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SCOPE POSITION AND INTERFERENCE DETECTION

Abstract

A method for controlling a surgical scope includes receiving an image feed including a plurality of images from the surgical scope. One or more features or characteristics of the plurality of images are then detected. In response to the one or more features or characteristics, an operating state of the surgical scope is identified in a deployed state wherein the scope is within a patient cavity and alternatively in an undeployed state wherein the scope is outside the patient cavity.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application claims priority under 35 U.S.C. § 119 (e) and the benefit of U.S. Provisional Application No. 63/5542,449 entitled SCOPE POSITION AND INTERFERENCE DETECTION, filed on Feb. 12, 2024, by Speier et al., the entire disclosure of which is incorporated herein by reference.

BACKGROUND
[0002] The disclosure generally relates to endoscopic surgical systems and, more particularly, to endoscopic systems and methods of operation that may detect the position of endoscopes and objects that may interfere with their operation. Developments in endoscopic devices have provided improved resolution, brightness, and resulting enhanced visibility allowing surgeons to improve surgical accuracy and the sophistication of procedures. An integral part of improving the visibility achieved in endoscopic systems may include increasing the intensity of light sources. The disclosure provides for methods and control systems that may control the operation of endoscopes to control the activation of light sources, which may allow surgeons and medical professionals to focus on managing the patient and procedure rather than manually managing the operation of the scope.
SUMMARY
[0003] Managing the operation of light sources associated with endoscopes may increase tasks associated with surgical procedures and, in some cases, may result in conditions that could interrupt or interfere with the steps required to conduct a surgical procedure. For example, the continuing operation of a light source of a surgical scope may result in intense glare light and/or increased operating temperatures of the scope, particularly following the withdrawal of a scope from a patient cavity. Glare light may cause distractions, and elevated temperatures could cause discomfort or operation that is unsuitable in a surgical field. The disclosure provides for various systems and methods that may detect a position of the endoscope, which may be deployed or undeployed within a patient anatomy or cavity. In some implementations, the disclosure may further provide for the detection of one or more interference objects (e.g., drapes, bandages, gauze, tissue, etc.) in close proximity to a distal end of the surgical scope. In response to the detection of such objects when the surgical scope is undeployed or is located outside the patient anatomy, the disclosed methods may deactivate a light source of the scope.
[0004] In various implementations, the disclosure provides for a method for controlling a light source of a surgical scope in response to a plurality of images received via an image feed of the surgical scope. A control unit of the surgical scope may detect one or more features present in the plurality of images over time and determine whether the surgical scope is operating in a deployed state within a patient cavity or an undeployed state outside the patient cavity. In some cases, the operating method may monitor a lapsed time of the scope when identified in the undeployed state. In response to the lapsed time in the undeployed state exceeding a predetermined time, the operating method may deactivate the light source in the surgical scope. In other cases, the operating method may detect one or more interference objects within an interference proximity based on the one or more features identified in the plurality of images. In response to identifying the interference

object at the interference proximity, the operating method may deactivate the light source of the surgical scope. These control techniques may be applied in combination to provide effective and intuitive control of the light source.

[0005] The deactivation of the light source responsive to the interference object in close proximity to the scope may bypass a countdown timer associated with the operation of the surgical scope to promptly deactivate the light source rather than awaiting the lapsed time of the countdown timer to exceed a predetermined time. In this way, the disclosure may provide for the deactivation of the light source in cases where the surgical scope is undeployed and further expedite the deactivation of the light source in cases where one or more objects or interference objects are identified at an interference proximity to the scope. As discussed herein, interference objects may correspond to various objects that may negatively interact with heat radiating from the light source of the surgical scope. Examples of interference objects may include a drape, paper or cloth products, bandages, gauze, wraps, biological tissue, or other objects ill-suited to exposure to elevated temperatures.

[0006] These and other features, objects and advantages of the present disclosure will become apparent upon reading the following description thereof together with reference to the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** demonstrates an environmental view of an endoscope deployed in a surgical procedure;

[0008] FIG. **2** is a process diagram demonstrating a scope feed output from a surgical scope;

[0009] FIG. **3**A is a process diagram demonstrating a method for training a position detection model;

[0010] FIG. **3**B is a process diagram demonstrating a method for training an interference detection model;

[0011] FIG. **4** is a flowchart demonstrating a light control routine; and

[0012] FIG. **5** is a block diagram demonstrating a surgical system in accordance with the disclosure.

DETAILED DESCRIPTION

[0013] In the following description, reference is made to the accompanying drawings, which show specific implementations that may be practiced. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts. It is to be understood that other implementations may be utilized and structural and functional changes may be made without departing from the scope of this disclosure.

[0014] Referring generally to FIG. **1**, an exemplary arthroscopic surgical procedure is shown demonstrating the deployment of a surgical scope **10** by a surgeon **12** in an opening or cavity **14** of a patient **16**. In the example shown, the surgical scope or scope **10** may correspond to an arthroscope including a narrow distal end **18** deployed in the cavity **14** of the patient **16**. In operation, light may be supplied to the distal end **18** from a light source **20** via a light guide through a scope body **22**, which may be in the form of an elongated tubular structure. The light transmitted from the light source **20** may reflect from one or more features or anatomical structures present within the cavity **14** and reflect light back to the surgical scope **10**. The reflected light is captured via an imager **24** of the scope **10**, which may commonly be disposed within a camera body **26**. As generally shown in FIG. **2** and discussed later in further detail, the imager **24** may be configured to capture an image feed comprising a plurality of images or frames illuminated by the light source **20** and depicting the one or more features in the patient cavity **14**. The image feed may then be presented on a display **28** (FIG. **2**), allowing the surgeon **12** to navigate one or more surgical tools in the cavity **14** to perform a surgical procedure.

[0015] Referring to FIGS. **1** and **2**, at various times throughout the surgical procedure, the surgeon **12** may withdraw the distal end **18** of the surgical scope **10** from the patient cavity **14**, such that a light emission **30** from the light source **20** may be output from the distal end **18** of the scope **10** and into a local environment **32**. As demonstrated in Detail A, the scope **10** is shown in an undeployed state **36** demonstrated in contrast to the deployed state **38** generally shown in FIG. **1**. The result of the light emission **30** and operation of the light source **20** in the undeployed state **36** may result in highly distracting glare light as well as potential heat generation and elevated temperatures of the scope **10**. The disclosure provides for an image-based control method that may infer an operating state of the scope **10** (e.g., undeployed **36**, deployed **38**) based on one or more features **40** presented in the image data or image feed **42**. Responsive to the operating state, the control method may adjust or control the operation of the light source **20**.

[0016] Still referring to FIGS. **1** and **2**, the operation of the surgical scope **10** in a surgical field **46** may be accompanied by a variety of objects that may interfere with or otherwise respond negatively to the light emission **30** and/or excess heat generated by the scope **10**. For example, as shown in FIG. **1**, the surgical field **44** may include a variety of interference objects **48** that may preferably be avoided from contact and/or exposure to radiation and/or elevated temperatures associated with the operation of the light source **20**. For example, interference objects **48** may include at least one of a drape **50**, biological tissue, paper or cloth products, gauze, wraps, etc. In the example shown, a plurality of drapes **50** are positioned proximate to the cavity **14** of the patient **16** and may inadvertently come into contact with or in close proximity to the surgical scope **10** in the undeployed state **36**. By determining the operating conditions or operating state of the scope **10**, a controller **52** may control the light source **20** to avoid conditions that may interrupt or cause distractions during surgical procedures. The controller **52** is shown and described in further detail in FIG. **5** in reference to an exemplary camera system **130**.

[0017] In operation, the interference objects **48** may be detected in the image feed **42** by a camera control unit or controller **52** to infer or deduce the operating state associated with the utilization of the scope **10**. For example, the controller **52** may process images **54** or image frames of the image feed **42** with one or more trained models to determine whether the scope **10** is operating in the undeployed state **36** or the deployed state **38**. Additionally, the controller **52** may apply a detection routine or trained model to infer or identify the interference objects **48** in the surgical field **44**. The detection of the interference objects **48** may further determine whether the objects **48** are sufficiently close to the surgical scope **10** to be within an interference proximity **56**. Based on these inferred operating conditions or states of the scope **10**, the controller **52** may intuitively deactivate the light source **20** responsive to the deployment state **36**, **38** and detection of the interference objects **48** within the interference proximity **56**.

[0018] Referring now to FIG. **2**, an image processing procedure **60** is depicted and described in reference to the image feed **42** output from a surgical scope **10**. In the example shown, the image feed **42** may comprise image data representative of multiple light spectrums. In the example shown, the images **54** or image frames processed from the image feed **42** may include infrared (IR) image data **62***a* captured at a near IR spectrum, as well as visible light image data **62***b* captured in the visible light spectrum. The IR image data **62***a* and/or the visible light image data **62***b* may be supplied to the controller **52** and processed by control logic **64** that may include one or more trained computer vision models. The control logic **64** may include or more trained models that may infer or deduce the operating conditions or operating states of the scope responsive to the image feed **42**. Additionally, the IR image data **62***a* and the visible light data **62***b* may be processed to generate formatted image data **62***c* for viewing on the display **28** for visualization, which may include portions or components of the IR image data **62***a* and the visible light data **62***b*.

[0019] Referring now to FIGS. **3**A and **3**B, the computer vision models utilized to determine the operating states or conditions of the scope **10** are shown and discussed in further detail. For example, the detection models may include a position detection model **70** and an interference detection model **72**. Each of the detection models **70**, **72** may be applied by the control logic **64** of the controller **52** to determine the operating state of the surgical scope **10**. As depicted in FIGS. **3**A and **3**B, a model training process is shown for each of the models **70**, **72**. Referring first to FIG. **3**A, a model training routine **74** may generally include processing, augmenting, and/or labeling in step **76** of a plurality of images from a video library **78**. In FIG. **3**A, the data in the video library **78** may include representative images **54** captured of surgical scopes in the undeployed state **36** and the deployed state **38**. The images **54** from the video library may generally be labeled or associated with the corresponding operating state **36**, **38** by automated software or via direct human inspection. For example, in training the position detection model **70**, the images of the video library **78** may be classified as outside images **82**, inside images **84**, and/or unknown images **86**.

[0020] Following the labeling of the images **54** in step **76**, the associated states of the images **82**, **84**, **86** may further be reviewed in step **88** to confirm that the conditions are representative of the corresponding operating states **80** (FIG. **4**) of the surgical scope **10**. Specifically, the outside images **82** may be confirmed to be representative of image data captured with the scope **10** in the undeployed state **36**. The inside images **84** may be confirmed to correspond to image data representative of the scope **10** in the deployed state **38**. Finally, the unknown images **86** may be confirmed to correspond to conditions that are not apparently representative of the undeployed or deployed states **36**, **38**, which may require a different control structure (e.g., manual control) of the light source **20**. Once the representative images **82**, **84**, **86**, are accurately labeled, they may be supplied to an untrained AI image processing model **90** to train and/or optimize the position detection model **70**. The resulting position detection model **70** may be configured and trained to accurately distinguish whether the scope **10** is implemented in the undeployed state **36**, deployed state **38**, or other unknown states that may be tracked to disable one or more automated algorithms or controls or otherwise notify users of outlying image data.

[0021] Referring now to FIG. **3**B, the model training for the interference detection model **72** may similarly be implemented to that previously discussed in reference to the position detection model **70**. In operation, the training procedure for the interference detection model **72** may relate to the type of image data and associated conditions labeled in step **76**. For example, the images labeled to train the interference detection model **72** may be limited to the outside images **82**. In this way, the training procedure may focus the operation of the model **72** to distinguish characteristics of the outside images **82** representative of the operating conditions of the scope **10** in the local environment **32**. As shown, the outside images **82** may be identified and labeled as object interference images **92**, object present images **94**, and noninterference images **96**. Following the labeling procedure in step **76**, the labels associated with the images **92**, **94**, **96** may be reviewed for accuracy in step **88**. In this way, the images supplied to the untrained image processing model **90** may be confirmed to accurately exemplify the associate conditions shown in the images **92**, **94**, **96**.

[0022] As with the position detection model **70**, the images used to train the interference detection model **72** represent conditions associated with the operation of the scope **10**. The noninterference images **96** may correspond to images that are free of objects identified in the local environment **32**, while the object present images **94** may correspond to images where objects are present in the local environment **32** but not present within the interference proximity **56**. Finally, the object interference images **92** may correspond to images where the associated features **40** indicate that one or more of the interference objects **48** (e.g., drapes **50**, tissue, paper products, etc.) are present in the image data within the interference proximity **56**. Once the images **92**, **94**, **96** are confirmed through the review step **88**, the images **92**, **94**, **96** may be supplied to the untrained image processing model **90** to tune and train the interference detection model **72**. Once effectively trained, the interference detection model **72** may distinguish interference from noninterference conditions of the scope **10** and be applied by the controller **52** to control the operation of the light source **20**. In the exemplary control routine **100** later described in reference to FIG. **4**, the position detection model **70** and the interference detection model **72** are applied in combination to intuitively control the operation of the light source **20** of the scope **10**.

[0023] Referring again to FIGS. **3**A and **3**B, the image processing model **90** may correspond to a neural network that may be trained to recognize patterns in the images **54** representative of each of the states or operating conditions depicted in the labeled images **82**, **84**, **86**, **92**, **94**, **96**. By reviewing the respective labeled data relative the one or more features **40**, conditions, levels of contrast, colors, line details, etc. present in the images **54**, nodes of the untrained image processing model **90** may be arranged and attributed to a plurality of classifying functions and corresponding thresholds to determine patterns in the images **54** indicating or pointing to the corresponding operating states or conditions of the scope **10**. Through one or more training operations, the training procedure may tune the image processing model **90** and verify a level of accuracy of the resulting trained models **70**, **72** to deduce or infer the operating conditions of the scope **10**. Such determinations may be processed rapidly by the controller **52** in part due to the nature of the detection being based on multiple layers of functions and weights attributed to the features **40** of characteristics of the images **54**. In this way, the image data from the image feed **42** may be rapidly processed to indicate the state or condition of operation of the scope **10** and control the light source **20** to appropriately illuminate the field of view of the imager **24** or deactivate when warranted. Examples of untrained models for image classification may include, but are not limited to, the following: LeNet, AlexNet, ZF Net, GoogleNet, VGGNet, ResNet, etc.

[0024] Though only discussed generally in reference to step **76**, the image processing, augmentation, and enabling steps associated with the generation of the labeled image data may be beneficial to improve the robust operation of the resulting models **70**, **72**. For example, the images in the generic scope video library **78**, as well as the outside images **82**, may largely correspond to images processed and controlled to have a high level of clarity during surgical procedures. Accordingly, the images from the video library **78** and the outside images **82** may be supplemented with augmented images that may be adjusted to introduce variations of the existing image data that may assist the detection models **70**, **72** in accurately identifying the corresponding operating states **80** with improved accuracy over a wide range of conditions. For example, the image data may be augmented to simulate and supplement the existing images with simulated zoom or blur situations, variations in color, variations in brightness and/or contrast, additive noise, or other variations that may be representative of scenarios that may be presented in the image feed **42**. Additional examples of features or simulated image data may include images that are rigidly or elastically transformed as well as examples of images that demonstrate pixel dropout or occluded portions. Such features may be incorporated to supplement the captured images in the training libraries **78**, **82** at random and at a defined probability to improve the detection capability and robust operation of the detection models **70**, **72**.

[0025] Referring now to FIG. **4**, a flow chart is shown demonstrating a control routine **100** for the light source **20** of the surgical scope **10**. As shown, the image feed **42** may be supplied to the position detection model **70** and the interference detection model **72**. In operation, the controller **52** or camera control unit of the surgical scope **10** may process the image data concurrently or in rapid succession with each of the models **70**, **72** to identify the corresponding operating states **80** of the surgical scope **10**. As shown, the operating states **80** may include the undeployed state **36**, the deployed state **38**, the object present state **102**, and the interference present state **104**. Further, as previously discussed, the unknown deployment state **106** and the clear or no-object-present state **108** may also be identified by the models **70**, **72** and applied to deactivate or adjust the operation of the control routine **100** or otherwise present messages alerting one or more users of the scope **10** of corresponding conditions.

[0026] As the images **54** of the image feed **42** are supplied to the models **70**, **72**, the states **36**, **38**, **102**, **104**, **106**, **108** may be applied by the control routine **100** to intuitively operate the light source **20**. In operation, the controller **52** may receive a state identification stream in step **110** indicating the states **80** or conditions determined by the models **70**, **72**. In addition to the operating states **80**, the control routine **100** may further monitor various settings of the surgical scope **10** or other connected devices in step **112** as later described. In step **114**, the routine **100** may query the state identification stream (**110**) to determine if the scope **10** is inside the patient cavity **14** in the deployed state **38**. If the scope **10** is determined to be in the deployed state **38**, the routine **100** may continue by activating or maintaining the illuminated operation of the light source **20** (**116**). Following step **116**, the routine **100** or method may continue to Reference A and continue to monitor the state identification stream for updates. Alternatively in step **114**, if the scope **10** is determined to be in the undeployed state **36**, the routine **100** may continue to determine if an interference object **48** is present within the interference proximity **56**, thereby activating the interference present state **104** (**118**). If the interference present state **104** is activated in step **118**, the routine **100** may continue without a timed delay to step **120** to deactivate the light source **20**. In this way, the routine may provide for the immediate or undelayed deactivation of the light source **20** in response to the presence of the interference object **48** detected within the interference proximity **56**.

[0027] Concurrent to or in rapid succession with step **118**, the routine **100** may initiate a timer (t) to monitor a lapsed time of the scope **10** identified in the undeployed state **36** (**122**). If the timer (t) exceeds a predetermined time threshold (tout) in step **124**, the routine may continue to step **120** to deactivate the light source **20**. Accordingly, the controller **52** may respond differently in cases when the interference state **104** is identified. When the interference state **104** is not identified, the controller **52** may control the light source **20** on a timed delay to avoid situations where the light emission **30** results in glare light that may cause distractions in the surgical field **44**.

[0028] As previously discussed in step **112**, the routine **100** may further monitor various settings of the surgical scope **10** as well as one or more additional devices that may be in communication with the controller **52** to modify or control the operation of the light source **20**. In one example, the controller **52** may monitor an exposure detected and associated with the operation of the imager **24** of the scope **10** to assist in the determination of the scope position in step **114**. For example, a setting of the exposure (e.g., a minimum exposure time setting) over a predetermined time period may be characteristic of the scope **10** exposed to the local environment **32** in the undeployed state **36**. Accordingly, in such cases, the exposure may be monitored by the routine to determine if it is characteristic of the deployed state **38** or the undeployed state **36**. Such information may be utilized to assist in the determination of the scope position in step **114**, particularly in cases where the scope position model **70** indicates that the scope position is unknown or in an unknown deployment state **106**. Accordingly, the settings of one or more connected devices associated with the operation of the surgical scope **10** may be applied in combination with the states **80** identified by the detection models **70**, **72** to improve the operation of the routine **100**.

[0029] Referring now to FIG. **5**, a block diagram of a camera system **130** is shown. As discussed throughout the disclosure, the system **130** may comprise a surgical scope **10** in communication with a camera controller **52**. The surgical scope **10** may comprise the light source **20** at the image sensor or imager **24**, a display controller **132**, and a user interface **134**. In various implementations, the scope **10** may correspond to an endoscope with an elongated scope comprising the narrow distal end **18** suited to various non-invasive surgical techniques. For example, the distal end **18** may include a diameter of less than 2 mm. As demonstrated, the scope **10** may be in communication with a control console **140** that may comprise the camera controller **52** and the display controller **132** via a communication interface. Though shown connected via a conductive connection, the communication interface may correspond to a wireless communication interface operating via one or more wireless communication protocols (e.g., Wi-Fi, 802.11 b/g/n, etc.).

[0030] The light source **20** may correspond various light emitters configured to generate light in the visible range and/or the near infrared range. In various implementations, the light source **20** may include light emitting diodes (LEDs), laser diodes, or other lighting technologies. In some cases, the light source **20** may correspond to a plurality of light sources configured to emit light in a plurality of wavelengths. For example, the light sources **20** may include a laser emitter configured to output emissions in the near infrared range including wavelengths from approximately 650 nm to 900 nm. Additionally, the light sources **20** may emit light in the visible spectrum including wavelengths ranging from approximately 380 nm to 700 nm. The imager or image sensor **24** may correspond to various sensors and configurations comprising, for example, charge-coupled devices (CCD) sensors, complementary metal-oxide semiconductor (CMOS) sensors, or similar sensor technologies.

[0031] The camera controller **52** may correspond to a control circuit configured to control the operation of image sensors **24** and the light source **20** by monitoring the operating states **80** of the scope **10** identified by the detection models **70**, **72**. The camera controller **52** may be in communication with the user interface **134**, which may include one or more input devices, indicators, displays, etc. The user interface **134** may provide for the control of the scope **10** including the activation of one or more routines as discussed herein. The camera controller **52** may be implemented by various forms of controller, microcontrollers, application-specific integrated controllers (ASICs), and/or various control circuits or combinations.

[0032] Each of the display controller **132** and the camera controller **52**, controller, or control unit may comprise various processors or memory devices and may be implemented as separate processing pipelines or via a combined processing architecture. The processor(s) may include one or more digital processing devices including, for example, a central processing unit (CPU) with one or more processing cores, a graphics processing unit (GPU), digital signal processors (DSPs), field programmable gate arrays (FPGAs), application specific integrated circuits (ASICs) and the like. In some configurations multiple processing devices are combined into a System on a Chip (SoC) configuration while in other configurations the processing devices may correspond to discrete components. In operation, the processor executes program instructions stored in the memory to perform the operations described herein. The memory may comprise one or more data storage devices including, for example, magnetic or solid state drives and random access memory (RAM) devices that store digital data. The memory may include one or more stored program instructions, object detection templates, image processing algorithms, etc. As shown, the position detection model **70** and the interference detection model **72** may be stored in the memory, such that the light control routine **100** may be processed by the camera system **130**.

[0033] The display controller **132** may further comprise one of more formatting circuits, which may process the image data received from the scope **10**, communicate with the processor, and output the enhanced image data to the display device **28**. The formatting circuits **222** may include one or more signal processing circuits, analog-to-digital converters, digital-to-analog converters, etc. The display controller may also comprise a user interface **134**, which may be separate or combined with the user interface of the camera controller **52**. For example, the user interface(s) **134** may be in the form of an integrated interface (e.g., a touchscreen, input buttons, an electronic display, etc.) or may be implemented by one or more external devices **136** (e.g., a tablet) or peripheral devices (e.g., keyboard, mouse, etc.). In some implementations, the camera system **130** may also be in communication with an external server, which may correspond to a network, local or cloud-based server, device hub, central controller, or various devices that may be in communication with the camera controller **52** and/or the display controller **132** and, more generally, the camera system **10** via one or more wired (e.g., Ethernet) or wireless communication (e.g., Wi-Fi, 802.11 b/g/n, etc.) protocols. For example, the controllers **52**, **132** may receive updates to the various trained models, operating modules, and routines as well as communicate sample image data from the scope **10** to a remote server for improved operation, diagnostics, and updates to the system.

[0034] According to some aspects of the disclosure, a method for controlling a surgical scope includes receiving an image feed comprising a plurality of images from the surgical scope; detecting one or more features or characteristics present in the plurality of images over time; and in response to the one or more features, identifying an operating state of the surgical scope in a deployed state wherein the scope is within a patient cavity and alternatively in an undeployed state wherein the scope is outside the patient cavity.

[0035] According to various aspects, the disclosure may implement one or more of the following features or configurations in various combinations: [0036] in response to identifying the scope in the undeployed state, monitoring a lapsed time of the undeployed state; [0037] in response to the lapsed time exceeding a predetermined time, deactivating a light source of the surgical scope; [0038] evaluating the one or more features to detect a presence of an interference object; [0039] in response to the operating state identified as the deployed state, suppressing a detection of the interference object identified responsive to the one or more features; [0040] the interference object comprises an extrinsic object that negatively interacts with heat radiating from a light source of the surgical scope; [0041] the interference object comprises at least one of a drape, biological tissue, paper or cloth products, gauze, wraps, etc.; [0042] wherein the interference object is further determined to be within an interference proximity, and in response to the one or more features identified as the interference object at the interference proximity, deactivating a light source of the surgical scope; [0043] wherein the deactivation of the light source in response to identifying the interference object at the interference proximity bypasses a countdown timer associated with the undeployed state deactivating the light source before a lapsed time of the countdown timer exceeds a predetermined time; [0044] wherein the interference object and the interference proximity are identified by a first image classification model trained from image data captured in the undeployed state; [0045] wherein the operating state is identified by a second image classification model trained from image data captured in both the deployed state and the undeployed state; and/or [0046] suppressing the identification of the interference object from the first image classification model in response to the operating state identified by the second image classification model.

[0047] According to another aspect of the disclosure, a control system is configured to control a light source configured to illuminate a field of view of a surgical scope. The control system comprises a camera control unit including a memory, wherein the camera control unit receives an image feed comprising a plurality of images and is in communication with the light source. The control unit is configured to detect one or more features or characteristics present in the plurality of images over time; evaluating the one or more features to detect an interference object within an interference proximity; and in response to the detection of the interference object, deactivate or suppress the activation of the light source.

[0048] According to various aspects, the disclosure may implement one or more of the following features or configurations in various combinations: [0049] the camera control unit is further configured to distinguish the interference object from other objects not presenting interaction hazards with an operation of the light source; [0050] wherein the camera control unit is further configured to, in response to the one or more features or characteristics, identify an operating state of the surgical scope in a deployed state wherein the scope is within a patient cavity and alternatively in an undeployed state wherein the scope is outside the patient cavity; [0051] wherein the camera control unit is further configured to, in response to identifying the scope in the undeployed state, monitoring a lapsed time of the undeployed state, and in response to the lapsed time exceeding a predetermined time, deactivating a light source of the surgical scope; [0052] wherein the camera control unit is further configured to, in response to the operating state identified as the deployed state, suppress the identification of the interference object identified responsive to the one or more features or characteristics; [0053] the interference object comprises an extrinsic object that negatively interacts with heat radiating from a light source of the surgical scope; [0054] the interference object comprises at least one of a drape, biological tissue, paper or cloth products, gauze, wraps, etc.; and/or [0055] the control system comprises the surgical scope and the surgical scope is an endoscope comprising an elongated insertion tube that is selectively deployed in the patient cavity.

[0056] According to yet another aspect of the disclosure, a control system configured to control a light source configured to illuminate a field of view of a surgical scope is disclosed. The control system comprises a camera control unit comprising a memory, wherein the camera control unit receives an image feed comprising a plurality of images and is in communication with the light source. The control unit is configured to detect one or more features or characteristics present in the plurality of images over time. In response to the one or more features or characteristics, the control unit identifies an operating state of the surgical scope in a deployed state wherein the scope is within a patient cavity and alternatively in an undeployed state wherein the scope is outside the patient cavity. The control unit may further evaluate the one or more features to detect an interference object within an interference proximity, and in response to the operating state identified as the deployed state, suppress the identification of the interference object identified responsive to the one or more features or characteristics. In response to the detection of the interference object in the undeployed state, the control unit suppresses the activation of the light source.
[0057] There is disclosed in the above description and the drawings a surgical camera system and method that fully and effectively overcomes the disadvantages associated with the prior art. However, it will be apparent that variations and modifications of the disclosed implementations may be made without departing from the principles described herein. The presentation of the implementations herein is offered by way of example only and not limitation, with a true scope and spirit being indicated by the following claims.
[0058] As used herein, words of approximation such as, without limitation, “approximately,” “substantially,” or “about” refer to a condition that when so modified is understood to not necessarily be absolute or perfect but would be considered close enough to those of ordinary skill in the art to warrant designating the condition as being present. The extent to which the description may vary will depend on how great a change can be instituted and still have one of ordinary skill in the art recognize the modified feature as having the required characteristics or capabilities of the unmodified feature. In general, but subject to the preceding discussion, a numerical value herein that is modified by a word of approximation such as “approximately” may vary from the stated value by +0.5%, +1%, +2%, +3%, +4%, +5%, +10%, +12%, or +15%.
[0059] Any element in a claim that does not explicitly state “means” for performing a specified function or “step” for performing a specified function, should not be interpreted as a “means” or “step” clause as specified in 35 U.S.C. § 112.
[0060] It will be understood that any described processes or steps within described processes may be combined with other disclosed processes or steps to form structures within the scope of the present device. The exemplary structures and processes disclosed herein are for illustrative purposes and are not to be construed as limiting.
[0061] It is also to be understood that variations and modifications can be made on the aforementioned structures and methods without departing from the concepts of the present device, and further it is to be understood that such concepts are intended to be covered by the following claims unless these claims by their language expressly state otherwise.
[0062] The above description is considered that of the illustrated embodiments only. Modifications of the device will occur to those skilled in the art and to those who make or use the device. Therefore, it is understood that the embodiments shown in the drawings and described above are merely for illustrative purposes and not intended to limit the scope of the device, which is defined by the following claims as interpreted according to the principles of patent law, including the Doctrine of Equivalents.

Claims

1. A method for controlling a surgical scope comprising: receiving an image feed comprising a plurality of images from the surgical scope; detecting one or more features or characteristics present in the plurality of images over time; and in response to the one or more features, identifying an operating state of the surgical scope in a deployed state wherein the scope is within a patient cavity and alternatively in an undeployed state wherein the scope is outside the patient cavity.
2. The method according to claim 1, further comprising: in response to identifying the scope in the undeployed state, monitoring a lapsed time of the undeployed state, and in response to the lapsed time exceeding a predetermined time, deactivating a light source of the surgical scope.
3. The method according to claim 1, further comprising: evaluating the one or more features to detect a presence of an interference object.
4. The method according to claim 3, further comprising: in response to the operating state identified as the deployed state, suppressing a detection of the interference object identified responsive to the one or more features.
5. The method according to claim 3, wherein the interference object comprises an extrinsic object that negatively interacts with heat radiating from a light source of the surgical scope.
6. The method according to claim 3, wherein the interference object comprises at least one of a drape, biological tissue, paper or cloth products, gauze, wraps.
7. The method according to claim 3, further comprising: wherein the interference object is further determined to be within an interference proximity, and in response to the one or more features identified as the interference object at the interference proximity, deactivating a light source of the surgical scope.
8. The method according to claim 7, wherein the deactivation of the light source in response to identifying the interference object at the interference proximity bypasses a countdown timer associated with the undeployed state deactivating the light source before a lapsed time of the countdown timer exceeds a predetermined time.
9. The method according to claim 7, wherein the interference object and the interference proximity are identified by a first image classification model trained from image data captured in the undeployed state.
10. The method according to claim 9, wherein the operating state is identified by a second image classification model trained from image data captured in both the deployed state and the undeployed state.
11. The method according to claim 10, further comprising: suppressing the identification of the interference object from the first image classification model in response to the operating state identified by the second image classification model.
12. A control system configured to control a light source configured to illuminate a field of view of a surgical scope, the control system comprising: a camera control unit comprising a memory, wherein the camera control unit receives an image feed comprising a plurality of images and is in communication with the light source, wherein the control unit is configured to: detect one or more features or characteristics present in the plurality of images over time; evaluate the one or more features to detect an interference object within an interference proximity; and in response to the detection of the interference object, suppress the activation of the light source.
13. The control system according to claim 12, wherein the camera control unit is further configured to: distinguish the interference object from other objects not presenting interaction hazards with an operation of the light source.
14. The control system according to claim 12, wherein the camera control unit is further configured to: in response to the one or more features or characteristics, identify an operating state of the surgical scope in a deployed state wherein the scope is within a patient cavity and alternatively in an undeployed state wherein the scope is outside the patient cavity.
15. The control system according to claim 14, wherein the camera control unit is further configured

to: in response to identifying the scope in the undeployed state, monitoring a lapsed time of the undeployed state, and in response to the lapsed time exceeding a predetermined time, deactivating a light source of the surgical scope.

16. The control system according to claim 14, wherein the camera control unit is further configured to: in response to the operating state identified as the deployed state, suppress the identification of the interference object identified responsive to the one or more features or characteristics.

17. The control system according to claim 12, wherein the interference object comprises an extrinsic object that negatively interacts with heat radiating from a light source of the surgical scope.

18. The control system according to claim 12, wherein the interference object comprises at least one of a drape, biological tissue, paper or cloth products, gauze, wraps.

19. The control system according to claim 12, wherein the control system comprises the surgical scope and the surgical scope is an endoscope comprising an elongated insertion tube that is selectively deployed in the patient cavity.

20. A control system configured to control a light source configured to illuminate a field of view of a surgical scope, the control system comprising: a camera control unit comprising a memory, wherein the camera control unit receives an image feed comprising a plurality of images and is in communication with the light source, wherein the control unit is configured to: detect one or more features or characteristics present in the plurality of images over time; in response to the one or more features or characteristics, identify an operating state of the surgical scope in a deployed state wherein the scope is within a patient cavity and alternatively in an undeployed state wherein the scope is outside the patient cavity; evaluate the one or more features to detect an interference object within an interference proximity; in response to the operating state identified as the deployed state, suppress the identification of the interference object identified responsive to the one or more features or characteristics; and in response to the detection of the interference object in the undeployed state, suppress the activation of the light source.