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(74) Agent: PEARL COHEN ZEDEK LATZER; P.O. Box 12704, 46733 Herzlia (IL).

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(71) Applicant (for all designated States except US): GIVEN IMAGING LTD. [IL/IL]; 2 HaCarmel St., Industrial Park, 20692 Yoqneam (IL).

(72) Inventors; and

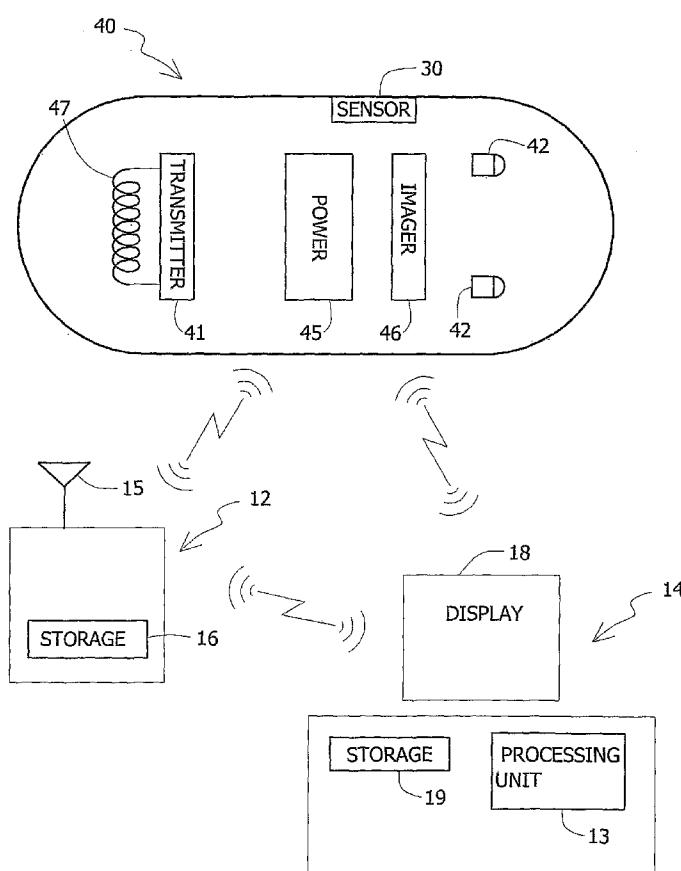
(75) Inventors/Applicants (for US only): KRUPNIK, Hagai [IL/IL]; 251 Haeme, 36001 Nofit (IL). HORN, Eli [IL/IL]; 13 Barak, 26315 Kiryat Motzkin (IL). MERON, Gavriel [IL/IL]; 21 Weizmann Street, Kfar-Ganim, 49556 Petach Tikva (IL).

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*[Continued on next page]*

(54) Title: SYSTEM AND METHOD FOR PRESENTATION OF DATA STREAMS



**(57) Abstract:** An in-vivo sensing system and a method for creating a summarized graphical presentation of a data stream captured in-vivo. The graphical presentation may be in the form of a series of summarized data points, for example a color bar. The color bar may be a fixed display along side a streaming display of the data stream. A cursor, icon or other indicator may move along the fixed color bar as the data stream is displayed and/or streamed so as to indicate to a health professional what part of the data stream may be currently displayed. The color content in the color bar may map out the data stream and give indication of the location of anatomical sites as well as possible locations of pathology.

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## SYSTEM AND METHOD FOR PRESENTATION OF DATA STREAMS

### FIELD OF THE INVENTION

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The present invention relates to presentations of data streams and to a system and method for presenting in-vivo data.

### BACKGROUND OF THE INVENTION

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Known in-vivo imaging devices include ingestible capsules that may capture images from the inside of the gastrointestinal (GI) tract. Captured images may be transmitted to an external source to be examined, for example, for pathology by a healthcare professional. In some embodiments, in-vivo devices may include various other sensors that may transmit data 15 to an external source for monitoring and diagnosis.

An in-vivo device may collect data from different points along a body lumen, for example lumens of the GI tract, and transmit them externally for analysis and diagnosis. The GI tract is a very long and curvy path such that it may be difficult to get a good indication of where along this tract each transmitted datum was obtained.

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Time bars are known to be used when reviewing data, so as to indicate to the health professional how far along the image stream he/she may have advanced. However, since the in-vivo device may stall or advance at different speeds through various sections of a body lumen, for example, the GI tract, it may not be positively determined in some cases where or at what distance along the GI tract was a particular datum, for example an image, captured.

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In addition, on the time bar there may be no indication as to when the device may have reached certain anatomical milestones, for example, the duodenum, the cecum, or other anatomical locations in the GI tract.

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Localization methods have been applied. Some localization methods may indicate the spatial position of the device in space at any given time. Although this information together with the time log may give the health professional a better indication of the rate at which the device has advanced it may still be difficult to correlate the spatial position of the device in space to the specific anatomy of, for example, the GI tract.

An in-vivo device may collect data from more than one sensor along the very long and curvy path resulting in multiple data streams captured by the in-vivo sensor. It may be

time consuming and difficult to review multiple long streams of data. In addition, it may be difficult for a health profession to get an overall view of the contents of all the data obtained.

## SUMMARY OF THE INVENTION

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Embodiments of the present invention may provide a system and method for generating and displaying a fixed graphical presentation of captured in-vivo data streams. In one embodiment of the present invention, the fixed graphical presentation includes a varying visual representation of a quantity or a dimension captured in an in-vivo data stream. In one example the graphical presentation is in the form of a color bar or a bar or series of data items differentiated by color, shape, size, etc. Different colors or intensities in the color bar may represent for example different levels of activity or change of activity in the video and/or image stream. In one embodiment of the present invention, the degree of change in activity in an image stream may be representative of the level of motility of an in-vivo device within a body lumen. In other embodiments of the present invention, the activity in an image stream may represent other information, e.g. diagnosis of pathology. In other embodiments of the present invention, the fixed graphical presentation may be displayed alongside or along with a streaming display of a data stream.

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## BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, together with objects, features and advantages thereof, 25 may best be understood by reference to the following detailed description when read with the accompanied drawings in which:

Figure 1 is a schematic illustration of an in-vivo imaging system in accordance with embodiments of the present invention;

Figure 2 is a schematic illustration of a display of a color bar together with other data 30 captured in-vivo in accordance with an embodiment of the present invention;

Figure 3 is a schematic illustration of a color bar with an identified anatomical site in accordance with an embodiment of the current invention;

Figure 4A and 4B are schematic illustrations of exemplary pH and blood detecting color bars respectively in accordance with embodiments of the present invention;

Figure 5 is a display with more than one color bar that may be viewed substantially simultaneously according to an embodiment of the present invention;

Figure 6 is a flow chart describing a method for presentation of in-vivo data according to an embodiment of the present invention;

5 Figure 7 is a flow chart describing a method for constructing a color bar from a stream of images in accordance with an embodiment of the present invention;

Figures 8A and 8B are schematic illustrations of a change graph and a color bar representation of the change graph indicating degree of changes in image scenery according to an embodiment of the present invention;

10 Figure 9 is a GUI screen including a color bar representing the level of change in scenery according to an exemplary embodiment of the present invention; and

Fig. 10 is a GUI screen with a color bar representing the level of change in scenery according to another exemplary embodiment of the present invention.

15 It will be appreciated that for simplicity and clarity of illustration, elements shown in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements may be exaggerated relative to other elements for clarity. Further, where considered appropriate, reference numerals may be repeated among the figures to indicate corresponding or analogous elements.

## 20 DETAILED DESCRIPTION OF THE INVENTION

The following description is presented to enable one of ordinary skill in the art to make and use the invention as provided in the context of a particular application and its requirements. Various modifications to the described embodiments will be apparent to those 25 with skill in the art, and the general principles defined herein may be applied to other embodiments. Therefore, the present invention is not intended to be limited to the particular embodiments shown and described, but is to be accorded the widest scope consistent with the principles and novel features herein disclosed. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be understood by those skilled in the art that the present 30 invention may be practiced without these specific details. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention.

Embodiments of the present invention offer a device, system and method for generating a fixed graphical presentation of a captured data stream, for example image streams, other non-imaged data, or other data such as color coded, possibly imaged data (e.g., pH data, temperature data, etc.) that may have been collected *in vivo*, for example along the 5 GI tract. The summarized graphical presentation may include, for example, a varying visual representation, for example, a color coded presentation, a series of colors that may be at least partially representative of a quantity and/or data collected, e.g. a series of colors where each 10 color presented on the bar may representative of a value of a parameter. Other suitable representations may be used, and other visual dimensions or qualities, such as brightness, size, width, pattern, etc. may be used. In some embodiments of the present invention, the 15 summarized graphical presentation may be a fixed display along side a streaming display of the data stream.

In one embodiment of the invention, the presentation may map out a varying quantity (e.g. a captured data stream) and may, for example, give indication of the relationship 15 between the data stream captured and the anatomical origin or position relative to a start of the captured data stream, for example, the corresponding, approximate or exact site, for example, in the GI tract from where various data captured may have originated. In another embodiment of the invention, the mapping may give, for example, an indication of an event (e.g. a physiological event) captured, measured, or otherwise obtained. In yet another 20 embodiment of the invention, the mapping may give for example an indication of change of one or more parameters measured over time, for example, a change occurring due to pathology, a natural change in the local environment, or due to other relevant changes. The location may be relative to other information, for example, anatomical attributes along for 25 example the GI tract. The location may in some embodiments be an absolute location, such as a location based on time or based on position of an *in-vivo* information capture device, based on an image frame in a sequence of images, etc.

Reference is made to Fig. 1, which shows a schematic diagram of an *in-vivo* sensing system according to one embodiment of the present invention. Typically the *in-vivo* sensing system, for example, an image sensing system, may include an *in-vivo* sensing device 40, for 30 example an imaging device having an imager 46, for capturing images, an illumination source 42, for illuminating the body lumen, a power source 45 for powering device 40, and a transmitter 41 with antenna 47, for transmitting image and possibly other data to an external receiving device 12. Imager 46 may be for example, a CCD imager, a CMOS imager, another

solid state imager or other suitable imager. In some embodiments of the present invention, in-vivo device 40 may include one or more sensors 30 other than and/or in addition to imager 46, for example, temperature sensors, pH sensors, pressure sensors, blood sensors, etc. In some embodiments of the present invention, device 40 may be an autonomous device, a capsule, or a 5 swallowable capsule. In other embodiments of the present invention, device 40 may not be autonomous, for example, device 40 may be an endoscope or other in-vivo imaging sensing device.

The in-vivo imaging device 40 may typically, according to embodiments of the present invention, transmit information (e.g., images or other data) to an external data 10 receiver and/or recorder 12 possibly close to or worn on a subject. Typically, the data receiver 12 may include an antenna or antenna array 15 and a data receiver storage unit 16. The data receiver and/or recorder 12 may of course take other suitable configurations and may not include an antenna or antenna array. In some embodiments of the present invention, the receiver may, for example, include processing power and a LCD display from displaying 15 image data.

The data receiver and/or recorder 12 may, for example, transfer the received data to a larger computing device 14, such as a workstation or personal computer, where the data may be further analyzed, stored, and/or displayed to a user. Typically, computing device 14 may include processing unit 13, data processor storage unit 19 and monitor 18. Computing device 20 14 may typically be a personal computer or workstation, which includes standard components such as processing unit 13, a memory, for example storage or memory 19, a disk drive, a monitor 18, and input-output devices, although alternate configurations are possible. Processing unit 13 typically, as part of its functionality, acts as a controller controlling the display of data for example, image data or other data. Monitor 18 is typically a conventional 25 video display, but may, in addition, be any other device capable of providing image or other data. Instructions or software for carrying out a method according to an embodiment of the invention may be included as part of computing device 14, for example stored in memory 19.

In other embodiments, each of the various components need not be required; for example, the in-vivo device 40 may transmit or otherwise transfer (e.g., by wire) data directly 30 to a viewing or computing device 14

In-vivo imaging systems suitable for use with embodiments of the present invention may be similar to various embodiments described in US Patent Application Publication Number 20030077223, published April 24, 2003 and entitled "Motility Analysis within a

Gastrointestinal Tract", assigned to the common assignee of the present application and incorporated herein by reference in its entirety, and/or US Patent Number 5,604,531, entitled "In-Vivo Video Camera System", assigned to the common assignee of the present application and incorporated herein by reference in its entirety, and/or US Patent Application Publication Number 20010035902 published on November 1, 2001 and entitled "Device and System for In-Vivo Imaging", also assigned to the common assignee of the present application and incorporated herein-by-reference in its entirety.

Other in-vivo systems, having other configurations, may be used. Of course, devices, systems, structures, functionalities and methods as described herein may have other configurations, sets of components, processes, etc.

Embodiments of the present invention include a device, system, and method for generating a typically concise and/or summarized graphical presentation of parameters sensed through or over time in a body lumen, for example the GI tract or any other tract, through which a sensing device may be present and/or traveling. Viewing a data stream captured by an in-vivo device, e.g., viewing an image stream transmitted by an ingestible imaging capsule may be a prolonged procedure. A summarized presentation of the data captured that may, for example, provide a visual representation and/or map of the captured data and may help focus a health professional's attention that may be reviewing the data stream to an area of interest and/or may promote a health professional's understanding of the origin and contents of the data being viewed.

One or more streams of data obtained from said sensing device may be processed to create one or more summarized presentations that may, for example, be displayed in a graphical user interface, for example a graphical user interface of analysis software.

According to one embodiment, presentation of a data stream (e.g., a stream or set of images, a sequence of pH data, etc.) may be with a bar, for example, a color bar that may be displayed, for example, on a monitor 18 perhaps through a graphical user interface, or, for example, in real time on an LCD display on a receiver 12 as a data stream is being captured. The presentation may include a varying visual representation of a quantity or a dimension representing, for example, a varying quantity captured in a portion of (e.g., an image frame) an in-vivo data stream. In one example the dimension may be color. The presentation may typically be an abstracted or summarized version of image or other data being presented, for example, streamed on a different portion of the display. The presentation may typically include multiple image items or data items such as bars, stripes, pixels or other components,

assembled in a continuing series, such as a bar including multiple strips, each strip corresponding to an image frame. For example, a portion of the presentation may represent a summary of the overall color scheme, brightness, pH level, temperature, pressure, or other quantity on a displayed frame or data item. Other mechanisms may be used to represent data, 5 such as intensity, shape, length or other dimension of a data element within a bar or display, or other mechanisms.

Reference is now made to Fig. 2 showing a display and/or a graphical user interface 200 for displaying data captured in-vivo data. Display 200 may include a summarized graphical presentation 220 of an in-vivo data stream, for example, a color bar. Typically, the 10 graphical presentation 220 may be a fixed presentation displayed alongside a streaming display 210 of a data stream, for example, an image stream in accordance with some embodiments of the present invention. In other embodiments of the present invention, graphical presentation 220 may be displayed separately. The graphical presentation 220 may include a series of colors, a series of colored areas, or a series of patterns, image items, 15 images or pixel groups (e.g., a series of stripes 222 or areas of color arranged to form a larger bar or rectangular area), where each, for example, color in the series 222 may be associated with and/or correspond to an element or a group of elements in the original data stream. For example, each colored stripe 222 may correspond to an image or a group of images from a data stream displayed 210. Image units other than stripes (e.g., pixels, blocks, etc.) may be 20 used, and the image units may vary in a dimension other than color (e.g., pattern, size, width, brightness, animation, etc). One image unit (e.g., a stripe 222) may represent one or more units (e.g., image frames) in the original data stream. Typically, the series of, for example, colors in the bar may be arranged in the same sequence or order in which the data stream, for 25 example, the images or groups of images may typically be displayed. In one embodiment of the present invention, pointing at a stripe in a graphical presentation 220 may advance the image stream to the frames corresponding to that stripe.

The color bar may be generated by, for example, assigning a color to each element (e.g., an image frame) or subgroup of elements in the data stream and then processing the 30 series of colors, for example such that it may emphasize variations within the displayed properties. In one embodiment of the invention, it may be processed, for example to emphasize cue points in an accompanying video such that, for example, it may be used as an ancillary tool for indicating points of interest. In one embodiment of the invention, a stream of data display 210 may be displayed along side one or more bars and/or graphical

presentations (220 and 230) described herein. The data stream display 210 may be for example a display of data represented in the graphical presentation 220 (e.g. a captured in-vivo image stream) or other data obtained and/or sampled simultaneously or substantially simultaneously with the data represented in the graphical presentation 220. In one example, a 5 marker, slider, cursor or indicator 250 may progress across or along the graphical presentation 220 as the substantially corresponding datum in data stream display 210 (e.g., video display) may be currently displayed to indicate the correspondence between the graphical presentation 220 and the data stream display 210. In other embodiments of the invention, the presentation may be of a shape other than a bar, for example a circle, oval, 10 square, etc. According to other embodiments, the presentation may be in the form of an audio tract, graph, and other suitable graphic presentations.

An indicator 250 such as a cursor or icon may move or advance along the time bar 230 and/or graphical presentation 220 as the image stream display 210 is streamed and/or scrolled on the display 200. In one example, control buttons 240 may be included in the 15 display that may allow the user to, for example, fast-forward, rewind, stop play or reach the beginning or end of, for example, an image stream. In other embodiments of the present invention, a user may control the display of a data stream 210, for example, by altering the start position of the streaming display, e.g. skipping to areas of interest, by moving the position of cursor 250, for example with a mouse or other pointing device. In other 20 embodiments of the present invention, a user and/or health professional may insert indications or markers such as thumbnails to mark location along the image stream for easy access to those locations in the future. For example, a health professional may mark these milestones on the graphical presentation 220 (e.g., using a pointing device such as a mouse, a keyboard, etc). Some embodiments described in Published United States patent application 25 US-2002-0171669-A1, entitled "System and Method for Annotation on a Moving Image", published on November 21, 2002, assigned to the assignee of the present invention and incorporated by reference herein in its entirety, include methods and devices to mark or annotate portions of an image stream; such methods may be used in conjunction with embodiments of the present invention. Other suitable methods for marking or annotating a 30 stream of data may be used. A user may then "click" on the thumbnails to advance to the site of datum, for example the image frame, of interest or alternatively click on the graphical presentation 220 to advance or retract to the image frame, of interest and then, for example,

continue or begin streaming and/or viewing the data stream from that desired point of interest.

5 Thumbnails or other markers may be defined based on an image frame of interest displayed on the data stream display 210, based on a location identified on the graphical presentation 220 or based on a time recorded on time bar 230 and/or directly on the graphical presentation 220. Other suitable methods of defining thumbnails or other markers or notations may be used. For example, a computer algorithm may be used to identify thumbnails that may be of interest to, for example, the health professional. Algorithm based thumbnails may also, for example, be based on an image of interest from the data stream display 210, based on a location identified on the graphical presentation 220 or based on a time recorded on time bar 230, or other methods. In other embodiments, the graphical presentation 220 may be in itself a series of color thumbnails, so that a user may point or "click" on colors in the color bar to restart the display of the data stream from a different point in the stream.

15 Fig. 3 is a schematic illustration of a graphical summary such as a tissue color bar according to an embodiment of the present invention. Tissue graphical presentation 220 may have been obtained through image processing of a stream of images obtained, for example, from an imager 46 imaging the tissue of the GI tract. Other lumens may be sensed, and other modalities (e.g., temperature) may be sensed. The tissue graphical presentation 220 represents, for example, a compressed, shortened, and perhaps smoothed version of the image stream captured such that the top horizontal strip of color on the bar may represent a first image, a first representative image, or a first group of images captured and the bottom horizontal strip of color may represent the last image, the last representative image, or a final set of images captured; in alternate embodiments only a portion of the image stream and/or 20 other data stream may be represented. In yet alternate embodiments, the graphical presentation 220 may be horizontal and a left vertical strip of color on the bar may represent a first image, a first representative image, or a first group of images captured and right vertical strip of color may represent the last image, the last representative image, or a final set of images captured. In yet other embodiments of the present, the graphical presentation 220 25 may be in the shape of a curve tracing the two or three dimensional path of the in-vivo device traveling through a body lumen.

30 In one embodiment of the present invention, the color scheme of image frames taken of tissue over time may change, for example as an in-vivo imaging device 40 travels along

the GI tract. Changes in the color scheme of the images may be used to identify, for example, passage through a specific anatomical site, for example, the duodenal, cecum or other sites, and/or may indicate pathology, for example bleeding or other pathology. When presenting an image stream of a tissue in a summarized, concise color bar, the changes in 5 color streams may be readily identified. For example, passage into the cecum may be identified by a color that may be typical to the large intestine, for example, a color that may indicate content or a color typical of the tissue found in the large intestine. Entrance into the duodenum may be identified by another color that may be typical of the tissue in the small intestine. Other anatomical sites may be identified by observing color and/or changing color 10 streams on a color bar, for example, a tissue color bar. In other embodiments a pathological condition, such as for example, the presence of polyps, bleeding, etc., may be identified by viewing, for example, a tissue graphical presentation 220. A specific area of interest, such as pathology indicated by blood, may be directly identified through the tissue. As such a health professional may first examine the tissue graphical presentation 220 and only afterwards 15 decide what block of images to review. In some embodiments of the present invention, an algorithm may be employed to identify anatomical sites, pathologies, or areas of interest using data from such a color bar and bring them to the attention of a health professional, by for example marking the area of interest along the displayed color bar. A health professional may use the thumbnails or markings along a tissue color bar, for example, markings and/or 20 markings of the first gastric image 320, the first duodenum image 330 and the first cecum image 340 to locate where along the GI tract the data (concurrently being displayed in the data stream display 210) may be originating from. Knowing the area at which an image was captured may help a health professional decide if an image viewed is representative of a healthy or pathological tissue, and may help a health professional to determine other 25 conditions of interest.

According to some embodiments, different colors or other visual indications, shades, hues, sizes or widths, etc. may be artificially added to a processed data stream, for example, in order to accentuate changes along the data stream. Other processing methods may be used to enhance the information presented to the user. In one embodiment of the invention 30 smoothing may or may not be performed on selected pixels based on decision rules. For example in one embodiment of the invention smoothing may not be performed on dark pixels or on green pixels that may indicate content in the intestines.

Reference is now made to Fig.4A and 4B showing an example, of graphical presentations in the form of a bar or series of summaries or distillations of data other than tissue color bars. For example, Fig. 4A shows a schematic example of a pH color bar 225 that may map out pH measurements obtained, for example over time or alternatively along a path of a body lumen. Other measurements may be used, for example, temperature, blood sensor, and pressure measurements may be used. Data obtained from an in-vivo pH sensor may be displayed with color, brightness, and/or patterns to map out the pH over time and/or over a path, for example a GI tract where different colors may represent, for example, different pH levels. In other examples, different colors may represent different levels of changes in pH levels. Other suitable presentations may be displayed. Changes in pH along a path may be due to pathology, entrance into or out of anatomical locations, etc. Observed changes in pH over time may, for example, classify physiological occurrences over time, for example a healing process, progression of a medical condition, pathology, etc. Fig. 4B is a schematic illustration of blood detecting color bar 226. In one example, color stripes 222 along the bar may indicate a site where blood may have been detected. In other embodiments of the present invention a graphical presentation may be used to map out and/or represent a stream of information obtained from a source other than the in-vivo device, for example, information obtained from the patient incorporating the in-vivo device, from the receiver 12, or the workstation 14. For example, the patient may input through an inputting device in receiver 12 tags that may correspond to sensations felt, or other events. Other suitable forms of information may be represented as well. The graphical presentation 220 may be a color representation of a parameter. Graphical presentation 220 may be a color coded presentation of a parameter associated with an image stream.

In one embodiment of the present invention, representation or color bar 226 may give indication of the presence of blood over a period of time. US Patent Application Publication Number 20020042562 entitled "An Immobilizable In Vivo Sensing Device" assigned to the assignee of the present invention and incorporated by reference herein in its entirety includes, inter alia, descriptions of embodiments of devices, such as capsules, that may be anchored at post-surgical sites. Embodiments described in US Patent Application Publication Number 20020042562 may be used in conjunction with the system and methods described herein to capture and transmit data for an in-vivo site over time. A presentation of the captured data, for example a color bar may give indication of any changes occurring over time from a

current static situation or may show an overview of how a tissue healed or changed over time without having to review the entire stream image by image.

Reference is now made to Fig. 5 showing schematically a graphical user interface for viewing a streaming display 210 of in-vivo data along with multiple fixed summarized 5 graphical presentations such as presentations 220, 225, and 226 of a data stream. A single scrolling cursor 250 may be used along with a time bar 230 to point to a position along the fixed presentation of the data streams (e.g., 220, 225, and 226) so as to indicate where along the bars the data from display 210 presently being displayed originated. The individual summaries such as color bars may include for example, a tissue graphical presentation 220, a 10 pH color bar 225, and a blood detector color bar 226. Other numbers of graphical presentations, other suitable types of bars summarizing other data, and other suitable types of presentations may be used.

Multiple graphical presentations may be helpful in diagnosis of medical conditions as well as locating within a stream of data, sites of interest. Multiple graphical presentation may 15 increase the parameters that are available to a health professional when reviewing, for example, an image stream and may give a better indication of the environmental condition that may exist at a point of observation. For example, in one embodiment, pH, temperature and tissue graphical presentations or other presentation may be displayed, possibly, side by side. In an alternate embodiment, two or more streams of information may be displayed 20 simultaneously and combined into a single graphical presentation using for example a unifying algorithm. For example, pH and temperature can be combined into a single color bar where, for example, red holds the temperature values and blue holds the pH values (other suitable colors may be used).

A physician may choose which parameters he/she is interested in viewing as a map or 25 summary. Having more than one set of parameter available at one time may make it easier to find more anatomical sites and to identify areas that may, for example, contain pathologies. Numerous algorithms based on case studies or other suitable data may be applied to suggest to the physician alert sites or other information obtained from one or more color bars or from the combination of one or more color bars. In another example, a graph representing one 30 parameter for example, a level of change in scenery, motility, or other parameters may be superimposed or constructed over a color bar representing the same or alternatively another parameter. For example, a level of change in scenery graph may be superimposed on a tissue color bar. Other suitable indicating maps, information summaries, or color bars may be used.

Non-limiting examples of different types of graphical presentations (e.g., color bars, series of brightness levels, etc.) may include:

- Tissue graphical presentation: brightness, pattern, or other visual representation of a tissue image stream;
- Temperature graphical presentation: color, brightness, pattern, or other visual representation of sensed in-vivo temperature data over time and/or along a body lumen;
- pH graphical presentation: color brightness, pattern, or other visual representation of sensed in-vivo temperature data over time and/or along a body lumen;
- Oxygen saturation graphical presentation: color, brightness, pattern, or other visual representation of sensed oxygen saturation over time and/or along a body lumen;
- Pressure graphical presentation: color, brightness, pattern, or other visual representation of sensed in-vivo pressure over time and/or along a body lumen;
- Blood detection graphical presentation: color, brightness, pattern, or other visual representation of sensed presence of bleeding over time and/or along a body lumen;
- Biosensor graphical presentation: color, brightness, pattern, or other visual representation of results obtained from one or more in-vivo biosensors;
- Speed graphical presentation: color, brightness, pattern, or other visual representation of the speed of a moving in-vivo device;
- Spatial position graphical presentation: color, brightness, pattern, or other visual representation of the spatial position and/or orientation of an in-vivo device over time;
- Ultrasound graphical presentation: color, brightness, pattern, or other visual representation of data sensed from an in-vivo ultrasound probe; and
- Motility graphical presentation: color, brightness, pattern, or other visual representation of the sensed motility of a traveling in-vivo device.
- Level of change in scenery: color, brightness, pattern, or other visual representation of the sensed level of change in scenery and or change in image and/or graphical content in the consecutive frames of an image stream captured by a movable in-vivo device.

US Patent Application Publication Number 20030077223 entitled "Motility Analysis within a Gastrointestinal Tract" describes various devices, systems, and methods for determining in-vivo motility that may be used in conjunction with the device, system, and method described herein. The devices, systems and methods described in US Patent Application Publication Number 20030077223 may in some embodiments of the present invention determine motility based on a comparison between consecutive image frames. In one example, a change in intensity, color, or other suitable parameter between one or more consecutive image frames or groups of frames may indicate that the in-vivo device may have moved or may have been displaced. In one embodiment of the present invention, changes, for example, average changes in intensity, color, or other suitable parameter between consecutive groups or one or more consecutive image frames, as may be described in US Patent Application Publication Number 20030077223 may be used as a measure of change in scenery, change in image content, image details and/or graphical content. Other methods may be used to indicate a change in scenery. The change in scenery between consecutive images may be, for example, quantified by levels or degrees of change in scenery in the captured image stream. Examples of different levels may include mild change in scenery, moderate change in scenery, significant change in scenery, and drastic change in scenery between consecutive images or consecutive groups of images. The levels may be based on changes in one or more parameters between consecutive image frames or based on other quantifying means. Other methods of quantifying change in scenery and other number of levels may be used. Devices, systems and methods described in US Patent Application Publication Number 20030077223 may be implemented to determine in a broader sense a level of change in scenery in the image stream.

The level of change in scenery measured over time or over the course of the image stream may, in some embodiments of the present invention give an indication of the motility of the in-vivo device movable and/or progressing through the body lumen as may have been described in US Patent Publication Number 20030077223. In other embodiments of the present invention, the level or measure of change in scenery may give other indications. In one example the degree or amount of overlap, or similarity between two or more consecutive images may be determined, according to image processing methods known in the art, for example by motion tracking methods known in the art. Examples for motion tracking methods may be *inter alia* inter-frame image registration, motion vectors, optical flow calculations, or other known methods. In one example motion tracking failure may indicate a

high, or the highest level of change in scenery. In one embodiment, the degree, amount, or percent of overlap found between consecutive images or the number of consecutive images that share an overlapping area may give indication on the level of change in scenery. For example, if a significant number or a group of consecutive images share an overlapping area, 5 the level of the change in scenery during the time period corresponding to the time period the group of consecutive images was captured may be considered low. In another example, if no overlapping area may have been identified between consecutive images, or only a small percent of overlap was identified between two consecutive images, the level of the change in scenery may be considered high. Other suitable representations other than bars and other 10 suitable types of data may be implemented using the device, system, and method described herein.

Reference is now made to Fig. 6 showing a flow chart of a method for presentation of an in-vivo data stream according to an embodiment of the present invention. In block 610 a fixed presentation of a data stream may be displayed, e.g. a color bar, a series of strips of 15 varying width or brightness, etc., summarizing, for example, an image stream, a pH data stream, temperature data stream etc. A user may annotate portions of the fixed presentation (block 680) for example identified anatomical sites and/or physiological events. In other embodiments of the present invention, the user may search for one or more occurrence of a color, feature, or other representation in the fixed representation. More than one fixed 20 presentation may be displayed concurrently. In block 620 a time bar may be displayed indicating the time that data from a displayed data stream may have been sampled and/or captured. A time bar need not be used. The data stream to be displayed may be initiated (block 630) so as, for example, to begin the streaming display. In one example, initiating 25 may be achieved by a user input through control bar 240 (Fig. 2). In block 640, streaming of the data stream may begin. The displayed data stream may be other than the data stream represented in the fixed presentation. For example, an in-vivo device may capture images as well as sample, for example, temperature values, as it progresses through the body lumen. In one example, a fixed presentation of temperature values may be displayed along side a streaming display of image frames captured substantially simultaneously. In other examples, 30 the fixed presentation as well as the streaming display may be of the captured image frame. In block 650 as the data stream progress, a cursor, icon or other indicator may point to or label on-screen a position on the fixed presentation (as well as the time bar) that may correspond to the data (e.g., an image frame, a pH value) displayed in the displayed data

stream. In block 660, a command may be received to stream the display from a different point in the data stream. In one example, the user may drag the cursor along the fixed presentation to indicate the point at which the streaming should begin. In other examples, the user may annotate portions in the fixed presentation (block 680) and at some point click on 5 the annotations to begin streaming the data stream at the corresponding point in the displayed streamed data stream. Other suitable methods of receiving user inputs may be implemented and other suitable methods of annotations other than user input annotations may be implemented, for example as may have been described herein. In block 670 the start position of the streaming display may be defined by a user input and with that information a command 10 to begin streaming from the defined point may be implemented. Other operations or series of operations may be used.

Various suitable methods may be used to abstract data from the source data stream (e.g. an image stream; a series of temperature data items) to the fixed representation. Reference is now made to Fig. 7 describing a method of generating a fixed summary of a data 15 representation, for example a tissue color bar, according to an embodiment of the present invention. In an exemplary embodiment, in block 510 a set (wherein set may include one item) or series of data items, for example frames from an image stream may be extracted. For example every 10<sup>th</sup> frame from the image stream may be extracted and/or chosen to represent the image stream in a fixed presentation. In other embodiments, all the data items 20 or frames may be included, or every 5<sup>th</sup>, 20<sup>th</sup>, or any other suitable number of frames may be used. In yet other embodiment of the present invention, an image representing a group of frames, e.g. an average of every two or more frames may be used. In one example, a criterion may be defined by which to define one frame out of a block of frames (e.g. two or 25 more frames) to be representative of that block. In block 520 a vector and/or a stream of average color or other values (e.g., brightness values) may be calculated. In one embodiment of the present invention, the average color may be calculated in a defined area in each frame, for example, a defined area that is smaller than the area of the image frame. For example, an average red, blue, and green value in a defined area of each frame in the series of frames chosen may be calculated to form 3 color vectors and/or streams. In one example, the 30 defined area may be a centered circle, for example with a radius of 102 pixels taken from an image frame containing, for example 256 x 256 pixels. In other examples, only one or two colors may be used to generate a color bar. In block 530 a filter may be applied, for example a median filter, on the vector of average color values, for example, the three color vectors:

red, green, and blue. An exemplary filter may for example have a length defined by the following equation:

$$1+2(\alpha * N/N_p); \alpha = 2.2;$$

where  $N$  is the original pixel size and  $N_p$  is the desired pixel size of the resultant 5 tissue color bar presentation. Other equations or formulae may be used.

In block 540 the pixel size of the resultant tissue color bar presentation may be set by decimating the vector of colors to a desired size, for example, decimating each color vector to the desired size by interpolation.

Other methods of generating a tissue color bar or other data summary may be 10 implemented. In one embodiment, a series of data items, such as for example one or more individual images, may be converted to a data point, such as a color area or a color strip within a larger display area, such as a color bar. An average brightness value for each image or set of images may be found, and a bar or assemblage of strips of widths, patterns, colors or 15 brightness corresponding to the averaged values may be generated. The values such as pH, pressure or temperature corresponding to each of an image or set of images (e.g., in a device collecting both image and other data) may be found, and a bar or assemblage of strips or other image units of widths, colors or brightness corresponding to the averaged values may 20 be generated. One or more images may be converted or processed to a corresponding stripe of color. Various data items may be combined together to individual data points using, for example, averaging, smoothing, etc. In one embodiment the luminance of the images can be normalized and only normalized chromatic information of the data for example the tissue's color, can be shown, eliminating, for example, the contribution of the light source. Other color bars or other presentations of data obtained in-vivo other than imaged data may be generated.

25 Summaries or series of summarized data such as color bars and other representations of data may aid in reducing the viewing time necessary to review an image stream. A health professional may, in one embodiment of the present invention, use a pointer or pointing device, for example, a mouse to point at an area along the color bar that may be of interest. The graphical user interface may in turn skip to the corresponding location on the data 30 stream, so that a user and/or health professional may focus into the area of interest without having to review an entire image stream. A health professional may for example, change the rate at which to view different portions defined by a tissue color bar. A specific area of interest, such as pathology indicated by blood, may be directly identified through the tissue.

As such a health professional may first examine the tissue color bar and only afterwards decide what block of images he may be interested in reviewing. When screening patients it may be possible only to review one or more data presentations, such as a tissue color bar. In other examples, a summarized graphical presentation of a data stream may be generated in 5 real time in for example a recorder 12, and displayed in real time on a display included in recorder 12.

In other embodiments of the present invention, a graphical presentation, for example, color bar may be used for other purposes besides presentation of in-vivo data. For example, a color bar may be used as a summarizing presentation of any stream of frames, for example a 10 video. A summarized graphical presentation, for example a color bar as described herein, of a video may help a viewer to locate different scenes in a video and possibly fast forward, rewind or skip to that scene. For example, a scene in a movie that might have been filmed outdoors may for example have a different color scheme than a later or earlier scene that may have been filmed indoors. The color bar may be analogous to a color table of contents.

15 A change in scenery or a difference between substantially consecutive image frames in an image stream captured by an in-vivo device may for example, result from the in-vivo device advancing to another section or organ of a body lumen, due to the in-vivo device changing orientation to view a different side of a body lumen, or may be due to the in-vivo device capturing an image frame at different stages of for example, peristaltic motion. In one 20 example, the scenery in an image frame captured during a peristaltic contraction may be different than the scenery in an image frame taken in the same location, during a period with no contraction. Changes in scenery may be due to other factors, for example an appearance of pathology, e.g. the appearance of polyps, bleeding and other pathologies. Other factors may contribute to a change in scenery.

25 In one embodiment of the present invention, an indication of a level of change in scenery may help draw the attention of a health professional to particular image frames of interest, to portions of the image stream where there may be activity e.g. a change in scenery or new information. In other examples, an indication of a level of change in scenery may help give indication of the motion pattern of the in-vivo device, the peristaltic pattern of the 30 body lumen. In yet other examples, an indication of a level of change in scenery may be used to identify different organs for example in the GI tract. For example, a change in scenery may occur in the transition points between different organs, e.g. the duodenum, the cecum, the transition between esophagus and the stomach, or other transition points. An indication of

a level if change in scenery may be used for other purposes, for example, to locate image frames that show pathologies.

Reference is now made to Figs. 8A and 8B showing an example of graphical and color bar representations of a level or measure of changes in image scenery that may indicate in one example, motility of an in-vivo sensing device movable within a body lumen. Changes in image scenery, activity in the image stream, and/or the level and/or degree of activity in an image stream may be determined by methods and systems, such as for example, disclosed US Patent Application Publication Number 20030077223. According to one embodiment of US Patent Application Publication Number 20030077223 a processor may compare a parameter, e.g. intensity, color, etc. of pairs or images, consecutive images and/or groups of images, may generate an average difference for the compared images, and may calculate the motility of the in-vivo imaging device from, for example, the average differences. Other suitable parameters besides or together with intensity may be used, for example color comparison between images may be used. Embodiments such as those described in US Patent Application Publication Number 20030077223 to determine motility may be based on depicting a change in scenery, for example, a change in the image content between consecutive image frames or consecutive groups of image frames and therefore the same, or similar methods may be used in the present invention to determine a level or measure of the change in scenery in an image stream. However, the invention is not limited in this respect and other method may be used to measure level of activity and/or change in scenery in an image stream captured by an in-vivo device may be applied. For example, motion tracking methods or other methods as may be known in the art may be used to determine the amount, percent, or degree of correspondence between images, for example, the amount of overlap between consecutive images or substantially consecutive images, or groups of substantially consecutive images may be determined by methods known in the art. Examples for motion tracking methods may be inter alia inter-frame image registration, motion vectors, optical flow calculations, or other known methods. In one example motion tracking failure may indicate a high, or the highest level of change in scenery. In one embodiment, the degree, amount, or percent of overlap found between consecutive images or the number of consecutive images that share an overlapping area may give indication on the level of change in scenery. For example, if a significant number or a group of consecutive images share an overlapping area, the level of the change in scenery during the time period corresponding to the time period the group of consecutive images was captured may be

considered low. In another example, if no overlapping area may have been identified between consecutive images, or only a small percent of overlap was identified between two consecutive images, the level of the change in scenery may be considered high.

Fig. 8A illustrates, in a relative scale in the Y-axis, the change in scenery of an image stream captured by an in-vivo sensing device versus time, shown in the X-axis also in a relative scale according to an embodiment of the present invention. The X-axis may represent absolute time, and/or the number of frames captured by the device. Fig. 8B illustrates a color bar converted or derived or mapped from the change graph shown in Fig. 8A. Visual cues other than color may be used to represent or distinguish data in such a bar or other representation; for example data points or frames may be represented by varying intensity, color shape, size, length, etc. The X-axis may represent frame identifier or time. The conversion or derivation or mapping may be made with respect to a certain color map or key.

According to exemplary embodiments of the invention, a particular level in change of scenery or level in change in image stream activity in Fig. 8A may correspond to a corresponding color and/or gray scale in Fig. 8B. For example, black may be indicative of scenery that may be stable and may not be changing or that may be changing mildly or little while white may indicate that the scenery is drastically changing and/or substantially changing in the image stream. Shades of gray may represent intermediate levels. In other embodiments, different degree of change may be represented by different colors. For example, in a relative sense, blue may indicate no change, moderate change or little change in scenery and deep-blue may imply the device may be in static state while red may indicate fast changes in scenery. Other colors, for example, green and yellow, may indicate levels of activity in between those represented by the blue and red colors. The color bar representation of the image stream activity may provide a visual tool, for example, for a physician or pathologist or healthcare professional, to be aware the movement of the in-vivo sensing device inside the human body, to assist the diagnose of a patient. Other mappings of change in scenery to color may be used. In some embodiments of the present invention, change in scenery may give indication of the motility of the in-vivo device that may be movable and/or may travel through a body lumen. Change in scenery may be mapped to other visual cues such as brightness or intensity. Changes in other visual parameters in the image stream other than change in scenery may be monitored and presented as a color and/or graphical representation. In some embodiments of the present invention, a level of activity or a pattern

of activity levels of an image stream may be indicative of a specific pathology, condition, or occurrence in a body lumen, for example, the GI tract.

In other embodiments of the present invention, the activity level, or a specific pattern of a visual parameter in an image stream may correspond and/or give indication of a specific 5 location in a body lumen, e.g. the esophagus, stomach, small intestine, etc. in which specific images in the image stream may have been captured. Reference is now made to Fig. 9 showing a display with a graphical user interface and a color bar representation 227 of a change in scenery graph of an in-vivo device according to exemplary embodiments of the invention. The change graph may be indicative of the motility of an in-vivo device. The 10 graphical user interface may include a control bar 240 with a set of buttons or other controls like a slider, push buttons, arrow buttons, and radial buttons, for example, for controlling and displaying data, for example, images, captured by an in-vivo sensing device. In one embodiment, a display rate control bar with slider 241 may be included to control the overall 15 display rate of the image stream. The display may also include a time bar 230, a summarized tissue color bar 220 and a summarized color bar 227 or other representation of the level in change in scenery of the device inside a human body. A cursor 250 may scroll along one or more bars, 230, 220, 227 to for example mark the point or area on the bar corresponding to the image frame displayed in a streaming display 210 of a data stream.

As is described with respect to Fig. 8B, different colors may be used to represent 20 different level of change in scenery in the captured image stream. For example, a red color may indicate a lot of changes in the device movement and a blue color may represent little or no change. Green and yellow colors may represent levels of change in scenery in between the red and blue colors. It will be appreciated by person skilled in the art that the invention is not limited in this respect. For example, a different color map may be defined to represent 25 different levels of changes in scenery. For example, instead of the above defined color scheme, a purple color may be designated to represent a great degree of changes in scenery, and the red color may be used to represent only moderate changes. Similarly, a black color may be designated to represent little or no change in the scenery of the image stream, and the blue color may be used to represent certain level of changes in scenery, which may be lower 30 than the red color but higher than the black color. In other embodiments of the present invention, a grey scale bar may be used where black may represent small and/or no changes in scenery while white may represent significant changes in scenery.

According to some embodiments of the present invention, the level of change in scenery may be represented, for example, as discrete marks such as tick marks, dots, or other marks 950 along a time scale 230, where the distance between the tick marks 950 may give an indication of the level of change in scenery. For example tick marks 950, along the length 5 of the time scale 230, occurring in high frequency 950a, positioned close together, for example, concentrated in a portion of the time scale 230 may indicate that the corresponding portion of the image stream may have a low level of change in scenery. In another area along the time scale 230 tick marks 950b may be dispersed and/or the tick marks 950b may be distanced to indicate that in the corresponding portion of the image stream, the level of 10 change in scenery may be high. According to one embodiment of the present invention the distances between the tick marks 950 may correspond to the level of change in scenery. In another embodiment of the present invention, position data and/or localization data may be used as well in determining the positioning of the tick marks 950. In yet another embodiment 15 of the present invention each of the tick marks 950 may represent a distance traveled, e.g. one meter. As such a portion of the tick marks 950b where tick marks 950 may be positioned close together may indicate that the in-vivo device may be traveling at a low velocity, while a portion of the tick marks 950a where tick marks 950 may be positioned far apart may indicate that the in-vivo device may be traveling at a high, or higher velocity. In other embodiments, 20 bar 230 may not be shown, and tick marks 950 may be positioned along an alternate bar for example, bar 220 or bar 227.

According to another embodiment of the present invention, the streaming rate of the image stream displayed in the streaming portion 210 may be variable and may be related and/or correspond to the level of change in scenery. For example, when the level of change 25 in scenery may be depicted to be low, the streaming rate of the image stream may be increased. In another example, when the level of change in scenery may be determined to be higher the streaming rate may be decreased so that changes in the scenery of the image stream may be emphasized while stagnant portions of the image stream may be, for example, less emphasized. According to one embodiment of the present invention, controlling the rate 30 of the image stream based on the level of change in scenery may provide a method for reducing the overall viewing time required to review an image stream so that portions of the image stream with little or no activity will stream quickly while other portions of the image stream with high activity will stream slowly so that a viewer can examine all the details and activities occurring in the image stream while not spending unnecessary time viewing a

constant non-changing scenery. According to one embodiment, varying the rate of image streaming may serve to warp time so as to simulate smooth advancement of an in-vivo device through a body lumen. In other embodiments, the variable streaming rate may be used to preview the image stream so as to bring to the attention of the user the most active parts of 5 the image stream. Other applications for varying the streaming rate of the image stream may be used.

In one example, the distance between discrete tick marks 950 may correspond to the current display rate and may, for example, represent a warped time bar scale where the tick marks on the scale may not be distributed at equidistance. For example, close ticks marks 10 950b may correspond or represent fast streaming of a portion or segment of the image stream being displayed in streaming display 210 due to for example, a low level of change in scenery. In another example, sparse or distanced tick marks 950a may correspond or represent fast streaming of a portion or segment of the image stream being displayed in streaming display 210 due to for example, a high level of change in scenery. According to 15 one embodiment, the cursor 250 movement speed may be held constant while the video display speed might vary. Reference is now made to Fig. 10 showing a display with a graphical user interface and a color bar representation of a change graph of scenery of an in-vivo device according to another embodiment of the present invention. The graphical user interface may include a control bar 240 with a set of buttons like a slider, push buttons, arrow 20 buttons, and radial buttons, for example, for controlling and displaying data, for example, images, captured by an in-vivo sensing device. In one embodiment, a display rate control bar with slider 241 may be included to control the overall display rate of the image stream. The display may also include a time bar 230, a summarized tissue color bar 220, and other information or control options. In one embodiment of the present invention, a bar may not be 25 used to indicate a change in scenery and a change in scenery may be indicated by changing a color of a graph 228, for example, a graph displayed on the GUI (graphical user interface) for example, a position graph, localization graph, tracking curve or other graph, curve etc. For example, a curve tracing a position of capsule may change color in accordance to the level of change in scenery and/or the change in image content. Other methods of displaying a change 30 of image scenery may be used. A cursor 250 may scroll along one or more bars, 230, 220, 228 to for example mark the point or area on the bar corresponding to the image frame displayed in a streaming display 210 of a data stream.

The foregoing description of the embodiments of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. It should be appreciated by persons skilled in the art that many modifications, variations, substitutions, changes, and equivalents are possible in light of the above teaching. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

## CLAIMS

1. A method for presenting an image stream captured by an in-vivo device, the method comprising:  
generating data corresponding to a level of change in scenery in said image stream;  
displaying a streaming display of the image stream;  
displaying a display of the level of change in scenery of said streaming display.
2. The method according to claim 1 comprising displaying an indicator indicating the portion of the display of the level of change in scenery that corresponds to a current image displayed in said streaming display.
3. The method according to claim 1 wherein the generating of data corresponding to a level in change is in real time.
4. The method according to claim 1 wherein the streaming display is displayed at a varying rate that corresponds to the level of change in scenery.
5. The method according to claim 1 wherein the display of the level of change in scenery includes more than one color, each different color corresponding to a different level in change of scenery.
6. The method according to claim 1 comprising generating a color graphical presentation of the image stream; and displaying said color graphical presentation.
7. The method according to claim 1 comprising comparing substantially consecutive images of said image stream; and determining degree of overlap between said substantially consecutive images.
8. The method according to claim 7 comprising performing motion tracking between said substantially consecutive images.
9. The method according to claim 7 comprising comparing intensity of said substantially consecutive images.
10. A system for presentation of in-vivo image stream, the system comprising:  
an in-vivo imaging device to capture said image stream;  
a processing unit to generate a summarized presentation of said image stream;  
and

a display to display said image stream together with a summarized presentation corresponding to the level of change in scenery in the image stream.

11. The system according to claim 10 wherein the display includes an indicator indicating the position along said summarized presentation that corresponds to a current image of said image stream displayed.
12. The system according to claim 10 wherein said processor processes said summarized presentation in real time.
13. The system according to claim 10 wherein said display of said image stream is displayed at a varying rate that corresponds to said level of change in scenery.
14. The system according to claim 10 wherein said summarized presentation is color coded.
15. The system according to claim 10 wherein the processor is to compare two or more substantially consecutive images of said image stream; and determine a degree of overlap between said substantially consecutive images.
16. The system according to claim 10 wherein the processor is to perform motion tracking between substantially consecutive images of said image stream.
17. A method for presentation of an image stream, said method comprising:  
generating a fixed graphical presentation of the image stream wherein said presentation includes at least a varying visual representation, said visual representation varying in accordance with a level of change in the scenery in the image stream; and  
displaying the fixed graphical presentation.
18. The method according to claim 17 comprising displaying a streaming display of said image stream along with said fixed presentation.
19. The method according to claim 18 comprising displaying an indicator indicating the portion of said presentation that corresponds to an image displayed in said streaming display.
20. The method according to claim 17 wherein the visual representation is a color representation.
21. The method according to claim 17 comprising comparing one or more substantially consecutive images of said image stream; and determining degree of overlap between said substantially consecutive images.

22. The method according to claim 21 comprising performing motion tracking between said substantially consecutive images.

1/9

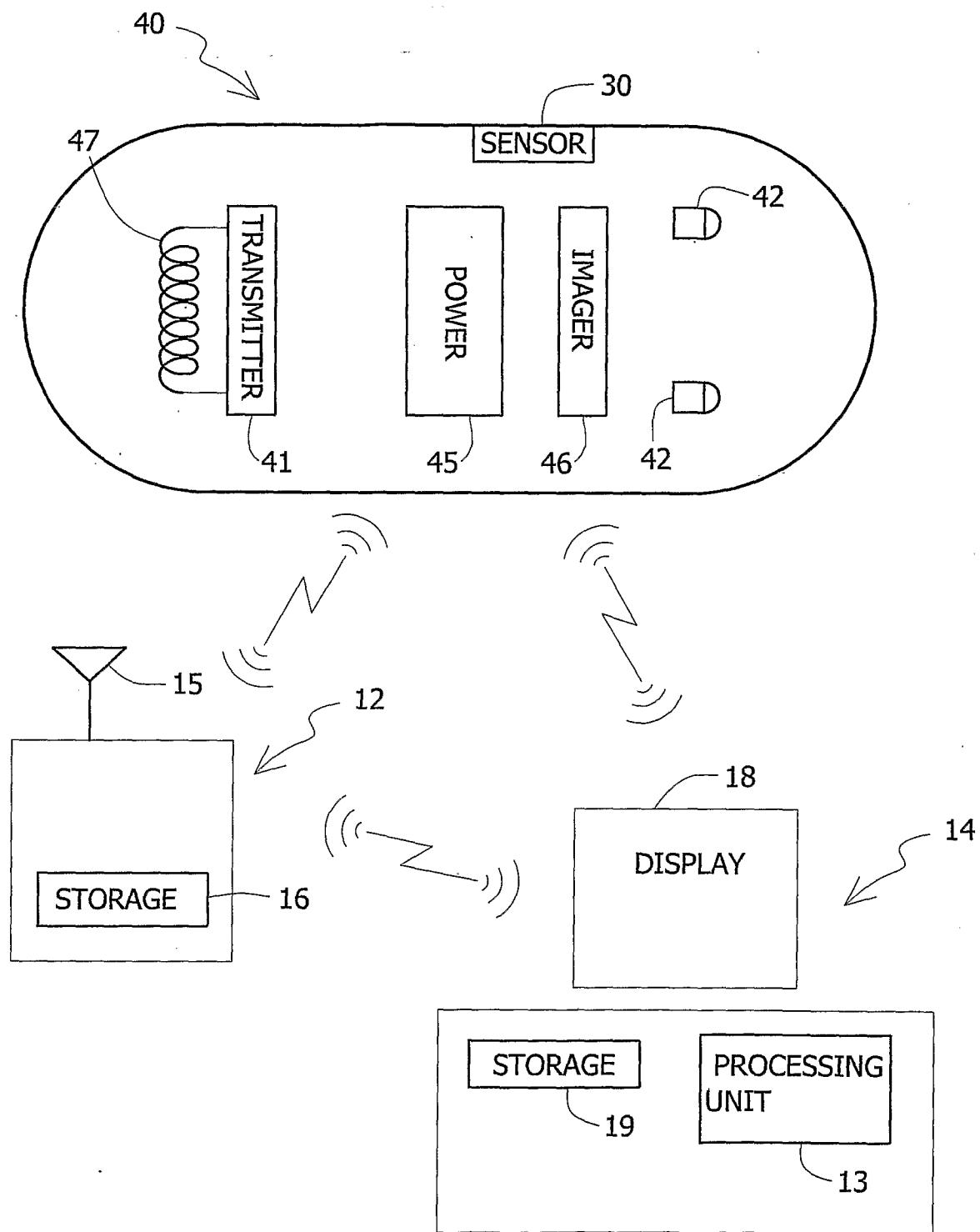


Fig. 1

2/9

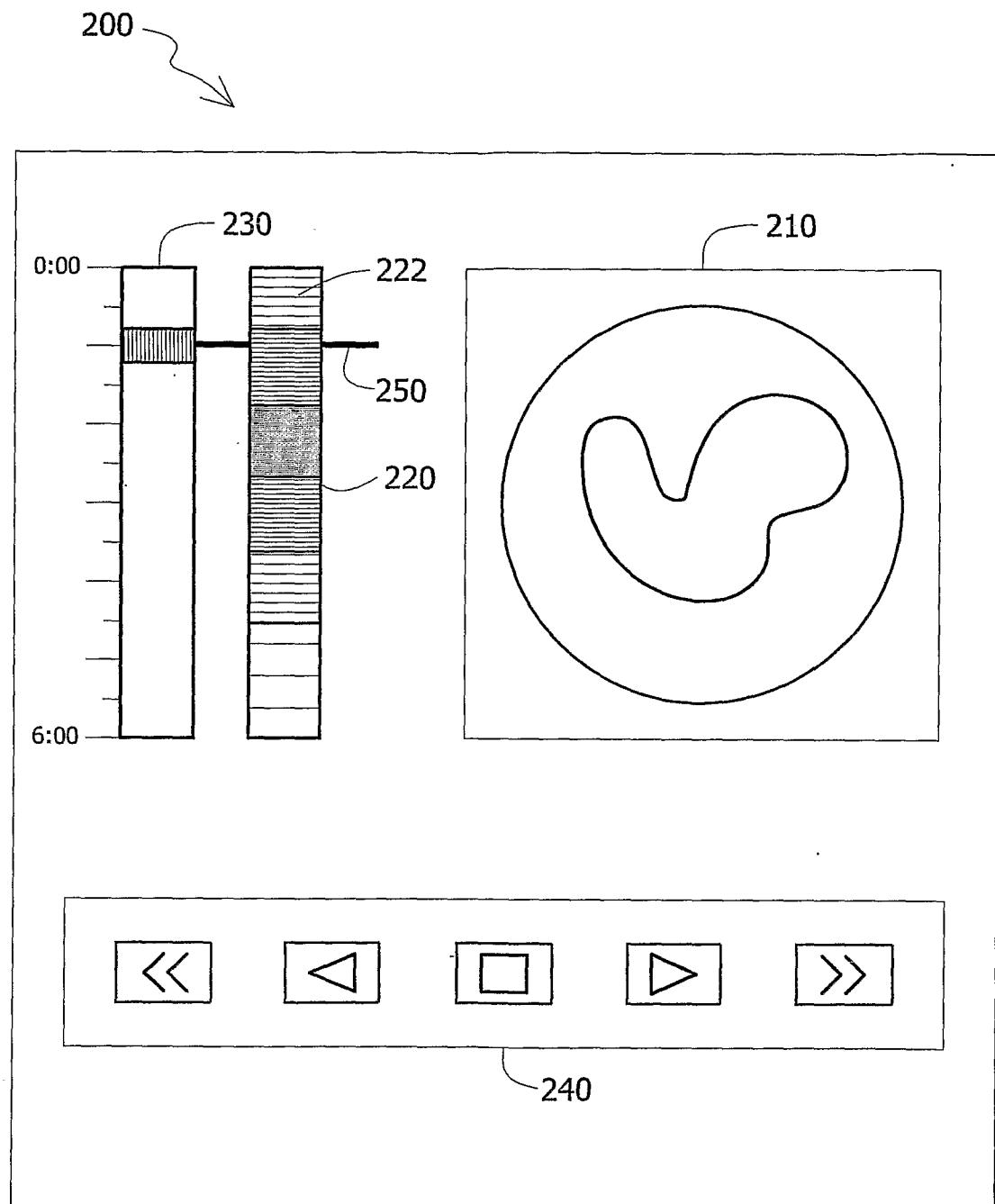


Fig. 2

3/9

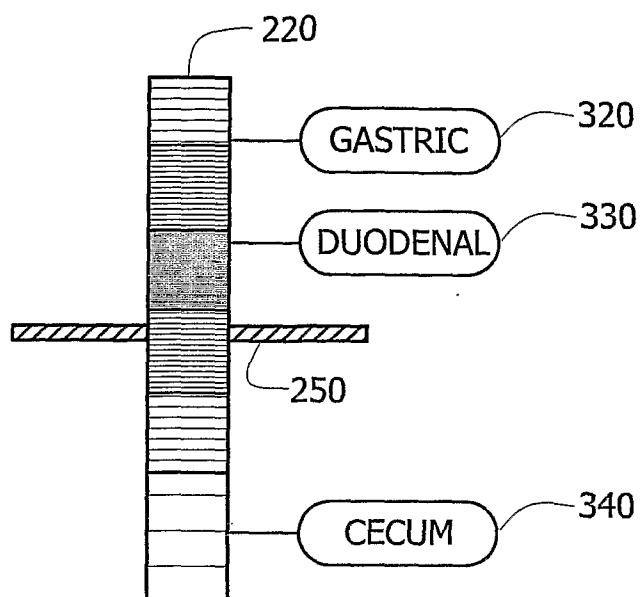


Fig. 3

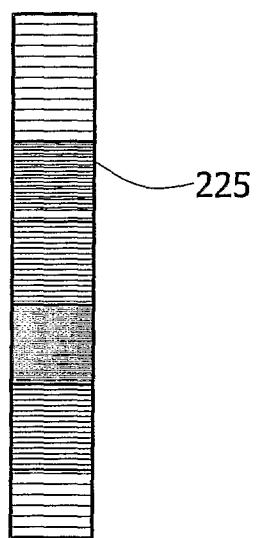


Fig. 4A

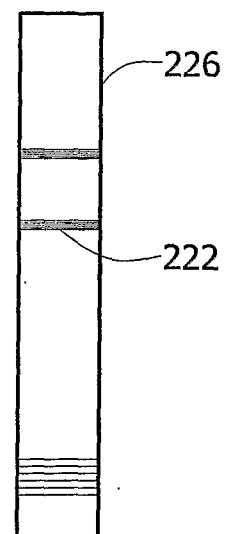


Fig. 4B

4/9

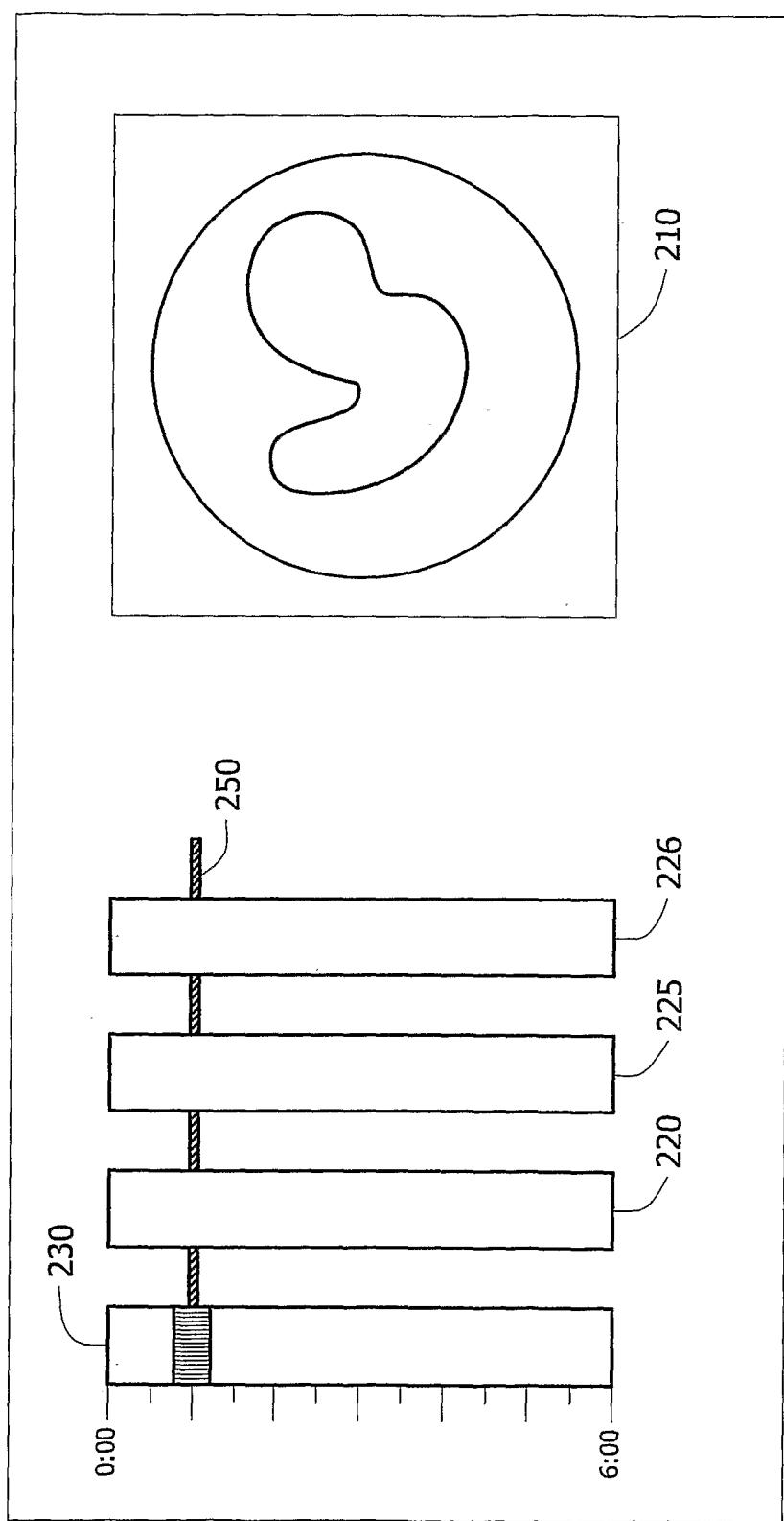


Fig. 5

5/9

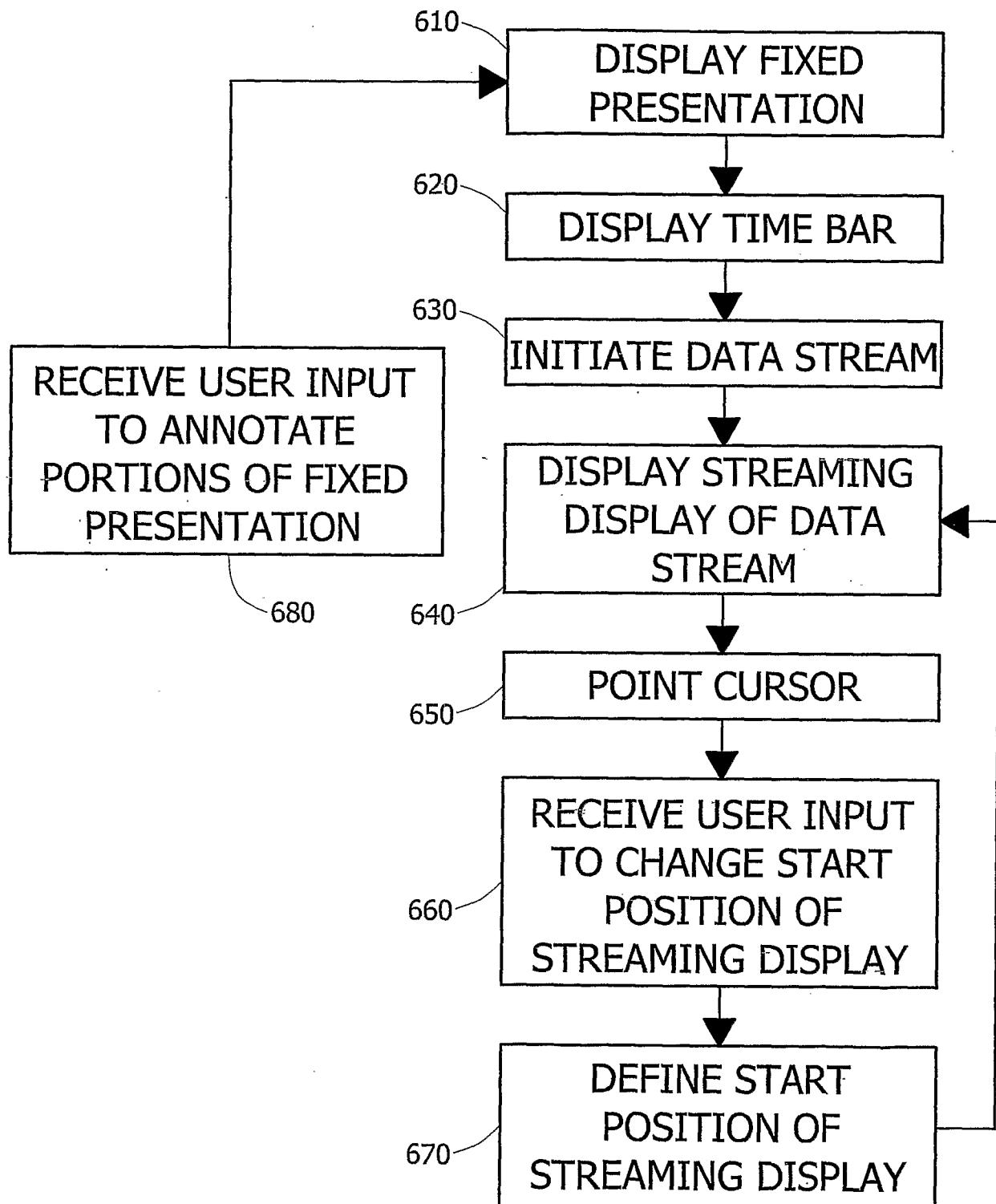


Fig. 6

6/9

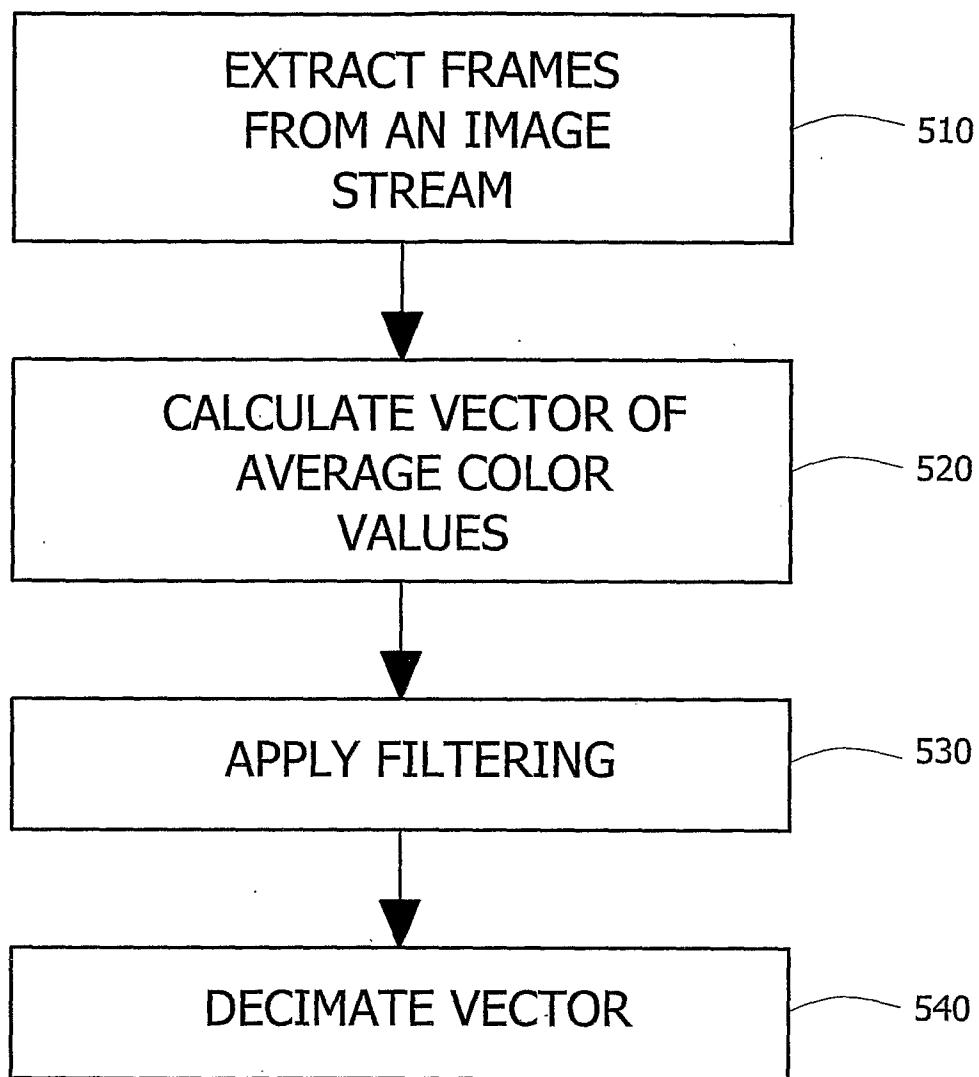


Fig. 7

7/9

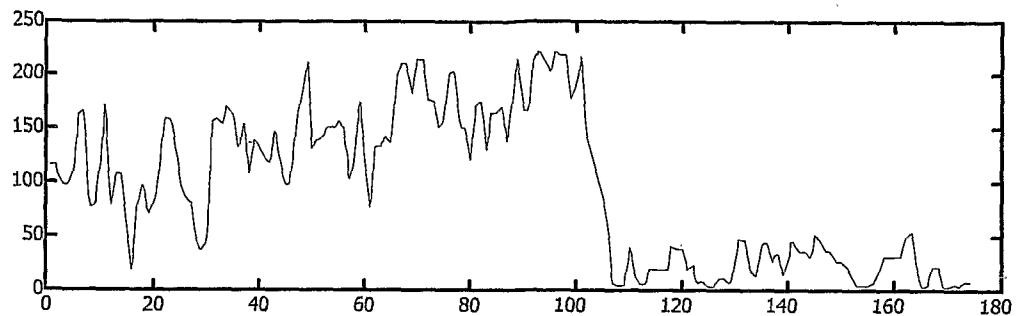


Fig. 8A

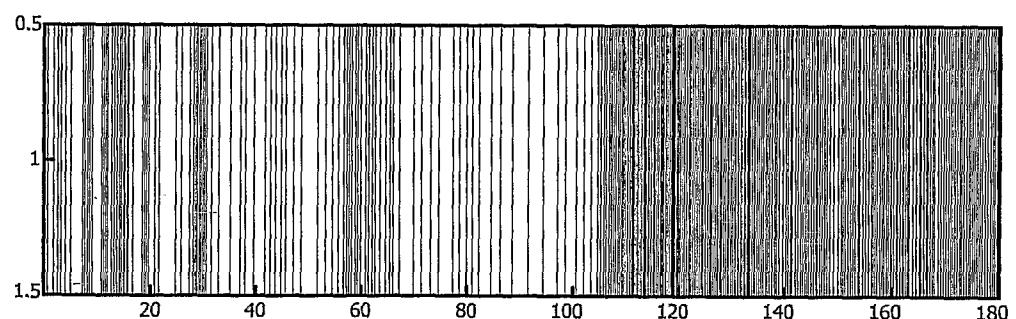


Fig. 8B

8/9

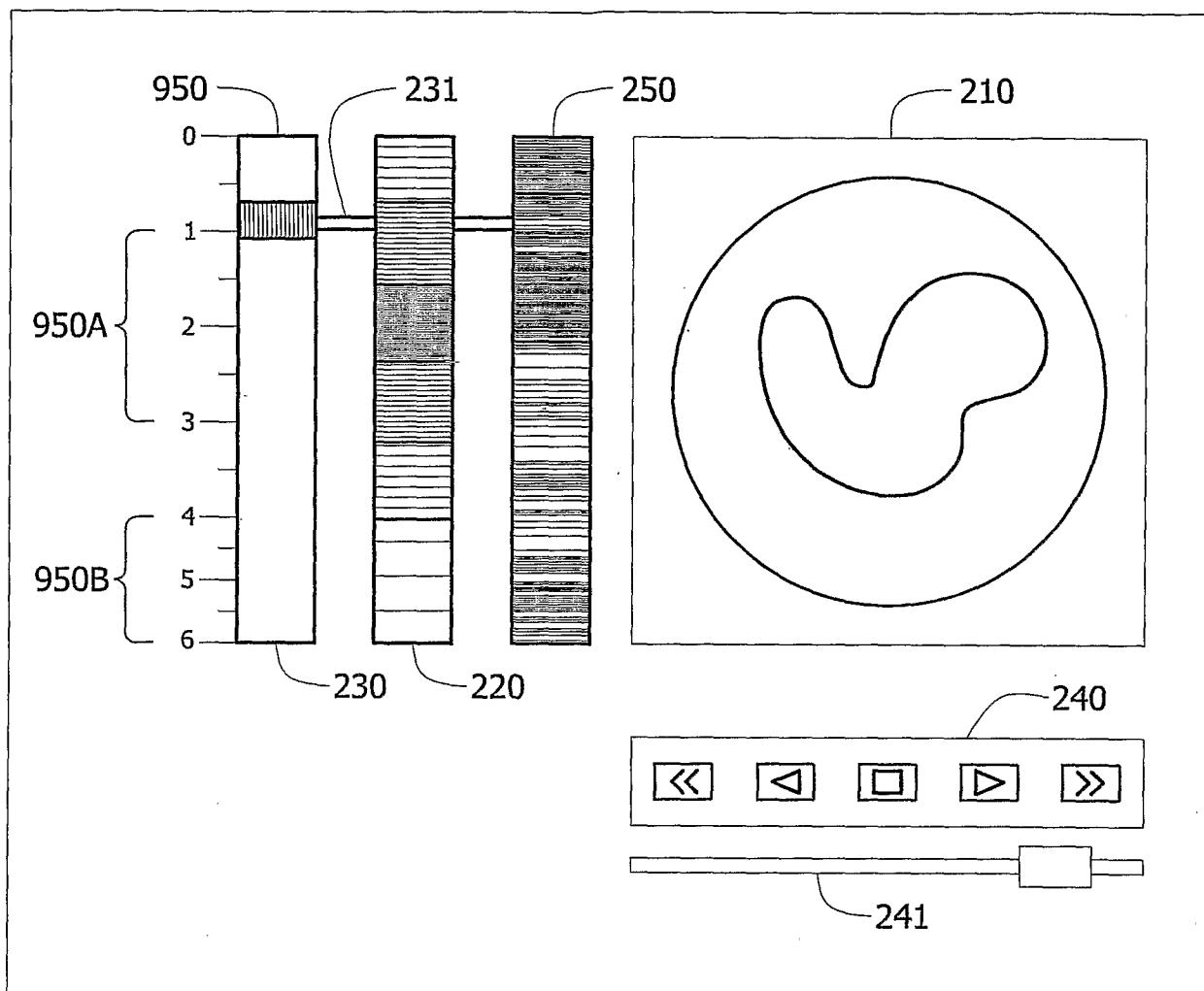


Fig. 9

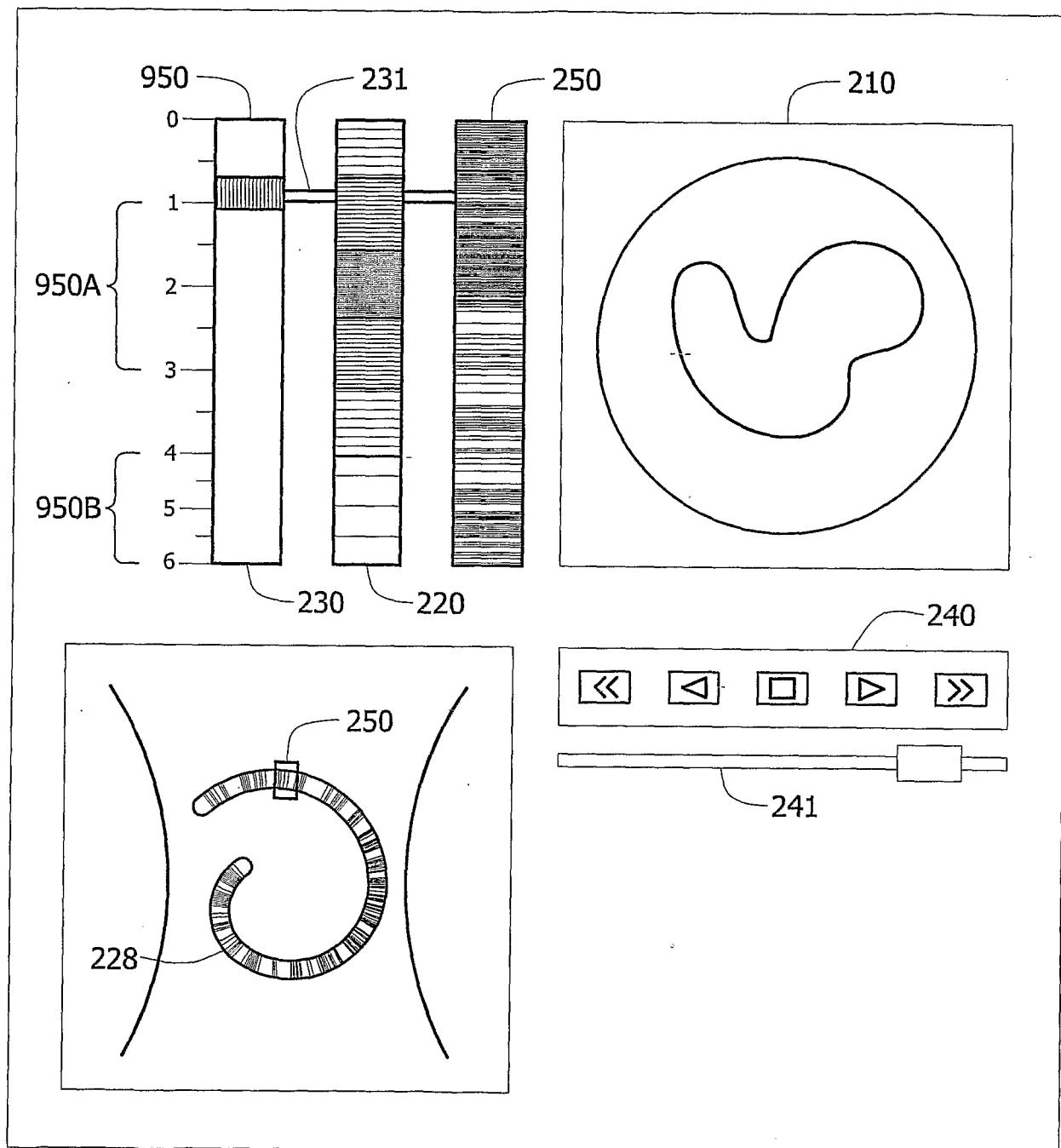


Fig. 10