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(54) **Title:** PORTABLE ENDOSCOPE

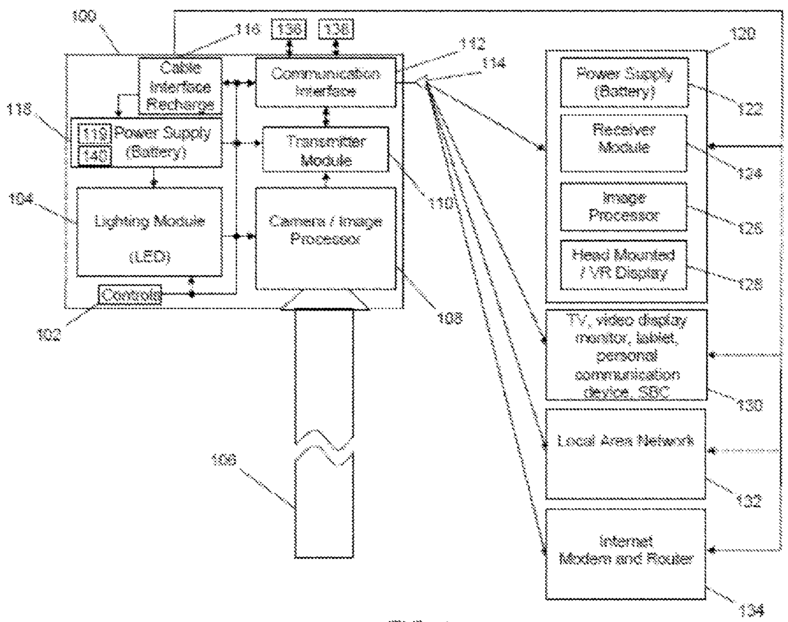

FIG. 1

(57) **Abstract:** A scope with secure and interference free data signals is provided that integrates the functions of an optical tower into a portable device. The scope is compact and eliminates the need for an optical tower that traditionally provides a power source, monitor, light source, and video processing. The scope eliminates the use of cords or cables that carry light, video signals or images, and power to the scope that may conflict with the movement of a surgeon and other operators in non-medical related applications. The scope also addresses issues unique to operation in the field that specifically include the problems of a lack of reliable power, operation during power pack switching, secure operation by remote surgical specialists with present medical professionals that lack surgical skills to perform laparoscopic procedures, interface with conventional devices including tablets, dongles, or smart phones, and robust recharge capabilities.

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PORTABLE ENDOSCOPE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority of United States Provisional Patent Application Serial No. 63/472,777 filed June 13, 2023, which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention in general relates to medical and inspection devices and in particular to a wireless portable examination scope including an endoscope or laparoscope with integrated components to facilitate field operation.

BACKGROUND OF THE INVENTION

[0003] Endoscopes and laparoscopes are devices with a light attached to one end that are used to look inside or inspect a region inside a confined area or a specific body cavity or organ. Endoscopes are inserted through a natural opening, such as the mouth or rectum and are commonly used to detect ulcers, inflammation, erosions, polyps, strictures, malignancies, varices, and bleeding sites. In a surgical procedure, laparoscopes are inserted through a small incision that permits minimally invasive procedures that improve patient care and minimize recovery time. Any medical procedure that uses endoscope equipment is called an endoscopy. Particular medical procedures that employ endoscopes include arthroscopy (orthopedic joints), bronchoscopy (lung), colonoscopy (colon), cystoscopy (bladder), gastroscopy (upper gastrointestinal tract), laryngoscopy (larynx), laparoscopy (abdomen, peritoneal cavity, ovaries, fallopian tubes and uterus), nephroscopy (kidney), otoscopy (ear), and rhinoscopy (nose).

[0004] Endoscopes capture images through a long tube, which can be rigid or flexible. Images may be captured by a purely fiber optic scope with a bundle of glass fibers that collect the lighted images at one end and transfer them to an eye piece, or video images may be obtained using a small, optically sensitive computer chip at the end of the scope. The computer chip transmits electronic signals up the scope to a computer which then displays the image on a large video screen. Advances in lighting technologies, such as light emitting diodes (LED) have improved the imaging performance of endoscopes. Additional instruments for cutting, grasping and other functions are often attached to the endoscope, or are supplied via an open channel in the endoscope to allow other instruments to pass through in order to perform biopsies, remove polyps or inject solutions, as needed. Endoscopes are also well suited for a number of industrial applications such as inspections and are synonymously referred to herein as borescopes. It is noted that in laparoscopic procedures, tools usually enter through their own dedicated trocars or openings.

[0005] While endoscopes offer many advantages to physicians and patients, the use of current endoscopes require the use of an optical tower. Optical towers include a power source for the endoscope, a monitor/display, a light source, and a video receiver and processor. Optical towers are generally quite large, are not easily moved, and take up valuable floor space in an operating room. In addition, the use of cords or cables that carry light, video signals or images, and power to the endoscope interfere with the movement of the surgeon and the members of the surgical team.

[0006] Modern operating rooms and surgical theaters, even in remote locations, have several electrical and mechanical instruments, as well as data gathering electronics that potentially generate electromagnetic and radio wave interference. These sources of interference can potentially disrupt data transmission from surgical diagnostic devices such as endoscopes.

[0007] Spread Spectrum refers to a system that spreads a signal over a large frequency band thereby providing a secure communication signal that is also more robust and impervious to potential sources of signal interference, signal jamming, and unauthorized eavesdropping and signal interception. A spread spectrum signal does not have a clearly distinguishable peak in the spectrum, which makes the signal more difficult to distinguish from noise and therefore more difficult to jam or intercept. Furthermore, an interfering signal in a specific frequency will have little to no impact on the spread spectrum signal. While these problems have largely been addressed by the portable endoscope detailed in US Patent No, 11,517,189 problems persist in the development of a portable endoscope.

[0008] While there have been many advancements in scope technology for endoscopes and laparoscopes, these existing scopes are still large, lack portability, are costly, and cannot be easily deployed for remote field use. Therefore, there exists a need for a field deployable scope that integrates the functions of an optical tower into a portable device, while providing flexibility by eliminating the use of cords or cables that carry light, video signals or images, and power to the endoscope or laparoscope that may conflict with the movement of a surgeon and the members of the surgical team.

SUMMARY OF THE INVENTION

[0009] A scope device including an endoscope or laparoscope with secure and interference free data signals is provided that integrates functionality of an optical tower within a self-contained unit. The endoscope device includes an elongated endoscope tube emerging from or attaches to an enclosure integrating the functionality of the optical tower, where the enclosure contains a camera, an image processor, a lighting module, a transmitter module, a communication interface, a control interface, and one or more power sources. A lighting module with a light source illuminates a viewing field of the endoscope via the elongated tube. The camera is in electrical communication with the image processor and supplies images and video to the image processor that are obtained via the elongated endoscope tube. The images and video are displayed on one or more of a head mounted display, heads up display (HUD), virtual reality (VR) headset, extended reality (XR) headset that combines VR with augmented reality, TV if the images are broadcasted on a specific frequency, video display monitor, mobile computing devices, cellular phone, tablet, or mobile communication and entertainment devices.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The subject matter that is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other objects, features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0011] FIG. 1 illustrates a block diagram of an embodiment of the endoscope in communication with various user and network devices;

[0012] FIGs. 2A and 2B provide an example of image stabilization used in embodiments of the invention; and

[0013] FIG. 3 is a schematic diagram illustrating an overall view of communication devices, computing devices, and mediums for interfacing with the inventive endoscope.

DESCRIPTION OF THE INVENTION

[0014] The present invention has utility as an endoscope or laparoscope (herein referred to as a scope) with secure and interference free data signals that integrates the functions of an optical tower into a portable device, while eliminating the reliance on cords or cables that carry light, video signals or images, and power to the endoscope that may conflict with the movement of a surgeon and the members of the surgical team, or other operators in non-medical related applications. The present invention also addresses issues unique to operation in the field that specifically include the problems of a lack of reliable power, operation during power pack switching, secure operation by remote surgical specialists with present medical professionals that lack surgical skills to perform laparoscopic procedures, interface with conventional devices such as tablets, dongles, or smart phones, and robust recharge capabilities.

[0015] Embodiments of the inventive scope eliminate the need for an optical tower that traditionally provides a power source, monitor, light source, and video processing. The inventive scope is a compact and inexpensive tool for performing endoscopic and laparoscopic procedures by eliminating the optical tower currently used in these procedures. Embodiments of the medical hardware invention saves space through the elimination of the optical tower, and as a result provides surgeons with the flexibility and option to perform endoscopic based surgery in a smaller operating room of a clinic or office setting. It is appreciated that the scope is well suited for field hospital usage. The inventive scope affords portability, since an optical tower is not necessary for the operation of embodiments of the scope, and surgery using the inventive scope can now be performed anywhere that has carbon dioxide gas, a power source for cauterization, and anesthesia. The reduced size, light weight, and robust construction of the portable scope allows the device to be handheld or fixed to a mechanical or robotic arm. It is further noted that since all components of an optical tower are now integrated into the inventive device, the components are all able to cleaned through the same fashion as an endoscope or laparoscope.

[0016] The inventive scope has potential uses for the military and non-governmental agencies that provide medical care in a mobile facility with limited facilities. In addition, embodiments of the invention can also be used in smaller or rural facilities that cannot designate a room purely for endoscopic surgery. Furthermore, the portability of the inventive endoscope allows for non-medical related applications such as industrial inspection, search and rescue, pest control, and remediation, etc.

[0017] As previously noted, the reduction in size and portability of embodiments of the inventive scope makes the device amenable to use in field hospitals. However, in the field, embodiments of the scope may be subjected to unpredictable electromagnetic and radio frequency interferences in the surrounding area of use, which may not be a problem in a hospital setting using immobile equipment; as well as the aforementioned problems as to remote specialists, unreliable power, and the need to couple to conventional electronic devices. For example, in a practical use setting that illustrates the advantages of embodiments of the inventive endoscope, as an injured patient is being transported to an emergency room in a helicopter flying over variable terrain, first responders can perform an endoscopic procedure en route to assess the patient's injuries and if needed open an airway or stop critical hemorrhaging. Images and video of such an en route endoscopic procedure can be vitally important for determining a lifesaving course of action for both the first responders and possible communication to remote emergency room personnel. However, this lifesaving value creates a problem not encountered by the prior art endoscopic devices designed for use in the electronic signal protected confines of hospitals and other fixed medical facilities, namely "interfering signals" that disrupt reliable transmission of the endoscopic data to a remote location. In contrast to the controlled environments of fixed medical facilities, these "interfering signals" abound in the environment during the helicopter flight in which the claimed endoscope is in use. For example, "interfering signals" may come from cellular towers, radio or television broadcasting equipment, WIFI networks, air traffic control towers, emergency services communication networks, and more; any number of which are randomly encountered during the helicopter flight to the hospital emergency room. In order to overcome signal interference and provide a high level of signal reliability, embodiments of the inventive scope may use redundant communication channels that at least makes use of spread-spectrum techniques to minimize any environmental interference. The latter may be particularly prevalent in electrosurgery. Furthermore, since the safety of the patient is dependent on the fidelity of the wireless video transmission in terms of both resolution and framerate graceful degradation in both aspects may be implemented with any combination the framerate and resolution being made. For example, the following progression of video signal transmission may be followed:

4K:60fps –> UHD:60fps –> HD:60fps –> HD:30fps

[0018] Embodiments of the inventive scope employ advanced signal processing algorithms that dynamically adjust to environmental factors in real-time that affect signal transmission as well as available bandwidth. Embodiments of the algorithm may continually monitor the communication channel quality to ensure maximal throughput against the graceful degradation of video stream quality (and the inverse thereof) as noted above. This gradual reduction of a combination of resolution and frame rate can also be used during low remain battery life situations. A surgeon override feature may be provided to manually control signal resolution and framerate if required by the surgeon to better discern information from an image or view. If available bandwidth is a constraint users may be ranked based on criticality such that non-critical viewers can be dropped to ensure transmission quality within a limited bandwidth.

[0019] As wireless transmissions may be vulnerable to attack, embodiments of the endoscope system may use end-to-end encryption to ensure that only authorized display devices are able to interpret the video stream. Authentication strategies such as two factor authentication may be employed to verify intended recipients. In embodiments, pairing the endoscope with the selected end-point receivers may employ technologies such as radio frequency identification (RFID), quick response (QR) codes, or other automatic ID technologies. For example, and endpoint device with a dedicated camera can scan a QR code as part of a verification process. Adding additional endpoint devices can be managed from the initial (main) endpoint device and may include the sharing of a connection pin/password, a waiting room / queue (virtual), and possibly additional remote user identification. An exemplary embodiment of a workflow for adding endpoint users is as follows:

1. Main endpoint is paired and operational.

2. A remote sharing code / pin or other form of authentication is generated and shared with the remote operator via an alternative channel (email, Short Message/Messaging Service (SMS), instant messaging, etc.)

3. Remote user utilizes the pin to connect to a queue / waiting room.

4. Main terminal identifies remote user in waiting room and establishes a remote connection.

5. Main terminal can now be used to grant viewing/control / augmentation and annotation rights to remote endpoints on an endpoint-by-endpoint basis.

a. Augmentation and annotation can be presented or omitted to specific users to avoid visual noise or presentation of patient identifying information (PII)

b. Viewing can be suspended at any time to specific or all non-critical users to optimize bandwidth or during sensitive situations such as discussions that contain PII or during unexpected complications.

c. Audio can also be granted or restricted

d. Control of these functions and camera controls can be managed by a remote user

6. In the case of remote control, one option is to have the remote used be authenticated by scanning of an ID card or other secure form as an example before control is granted.

[0020] In embodiments of the inventive scope, the wireless communication technology used may be interoperable and unlicensed as to ensure that most devices capable of wirelessly receiving and displaying video streams can be used as endpoints in the system. A dongle may be used for secure and 'plug and play' connection with a viewing device. A wireless hotspot may be used for transmitting from the camera device to a viewing device.

[0021] With embodiments of the inventive endoscope, the insertion of and design of surgical tools will remain the same. Trocars are still required to provide the seal for the hand tools and laparoscope, and the hand tools are powered for cauterization. While a surgeon manipulates the hand tools, and another surgeon often navigates the laparoscope. The electronics (camera and imager, transmitter, lighting, communication interface, power supply) are mounted onto the endoscope in the same manner that the endoscope video camera is mounted onto existing endoscope designs. A light source, including light emitting diodes (LED), is attached to the inventive scope by a fiber-optic cable or via a series of lenses as known in the art. In certain inventive embodiments, a visual record of the viewing field of the endoscope is collected, and transmitted via wired or wireless signals to personal video viewers worn by the master surgeon manipulating the hand tools and by the surgeon navigating the endoscope. It is appreciated that in specific inventive embodiments, it is beneficial to have the capability to transmit endoscopic imagery to a TV, video display monitor, or handheld display of a mobile device, especially from remote locations with limited communications infrastructure. This added flexibility would still not require the optical tower common to conventional systems and provides and optional backup in cases where a heads-up display (HUD) or a display device or large tablet mounted on a bed frame holding a patient (an ergonomic, forward viewing direction screen) is not functioning. Additional wired/wireless signals can be transmitted to additional surgeons, nurses, students, and observers as necessary. In non-medical applications, the video features of the inventive endoscope may be used for inspection of remote or hard to reach areas that include, for example, industrial inspection, pest control, remediation such as in pipes, sewers, machinery enclosures, and nuclear facilities. Military and public safety agencies may use the video features for reconnaissance and rescue missions. The user‘s ability to switch video channels allows a soldier or emergency personnel to see via shared views what their teammates see from their own endoscopes, whether their teammate is alive or dead, providing a higher level of situational awareness. It is appreciated that the switchable video channels may be transmitted using spread spectrum communication techniques known in the art. It is further appreciated that transmissions may be encrypted for privacy and security.

[0022] With reference to the attached figures, an inventive scope is depicted generally at 100 in FIG. 1. The scope 100 includes within an integrated enclosure with optical tower function so as to eliminate the need of an optical tower. Controls 102 are present in the scope

100 in electrical communication with lighting module 104, camera/image processor 108, transmitter module 110, and communication interface 112. Controls 102 provide the user with the ability to control the intensity of the lighting with the lighting module 104, camera and imaging parameters of the camera/image processor 108, as well as communication parameters of the transmitter module 110 and communication interface 112. In an embodiment the controls may be on body controls that may include one or more of light/white balance control, recording (still or video) controls, on/off power, and pairing controls. The controls 102 may be tactile buttons and switches, scroll wheels, touchscreen based pull down menus, or a combination thereof. The lighting module 104 provides light via elongated tube 106 to the surgical area of interest with controlled intensity and apertures. It is appreciated that the lighting module 104 may be a light source that is a separate attachment to the scope and not included in the enclosure. Camera and image parameters illustratively include depth of field, frame rate, illumination wavelengths, focus, pixel density, false color, frame size (x/y ratio) or aspect ratio, noise filtering, and baud rate. Automated brightness, focus, and image stability may also be provided by the lighting module 104 in concert with the camera/image processor 108. In an embodiment a camera operating in the visible light spectrum as well as operating in the infra-red and ultraviolet spectra may provide additional diagnostic information to the surgeon.

[0023] The elongated tube 106 can be rigid or flexible, as are conventional to the art. In certain inventive embodiments, images may be captured by a purely fiber optic scope with a bundle of glass fibers that collect the lighted images at one end of the elongated tube 106 and transfer them to an eye piece, or video images may be obtained using a small, optically sensitive computer chip, such as a charged coupled device (CCD) within the camera/image processor 108 at the end of the scope tube 106. In an embodiment the camera 108 may take an image of a quick response (QR) code to wirelessly pair to a display 130 that is presenting a QR code.

[0024] In embodiments the camera/image processor 108 may have a lens or focus system that has an autofocus or manual (fixed) focus. In specific embodiments, a depth sensing camera may be incorporated in the camera/image processor 108 so as to aid in the surgeon's identification of abnormal or general anatomy. In specific embodiments, a volumetric camera may be utilized to provide a three-dimensional (3D) viewing experience. The combination of multiple laparoscope views could construct a 3D view of internal cavities. Furthermore, a combination of multiple information sources (images / video), depth, density, and other information sources such as vitals, camera battery life, annotation from proctors or viewers, imaging (computed tomography (CT) Scans) over lays, etc., may be combined to produce an immersive augmented or extended reality (XR) display to surgeons in real time with the use of extended reality headsets, which include virtual reality (VR) headsets or augmented reality (AR) headset. It is appreciated that multiple information sources may include multiple scopes that a viewer can toggle through. Additionally, multiple volumetric cameras scopes could be used to build a better 3D topography. The augmentation can be managed or turned off by critical users to reduce visual pollution. The augmentation can be automatically turned off to save on bandwidth or in low power situations. The automatic control of augmentation can be overridden to allow manual control.

[0025] Image processing may also utilize machine learning (ML) and artificial intelligence (AI) to recognize abnormal or general anatomical features and to assist in providing diagnostic information to the physician during a procedure. Speech recognition coupled with machine learning and AI may be utilized to provide a voice command feature and can identify the person giving the commands. The primary user (i.e., surgeon) or system operator will enable or disable the additional and redundant use of voice commands to interact with the system. Voice commands require the surgeon (or other designated user) to train a AI/ML model to only respond to a specific (single) user or more than one authorized user. The voice control system is defensive in nature and only executes commands after verifying the interpreted command with the target user.

[0026] It is noted that current laparoscopic systems do not include haptic feedback since the image processing is only done on a receiving terminal. However, in embodiments of the inventive endoscope system image processing is done on the instrument itself, and characteristics of the image itself can be used to provide haptic (and other) feedback to the surgeon based on defined parameters. This may include vibrations or audible feedback when the scope approaches too close to anatomy as an example.

[0027] The scope tube 106 besides providing a conduit for collecting images and a pathway for insertion of surgical tools is provided in certain inventive embodiments with a channel for providing suction to an examined area to remove obstructions such as smoke or liquids, or to remove materials such as masses of tissue that are being excised or debulked in a surgical procedure. In addition, the scope tube 106 is provided with a channel to introduce a fluid to a remote tissue area for example a liquid active agent, such as a curable resin, irrigation fluid, carbon dioxide, air, is provided via the channel to the tissue or cavity. Furthermore, other operations that may be conducted via scope tube 106 illustratively include the insertion of a spectroscopy system or the introduction of a manipulator or thermal tools such as an induction heating coil, welding gases (in an industrial pipe testing/repair setting), or cautery tool. It is appreciated that surgical tools from various original equipment manufacturers (OEM) may be used with embodiments of the inventive scope 100. For a non-limiting example, an OEM laparoscope and associated camera coupler using a type C mount may be adapted for use with the inventive scope 100, although any alternative instrument supplier that can couple to a type C camera mount should be a substitutive direct drop-in. Embodiments of the scope 100 may be configured with different adaptors to accommodate various camera mounts.

[0028] The transmitter module 110 broadcasts the images and video obtained from the camera/image processor 108 via predefined frequencies and protocols including CDMA, UMTS, WiFi (802.11 a,b,g,n), WiMax, Bluetooth®, near field, cellular protocols, and other existing and contemplated communication protocols. As previously described, many of the aforementioned communication protocols are based on spread spectrum communication techniques including frequency hopping and direct sequence. In certain inventive embodiments of the transmitter module 110 may also allow for user manual selectable transmission frequencies and video channels for the endoscope to account for interfering signals. In addition, a user may be able to switch video channels to access additional informational content or operating room views. In other embodiments, the transmitter module 110 provides the capability to overlay images from another source or piece of medical equipment or monitoring device onto the endoscope video feed via a wired or wireless connection to the overlay source. In inventive embodiments, the user may be able to switch between visualization options that provide a surgeon with flexibility of having the choice to switch between modalities (not just channels) such as Bluetooth®, radio (TV), HDMI, USB, etc. In addition, the transmitter module 110 may have circuitry and software for video compression and for video adjustment.

[0029] In another inventive embodiment, the transmission from the scope 100 is encrypted for instances where secure communications are required. The communication interface 112 routes the broadcast signals to an antenna 114, and/or takes the camera and image signals and routes them to a cable interface 116 for a wired connection via for example composite video, s-video, universal serial bus (USB), high definition media interface (HDMI), digital video interface (DVI), coax cable, or other wired standards. In an embodiment, the communication interface 112 use a dedicated dongle 136 for wireless communication and for pairing. In an embodiment, a smart phone or personal communication device 138 may connect via wireless pairing via WiFi (802.11 a,b,g,n), WiFi hotspots, WiMax, Bluetooth®, near field, cellular protocols or via a cable to the communication interface 112 for broadcasting and receiving information. Specific smart phones or personal communication devices 138 may also have the ability to connect to satellite networks when out of range of WiFi or cellular networks. The communication options offered by embodiments of the endoscope 100 allow for collaboration with remote specialists and for educational sessions with remote classes with multiple viewers. During a collaborative session with a remote specialist, the specialist may be presented as a picture-in-picture (PIP) on the endoscope display.

[0030] The power supply 118 may be directly connected to a 110-240 V AC electrical outlet, or may be a battery that is or is not rechargeable. A rechargeable battery may be charged while connected to an outlet, or via a communication cable such as a USB cable or other cable types. In addition, the battery may be configured for wireless charging via induction fields. Power supply 118 may act as a power source or supply to peripheral devices, such as a viewing device or a vacuum for suction or other medical assist devices, via a cable such as USB connector or DC power receptacle. In specific inventive embodiments the power supply 118 may automatically switch from a rechargeable battery to a wired power cord when the battery is running low. The internal power supply 118 ensures uninterrupted operations from a power perspective. A capacitor or auxiliary battery 119 may be provided to supply redundant power as well as power during a battery change thereby allowing for a hot swap of a replaceable battery without interruption of device operation or loss of device pairing with viewing devices. Power management software may automatically enter a power saver mode during a battery swap, and may reduce or fully suspend image or framerate quality or light brightness, suspend augmentation of imagining, reduce the number of display devices receiving broadcast based on priority, or other non-critical functions to ensure that pairing is maintained with a primary viewing device. The battery may be modular and allow for multiple sized power options (larger/smaller battery capacities). The batteries may be charged during use or detached in a separate charger. The batteries may be stackable during use and charging, which allows the power source selection to be balanced against the surgeon's preferences (weight distribution) and surgical requirements.

[0031] In an embodiment, the charging port may be placed on the inside, unexposed surface of the swappable battery. An audible tone or vibration may be emitted by the scope device 100 to notify the user that the battery is running low. In addition, visual indicators on a battery power display 140 may be provided to indicate battery charge level and a low power warning. The remaining useful life of the power sources (both internal and external) shall be determined continually by means of sensor data, usage information, and computing algorithms to provide an indication of when power sources such as batteries must be replaced. This will allow the doctor to strategically decide when a good opportunity for pausing the surgery for a battery swap. The dynamic remaining capacity indicators that take estimated battery demand surgical into account when indicating the remaining capacity of the current charge of the batteries. Embodiments of the inventive scope may have an internal securing mechanism to hold one or more swappable batteries in place, where the endoscope and battery connection are designed to withstand vibrations and movement during use. The stackable batteries may form a handle portion of the scope.

[0032] As noted above, embodiments of the inventive endoscope are portable self-contained units that are configured for wired or wireless operation thereby eliminating the need for an optical tower. The scope 100 may be in wired- or wireless-contact with personal viewer 120. Personal viewer 120 is readily configured with a self-contained power supply 122 such as a battery, a receiver module 124 for receiving the wired or wireless signals, an image processor 126 for translating the received signals to one or multi-dimensional views in a head mounted display, extended reality (XR) headset (which combines VR and AR), or heads up display (HUD) 128 or a display screen 130 illustratively including a TV, video display monitor, tablet, laptop, personal communication device (smart phone), personal digital assistant, a single board computer (SBC) with an attached screen, etc. A head mounted display, extended reality (XR) headset, or heads up display (HUD) 128 may allow for spatial computing that allows for control of the endoscope via eye movements. In embodiments connections to displays (128, 130) may be wireless or wired via USB, HDMI, optical via fiber optic cable, etc. The display devices (128, 130) may have processing circuitry including graphic processors (GPU) and software to process an incoming video stream that may have to be decoded, decompressed if the originating signal is compressed during transmission, or to dynamically adjust video quality based on network conditions, while ensuring an adequate signal is provided to a user(s).

[0033] Signals are readily sent via wired- or wireless-communication to a local area network (LAN) 132 such as by Ethernet for internal communication systems. In addition, signals from the endoscope 100 may be transmitted to an Internet modem and/or router 134 for computers and other data devices to access the patient images taken by the endoscope 100 anywhere in the world via wide area networks (WAN), WiFi, WiMAX, satellite, cellular telephone network, or other known or available wireless network connections.

[0034] Procedures conducted with the endoscope may be recorded for purpose of teaching, liability, research, etc. The procedural data may be sent wirelessly to the cloud or a hospital network for storing within the system. In addition, removeable memory cards or USB or wireless hard drives may be connected to the endoscope for collecting and archiving data.

[0035] The compact and modular size of the inventive scope allow for the camera system, power sources, and associated peripherals to be transported in an integrated carrying case. The carrying case provides resistance to impact, and may also provide an integrated charger capable of using energy from a range of sources including USB-C, universal AC power, and DC power from photovoltaic or other sources for charging modular batteries. The carrying case may include an integrated power source such as a battery or super capacitor. The carrying case may charge the swappable batteries via a physical connection or wireless charging.

[0036] FIGs. 2A and 2B provide an example of image stabilization used in embodiments of the invention. In FIG. 2A a slightly digitally zoomed in view of the captured area to the user is provided. As an example, if 4k viewing provides 100% of the 1x zoom (Circle A – What the camera captures (original position)), the user may be presented with a slightly digitally zoomed in view/slightly lower resolution and losing 10% of the periphery (Circle B – What the user sees – zoomed in slightly to provide hand shaking filtration, centered on duck). In FIG. 2B as hand shaking is expected, the system filters out the hand shaking by leveraging the surrounding 10% and dampens the camera movement, keeping the view centered on the same point. As shown in FIG. 2B, Circle A– What the camera captures (original position)), Circle B – What the user sees – zoomed in slightly to provide hand shaking filtration, centered on duck, Circle C- The new camera view due to unintended hand shaking.

[0037] FIG. 3 is a schematic diagram illustrating an overall view of communication devices, computing devices, and mediums for interacting with the endoscope according to embodiments of the invention. The elements of the embodiments of the scope in FIG. 1 are included in the networks and devices of FIG. 3.

[0038] The system 200 includes scope 100, the scope 100 including within an integrated enclosure optical tower function so as to eliminate the need of a separate optical tower, multimedia devices 202 and desktop computer devices 204 configured with display capabilities 214. The multimedia devices 202 illustratively include mobile communication and entertainment devices, such as cellular phones, mobile computing devices, projector, tablet, TV, and personal displays that are wirelessly connected to a network 208. The multimedia devices 202 have video displays 218 and audio outputs 216. The multimedia devices 202 and desktop computer devices 204 are readily configured with internal storage, software, and a graphical user interface (GUI) for controlling and viewing images from the scope 100 according to embodiments of the invention. The network 208 is any type of known network including a fixed wire line network, cable and fiber optics, over the air broadcasts, satellite 220, local area network (LAN), wide area network (WAN), global network (e.g., Internet), intranet, etc. with data/Internet capabilities as represented by server 206. Communication aspects of the network are represented by cellular base station 210 and antenna 212. It is appreciated that the network 208 is in certain inventive embodiments a LAN and each remote device 202 and desktop device 204 executes a user interface application (e.g., Web browser) to contact the server system 206 and or scope 100 through the network 208. Alternatively, the remote devices 202 and 204 may be implemented using a device programmed primarily for accessing network 208 such as a remote client.

[0039] The software for viewing information from the scope 100 of embodiments of the invention, may be resident on the individual multimedia devices 202 and desktop computers 204, or stored within the server 206 or cellular base station 210. Server 206 may implement a cloud-based service for implementing embodiments of the endoscope with a multi-tenant database for storage of separate client data.

[0040] Patent documents and publications mentioned in the specification are indicative of the levels of those skilled in the art to which the invention pertains. These documents and publications are incorporated herein by reference to the same extent as if each individual document or publication was specifically and individually incorporated herein by reference.

[0041] The foregoing description is illustrative of particular embodiments of the invention, but is not meant to be a limitation upon the practice thereof. The following claims, including all equivalents thereof, are intended to define the scope of the invention.

CLAIMS

1. A scope device integrating functionality of an optical tower comprising:

an elongated scope tube;

an enclosure integrating the functionality of the optical tower, said enclosure containing;

a camera;

an image processor, said camera in electrical communication with said image processor and supplies images and video to said image processor obtained via said elongated scope tube that are displayed on one or more of a head mounted display, heads up display (HUD), virtual reality (VR) headset, augmented reality headset, extended reality (XR), TV if the images are broadcasted on a specific frequency, video display monitor, mobile computing devices, projector, cellular phone, tablet, or mobile communication and entertainment devices;

a lighting module with a light source that illuminates a viewing field of said scope via said elongated tube;

a transmitter module that transmits secure and interference free data signals;

a communication interface;

a control interface; and

at least one power source, said at least one power source supplies power to said camera, said image processor, said light source, said control interface, said communication interface, and said transmitter module.

2. The device of claim 1 further comprising a charged coupled device (CCD) within said camera at a proximal end of said elongated tube.

3. The device of claim 1 further comprising haptic feedback.

4. The device of claim 1 further comprising a channel for application of suction or introduction of fluids.

5. The device of claim 1 wherein said transmitter module broadcasts images and video obtained from said camera and said image processor via predefined frequencies and protocols comprising CDMA, UMTS, WiFi (802.11 a,b,g,n), WiMax, Bluetooth®, near field, cellular protocols, and other existing and contemplated communication protocols.

6. The device of claim 1 wherein transmission from said transmitter module is encrypted.

7. The device of claim 1 wherein spread spectrum communication techniques including frequency hopping and direct sequence are utilized.

8. The device of any one of claims 1 to 7 wherein said camera operates in one or more of visible light spectrum, infra-red spectrum, and ultraviolet spectrum.

9. The device of any one of claims 1 to 7 wherein said elongated tube is rigid or flexible.

10. The device of any one of claims 1 to 7 wherein said camera has a lens or focus system that has an autofocus or a manual fixed focus.

11. The device of any one of claims 1 to 7 wherein said power source is a modular battery system removeable and replaceable.

12. The device of claim 1 wherein said control interface is in electrical communication with said lighting module, said camera, said image processor, said transmitter module, and said communication interface; and

wherein control provided by said control interface comprises control of intensity of lighting from said lighting module, camera and imaging parameters of said camera and said image processor, and communication parameters of said transmitter module and said communication interface.

13. The device of claim 12 wherein said control interface are on body controls comprising light/white balance control, recording (still or video) controls, on/off power, zoom and focus, and pairing controls.

14. The device of claim 13 wherein said on body controls comprise tactile buttons and switches, scroll wheels, touchscreen based pull down menus, or a combination thereof.

15. The device of claim 12 wherein said camera and image parameters comprise one or more of depth of field, frame rate, illumination wavelengths, focus, pixel density, false color, frame size (x/y ratio) or aspect ratio, noise filtering, and baud rate; and

wherein automated brightness, focus, and image stability are provided by said lighting module in concert with said camera and said image processor.

16. The device of claim 1 wherein said camera is a depth sensing camera or a volumetric camera.

17. The device of claim 16 wherein said volumetric camera provides a three-dimensional (3D) viewing experience where a combination of multiple information sources (images / video), depth, density, and other information sources comprising vitals, camera battery life, annotation from proctors or viewers, imaging (computed tomography (CT) Scans) over lays produce an immersive augmented or extended reality display in real time with the use of said extended reality (XR) headsets;

wherein augmentation can be turned off to reduce visual pollution, to save on bandwidth, or in low power situations; and

wherein automatic control of augmentation can be overridden to allow manual control.

18. The device of claim 1 wherein said image processor is configured with machine learning (ML) and artificial intelligence (AI) capabilities to recognize abnormal or general anatomical features and to assist in providing diagnostic information to a physician during a procedure.

19. The device of claim 17 wherein said machine learning (ML) and artificial intelligence (AI) capabilities are trained to provide speech recognition and voice command features.

20. The device of any one of claims 1 to 7 wherein said transmitter module is configured with user manual selectable transmission frequencies and video channels for the endoscope to account for interfering signals.

21. The device of any one of claims 1 to 7 wherein said transmitter module is configured to switch video channels to access additional informational content or operating room views, and provides the capability to overlay images from another source or piece of medical equipment or monitoring device onto a video feed via a wired or wireless connection to the overlay source; and

wherein a user can switch between visualization options that provide a surgeon with flexibility of having a choice to switch between channels and modalities comprising Bluetooth®, radio (TV), HDMI, USB, etc.

22. The device of any one of claims 1 to 7 wherein said transmitter module further comprises circuitry and software for video compression and for video adjustment.

23. The device of claim 1 wherein said communication interface routes camera and image signals to an antenna for wireless transmission, or takes the camera and image signals and routes them to a cable interface for a wired connection via at least one of composite video, s-video, universal serial bus (USB), high definition media interface (HDMI), digital video interface (DVI), coax cable, or other wired standards.

24. The device of claim 23 wherein said universal serial bus (USB) of said communication interface connects to a dongle for wireless communication and for pairing.

25. The device of claim 24 wherein one or more smart phones or personal communication devices connect via wireless pairing via WiFi (802.11 a,b,g,n), WiFi

hotspots, WiMax, Bluetooth®, near field, cellular protocols, and satellite networks or via a cable to said communication interface for broadcasting and receiving information.

26. The device of claim 25 wherein two factor authentication is employed to verify intended recipients, and pairing said endoscope with selected end-point receivers that comprise said one or more smart phones or personal communication devices employs technologies including radio frequency identification (RFID), quick response (QR) codes, or other automatic ID technologies.

27. The device any one of claims 1 to 7 wherein said power supply acts as a power source or supply to peripheral devices, including viewing devices, a vacuum for suction or other medical assist devices, via a USB connector, DC power receptacle, or other cable types.

28. The device any one of claims 1 to 7 wherein said power supply automatically switches from a rechargeable battery to a wired power cord when the battery is running low or when the device is already plugged in.

29. The device any one of claims 1 to 7 wherein said power supply ensures uninterrupted operations from a power perspective, where a capacitor or auxiliary battery is provided to supply redundant power as well as power during a battery change thereby allowing for a hot swap of a replaceable battery without interruption of device operation or loss of pairing with viewing devices.

30. The device of any one of claims 1 to 7 wherein said power supply further comprises power management software that automatically enters said device into a power saver mode during a battery swap, and reduces or fully suspends image or framerate quality, suspends augmentation of imagining, reduces or suspends the light, or other non-critical functions to ensure that pairing is maintained with a primary viewing device.

31. The device of claim 1 wherein said power supply is at least one of directly connected to a 110-240V AC electrical outlet, or is a battery that is or is not rechargeable; and

wherein said rechargeable battery is charged by at least one of while connected to an outlet, via a communication cable including a USB cable or other cable types, and via wireless charging via induction fields.

32. The device of claim 31 wherein said battery is modular and allows for multiple sized power options (larger/smaller battery capacities), and said battery may be charged during use or is charged while detached in a separate charger.

33. The device of claim 31 wherein said battery is a plurality of batteries that are stackable, which allows the power source selection to be balanced against a surgeon's preferences of weight distribution and surgical requirements.

34. The device of claim 33 wherein said plurality of stackable batteries form a handle portion of said scope.

35. The device of claim 31 wherein an audible tone or tactile vibration is emitted to notify the user that said battery is running low, as well as visual indicators on a battery power display are provided to indicate battery charge level and a low power warning.

36. Use of the scope integrating functionality of an optical tower of claim 1 for performing a laparoscopic procedure.

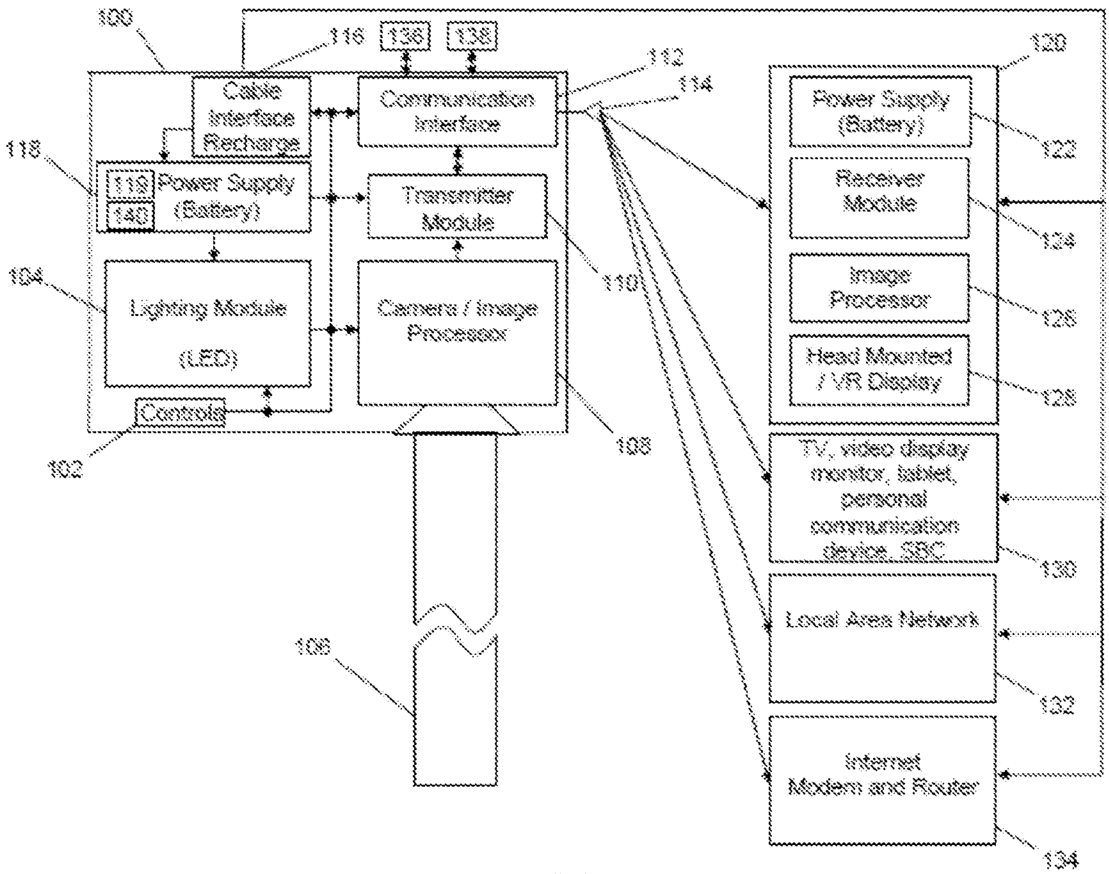
100
116
136
138
112
114
120
Cable Interface Recharge
Communication Interface
Power Supply (Battery)
122
118
119
140
Power Supply (Battery)
Transmitter Module
Receiver Module
124
104
Lighting Module
(LED)
Camera / Image Processor
110
Image Processor
126
Head Mounted / VR Display
128
Controls
102
108
TV, video display monitor, tablet, personal communication device, SBC
130
106
Local Area Network
132
Internet Modem and Router
134

FIG. 1

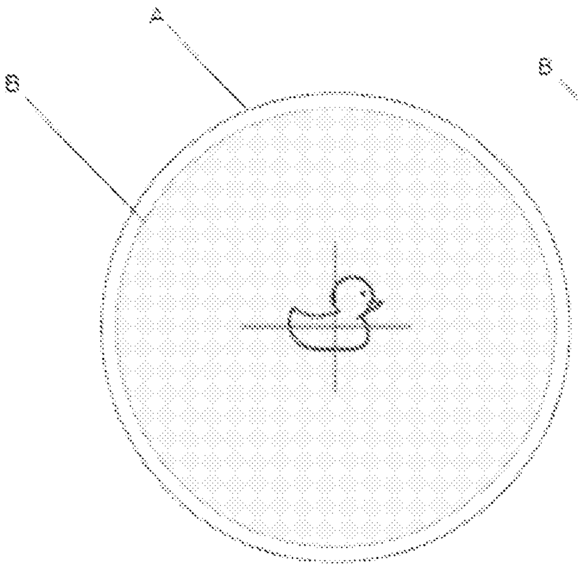

FIG. 2A

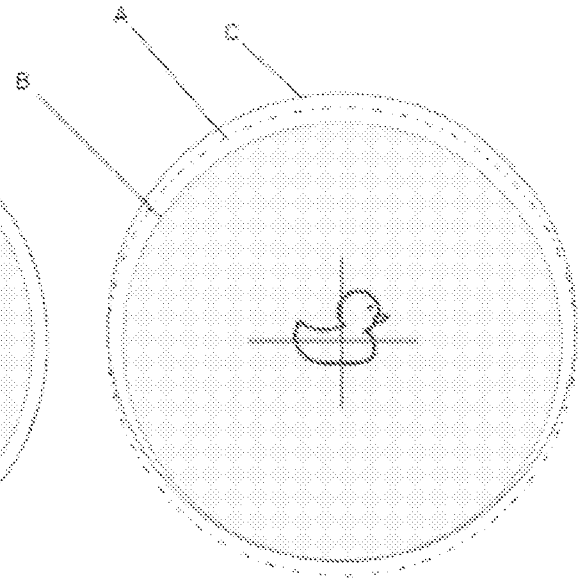

FIG. 2B

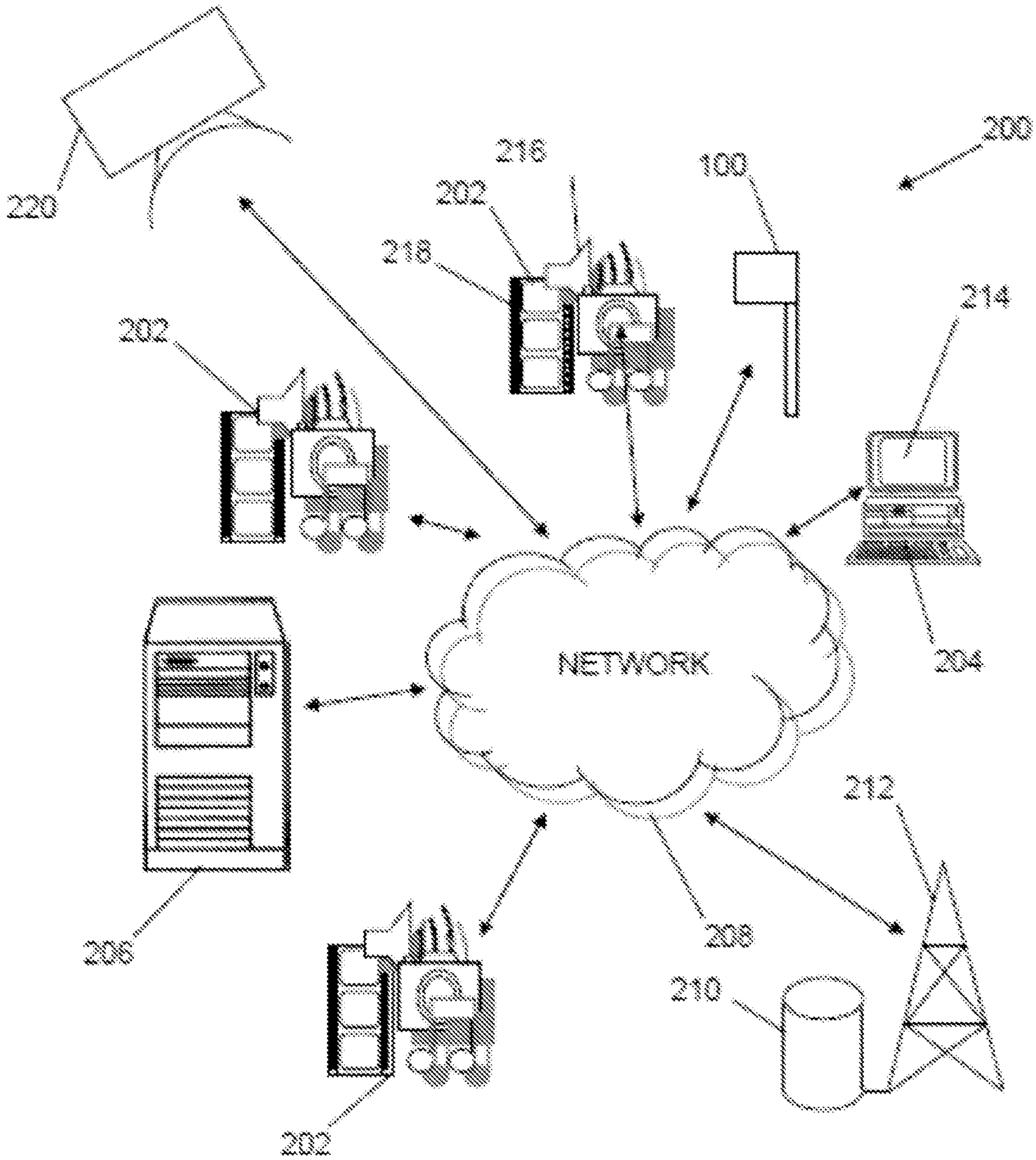

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No. **PCT/US2024/033822**

A. CLASSIFICATION OF SUBJECT MATTER

A61B 1/00(2006.01)i; **A61B 1/015**(2006.01)i; **A61B 1/06**(2006.01)i; **A61B 1/05**(2006.01)i

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)

A61B 1/00(2006.01); A61B 1/05(2006.01); A61B 34/00(2016.01); A61B 5/00(2006.01); A61B 5/055(2006.01); H04M 1/725(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: scope, enclosure, integrate, camera, processor, light, communication, power, interface

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2021-0045623 A1 (LAVIE GOLENBERG et al.) 18 February 2021 (2021-02-18) paragraphs [0022]-[0030]; claims 1-10	1,2,4-17,19-25,27-36 3,18,26
Y	US 2023-0105300 A1 (MOMENTIS SURGICAL LTD.) 06 April 2023 (2023-04-06) claim 7	3
Y	US 11443433 B2 (THE TRUSTEES OF THE UNIVERSITY OF PENNSYLVANIA) 13 September 2022 (2022-09-13) claims 8,13	18
Y	US 2018-0270340 A1 (INVOY TECHNOLOGIES, LLC) 20 September 2018 (2018-09-20) paragraph [0063]; claim 1	26
A	US 2012-0071721 A1 (REMIJAN et al.) 22 March 2012 (2012-03-22) claims 1-3,18	1-36

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
- "A" document defining the general state of the art which is not considered to be of particular relevance
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- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 September 2024	**30 September 2024**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2024/033822

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