference images of possible surgical instruments, which may be used to determine the identity of the surgical instrument 110 in the captured image(s). It should be appreciated that the particular techniques, algorithms, and/or mechanisms utilized to analyze the captured image(s) and/or sensor data may vary depending on the particular embodiment. For example, in some embodiments, edge detection algorithms (e.g., Canny edge detection, Sobel filters, etc.), image segmentation algorithms (e.g., pyramid segmentation, watershed segmentation, etc.), blob detection algorithms, feature identification or matching algorithms (e.g., SIFT, SURF, etc.), and/or other suitable algorithms may be used to analyze the captured images (e.g., in conjunction with the reference data). In some embodiments, if a reference image corresponding with the captured image(s) cannot be identified, the analyzing device (e.g., the control system 104, the management system 106, and/or another computing device) may search/retrieve corresponding reference data from a remote server (e.g., via the Internet or from a remote database). In analyzing the captured image(s), a scaling process may be employed to identify one or more real-world physical dimensions of the surgical instrument 110 (e.g., based on a known dimension of a reference object such as a surgical storage container 108 or sterilization tray).

[00074] At step 408, the identity of one or more surgical storage containers 108 to which the type of surgical instrument 110 belongs is identified based on the analysis of the captured image(s) and/or sensor data. For example, in some embodiments, the analyzing computing

device (e.g., the control system 104, the management system 106, and/or another suitable computing device) may compare the identified type of the surgical instrument 110 to a list or database that identifies particular surgical storage containers 108 and the surgical instruments 110 within those containers 108. The list or database may identify in general the types/quantity of surgical instruments 110 that are generally included within a particular surgical storage container 108. Further, in some embodiments, the list or database may identify, additionally or alternatively, identify the particular surgical instruments 110 included in and/or missing from particular surgical storage containers 108. At step 410, the management system 106 may notify the operator of the surgical storage container(s) associated with the analyzed surgical instrument 110 via, for example, one or more audiovisual outputs generated by virtue of the I/O device(s) 128.

[00075] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment(s), but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures as permitted under the law. Furthermore it should be understood that while the use of the word preferable, preferably, or preferred in the description above indicates that feature so described may be more desirable, it nonetheless may not be necessary and any embodiment lacking the same may be contemplated as within the scope of the invention, that scope being defined by the claims that follow. In reading the claims it is intended that when words such as “a,” “an,” “at least one” and “at least a portion” are used, there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. Further, when the language “at least a portion” and/or “a portion” is used the item may include a portion and/or the entire item unless specifically stated to the contrary.

CLAIMS

1. A method comprising:
capturing a captured data set of one or more surgical instruments;
comparing, by a control system, the captured data set with a reference data set;
identifying, by the control system, discrepancies between the captured data set and the reference data set;
communicating, by an input/output device of a management system, the identified discrepancies between the captured data set and the reference data set; and
determining, by the management system, a course of action based on the nature of the identified discrepancies, the course of action comprising at least one of (i) decommissioning the one or more surgical instruments, (ii) locating a replacement surgical instrument, (iii) identifying an owner of the one or more surgical instruments, and/or (iv) identifying a storage location for the one or more surgical instruments.
2. The method of claim 1, wherein capturing the captured data set of the one or more surgical instruments comprises capturing a captured data set of a plurality of surgical instruments included in an assembled storage container;
wherein the reference data set identifies a reference set of surgical instruments included in a reference assembled storage container; and
wherein identifying the discrepancies between the captured data set and the reference data set comprises identifying an absence of one or more surgical instruments of the plurality of surgical instruments from the captured data set.
3. The method of claim 2, further comprising identifying an identifier of the one or more surgical instruments, the identifier providing at least one of an indication of a surgical instrument type and/or an identity of the assembled storage container associated with the one or more surgical instrument.
4. The method of any of claims 1-3, wherein identifying the one or more surgical instruments comprises comparing the captured data set with a plurality of reference data sets that are stored in a database of the control system.

5. The method of any of claims 1-4, wherein identifying the one or more surgical instruments comprises detecting at least one of a bar code or radio frequency identifier of the one or more surgical instruments.

6. The method of any of claims 1-5, further comprising determining, based on an identified discrepancy between the captured data set and the reference data set, whether the one or more surgical instruments is fit for use in a surgical procedure.

7. The method of any of claims 1-6, further comprising determining that the one or more surgical instruments is owned by a third party;

wherein identifying the owner of the one or more surgical instruments is in response to the determination that the one or more surgical instruments is owned by the third party.

8. The method of any of claims 1-7, wherein locating the replacement surgical instrument comprises at least one of (i) ordering, by the management system, a replacement surgical instrument for the one or more surgical instruments or (ii) identifying an instrument storage container containing the missing instrument.

9. The method of any of claims 1-8, further comprising determining, by the control system and based on a comparison of the captured data set and the reference data set, whether any of the one or more surgical instruments is damaged.

10. The method of any of claims 1-9, further comprising determining, by the management system and based on an identified discrepancy between the captured data set and the reference data set, the availability of a replacement surgical instrument for the one or more surgical instruments.

11. The method of any of claims 1-10, wherein the captured data set includes a plurality of images of the one or more surgical instruments.

12. The method of claim 11, wherein the captured data set and the reference data set include at least one of a depth value or a distance value relating to the one or more surgical instruments.

13. A system comprising:

at least one image capture device structured to capture a captured data set of one or more surgical instruments, the captured data set comprising an image of the one or more surgical instruments;

a control system having a plurality of reference data sets, the control system structured to receive the captured data set and identify one or more discrepancies between the captured data set and at least one of the plurality of reference data sets; and

a management system adapted to receive an identifier from the control system, the identifier corresponding to the one or more discrepancies identified by the control system, the management system adapted to use the identifier to determine a course of action for the one or more surgical instruments.

14. The system of claim 13, wherein the one or more surgical instruments comprises a plurality of surgical instruments stored in an assembled storage container; and

wherein at least one of the plurality of reference data sets indicates a location and an identifier corresponding to the plurality of surgical instruments.

15. The system of any of claims 13 or 14, wherein the control system comprises a cloud-based server.

16. The system of any of claims 13-15, wherein the control system comprises a first connecting device that is structured to communicate with a second connecting device of the management system.

17. The system of any of claims 13-16, wherein the at least one image capture device is structured to obtain three-dimensional images of the one or more surgical instruments.

18. The system of any of claims 13-17, wherein the at least one image capture device is structured to obtain a distance of the one or more surgical instruments from a reference point.

19. The system of any of claims 13-18, wherein the management system is structured to determine a course of action that includes locating a replacement surgical instrument for the one or more surgical instruments from at least one of an inventory of an associated surgical site or a vendor.

20. The system of claim 19, wherein the management system is structured to determine a course of action that includes at least one of identifying an owner of one or more surgical instruments or determining a storage location for the one or more surgical instruments.

21. A system comprising:
at least one processor; and
at least one memory comprising a plurality of instructions stored thereon that, in response to execution by the at least one processor, causes the system to:
receive at least one image of a surgical instrument captured by an image capture device;
analyze the at least one image to determine a type of the surgical instrument;
determine a surgical storage container within which to store the surgical instrument based on the identified type of the surgical instrument; and
notify an operator of the system of the surgical storage container.

22. The system of claim 21, wherein the plurality of instructions, in response to execution by the at least one processor, further causes the system to receive sensor data different from the least one image; and

wherein to analyze the at least one image comprises to analyze the at least one image and the sensor data to determine the type of the surgical instrument.

23. The system of claim 22, wherein the sensor data is indicative of a weight of the surgical instrument.

24. The system of claim 21, wherein to analyze the at least one image comprises to compare the at least one image to reference data that identifies possible reference surgical instruments of different types.

25. The system of claim 21, wherein to determine the surgical storage container within which to store the surgical instrument comprises to compare the identified type of the surgical instrument to a database that identifies reference surgical instruments included in one or more surgical storage containers.

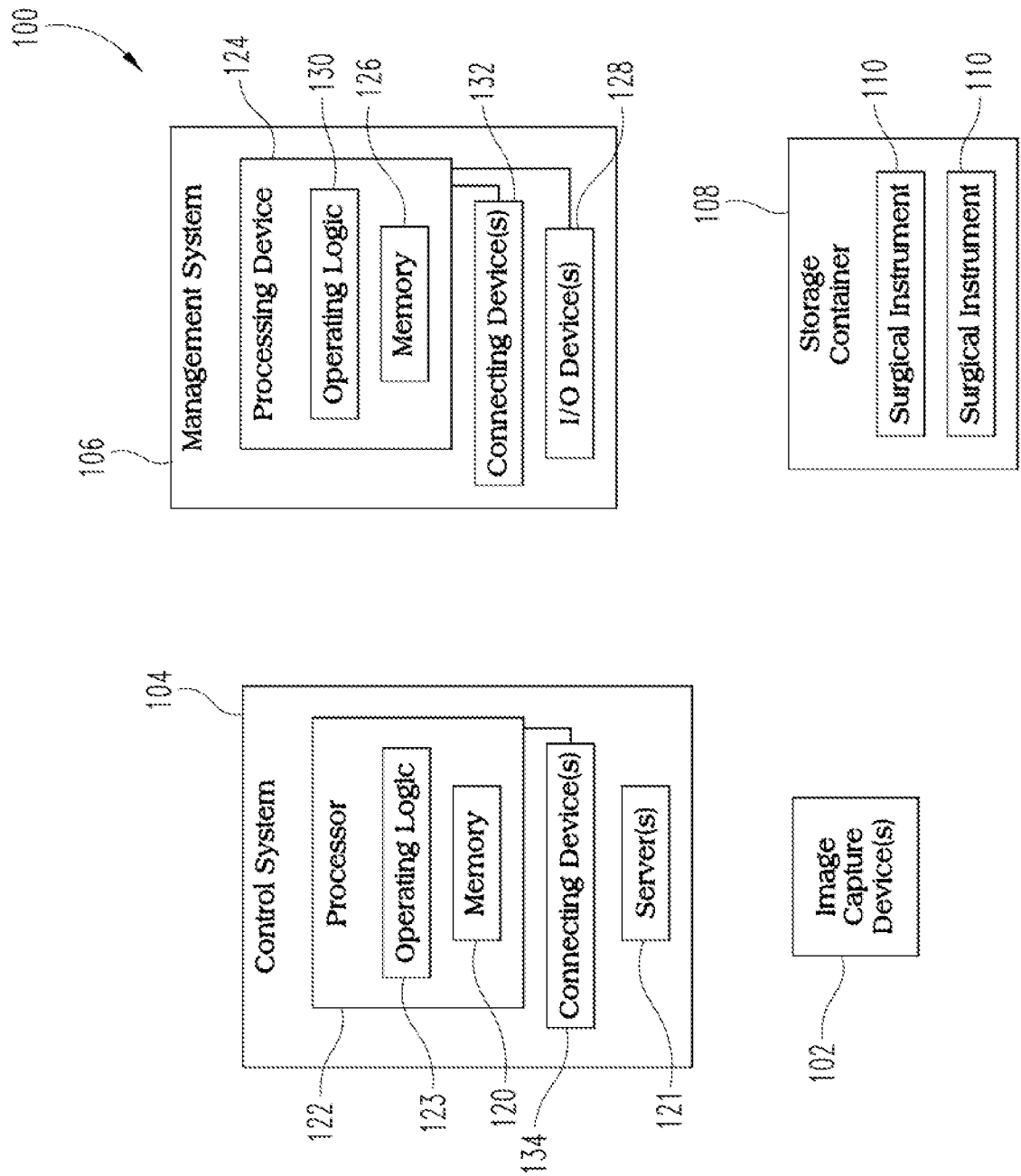


Fig. 1

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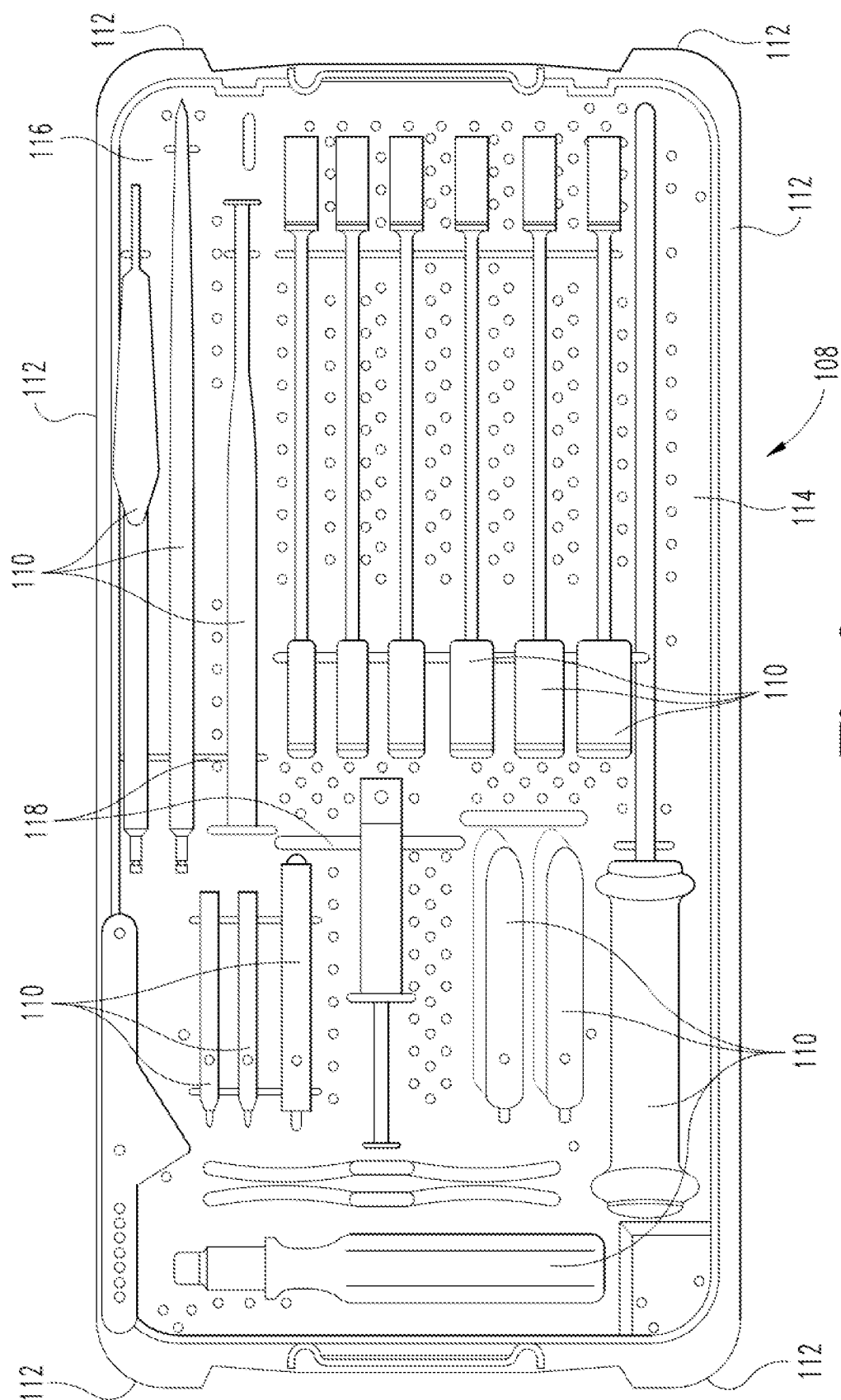
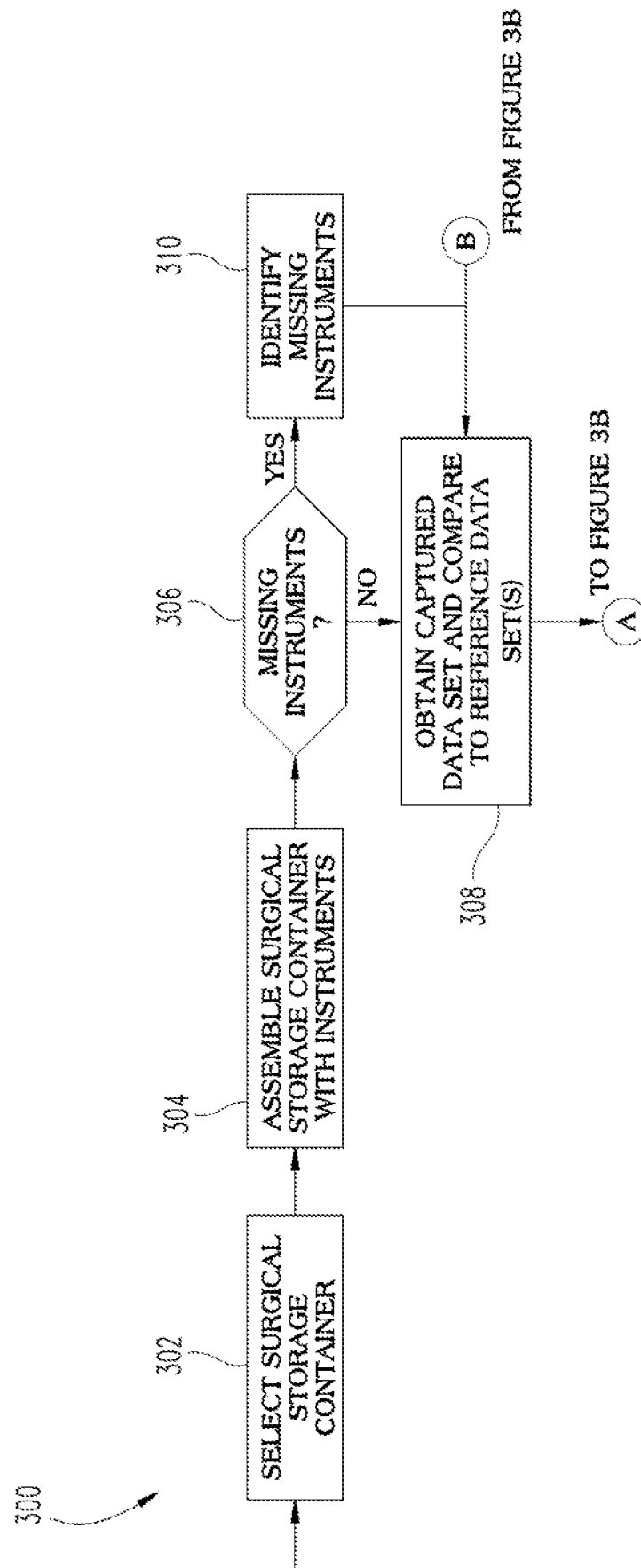
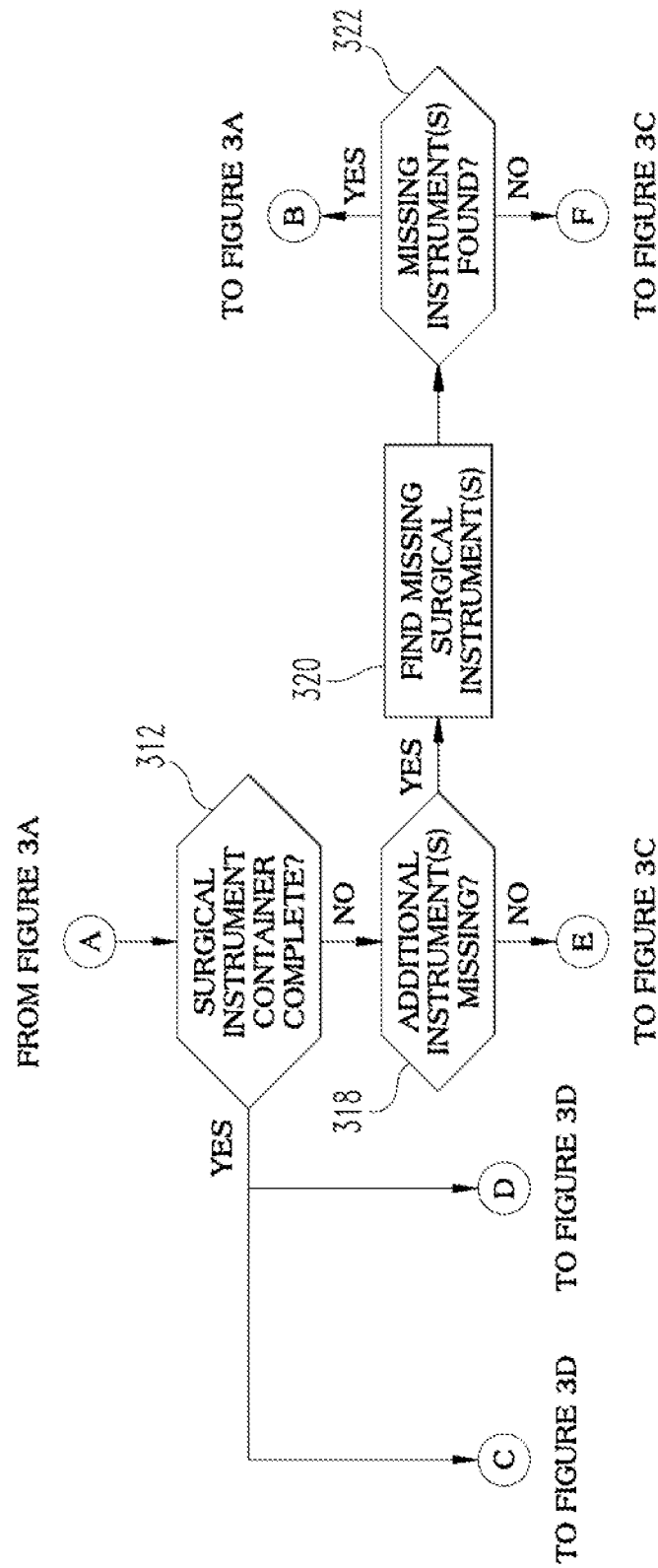


Fig. 2

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**Fig. 3A**



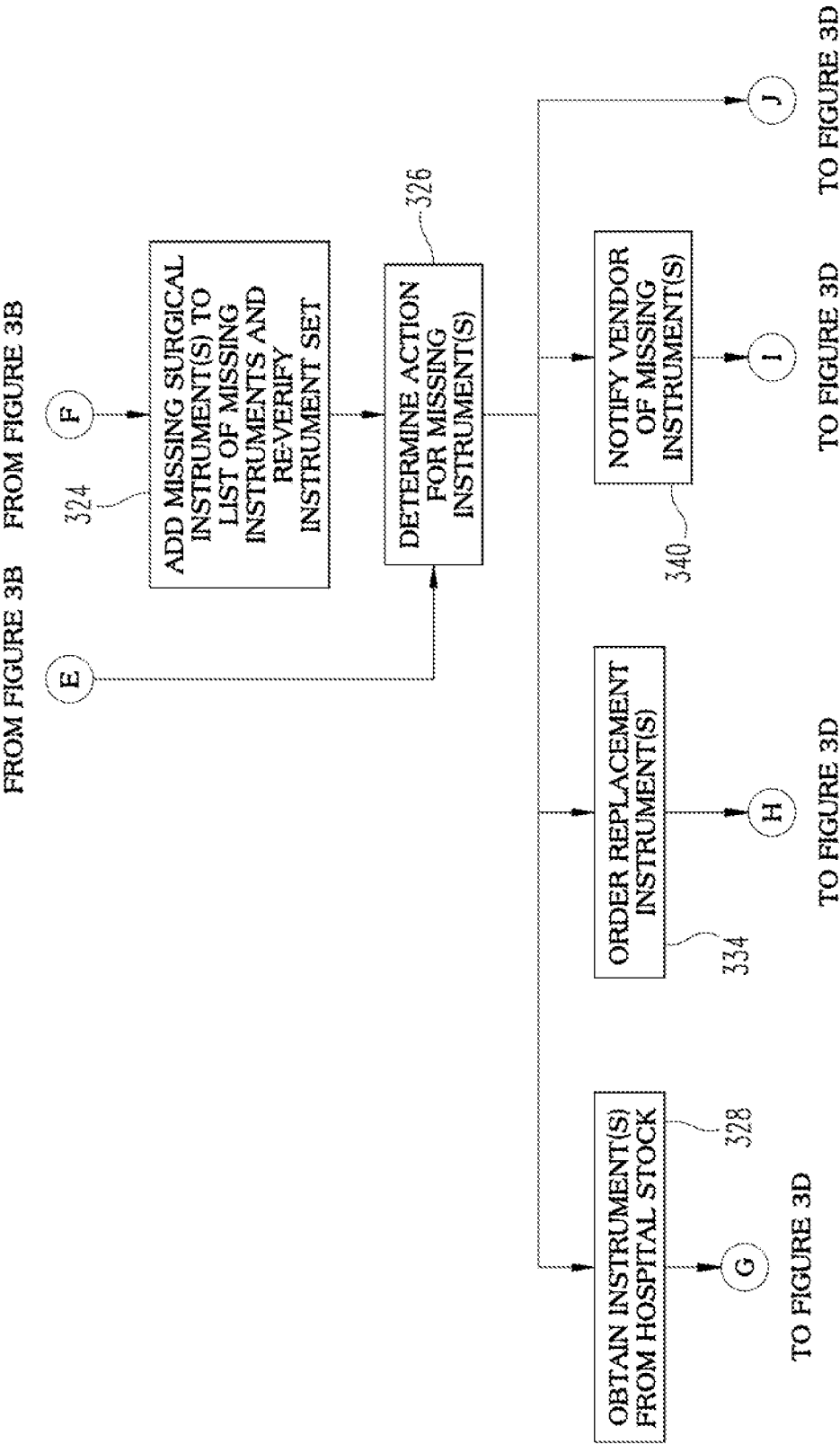


Fig. 3C

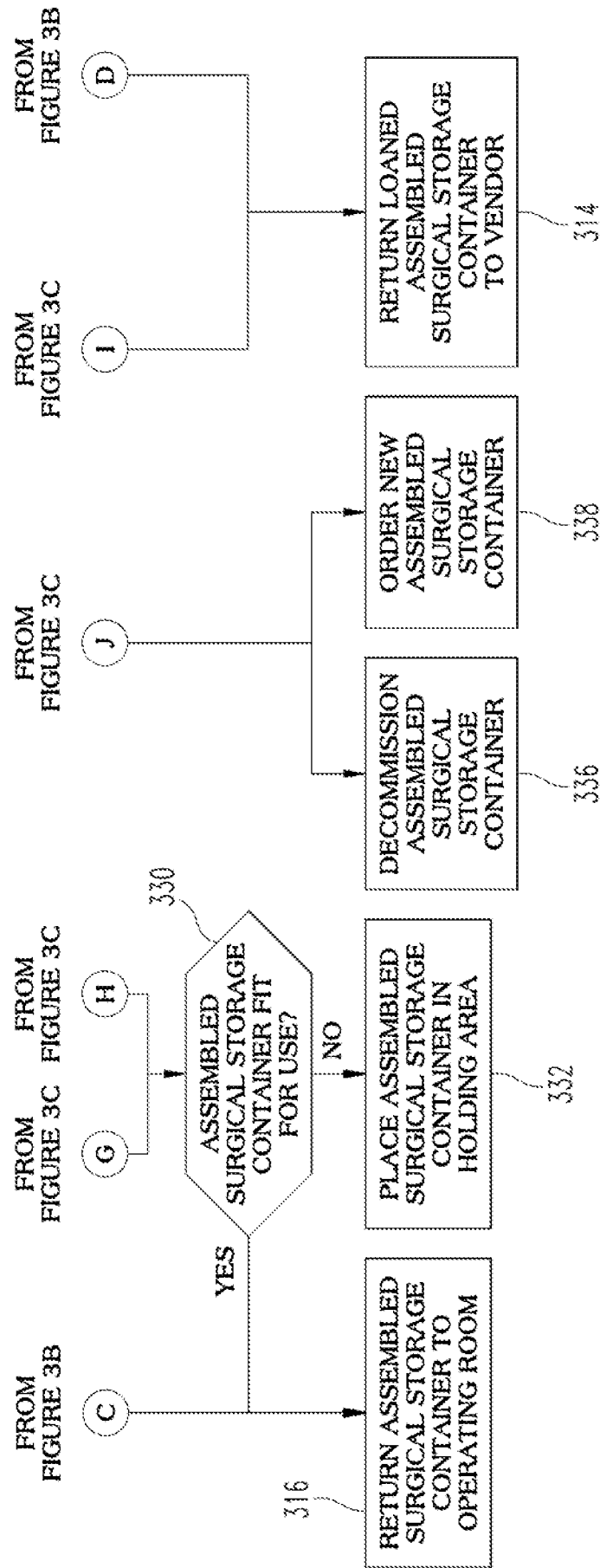
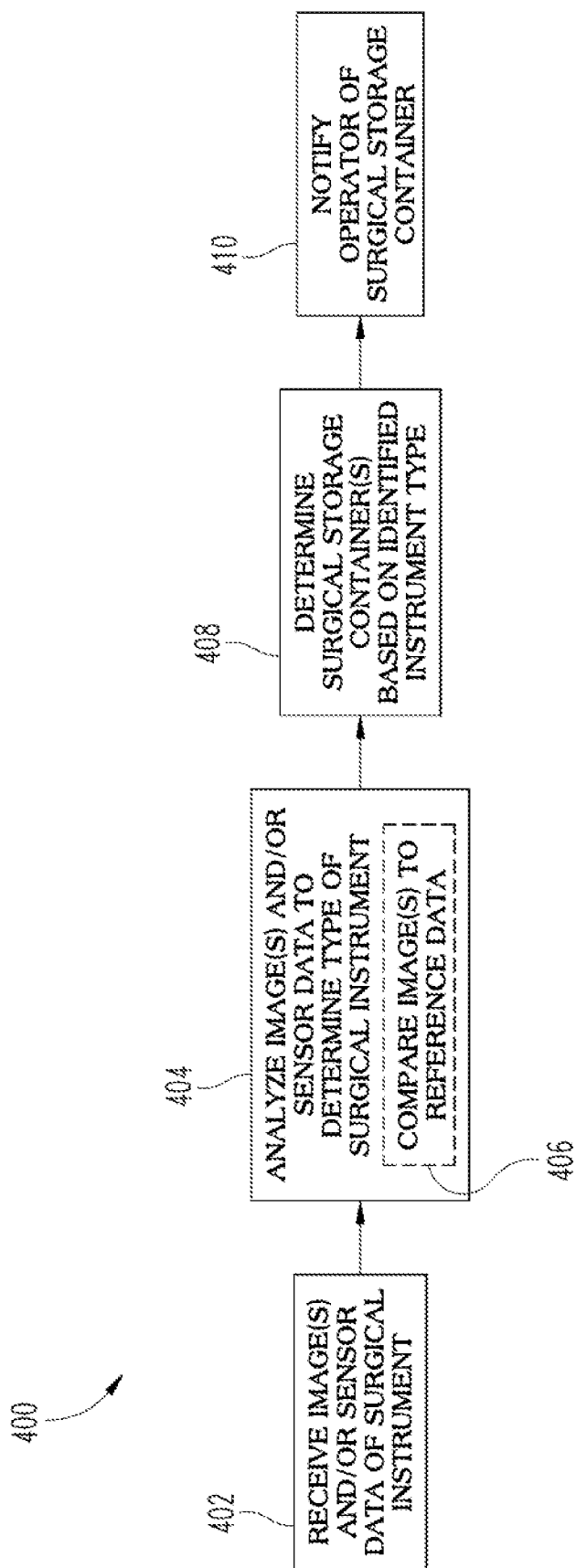


Fig. 3D

**Fig. 4**

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/042256

A. CLASSIFICATION OF SUBJECT MATTER INV. G06Q10/00 G06Q10/08 G06Q50/22 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) G06Q		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/336554 A1 (LEWIS RUSSELL F [US] ET AL) 19 December 2013 (2013-12-19) figures 1, 2, 4-9 paragraphs [0002], [0004], [0005] paragraphs [0007] - [0012], [0016] - [0024], [0070] - [0081] paragraphs [0086], [0092], [0097] paragraphs [0102] - [0106], [0110] - [0115] paragraphs [0121], [0125] paragraphs [0131] - [0135] paragraphs [0147], [0150], [0153], [0154], [0155] ----- -/--	1-25
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/091679 A1 (GLOGER OLIVER [DE] ET AL) 18 April 2013 (2013-04-18) figures 1, 2 paragraphs [0002] - [0006], [0015] - [0038], [0043] - [0044], [0070] - [0074], [0098] - [0125] -----	1-25

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2016/042256

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013336554	A1	19-12-2013	NONE

US 2013091679	A1	18-04-2013	DE 102011054452 A1
			EP 2581863 A1
			US 2013091679 A1
