

**MEDICAL DIAGNOSTIC APPARATUS AND METHOD OF MARKING
AND/OR TREATING AN AREA OF INTEREST IN THE BODY OF A HUMAN
OR AN ANIMAL**

TECHNICAL FIELD

[0001] Various embodiments relate generally to a medical diagnostic apparatus and a method of marking and/or treating an area of interest in the body of a human or an animal.

BACKGROUND

[0002] Gastroscopy and colonoscopy are commonly used for diagnosis of ailments related to gastrointestinal tract. Gastroscopy is generally used to check the first four feet of the upper digestive tract and colonoscopy is generally used to evaluate the colon and rectum. Unfortunately, gastroscopy and colonoscopy are usually unable to reach most parts of the small intestine of the gastrointestinal tract. As such, a site of hemorrhage at the small intestine may not be detected after diagnosis via gastroscopy and colonoscopy. Further, early stage cancer detection may not be achieved if cancerous cells are in the unreachable parts of the small intestine. Therefore, a flexible imaging system that can scan the whole gastrointestinal tract to get a better optical vision of an alimentary location of the gastrointestinal tract is desirable.

[0003] Wireless capsule endoscopy (WCE) may provide a flexible imaging system. Figure 1 shows a schematic diagram of a conventional endoscopic capsule 100. The endoscopic capsule 100 may include an imaging device 102, illumination modules 104,

power supply (e.g. a battery) 106 coupled to a control module 107 and a radio frequency (RF) transmitter 108 which are placed inside a biocompatible capsule casing 110. The endoscopic capsule 100 can be easily swallowed. After the endoscopic capsule 100 was swallowed, natural peristalsis moves the endoscopic capsule 100 through the gastrointestinal tract. The endoscopic capsule 100 may take images of the gastrointestinal tract as the endoscopic capsule 100 move through the gastrointestinal tract. The patient can continue with regular activities throughout the examination without feeling sensations resulting from the movement of the endoscopic capsule 100. The duration of the examination may be about 8 hours. During the examination, the images of the gastrointestinal tract may be continuously transmitted to special antenna pads placed on the body of the patient and may be stored in a recording device e.g. worn by the patient. The stored images may be transferred from the recording device to a computer via a cable connection or wirelessly. The images may be transformed into a digital movie on the computer for examination by a doctor. The endoscopic capsule 100 may be disposable and may be expelled normally and effortlessly from the body via bowel movement.

[0004] From the recorded images, one or more locations of interest (for example, pathological area(s) in the gastrointestinal tract which may need further diagnosis, examination, or treatment) may be identified. Having information on the position(s) of the one or more locations of interest may help a physician to reach the one or more locations of interest in a shorter time. As a result, the procedural time for further treatment may be reduced and the patient's discomfort may be lowered. Further diagnosis, treatment or surgeries may be more accurate. Thus, it is desirable to determine the position(s) of the one or more locations of interest via wireless capsule endoscopy.

[0005] There are various conventional mechanisms for estimating the one or more locations of interest, for example labeled anatomic landmarks such as the pylorus and ileocecal valve, a capsule time bar, typical gastric and small bowel transit times, and models. However, other test(s) may be necessary to determine the exact position(s) of the one or more locations of interest if a surgical procedure is required.

[0006] In conventional endoscopy technique, the position(s) of the one or more locations of interest can be determined through chemical dye tagging method. However, due to size limitation, it is not possible for an endoscopic capsule to carry the required amount of dye for tagging. Other conventional electronic positioning techniques like global positioning system (GPS) cannot be implemented for diagnosis of the gastrointestinal tract because there can be erroneous position information due to the natural bowel movement. Therefore, the conventional tagging mechanisms may not be applicable in capsule endoscopy.

SUMMARY

[0007] According to one embodiment of the present invention, a medical diagnostic apparatus is provided. The medical diagnostic apparatus includes a sensor configured to sense areas of interest and a tagging device configured to release a tagging element from the tagging device to mark and/or treat an area of interest upon actuation.

[0008] According to another embodiment of the present invention, a method of marking and/or treating an area of interest in the body of a human or an animal is provided. The method includes placing a medical diagnostic apparatus comprising at least one tagging device comprising a tagging element into the body of a human or an animal,

transmitting an actuation signal to the at least one tagging device, and upon reception of the actuation signal at the at least one tagging device, releasing the tagging element from the at least one tagging device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] In the drawings, like reference characters generally refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments of the invention are described with reference to the following drawings, in which:

[0010] Figure 1 shows a schematic diagram of a conventional endoscopic capsule.

[0011] Figure 2 shows a schematic diagram of a medical diagnostic apparatus according to one embodiment of the present invention.

[0012] Figure 3 shows a schematic cross-sectional view of a tagging device usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0013] Figure 4a shows a schematic cross-sectional view of a tagging element usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0014] Figure 4b shows a schematic bottom view of a tagging element usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0015] Figure 5a shows a photograph of a tagging element usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0016] Figure 5b shows a photograph of a hollow space of a body segment of a tagging element usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0017] Figure 6a shows an X-ray image of a titanium tagging element filled with barium sulphate usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0018] Figure 6b shows an X-ray image of a silicon tagging element filled with barium sulphate usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0019] Figure 7 shows a flowchart of a method of marking and/or treating an area of interest in the body of a human or an animal according to one embodiment of the present invention.

[0020] Figure 8 shows a schematic diagram of a medical diagnostic apparatus in a gastrointestinal tract according to one embodiment of the present invention.

[0021] Figure 9 shows a schematic cross-sectional view of a tagging device usable in a medical diagnostic apparatus when a resilient element is in a second position according to one embodiment of the present invention.

[0022] Figure 10 shows a schematic diagram of a tagging element usable in a medical diagnostic apparatus being attached to an area of interest in a gastrointestinal tract according to one embodiment of the present invention.

[0023] Figure 11a shows a photograph of a front view of a tagging device prototype usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0024] Figure 11b shows a photograph of a top view of a tagging device prototype usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0025] Figure 12a shows a schematic cross-sectional view of a tagging device prototype usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0026] Figure 12b shows a schematic top view of a tagging device prototype usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0027] Figure 13 shows a photograph of an arrangement of various components within a tagging device prototype usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0028] Figure 14 shows a photograph of a set up of an experiment for a tagging device prototype usable in a medical diagnostic apparatus according to one embodiment of the present invention.

[0029] Figure 15 shows photographs of a tagging element usable in a medical diagnostic apparatus being embedded in a pig intestine tissue according to one embodiment of the present invention.

[0030] Figure 16a shows a photograph of a titanium tagging element filled with barium sulphate and silicon tagging elements filled with barium sulphate usable in a medical diagnostic apparatus being embedded in a pig intestine tissue according to one embodiment of the present invention.

[0031] Figure 16b shows an X-ray image of a titanium tagging element filled with barium sulphate and silicon tagging elements filled with barium sulphate usable in a

medical diagnostic apparatus being embedded in a pig intestine tissue according to one embodiment of the present invention.

DETAILED DESCRIPTION

[0032] Embodiments of a medical diagnostic apparatus and a method of marking and/or treating an area of interest in the body of a human or an animal will be described in detail below with reference to the accompanying figures. It will be appreciated that the embodiments described below can be modified in various aspects without changing the essence of the invention.

[0033] Figure 2 shows a schematic diagram of a medical diagnostic apparatus 200 according to one embodiment of the present invention. The medical diagnostic apparatus 200 may include a sensor 202, a power supply 206, an antenna 204 and one or more tagging device 208 (details of the tagging device 208 are shown in Figure 3). For illustration purposes, only two tagging devices 208 are shown in Figure 2. In one embodiment, the tagging devices 208 may be disposed between the power supply 206 and the sensor 202. The tagging devices 208 may be received in respective housings 210 of the medical diagnostic apparatus 200. The arrangement of the tagging devices 208 in the medical diagnostic apparatus 200 may be different in other embodiments.

[0034] The medical diagnostic apparatus 200 may be implemented as an endoscopic apparatus, for example as an endoscopic capsule which may be swallowed for diagnosis of ailments related to e.g. a gastrointestinal tract. However, the present invention is not limited thereto. For example, the medical diagnostic apparatus may also be an ultrasound imager, an optical coherence tomograph, a gastroscope and a colonoscope. The

ultrasound imager, the optical coherence tomograph, the gastroscope and the colonoscope may respectively be realized as devices which can be introduced into the human body or the animal body e.g. via the mouth or the anus. In other embodiments, different types of the medical diagnostic apparatus 200 may be used for diagnosis of ailments related to different parts of a human body or an animal body.

[0035] The sensor 202 of the medical diagnostic apparatus 200 may sense the areas of interest, for example parts of or whole of a gastrointestinal tract as the medical diagnostic apparatus 200 travels through the gastrointestinal tract. The sensor 202 may be implemented as an image sensor which may record images of the areas of interest, for example a gastrointestinal tract (or parts thereof) as the medical diagnostic apparatus 200 travels through the gastrointestinal tract. The image sensor may include but is not limited to an optical imager, an ultrasound imager, a thermographer, a photo-acoustic imager and a tomograph. At the same time, the antenna 204 may transmit the recorded images (e.g. wirelessly) to an external receiver, e.g. a data processing system (not shown). The data processing system may process the recorded images and may display the images on a display screen for viewing by a doctor in real-time (i.e. as the medical diagnostic apparatus 200 travels through the gastrointestinal tract). In the event that one or more areas in the gastrointestinal tract which may need further diagnosis, examination, or treatment (e.g. lesions) are observed from the recorded images, an actuation signal for actuating the one or more tagging devices 208 may be sent (e.g. wirelessly) to the antenna 204. In one embodiment, the actuation signal may be sent from an external source (e.g. data processing system) when the doctor pushes a button of the data processing system. In another embodiment, the actuation signal may be generated within

the medical diagnostic apparatus 200 based on images of the body (e.g. a gastrointestinal tract) recorded by the sensor 202 of the medical diagnostic apparatus 200.

[0036] In one embodiment, the sensor 202 may be implemented as a biochemical sensor like a pH sensor which may sense the areas of interest based on the pH levels or like a temperature sensor which may sense the areas of interest based on the temperatures. The antenna 204 may then transmit the measured pH values or the measured temperatures (e.g. wirelessly) to the external receiver, e.g. the data processing system (not shown). The data processing system may process the measured pH values or the measured temperatures and may display the measured pH values or the measured temperatures on the display screen. The measured pH values or the measured temperatures may be displayed in a graphical form using numbers and/or colors to represent the measured pH values or the measured temperatures. In another embodiment, the sensor 202 may be implemented as a biochemical sensor like a micro fluidic sensor.

[0037] Upon receiving the actuation signal, the one or more tagging devices 208 may release a tagging element from the tagging device 208 to mark the one or more areas of interest. The tagging element may alternatively or additionally be used for treating the one or more areas of interest. For example, the tagging element may contain or consist of chemicals, and the chemicals may be released from the tagging element (or the tagging element may dissolve completely if it consists of chemicals) for treating e.g. ulcers at the one or more areas of interest. In one embodiment, the tagging element may be formed to perform mechanical treatment or any other types of treatment at the one or more areas of interest. The power supply 206 may supply power to the sensor 202 and the antenna 204 throughout the whole duration of examination of a patient.

[0038] Figure 3 shows a schematic cross-sectional view of the tagging device 208 usable in the medical diagnostic apparatus 200. The tagging device 208 may include a resilient element 302 and an actuation element 304 coupled to the resilient element 302. An actuation of the tagging device 208 may result in an actuation of the actuation element 304. Upon the actuation of the actuation element 304, the resilient element 302 may be configured to move from a first position along a movement direction as indicated by arrow 305 to a second position. In one embodiment, the resilient element 302 may be a spring. The actuation element 304 may be a heating element.

[0039] The movement of the resilient element 302 from the first position to the second position may cause a tagging element 326 to be released from the tagging device 208 and attached to the gastrointestinal tract for marking an area of interest. A force of about 0.5 N to about 2.5 N may be sufficient to cause the tagging element 326 to attach to the gastrointestinal tract after the tagging element 326 is released from the tagging device 208. Therefore, the resilient element 302 may be selected based on a release force of the resilient element 302 after compression.

[0040] In the case when a spring is used as the resilient element 302, the release force of a spring can be calculated based on the Hooke's Law:

$$F = -kx, \quad (1)$$

where k is a spring constant and x is a displacement from an equilibrium position.

Therefore, in the case when a spring is used as the resilient element 302, the resilient element 302 may be selected based on the force constant of a spring which can generate a force of about 3 N after being released from maximum compression.

[0041] The tagging device 208 may also include a latch 306 coupled to the resilient element 302. In one embodiment, one end 308 of the resilient element 302 may be secured to the latch 306 and the other end 310 of the resilient element 302 may be secured to the base 312 of the housing 210. The latch 306 may be further coupled to a first guiding structure 314. In one embodiment, the first guiding structure 314 may include two vertical structures 316 disposed at two opposite sides of the resilient element 302. The arrangement of the first guiding structure 314 may be different in other embodiments. The first guiding structure 314 may be disposed above the base 312 of the housing 210.

[0042] The tagging device 208 may further include a securing element 318. The securing element 318 may be coupled to the actuation element 304. The securing element 318 may also be coupled to the latch 306. In one embodiment, the securing element 318 may include at least one string. The at least one string may be disposed adjacent to the respective vertical structure 316 of the first guiding structure 314. The at least one string may be a monofilament thread. In another embodiment, the at least one string may be a multifilament thread. The securing element 318 may be configured to hold the resilient element 302 in the first position before actuation of the tagging device 208. Therefore, it is desirable to select the securing element 318 based on e.g. material tensile strength to withstand the force of resilient element 302 before actuation of the tagging device 208 and low power requirement to break instantly upon actuation of the tagging device 208.

[0043] The tagging device 208 may include a piston 320 coupled to the latch 306. The piston 320 may extend away from the latch 306 and away from the resilient element 302 along the movement direction 305.

[0044] The tagging device 208 may also include a second guiding structure 322. The second guiding structure 322 may have a cavity shaped form including an opening 324 extending through the housing 210. The opening 324 of the cavity 322 may be covered with a thin film 325. The thin film 325 may include but is not limited to polyurethane and poly dimethyl siloxane (silicone). The thin film 325 covering the opening 324 may help to prevent the tagging element 326 from leaving the tagging device 208 before actuation.

[0045] The tagging element 326 of the tagging device 208 may be received in the second guiding structure 322 of the housing 210. As described above, the tagging element 326 may be released from the tagging device 208 for marking one or more areas of interest. The positions of the one or more areas of interest may then be determined from the positions of the tagging elements 326. The positions of the tagging elements 326 may be determined by X-ray imaging. Therefore, it is desirable that the tagging elements 326 include materials which are bio-compatible and visible under X-ray imaging (i.e. having a high X-ray intensity absorption). The X-ray intensity transmitted through a dense material is given by:

$$I = I_0 \cdot \exp(-\mu e), \quad (2)$$

where I is the transmitted X-ray intensity, I_0 is the incident X-ray intensity, μ is the linear attenuation coefficient (in cm^{-1}) and e is the thickness of the material (in cm).

[0046] Therefore, the tagging element 326 may include bio-compatible material. In one embodiment, the tagging element 326 may be coated with bio-compatible material. The bio-compatible material may include but is not limited to titanium and silicon. In another embodiment, the tagging element 326 may include bio-resorbable material. The bio-resorbable material may include but is not limited to caprolactone, lactide and poly

glycolide polymer Theoretical calculation using the above equation (2) shows that 100 μ m thick titanium can have X-ray intensity absorption of 97%. Theoretical calculation using the above equation (2) shows that 100 μ m thick silicon can have X-ray intensity absorption of 44%. Therefore, the tagging element 326 made of titanium or silicon may provide an X-ray intensity absorption which is sufficient to produce a high contrast X-ray image for determining the locations of areas of interest. Further, titanium and silicon may be suitable for implantable medical devices. In other embodiments, the tagging element 326 may include bio-degradable materials.

[0047] Figure 4a shows a cross-sectional view of the tagging element 326. Figure 4b shows a bottom view of the tagging element 326. Figure 5a shows a photograph of the tagging element 326. The tagging element 326 may have a height h_t of about 800 μ m and a largest diameter d_t of about 700 μ m. The tagging element 326 may include a guiding segment 402 and a body segment 404. In one embodiment, the guiding segment 402 may have a conical shape. The shape of the guiding segment 402 may be different in other embodiments. The guiding segment 402 may include a tapered tip 406 for marking the area of interest. The tapered tip 406 may enhance penetration at the area of interest. The guiding segment 402 may have an angle α of about 82.37°. The tapered tip 406 of the guiding segment 402 may have a radius of about 10 μ m. The guiding segment 402 may have a height h_1 of 400 μ m and a largest diameter d_1 of about 700 μ m.

[0048] Figure 5b shows a photograph of a hollow space 408 of the body segment 404 of the tagging element 326. In one embodiment, the body segment 404 may have a cylindrical shape. The shape of the body segment 404 may be different in other embodiments. The body segment 404 may include the hollow space 408 for storing

medical imaging contrast enhancement material. In one embodiment, the body segment 404 may be a solid structure (i.e. the body segment 404 does not have a hollow space). As such, the whole tagging element 326 or the body segment 404 of the tagging element 326 may be coated with medical imaging contrast enhancement materials. Alternatively, medical imaging contrast enhancement materials may be mixed with the material used for fabricating the tagging element 326 or the body segment 404. The body segment 404 may have a height h_2 of 400 μm and a constant diameter d_2 of about 700 μm . The hollow space 408 may have a height h_3 of about 400 μm and a constant diameter d_3 of about 500 μm . The hollow space 408 may contain about 78.5nL of medical imaging contrast enhancement material. The medical imaging contrast enhancement material may be used to enhance detection of the tagging element 208 in e.g. X-ray imaging or magnetic resonance imaging. The medical imaging contrast enhancement material may include but is not limited to barium sulphate for e.g. X-ray imaging and iron oxide for e.g. magnetic resonance imaging.

[0049] Barium sulphate (BaSO_4) may be selected as the X-ray contrast enhancement material as it is radio opaque. In order to have an X-ray image of high contrast, X-ray density should be equivalent to at least 0.1g/cm² of BaSO_4 . Theoretical calculation indicates that the body segment 404 having a hollow space 408 may have a minimum thickness of about 222 μm to achieve an X-ray density equivalent to 0.1g/cm² of BaSO_4 . Thus, as shown in Figures 4a and 4b, the tagging element 326 may be designed such that the body segment 404 having a hollow space 408 may have a thickness (t) of about 200 μm .

[0050] Figure 6a shows an X-ray image of a titanium tagging element 602 filled with barium sulphate. Figure 6b shows an X-ray image of a silicon tagging element 604 filled with barium sulphate. From the X-ray images of Figures 6a and 6b, it can be observed that barium sulphate 606 may improve the X-ray intensity absorption of titanium 608 and silicon 610.

[0051] Details of the operation of the tagging device 208 upon actuation to mark an area of interest in the body of a human or an animal are described in the following.

[0052] Figure 7 shows a flowchart 700 of marking and/or treating an area of interest in the body of a human or an animal. At 702, a medical diagnostic apparatus having at least one tagging device including a tagging element may be placed into the body of a human or an animal. At 704, an actuation signal may be transmitted to the at least one tagging device. At 706, the tagging element may be released from the at least one tagging device upon reception of the actuation signal at the at least one tagging device.

[0053] Before actuation of the tagging device 208, the resilient element 302 may be secured at the first position by the securing element 318 as shown in Figure 3. The resilient element 302 may be in a compression state at the first position. The piston 320 may contact the tagging element 326 at the first position of the resilient element 302. The sensor 202 of the medical diagnostic apparatus 200 may sense the parts of or whole of a gastrointestinal tract as the medical diagnostic apparatus 200 travels through the gastrointestinal tract 802, as shown in Figure 8. If one or more areas (e.g. lesions) 804 in the gastrointestinal tract 802 which may need further diagnosis, examination, or treatment are observed from the recorded images during the medical diagnostic procedure, an actuation signal may be transmitted wirelessly to the medical diagnostic apparatus 200

from an external source by a request of a doctor or an end user. Alternatively, an actuation signal may be generated within the medical diagnostic apparatus 200 based on the recorded images. Upon actuation, the actuation element 304 may remove or destroy the securing element 318. In one embodiment, the actuation element 304 may be a heating element which may supply heat to the securing element 318 to melt the securing element 318 upon actuation. After the securing element 318 is removed or destroyed by the actuation element 304, the release force of the resilient element 302 at the first position (i.e. compression state) may cause the resilient element 302 to move from the first position to the second position along the movement direction 305.

[0054] Figure 9 shows a schematic cross-sectional view of the tagging device 208 when the resilient element 302 is in the second position. The movement of the resilient element 302 from the first position to the second position may cause the latch 306 to move along the movement direction 305. The movement of the latch 306 along the movement direction 305 may be guided by the first guiding structure 314. That is, the latch 306 may move along the first guiding structure 314 as the latch 306 moves along the movement direction 305. The piston 320 may then move into the second guiding structure (cavity) 322. As a result, the tagging element 326 may be pushed out of the opening 324 of the second guiding structure 322. The thin film 325 may be torn by the release of the tagging element 326 from the tagging device 208. The tagging element 326 may be attached to the gastrointestinal tract 802 (e.g. the mucosa layer of the gastrointestinal tract) at the area of interest 804 as shown in Figure 10. The tagging element 326 may remain in the gastrointestinal tract to act as a marker for identification of the area of interest 804 for further treatment, diagnosis and/or surgical procedure. The

position of the tagging element 326 (i.e. the position of the area of interest) can be determined by X-ray imaging of the gastrointestinal tract 802.

[0055] Prototypes of the tagging device 208 may be fabricated for experimental purposes. Figure 11a shows a photograph of a front view of a tagging device prototype 1100. Figure 11b shows a photograph of a top view of the tagging device prototype 1100. Figure 12a shows a schematic diagram of a cross sectional view of the tagging device prototype 1100. Figure 12b shows a schematic diagram of a top view of the tagging device prototype 1100. The tagging device prototype 1100 may be made of aluminium. The tagging device prototype 1100 may have dimensions of about 16.3 mm x 10.0 mm x 5.5 mm. In one embodiment, the tagging device 208 for the medical diagnostic apparatus 200 may have a diameter of about 5 mm and a height of about 5 mm.

[0056] Figure 13 shows a photograph of an arrangement 1300 of various components (e.g. the resilient element 302, the actuation element 304, the latch 306, the securing element 312 and the piston 320) usable within the tagging device prototype 1100. The tagging device prototype 1100 may include a resilient element 302 in the form of a spring. The spring 302 may have a height of about 2 mm and a diameter of about 1.2 mm. The tagging device prototype 1100 may include a securing element 318 in the form of a nylon thread having a diameter of about 0.2 mm. The tagging device prototype 1100 may include an actuation element 304 in the form of a heater coil.

[0057] Ex-vivo experiments may be carried out on pig small intestine using the tagging device prototype 1100. The experiments may be carried to evaluate the ejection mechanism of the tagging device 208 used for releasing the tagging element 326 and the penetration depth of the tagging element 326 into a body tissue. Parameters such as the

distance between the pig intestine tissue and the tagging element 326 and the angle of penetration of the tagging element 326 may be evaluated. The fixed parameters of the experiments may be an overall height of the tagging element 326 of about 800 μ m and a spring release force of about 3N force.

[0058] Figure 14 shows a photograph of a set up 1400 of the experiment for the tagging device prototype 1100. A pig intestine tissue 1402 may be fixed on a Styrofoam block 1404 using pins 1406. The tagging device prototype 1100 having with tagging elements 326 (not shown) may be positioned in front of the pig intestine tissue 1402. During the experiment, the heater coil 304 of the tagging device prototype 1100 may melt the nylon thread 318 upon actuation. The spring 302 may then move from the first position to the second position. The tagging element 326 may be released from the tagging device prototype 1100 and may be attached to the pig intestine tissue 1402.

[0059] Figure 15 shows photographs of a tagging element 326 embedded in the pig intestine tissue 1402. Figure 16a shows a photograph of a titanium tagging element 1602 filled with barium sulphate and silicon tagging elements 1604 filled with barium sulphate embedded in the pig intestine tissue 1402. Figure 16b shows an X-ray image 1606 of the titanium tagging element 1602 filled with barium sulphate and the silicon tagging elements 1604 filled with barium sulphate embedded in the pig intestine tissue 1402. The positions of the titanium tagging element 1602 and the silicon tagging elements 1604 on the pig intestine tissue 1402 can be clearly seen from the X-ray image 1606.

[0060] Therefore, the medical diagnostic apparatus 200 having the tagging device 208 may provide a simple and effective way for locating an area of interest, e.g. a diseased region. As the location of the diseased region is marked by the tagging element

326, the location of the diseased region may be determined by the location of the tagging element 326 shown on an X-ray image. Thus, it may not be necessary to carry out further tests to determine an exact position of the diseased region. In addition, the procedure time for further treatment may be reduced and the patient's discomfort may be lowered. Further diagnosis, treatment or surgeries may be more accurate.

[0061] The medical diagnostic apparatus 200 having the tagging device 208 may also provide a faster way for locating the diseased region as the position of the diseased region may be marked at real time, i.e. during the duration of examination of e.g. a gastrointestinal tract. In addition, the medical diagnostic apparatus 200 having the tagging device 208 may provide a wireless diagnosis of the gastrointestinal tract. The medical diagnostic apparatus 200 having the tagging device 208 may be miniaturized and may require low power.

[0062] Further, the medical diagnostic apparatus 200 may be designed such that only the tagging elements 326 are released from the respective tagging devices 208 upon actuation. Other components of the medical diagnostic apparatus 200 remain inside the medical diagnostic apparatus 200. This can ensure that there is no component protruding out of the surface of the medical diagnostic apparatus 200. Thus, the situation of having the whole medical diagnostic apparatus 200 being attached to the gastrointestinal tract can be avoided.

[0063] In other embodiments, the medical diagnostic apparatus 200 having the tagging device 208 may be used for multiple purposes such as drug delivery, fluid sampling, and endoscopic imaging. In one embodiment, when the medical diagnostic apparatus 200 having the tagging device 208 may be used for localized therapeutics (e.g.

drug delivery), the hollow space 408 of the tagging element 326 may be configured to contain drugs. The tagging element 326 may be replaced with drugs in other embodiments. The tagging element 326 may contain drugs in other embodiments. In another embodiment, when the medical diagnostic apparatus 200 having the tagging device 208 may be used for biopsy collection (e.g. fluid sampling), the hollow space 408 of the tagging element 326 may be configured to be used for biopsy collection. In yet another embodiment, when the medical diagnostic apparatus 200 having the tagging device 208 may be used for localized ablation/removal of cancer cells, the hollow space 408 of the tagging element 326 may be configured to contain nano particles. The nano particles may include but are not limited to gold nano particles. A radio frequency (RF)/ultrasonic/light beam may be used to rupture the tagging element 326 and to heat up the nano particles for the localized ablation/removal of cancer cells/tissues at areas of interests (e.g. diseased regions in a gastrointestinal tract). In another embodiment, the hollow space 408 may be configured to contain materials that can enhance visibility of areas of interest via methods such as fluorescence or phosphorescence.

[0064] While embodiments of the invention have been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

CLAIMS

What is claimed is:

- 5 1. A medical diagnostic apparatus, comprising:
a sensor configured to sense the areas of interest; and
a tagging device configured to release a tagging element from the tagging device
to mark and/or treat an area of interest upon actuation;
wherein the tagging element comprises a body segment and a guiding segment,
10 and wherein the guiding segment comprises a tapered tip.
2. The medical diagnostic apparatus of claim 1,
wherein the sensor comprises an image sensor or a biochemical sensor.
- 15 3. The medical diagnostic apparatus of claim 2,
wherein the image sensor comprises any one of a group consisting of an optical
imager, an ultrasound imager, a thermographer, a photo-acoustic imager and a
tomograph.
- 20 4. The medical diagnostic apparatus of claim 2,
wherein the biochemical sensor comprises any one of a group consisting of a pH
sensor, a micro fluidic sensor and a temperature sensor.

5. The medical diagnostic apparatus of any one of claims 1 to 4,
wherein the tagging device comprises a resilient element and an actuation element
coupled to the resilient element, the resilient element being configured to move, upon
actuation of the actuation element, from a first position along a movement direction to a
5 second position to release the tagging element from the tagging device.
6. The medical diagnostic apparatus of claim 5,
wherein the tagging device further comprises a securing element coupled to the
actuation element, the securing means being configured to hold the resilient element at
10 the first position.
7. The medical diagnostic apparatus of claim 6,
wherein the actuation element is configured to remove or destroy the securing
element upon actuation to enable a movement of the resilient element from the first
15 position to the second position.
8. The medical diagnostic apparatus of claims 6 or 7,
wherein the actuation element configured to remove or destroy the securing
element comprises a heating element configured to supply heat to the securing element
20 when actuated to break the securing element.
9. The medical diagnostic apparatus of any one of claims 5 to 8,

wherein the tagging device further comprises a latch and a first guiding structure,
wherein the latch is coupled to the resilient element such that, if the resilient element is
moved from the first position to the second position, the latch is moved along the
movement direction, wherein the latch is coupled to the first guiding structure such that
5 its movement along the movement direction is guided by the first guiding structure.

10. The medical diagnostic apparatus of claim 9,
wherein the tagging device further comprises a piston which is coupled to the
latch and which extends away from the latch and away from the resilient element along
10 the movement direction.

11. The medical diagnostic apparatus of claim 10,
wherein the tagging device further comprises a second guiding structure adapted
to guide a movement of the tagging element along the movement direction, wherein the
15 piston and the tagging element are coupled such that a movement of the piston causes a
movement of the tagging element.

12. The medical diagnostic apparatus of claim 11,
wherein the second guiding structure has a cavity shaped form which comprises
20 an opening extending through a housing of the medical diagnostic apparatus.

13. The medical diagnostic apparatus of claim 12,

wherein the movement of the resilient element from the first position to the second position causes the piston to move into the cavity, thereby pushing the tagging element out of the tagging device.

- 5 14. The medical diagnostic apparatus of claim 13,
wherein the opening of the cavity is covered with a thin film.
15. The medical diagnostic apparatus of any one of claims 5 to 14,
wherein the resilient element is in a compression state at the first position.
- 10 16. The medical diagnostic apparatus of any one of claims 5 to 15,
wherein the resilient element comprises a spring.
- 15 17. The medical diagnostic apparatus of any one of claims 6 to 16,
wherein the securing element comprises at least one string
18. The medical diagnostic apparatus of claim 17,
wherein each string is a monofilament thread or a multifilament thread.
- 20 19. The medical diagnostic apparatus of any one of claims 5 to 18,
wherein the actuation element is activated by an actuation signal from an external
source,

20. The medical diagnostic apparatus of claim 1,
wherein the tapered tip is configured to enhance penetration at an area of interest.
21. The medical diagnostic apparatus of any one of claims 1 to 20,
5 wherein the body segment is a solid structure.
22. The medical diagnostic apparatus of any one of claims 1 to 21,
wherein the body segment comprises a hollow space.
- 10 23. The medical diagnostic apparatus of claim 22,
wherein the hollow space is configured to store medical imaging contrast
enhancement material.
24. The medical diagnostic apparatus of claim 23,
15 wherein the medical imaging contrast enhancement material are used to enhance
detection of the tagging element in X-ray imaging or magnetic resonance imaging.
25. The medical diagnostic apparatus of claims 23 or 24,
wherein the medical imaging contrast enhancement material comprises barium
20 sulphate for X-ray imaging or iron oxide for magnetic resonance imaging.
26. The medical diagnostic apparatus of claim 22,
wherein the hollow space is configured to contain drugs.

27. The medical diagnostic apparatus of claim 22,
wherein the hollow space is configured to be used for biopsy collection.
- 5 28. The medical diagnostic apparatus of claim 22,
wherein the hollow space is configured to contain nano particles that can be used
for localized removal of cancer cells at areas of interest.
- 10 29. The medical diagnostic apparatus of claim 22,
wherein the hollow space is configured to contain materials that can enhance
visibility of areas of interest via fluorescence or phosphorescence.
30. The medical diagnostic apparatus of any one of claims 1 to 29,
wherein the tagging element comprises bio-compatible material.
- 15 31. The medical diagnostic apparatus of any one of claims 1 to 30,
wherein the tagging element is coated with bio-compatible material.
32. The medical diagnostic apparatus of claims 30 or 31,
20 wherein the bio-compatible material comprises titanium or silicon.
33. The medical diagnostic apparatus of any one of claims 1 to 29,
wherein the tagging element comprises bio-resorbable material.

34. The medical diagnostic apparatus of any one of claims 5 to 33,
further comprising:

an antenna configured to receive the actuation signal from an external source for
5 actuating the actuation element, and to transmit data representing the recorded images of
areas of interest to an external receiver; and

a power supply configured to supply power to the sensor and the antenna.

35. The medical diagnostic apparatus of any one of claims 1 to 34,

10 wherein the medical diagnostic apparatus comprises any one of a group consisting
of an endoscopic apparatus, an endoscopic capsule, an ultrasound imager, an optical
coherence tomograph, a gastrocope and a colonoscope.