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SYSTEMS AND METHODS FOR CAPTURING DATA FROM A MEDICAL DEVICE

Abstract

A method for transferring data from a medical device to a server comprises receiving a video stream from the medical device, capturing an image from the video stream, transmitting the image to the server via a data network, and extracting the data from the image. The image may illustrate and/or represent data over a period of time. The method may also comprise transmitting, from a data module receiving the video stream from the medical device, a signal to a router that indicates that the data module is connected to the network. The method may also comprise transmitting a command to the data module to start capturing the image, transferring the image to the router, broadcasting a signal indicating that the data module has captured the image, receiving the broadcasted signal at the server, and storing the image at the server.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] The present application is a continuation of U.S. application Ser. No. 17/531,322, filed on Nov. 19, 2021, now allowed, which is a divisional of U.S. application Ser. No. 15/941,695, filed on Mar. 30, 2018, now U.S. Pat. No. 11,217,344, which claims the benefit of U.S. Provisional Application No. 62/523,890, filed on Jun. 23, 2017, the disclosures of which are hereby incorporated herein by reference.

FIELD OF THE INVENTION
[0002] The present disclosure relates to systems and methods for implementing a cloud-based architecture with a portal that controls destinations of video streaming, data upload, and notifications from medical devices to client devices using optical character recognition and digital signal processing with scalability to an indefinite amount of users.
BACKGROUND
[0003] Medical devices monitoring a patient generate a large amount of data since they operate continuously. Many of these medical devices have a graphical display to deliver the data they are monitoring but medical professionals need to be physically near the medical device to observe the data from the graphical display. In addition, the information on the graphical display often includes waveforms and other data represented by plots.
[0004] However, there remains a long felt need to remotely access these medical devices in order to allow medical professionals to monitor a patient without having to be physically present. In addition, there is a need to implement a system to capture information from the graphical display in order to extract information from the waveforms and plots displayed and deliver the information to medical professionals remotely.
SUMMARY OF INVENTION
[0005] The present disclosure relates to a method for transferring data from a medical device to a server. The method comprises receiving data video stream from the medical device. Further, the method comprises capturing a first image from the video stream at a first time. The first image may represent and/or illustrate first medical data over a first period of time. The method further comprises transmitting the first image to the server via a data network. The method also comprises extracting, at the server, the first medical data from the first image.
[0006] According to one implementation, the method further comprises capturing a second image from the video stream at a second time. The second image may represent and/or illustrate second medical data over a second period of time. The method further comprises transmitting the second image to the server via a data network. The method also comprises extracting, at the server, the second medical data from the second image.
[0007] In some implementations, the second period of time starts after the first period of time. In other implementations, the first period of time and the second period of time have the same

duration. In certain implementations, the duration is equal to or greater than about one of 1 second, 2 seconds, 3 seconds, 4 seconds, 5 seconds, 10 seconds, 20 seconds, 30 seconds, and 1 minute. According to some implementations, the first period of time and the second period of time have different durations.

[0008] In some implementations, extracting the first and second medical data from the first and second images includes optical character recognition (OCR) of the first and second images.

[0009] According to some implementations, the method further comprises sensing via at least one of a pressure sensor, temperature sensor, flow rate sensor, voltage sensor, current sensor, optical sensor, and audio sensor. In some implementations, the first and second medical data includes pressure, flow rate, pump speed, temperature, voltage, current, and biometric conditions.

[0010] In other implementations, the method further comprises repeatedly performing the features of claim **1** and claims **2**. According to some implementations, the server is a web server. In some implementations, the medical device is an intravascular blood pump.

[0011] In certain implementations, the method further comprises transmitting, from a data module receiving the video stream from the medical device, a first signal to a router that indicates that the data module is connected to the network. Further, the method comprises transmitting, from the router, a command to the data module to start capturing the first image. The method further comprises transferring the first image to the router from the data module. The method also comprises broadcasting, from the router, a second signal indicating that the data module has captured the first image. Further, the method comprises receiving, at the server, the broadcasted second signal from the router. The method further comprises storing the first image at the web server.

[0012] According to some implementations, the method further comprises connecting the data module to the data network.

[0013] A second aspect of the present disclosure relates to a system comprising a data module, a router, a client device, and a server. The data module may be configured to receive data from a medical device. The router may be communicatively coupled to the data module, and may be configured to receive the data from the data module and store the data in storage. The client device may be configured to display the data. The server may be communicatively coupled to the client device and the router, and may be configured to receive a request to access the data from the client device, receive the data from storage, and transmit the data to the client device.

[0014] A third aspect of the present disclosure relates to a method for extracting data from an image. The method comprises receiving a first image. The first image may represent and/or illustrate data from a medical device. Further, the method comprises masking first portions of the first image. The first image may comprise the first portions and second portions of the first image. The method further comprises generating a second image consisting of the second portions of the first image. The method also comprises extracting, using optical image recognition, data from the second image.

[0015] According to one implementation, the first image is captured from a video stream from the medical device.

[0016] In some implementations, the method further comprises extracting, using optical character recognition, first data from a first portion of the second image. Further, the method comprises determining a validity of the first data by comparing the first data to reference data. The method also comprises, in response to determining that the first data is valid, extracting, using optical character recognition, second data from a second portion of the second image.

[0017] According to some implementations, the method further comprises, in response to determining that the first data is not valid, broadcasting a signal indicating that the first data is not valid. Further, the method comprises receiving a third image. The third image may represent and/or illustrate data from the medical device.

[0018] In certain implementations, masking the first portions of the first image comprises selecting an image mask based on the size of the first image and occluding the first portions of the first image using the image mask.

[0019] In some implementations, the method further comprises extracting, using digital signal processing, waveform data from a waveform in the second image.

[0020] According to some implementations, the method further comprises selecting a first pixel from the second image. The first pixel may represent and/or illustrate a color. Further, the method comprises determining the color of the first pixel. The color of the first pixel may correspond to an alarm severity. The method also comprises determining the alarm severity based on the color of the first pixel. In certain implementations, the method further comprises selecting a second pixel from the second image and determining the alarm severity based on the first pixel and the second pixel.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The foregoing and other objects and advantages will be apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

[0022] FIG. **1** shows a schematic representation of a remote link architecture, configured according to one or more aspects of the present disclosure;

[0023] FIG. **2** is a flow diagram of method steps for transferring data from a medical device to a server, according to an aspect of the present disclosure;

[0024] FIG. **3** is a flow diagram of method steps for transferring data from a medical device to a server, according to an aspect of the present disclosure;

[0025] FIG. **4** shows a schematic representation of a remote link architecture, configured according to one or more aspects of the present disclosure;

[0026] FIG. **5** is a flow diagram of method steps for initializing a remote link, according to an aspect of the present disclosure;

[0027] FIG. **6** shows a schematic representation of a remote link architecture, configured according to one or more aspects of the present disclosure;

[0028] FIG. **7** shows a schematic representation of a remote link architecture, configured according to one or more aspects of the present disclosure;

[0029] FIG. **8** shows a schematic representation of a medical device, configured according to one or more aspects of the present disclosure;

[0030] FIG. **9** shows an exemplary medical device controller, configured according to one or more aspects of the present disclosure;

[0031] FIG. **10** shows an exemplary image displayed on a medical device controller screen, configured according to one or more aspects of the present disclosure;

[0032] FIG. **11** shows the exemplary image of FIG. **10** after removing select portions of the image, configured according to one or more aspects of the present disclosure;

[0033] FIG. **12** shows an exemplary image of the remaining portions of the image of FIG. **11**, configured according to one or more aspects of the present disclosure; and

[0034] FIGS. **13** and **14** are flow diagrams of method steps for extracting data from an image and determining the validity of the extracted data, according to an aspect of the present disclosure.

DETAILED DESCRIPTION

[0035] FIG. **1** is a schematic representation of a remote link architecture **100**. Remote link architecture **100** includes remote link **102**, client device **104**, remote link router (RLR) **150**, WEB load balancer **108**, video load balancer **110**, WEB server **114**, video server **116**, random-access memory (RAM) data type storage **118**, document data type storage **120**, and WEB socket server **122**.

[0036] Remote link **102** may be embedded in a medical device that is monitoring a patient at a hospital, clinic, the patient's house, or another location. Remote link **102** captures images and deliver video streams from the medical device display and transmit the images and video to the remote link router **150**. Remote link architecture **100** may comprise multiple remote links **102**. Remote link **102** interacts with the rest of remote link architecture **100** through RLR **150**. RLR **150** includes an RLR load balancer **106** and RLR server **112**. RLR **150** may comprise multiple RLR servers **112**. RLR server **112** may include a custom protocol used to communicate with one or more remote links **102**. RLR load balancer **106** manages the load to one or more RLR servers **112**. RLR load balancer **106** may generate a priority for multiple remote links **102**. The priority may be based on preferences obtained from the client device **104**. In other aspects, the priority is based on preferences obtained from the remote links **102**. In another aspect, the priority is based on preferences obtained from the RLR server **112**.

[0037] Client device **104** may be a personal computer, a tablet, or a mobile device with an internet connection. A medical professional using client device **104** may be interested in obtaining information from one or multiple remote links **102**. Images captured by a remote link **102** may be accessed by the client device **104**. In addition, if the medical professional is interested in observing a live video stream of the medical device embedded with remote link **102**, the client device can display the video stream. Remote link architecture may comprise multiple client devices **104**. A single client device **104** may access multiple remote links **102**, as long as the client device has access to the remote links **102**.

[0038] WEB load balancer **108** controls the load to one or more WEB servers **114**. WEB server **114** may include a mechanism for clients to view information, data, and video streams from one or more remote links **102**. WEB load balancer **108** may generate a priority for multiple client devices **104**. The priority may be based on preferences obtained from the client devices **104**. In other aspects, the priority is based on preferences obtained from the remote links **102**. In another aspect, the priority is based on preferences obtained from the WEB server **114**. WEB socket server **122** may push messages to groups of client devices **104**. Upon client device **104** connection to the WEB server **114**, the client device **104** will register to the WEB socket server **122** for messages for either one or multiple remote links **102**. The WEB socket server **122** will receive messages that will be applicable to one or more remote links **102**. This message with associated data will be broadcasted to all connected client devices **104** for updates from those remote links **102**.

[0039] Video load balancer **110** controls the load to one or more video servers **116**. Video server **116** may be the receiver and sender of video streams from one or more remote links **102**. Video load balancer **110** may generate a priority for multiple client devices **104**. The priority may be based on preferences obtained from the client devices **104**. In other aspects, the priority is based on preferences obtained from the remote links **102**. In another aspect, the priority is based on preferences obtained from the video server **116**.

[0040] RAM data type storage **118** may be volatile storage that can be accessed quickly. RAM data type storage **118** may comprise dynamic random-access memory (DRAM), static random-access memory (SRAM), or another type of high-speed volatile memory. Images captured by remote link **102** may be stored in RAM data type storage **118** before being transmitted to client device **104**. RAM data type storage **118** may also store video streams captured by remote link **102**. Document data type storage **120** may be non-volatile storage that can maintain data for long periods of time. Document data type storage **120** may be hard disks, optical disks, solid-state drives (SSDs), or another type of non-volatile memory.

[0041] A process **200** of transferring an image from a remote link **102** to a remote link router server **112** is illustrated in FIG. **2**. Process **200** begins by connecting a remote link **102** to the internet at step **202**. Step **202** may include a process to initialize remote link **102** as described below by process **500** in FIG. **5**.

[0042] Process **200** continues by sending, from the remote link **102**, a first signal to an RLR **150** that indicates that the remote link **102** is connected to the internet as step **204**. The first signal may be sent directly to the RLR load balancer **106**. In another aspect, the first signal may be sent directly to the RLR server **112**.

[0043] Process **200** continues by sending, from the RLR **150**, a command to the remote link **102** to start capturing an image at step **206**. For example, remote link **102** uses image capture unit **628**, described below, to capture the image from a medical device.

[0044] Process **200** continues by transferring the image to the RLR **150** from the remote link **102** at step **208**. For example, RLR load balancer manages the transfer of the image from the remote link **102** to the RLR server **112**. Once the image has been transferred to the RLR server **112**, process **200** continues to step **210**.

[0045] Process **200** continues by broadcasting, from the RLR **150**, a second signal indicating that the remote link **102** has captured the image at step **210**. For example, RLR **150** broadcasts the second signal such that the WEB servers **114** are notified that RLR **150** has the image captured by remote link **102**.

[0046] Process **200** continues by receiving, at a WEB server **114**, the broadcasted second signal from the remote link **102** at step **212**. For example, WEB server **114** receives the broadcasted signal from RLR **150** so that the WEB server **114** is notified that RLR **150** has the image captured by remote link **102**.

[0047] Process **200** finishes by storing the image at the WEB server **114** at step **214**. The image may be stored in RAM data type storage **118**. For example, RLR **150** transfers the image to WEB server **114**, after which WEB server **114** transfers the image to RAM data type storage **118**. In one aspect, RLR **150** may transfer the image directly to RAM data type storage **118**.

[0048] A process **300** of transferring a video stream from a remote link **102** to a client device **104** is illustrated in FIG. **3**. Process **300** begins by sending to a WEB server **114**, from a client device **104**, a request to view a video stream from a remote link **102** at step **302**. The request may be sent through WEB load balancer **108** before being transmitted to the WEB server **114**. In one aspect, the request may include information identifying the remote link **102** that is to be accessed.

[0049] Process **300** continues by broadcasting the request from the WEB server **114** at step **304**. For example, the WEB server **114** notifies the RLRs **150** that a client device **104** has requested to view a video stream from a remote link **102** by broadcasting the request to all of the RLRs **150**.

[0050] Process **300** continues by receiving the request at an RLR **150** at step **306**. For example, RLR server **112** receives the request from the WEB server **114**. In one aspect, RLR **150** receives the request after determining that the request identifies a remote link **102** that is communicatively coupled to the RLR **150**.

[0051] Process **300** continues by sending to the remote link **102**, from the RLR **150**, a command to transmit the video stream to a video server **116** at step **308**. For example, RLR server **112** transmits a signal through RLR load balancer **106** to remote link **102** that initiates a process to transmit a video stream from the remote link **102** to the video server **116**.

[0052] Process **300** continues by transmitting the video stream to the video server **116** from the remote link **102** at step **310**. In one aspect, the remote link **102** transmits the video stream to the video load balancer **110** which determines which video server **116** to send the video stream. The video load balancer **110** may make the determination based on the load of the video servers **116** and a priority of the remote link **102** and client device **104**.

[0053] Process **300** continues by receiving the video stream at the video server **116** at step **312**. For example, once video load balancer **110** determines which video server **116** can receive the video stream, the video server **116** receives the video stream.

[0054] Process **300** finishes by transmitting the video stream to the client device **104** from the video server **116**. For example, the video server **116** initiates transfer of the video stream to the client device **104** through video load balancer **110**.

[0055] FIG. **4** shows a schematic representation of a remote link architecture **400**. Remote link architecture **400** includes remote link **402**, client device **404**, RLR **450**, document data type storage **420**, HTTP service **430**, and cloud **460**.

[0056] Remote link **402** is similar to remote link **102** and may be embedded in a medical device that is monitoring a patient at a hospital, clinic, the patient's house, or another location. Remote link **402** may capture images and deliver video streams from the medical device display and transmit the images and video to the remote link router **450**. Remote link architecture **400** may comprise multiple remote links **402**. Remote link **402** interacts with the rest of remote link architecture **400** through RLR **450**. RLR **450** is similar to RLR **150** described above.

[0057] Client device **404** is similar to client device **104** and may be a personal computer, a tablet, or a mobile device with an internet connection. A medical professional using client device **404** may be interested in obtaining information from one or multiple remote links **402**. Images captured by a remote link **402** may be accessed by the client device **404**. In addition, if the medical professional is interested in observing a live video stream of the medical device embedded with remote link **402**, the client device can display the video stream. Remote link architecture may comprise multiple client devices **404**. A single client device **404** may access multiple remote links **402**, as long as the client device has access to the remote links **402**. Client device **404** may communicate with RLR **450** through cloud **460**. Cloud **460** represents a network of internet-based devices and connections such as servers, storage, and applications.

[0058] Document data type storage **420** is similar to document data type storage **120** and may be non-volatile storage that can maintain data for long periods of time. Document data type storage **420** may be hard disks, optical disks, solid-state drives (SSDs), or another type of non-volatile memory. Document data type storage **420** may store Wi-Fi credentials or other initialization information obtained from one or more client devices **404** or from RLR **450**. Document data type storage **420** may transmit the Wi-Fi credentials or other initialization information to RLR **450** or directly to one or more remote links **402**.

[0059] HTTP service **430** may be a framework that provides the ability for the RLR **450** to make HTTP requests. RLR **450** may use HTTP service **430** to obtain Wi-Fi credentials or other initialization information and store the information in document data type storage **420**.

[0060] A process **500** of initializing a remote link **402** is illustrated in FIG. **5**. Process **500** begins by connecting a remote link **402** to an LTE network at step **502**. In another aspect, the remote link **402** may connect to a 3G or 4G network.

[0061] Process **500** continues by transmitting, from the remote link **402**, a first signal to an RLR **450** that indicates that the remote link **402** is connected to the LTE network at step **504**. For example, once the remote link **402** is online, it transmits a signal to the RLR **450** in order to notify the RLR **450** that it is ready to transmit or receive data. In one aspect, the RLR **450** is also connected to the LTE network.

[0062] Process **500** continues by receiving, at the RLR **450**, Wi-Fi credentials from a client device **404** at step **506**. For example, a user inputs the Wi-Fi credentials onto a client device **404** which then transmits the Wi-Fi credentials to the RLR **450**. In one aspect, RLR **450** has the Wi-Fi credentials stored.

[0063] Process **500** continues by transmitting, from the RLR **450**, the Wi-Fi credentials to the remote link **402** at step **508**. For example, the RLR **450** transmits the Wi-Fi credentials to the remote link **402** using the LTE network.

[0064] Process **500** continues by connecting the remote link **402** to a Wi-Fi network corresponding to the Wi-Fi credentials at step **510**. For example, once the remote link **402** has received the Wi-Fi credentials, remote link **402** searches for the Wi-Fi network identified by the Wi-Fi credentials and connect to it.

[0065] Process **500** finishes by transmitting, from the remote link **402**, a second signal to the RLR **450** that indicates that the remote link **402** is connected to the Wi-Fi network. For example, in order to confirm that the remote link **402** has successfully connected to the Wi-Fi network, remote link

402 sends a signal to the RLR **450** using the Wi-Fi network that indicates that it has successfully connected. In another aspect, remote link **402** sends the signal to the RLR **450** using the LTE network if the connection is faster than the Wi-Fi network. In one aspect, if the remote link **402** cannot connect to the Wi-Fi network, it sends a signal to the RLR **450** using the LTE network that indicates that the connection was not successful.

[0066] FIG. **6** shows a schematic representation of a remote link architecture **600**. Remote link architecture **600** includes medical device **624**, remote link **102**, and media server **116**. Medical device **624** may include a sensor **626**. Remote link **102** may include an image capture unit **628**. Media server **116** may include an optical character recognition unit **630** and operational data unit **632**.

[0067] Medical device **624** may be a medical device that is monitoring a patient at a hospital, clinic, the patient's house, or another location. Medical device **624** includes a sensor **626** that may be measuring and recording health signals from a patient. The sensor **626** may be a pressure sensor, temperature sensor, flow rate sensor, voltage sensor, current sensor, optical sensor, or audio sensor.

[0068] Image capture unit **628** may be an application that enables remote link **102** to capture images from sensor **626**. For example, image capture unit **628** captures an image of the display of medical device **624**. The image of the display of medical device **624** may include data from sensor **626** represented alphanumerically or graphically, in a waveform plot. Image capture unit **628** may convert analog data captured from sensor **626** into digital data that may be used by optical character recognition unit **630**. For example, image capture unit **628** converts an analog signal from a video graphics array (VGA) connection from sensor **626**. Optical character recognition (OCR) may be used to convert images of text or shapes into digital data, as further described in relation to FIGS. **10-14**. In another aspect, other OCR equivalents, and/or digital signal processing (DSP) may be used to extract data from images.

[0069] OCR unit **630** may be an application that electronically converts images of text or shapes into digital data. For example, OCR unit **630** analyzes the image captured by image capture unit **628** in remote link **102** to extract data from the data embedded in the image. The OCR unit **630** may be able to extract data from a waveform.

[0070] In one aspect, media server **116** may include a DSP unit **634**. DSP unit **634** may be an application that converts images into digital data. For example, DSP unit **634** converts the image captured by image capture unit **628** in remote link **102** to digital data. Once in digital form, media server **116** may identify and/or filter the operational and/or medical data that is embedded in the image. In another aspect, DSP unit **634** may be used to extract data from a waveform included in the image. For example, OCR unit **630** extracts a period from a waveform portion of an image and DSP unit **634** uses the period and boundaries of the waveform to extract operational and/or medical data. By using the period and boundaries of the waveform portion of the image, DSP unit **634** associates the pixels in the waveform portion with a unit of time. In some aspects, OCR unit **630** is used to extract a measurement unit from the waveform portion of the image and DSP unit **634** uses the period and the measurement unit to extract operational and/or medical data. For example, OCR unit **630** determines that the waveform portion of the image displays placement signal and/or motor current over a period of ten seconds, and DSP unit **634** associates each pixel in the waveform portion with a corresponding placement signal and/or motor current, and a unit of time equal to the period divided by the number of pixels in the waveform portion of the image.

[0071] Operational and/or medical data unit **632** may be an application that databases and organizes the data extracted from OCR unit **630** and/or DSP unit **634**. For example, operational data unit **632** identifies the type of data extracted by OCR unit **630** and/or DSP unit **634**, and categorize the data into operational and/or medical conditions. Operational and/or medical conditions may include pressure, flow rate, pump speed, temperature, voltage, current, and biometric conditions.

[0072] Remote link architecture **600** can be implemented with process **200**, process **300**, and process **500** to control the bandwidth, quality, and type of video streaming from remote link devices **102**. Remote link architecture **600** may be scaled to an indefinite amount of remote link devices **102** and client devices **104**. OCR unit **630** and operational data unit **632** may be included in another component of remote link architecture **100**, remote link architecture **400**, remote link architecture **600**, or remote link architecture **700** (described below).

[0073] FIG. **7** is a schematic representation of a remote link architecture **700**. Remote link architecture **700** includes remote link **102**, client device **104**, RLR **150**, media server **116**, WEB socket server **122**, WEB server **114**, cloud **460**, RAM data type storage **118**, document data type storage **120**, and message service **770**.

[0074] Remote link **102** may be embedded in a medical device that is monitoring a patient at a hospital, clinic, the patient's house, or another location. Remote link **102** may capture images and deliver video streams from the medical device display and transmit the images and video to the remote link router **150**. Remote link architecture **100** may comprise multiple remote links **102**. Remote link **102** interacts with the rest of remote link architecture **100** through RLR **150**.

[0075] Client device **104** may be a personal computer, a tablet, or a mobile device with an internet connection. A medical professional using client device **104** may be interested in obtaining information from one or multiple remote links **102**. Images captured by a remote link **102** may be accessed by the client device **104**. In addition, if the medical professional is interested in observing a live video stream of the medical device embedded with remote link **102**, the client device can display the video stream. Remote link architecture may comprise multiple client devices **104**. A single client device **104** may access multiple remote links **102**, as long as the client device has access to the remote links **102**.

[0076] WEB server **114** may include a mechanism for clients to view information, data, and video streams from one or more remote links **102**. WEB socket server **122** may push messages to groups of client devices **104**. Upon client device **104** connection to the WEB server **114**, the client device **104** will register to the WEB socket server **122** for messages for either one or multiple remote links **102**. The WEB socket server **122** will receive messages that will be applicable to one or more remote links **102**. This message with associated data will be broadcasted to all connected client devices **104** for updates from those remote links **102**. Message service **770** may manage the transfer of messages between the different components of remote link architecture **700** through cloud **460**. Cloud **460** represents a network of internet-based devices and connections such as servers, storage, and applications.

[0077] Media server **116** may be the receiver and sender of video streams from one or more remote links **102**. Media server **116** may be similar to video server **116** described above. Media server **116** may also be the receiver and sender of images captured from one or more remote links **102**.

[0078] RAM data type storage **118** may be volatile storage that can be accessed quickly. RAM data type storage **118** may comprise dynamic random-access memory (DRAM), static random-access memory (SRAM), or another type of high-speed volatile memory. Images captured by remote link **102** may be stored in RAM data type storage **118** before being transmitted to client device **104**. RAM data type storage **118** may also store video streams captured by remote link **102**. Document data type storage **120** may be non-volatile storage that can maintain data for long periods of time. Document data type storage **120** may be hard disks, optical disks, solid-state drives (SSDs), or another type of non-volatile memory.

[0079] FIG. **8** shows an illustrative medical device such as an intravascular blood pump **800** according to certain implementations. The pump **800** comprises a pump handle **810**, a pump head **830**, a catheter **820** connecting the pump handle **810** to the pump head **830**, and a connecting hub **860**. The catheter **820** is tubular and has a substantially uniform outer diameter **850**. The catheter **820** enables the pump head **830** and the pump handle **810** to be in electro-mechanical communication. The pump handle **810** is in communication with control circuitry which allows the control of the pump head **830**. The pump head **830** contains electro-mechanical components that enable the device to perform various tasks within the body of a patient, such as pump blood from a location within the body. The pump head **830** has a diameter **840** that is larger than the diameter **850** of the catheter **820**. An example of such a percutaneous pump is the Impella 2.5.RTM. system (Abiomed, Inc., Danvers, Mass.) which includes the pump and an Automatic Impella Controller (AIC).

[0080] FIG. **9** shows an exemplary medical device controller **900**, such as the AIC, configured according to one or more aspects of the present disclosure. The medical device controller **900** provides an interface for monitoring and controlling the functions of pump **800**. Medical device controller **900** may include display screen **902** that may display images from a video stream where the images illustrate data associated with a medical device such as an intravascular blood pump **800** over a period of time. In certain implementations, display screen **902** displays real-time operating and/or medical data associated with the pump **800**.

[0081] FIG. **10** shows an exemplary image **1000** displayed on, for example, the display screen **902**, configured according to one or more aspects of the present disclosure. In some configurations, the image **1000** may be captured by an intermediate device or data module such as remote link **102** via a network and transmitted to another device such as, for example, media server **116**. Image **1000** may include waveforms **1002**. Waveforms **1002** illustrate medical and/or operational data corresponding to the operation of pump **800**. Examples of medical data illustrated by waveforms **1002** include placement signal and motor current. The waveforms **1002**, such as the motor current waveform may provide a history, representation, and/or illustration of motor current over a period time (e.g., 10 seconds). In this way, the image **1000** includes motor current data (and other data) associated with pump **800** over a 10 second period of time. Hence, in one implementation, a data module **102** continuously monitors a video stream output from the device controller **900**, but only periodically capture an image such as image **1000**. Then the data module **102** transmits the image **1000** to another device, such as server **116**, which converts the illustrated waveforms **1002** to medical and/or operation data using, for example, OCR. If, for example, the waveforms **1002** illustrate medical data over a 10 second period, the data module **102** may capture successive images **1000** every 10 second (at 10 second intervals) to ensure that there are no gaps in the data provided to server **116**. Processes **1300** and **1400**, as discussed in relation to FIGS. **13** and **14** below, describe exemplary methods of extracting data from an image and determining the validity of the extracted data, respectively.

[0082] In one aspect, server **116** masks certain portions of image **1000** before extracting the data using OCR unit **630** or an equivalent. FIG. **11** shows an exemplary image **1100**, configured according to one or more aspects of the present disclosure. Image **1100** is a masked version of image **1000** that has been stripped of certain portions of image **1000**. For example, all portions of image **1000** are stripped except alarm and serial number portion **1102**, performance level portion **1104**, and flow level portion **1106**. After generating image **1100**, server **116** performs image processing to clarify and enlarge alarm and serial number portion **1102**, performance level portion **1104**, and flow rate portion **1106**.

[0083] FIG. **12** shows an exemplary image **1200**, configured according to one or more aspects of the present disclosure. Image **1200** is a processed version of image **1100** in order to facilitate the extracting of data using OCR unit **630**. In one aspect, alarm and serial number portion **1102** may be processed into serial number portion **1202** and alarm portion **1204**. Serial number portion **1202** includes a certain number of digits that identify the medical device **624** that is currently being monitored and may be enlarged to facilitate OCR. For example, serial number portion **1202** includes six digits. Alarm portion **1204** may indicate the type of alarm that the medical device **624** may be experiencing. For example, alarm portion **1204** includes pixels of a color that indicate a severity of the alarm the medical device **624** may be experiencing. Examples of the colors in the alarm portion **1204** include red, yellow, and green. In some aspects, performance level portion **1206** indicates the performance level of the pump **800** and includes three characters. Examples of the characters in the performance level portion **1206** may include "OFF", "P-0", "P-1", "P-2", "P-3", "P-4", "P-5", "P-6", "P-7", "P-8", and "P-9". Performance level portion **1206** may be an enlarged version of performance level portion **1104**. In another aspect, flow rate portion **1106** may be processed into present flow rate portion **1208**, max flow rate portion **1210**, and min flow rate portion **1212**. Present flow rate portion **1208** indicates the present flow rate of pump **800** in units of liters per minute. Correspondingly, max flow rate portion **1210** and min flow rate portion **1212** indicate the range of the flow rate of the pump **800**, respectively, and may be enlarged to facilitate OCR. Present flow rate portion **1208**, max flow rate portion **1210**, and min flow rate portion **1212** includes three characters that range from "0.0" to "9.9".

[0084] A process **1300** of extracting data from an image is illustrated in FIG. **13**. Process **1300** begins by receiving a first image illustrating data from a medical device **624** at step **1302**. For example, remote link **102** captures image **1000** using image capture unit **628** and server **116** receives image **1000** from remote link **102**.

[0085] Process **1300** continues by masking first portions of the first image at step **1304**. For example, server **116** uses an image mask to occlude portions of image **1000** that will not be sent to OCR unit **630** for data extraction. Masking select portions of an image allows for improved efficiency of image processing because only the select portions of the image that are not masked will be sent to OCR unit **630** or DSP unit **634**. By masking select portions of the image, less data is transmitted between server **116**, OCR unit **630**, and DSP unit **634**, and OCR unit **630** and DSP unit **634** require less processing to extract data from the image. In one aspect, server **116** may generate image **1100** by using the image mask to strip image **1000** of certain portions of image **1000**. For example, server **116** generates image **1100** by using the image mask to strip image **1000** of all portions except alarm and serial number portion **1102**, performance level portion **1104**, and flow level portion **1106**. In another aspect, server **116** may select a different mask corresponding to features of image **1000**. For example, server **116** selects a different mask based on the size of image **1000** or the GUI version corresponding to image **1000**. For example, server **116** selects a mask based on a software version of the remote link **102**. In some aspects, server **116** may select a mask based on the type of display screen **902** being used. For example, if the image displayed on display screen **902** is not the appropriate image for the first mask selected by server **116**, server **116** determines that the first mask used is not the appropriate mask for image **1000** and select a different mask based on the image currently being displayed on display screen **902**. In one aspect, server **116** may wait to mask portions of image **1000** until the appropriate image is being displayed on display screen **902**. In another aspect, server **116** may select a mask based on the amount of data to be extracted from image **1000**.

[0086] Process **1300** continues by generating a second image with the remaining portions of the first image at step **1306**. For example, server **116** generates image **1200** by performing image processing to clarify and enlarge alarm and serial number portion **1102**, performance level portion **1104**, and flow rate portion **1106**. In one aspect, server **116** may generate serial number portion **1202** and alarm portion **1204** from serial number portion **1102**, performance level portion **1206** from performance level portion **1104**, and present flow rate portion **1208**, max flow rate portion **1210**, and min flow rate portion **1212** from flow rate portion **1106**.

[0087] Process **1300** finishes by extracting, using optical character recognition, data from the second image at step **1308**. For example, the serial number of medical device **624**, the type of alarm currently being indicated, the performance level of the pump **800**, and the flow rate are extracted from image **1200** using OCR unit **630**. In one aspect, OCR unit **630** may select a pixel from the second image to determine an alarm severity from alarm portion **1204**. For example, OCR unit **630** determines the color of the pixel and determine the alarm severity based on the color of the pixel. In some aspects, OCR unit **630** may select two different pixels from the second image to determine the alarm severity from alarm portion **1204**. For example, storage **120** stores a database of alarm types and alarm severity levels and corresponding alarm color. Server **116** may access the database stored in storage **120** and determine the alarm type and severity level associated with the color of the pixel or pixels from alarm portion **1204**. In another aspect, OCR unit **630** may select a first pixel at a first time and a second pixel at a second time. For example, in some instances where image **1000** is defective when received by server **116**, server **116** is not able to determine the color of a pixel from the second image at the first time. Server **116** receives another image **1000** to determine the color of another pixel from the second image at the second time. In other aspects, server **116** determines the alarm severity to be the same as the previous alarm severity if server **116** cannot determine the color of the pixel from the two pixels. In another aspect, process **1400**, described below, may be used to validate the extracted data from the second image.

[0088] A process **1400** of determining the validity of data from an image is illustrated in FIG. **14**. Process **1400** begins by extracting, using optical character recognition, first data from a first portion of an image at step **1402**. For example, the serial number of medical device **624** is extracted from serial number portion **1202**. In one aspect, process **1300**, described above, may be used to perform extraction of first data from the first portion of the image.

[0089] Process **1400** continues by comparing the first data to reference data at step **1404**. In one aspect, reference data may include a certain number of characters and/or digits that represent standard formats that may represent the first data. For example, the extracted serial number of medical device **624** is compared with possible serial numbers stored in document data type storage **120**. Additional examples of comparing data to reference data are described in U.S. Pat. No. 9,002,083, entitled “System, Method, and Software for Optical Device Recognition Association,” the entire contents of which are hereby incorporated by reference.

[0090] Process **1400** continues by determining the validity of the first data based on the comparison at step **1406**. For example, if the extracted serial number of medical device **624** does not match a standard format for a serial number consisting e.g., of a certain number of characters and/or digits, the extracted serial number is not valid. In one aspect, if the extracted serial number does not comprise six digits and the standard format for the serial number is six digits, the extracted serial number is not valid. In another aspect, step **1406** repeats a certain amount of times before making a final determination. For example, if three attempts are required to validate the first data, the first data is determined to be valid if comparison results in a positive match three times. If during the three attempts one of the comparisons does not result in a positive match, the first data is determined to not be valid.

[0091] In response to determining that the first data is valid based on the comparison, process **1400** continues to step **1408**. At step **1408**, process **1400** continues by extracting, using optical character recognition, second data from a second portion of the second image. For example, the performance level of pump **800** is extracted from performance level portion **1206**. As described in relation to FIG. **12**, examples of the characters in the performance level portion **1206** may include “OFF”, “P-0”, “P-1”, “P-2”, “P-3”, “P-4”, “P-5”, “P-6”, “P-7”, “P-8”, and “P-9”. In one aspect, process **1400** may continue to step **1402** until all data from the portions of image **1200** have been extracted.

[0092] In response to determining that the first data is not valid based on the comparison. Process **1400** continues to step **1410**. At step **1410**, process **1400** continues by broadcasting a signal indicating that the first data is not valid. For example, server **116** notifies the remote link **102** that image **1000** produced invalid first data.

[0093] Process **1400** finishes by receiving a third image illustrating data from the medical device at step **1412**. For example, remote link **102** captures another image similar to **1000** using image capture unit **628** and server **116** may receive the similar image from remote link **102**. In one aspect, process **1400** may continue to step **1402** until all data from the portions of image **1200** have been extracted.

[0094] It will be understood that while a percutaneous heart pump is described herein, any other medical device can be used on conjunction with the present disclosure. Furthermore, while FIGS. **8** and **9** show a media device configuration where a controller **900** is separate from a pump **800**, one of ordinary skill readily recognizes that a medical device may be configured such that the controller and pump (or other elements) are integrated in the same housing.

[0095] Other objects, advantages and aspects of the various aspects of the present invention will be apparent to those who are skilled in the field of the invention and are within the scope of the description and the accompanying Figures. For example, but without limitation, structural or functional elements might be rearranged consistent with the present invention. Similarly, principles according to the present invention could be applied to other examples, which, even if not specifically described here in detail, would nevertheless be within the scope of the present invention.

Claims

1-8. (canceled)

9. A system comprising: an intravascular blood pump comprising a motor; a medical device controller configured to: monitor the intravascular blood pump; and generate a video stream; an intermediate device configured to: receive the video stream generated by the medical device controller; and capture at least one image from the video stream, wherein the at least one image comprises motor current data associated with the intravascular blood pump; and a server configured to: receive the at least one image captured by the intermediate device; and extract the motor current data from the at least one image.

10. The system of claim 9, wherein the motor current data comprises a motor current waveform, and wherein the server is configured to extract the motor current waveform from the at least one image.

11. The system of claim 9, wherein the at least one image comprises additional data relating to at least one of pressure, flow rate, pump speed, temperature, voltage, current, or biometric conditions.

12. The system of claim 11, wherein the additional data is measured via at least of one of a pressure sensor, temperature sensor, flow rate sensor, voltage sensor, current sensor, optical sensor, or audio sensor.

13. The system of claim 9, wherein the extracting of the motor current data comprises masking one or more portions of the at least one image, and wherein the one or more masked portions do not include the motor current data.

14. The system of claim 9, wherein the intermediate device is further configured to: transmit a first signal to a router that indicates that the intermediate device is connected to a data network; receive a command from the router to start capturing the at least one image; and transmit the at least one image to the router, wherein the router is configured to broadcast a second signal indicating that the intermediate device has captured the at least one image, and wherein the server is configured to receive the broadcasted second signal from the router and store the at least one image in a database.

15. The system of claim 9, wherein the intravascular blood pump further comprises a pressure sensor, wherein the at least one image further comprises pressure data from the pressure sensor of the intravascular blood pump, and wherein the server is further configured to extract the pressure data from the at least one image.

16. The system of claim 15, wherein the at least one image further comprises alarm data associated with the intravascular blood pump, and wherein the server is further configured to extract the alarm data from the at least one image.

17. The system of claim 9, wherein the at least one image further comprises a serial number of the intravascular blood pump, and wherein the server is further configured to: extract the serial number from the at least one image; and determine a validity of the motor current data based on a comparison between the serial number and one or more predetermined values stored in a database.

18. The system of claim 9, wherein the intermediate device is embedded in the medical device controller.

19. A method comprising: generating, with a medical device controller, a video stream of data associated with an intravascular blood pump communicatively coupled to the medical device controller; receiving, with an intermediate device, the video stream generated by the medical device controller; capturing, with the intermediate device, at least one image from the video stream, wherein the at least one image comprises motor current data associated with the intravascular blood pump; receiving, with a server, the at least one image captured by the intermediate device; and extracting the motor current data from the at least one image.
20. The method of claim 19, wherein the motor current data comprises a motor current waveform, and wherein the extracting of the motor current data comprises extracting the motor current waveform from the at least one image.
21. The method of claim 19, wherein the at least one image comprises additional data relating to at least one of pressure, flow rate, pump speed, temperature, voltage, current, or biometric conditions.
22. The method of claim 21, further comprising: measuring the additional data via at least of one of a pressure sensor, temperature sensor, flow rate sensor, voltage sensor, current sensor, optical sensor, or audio sensor.
23. The method of claim 19, wherein the extracting of the motor current data comprises masking one or more portions of the at least one image, and wherein the one or more masked portions do not include the motor current data.
24. The method of claim 19, further comprising: transmitting, with the intermediate device, a first signal to a router that indicates that the intermediate device is connected to a data network; transmitting, with the router, a command to the intermediate device to start capturing the at least one image; transmitting, with the intermediate device, the at least one image to the router; broadcasting, with the router, a second signal indicating that the intermediate device has captured the at least one image; receiving, with the server, the broadcasted second signal from the router; and storing, with the server, the at least one image in a database.
25. The method of claim 19, wherein the at least one image further comprises pressure data from a pressure sensor of the intravascular blood pump, and wherein the method further comprises extracting, with the server, the pressure data from the at least one image.
26. The method of claim 25, wherein the at least one image further comprises alarm data associated with the intravascular blood pump, and wherein the method further comprises extracting, with the server, the alarm data from the at least one image.
27. The method of claim 19, wherein the at least one image further comprises a serial number of the intravascular blood pump, and wherein the method further comprises: extracting, with the server, the serial number from the at least one image; and determining, with the server, a validity of the motor current data based on a comparison between the serial number and one or more predetermined values stored in a database.
28. The method of claim 19, wherein the intermediate device is embedded in the medical device controller.