ELECTROMECHANICAL PILL DEVICE WITH LOCALIZATION CAPABILITIES

Background

[0001] The gastrointestinal (GI) tract generally contains a wealth of information regarding an individual's body. For example, contents in the GI tract may provide information regarding the individual's metabolism. An analysis of the contents of the GI tract may also provide information for identifying relationships between the GI content composition (e.g., relationship between bacterial and biochemical contents) and certain diseases or disorders.

[0002] Present methods and devices for analyzing the GI tract are limited in certain aspects, such as the accuracy of the data retrieved from the GI tract. Data retrieved from the GI tract can include physical samples and/or measurements. The value of the retrieved data can depend, to an extent, on how accurately the location from which the data is retrieved can be identified. However, in vivo location detection within the GI tract can be difficult. The different segments within the GI tract may, at times, include certain substances (e.g., blood) that can impact in vivo location detection and there may also be differences in the GI tract amongst different individuals.

Summary

[0002A] In an example, there is provided a method for identifying a location within a gastrointestinal (GI) tract of a body, the method comprising: using an ingestible device comprising: a housing having a first end, a second end substantially opposite from the first end, and a radial wall extending longitudinally from the first end to the second end; and a sensing unit inside the housing, the sensing unit comprising: an axial optical sensing sub-unit located proximal to at least one of the first end and the second end, the axial optical sensing sub-unit being configured to transmit an axial illumination towards an environment external to the housing and to detect an axial reflectance from the environment resulting from the axial illumination; and a radial optical sensing sub-unit located proximal to the radial wall, the radial optical sensing sub-unit being configured to transmit a radial illumination towards the environment external to the housing and to detect a radial reflectance from the environment resulting from the radial illumination, the radial illumination being substantially perpendicular to the axial illumination; and operating a processing module to identify the location based on at least the detected radial and axial

reflectance; wherein the ingestible device is for identifying a location within a gastrointestinal (GI) tract of a body, the ingestible device comprising: a housing defined by a first end, a second end substantially opposite from the first end, and a radial wall extending longitudinally from the first end to the second end; a sensing unit inside the housing, the sensing unit comprising: an axial optical sensing sub-unit located proximal to at least one of the first end and the second end, the axial optical sensing sub-unit being configured to transmit an axial illumination towards an environment external to the housing and to detect an axial reflectance from the environment resulting from the axial illumination; and a radial optical sensing sub-unit located proximal to the radial wall, the radial optical sensing sub-unit being configured to transmit a radial illumination towards the environment external to the housing and to detect a radial reflectance from the environment resulting from the radial illumination, the radial illumination being substantially perpendicular to the axial illumination; wherein a processing module is configured to identify the location of the ingestible device based on at least the detected radial and axial reflectance; and wherein: the processing module is an external processing module and the device further comprises a communication module configured to transmit one or more radial reflectance values corresponding to the detected radial reflectance and one or more axial reflectance values corresponding to the detected axial reflectance to the external processing module; or the device comprises the processing module; or the axial optical sensing sub-unit comprises at least one axial sensor having an axial illuminator configured to transmit the axial illumination and an axial detector configured to detect the axial reflectance; or the radial optical sensing sub-unit comprises at least one radial sensor having a radial illuminator configured to transmit the radial illumination and a radial detector configured to detect the radial reflectance; or the axial optical sensing sub-unit comprises: a first axial sensor located proximal to the first end of the ingestible device, the first axial sensor configured to transmit a first axial illumination towards the environment and to detect a first axial reflectance from the environment resulting from the first axial illumination; and a second axial sensor located proximal to the second end of the ingestible device, the second axial sensor configured to transmit a second axial illumination towards the environment and to detect a second axial reflectance from the environment resulting from the second axial illumination, the second axial illumination being in a substantially opposite direction from the first axial illumination; or the radial optical sensing sub-unit comprises: a first radial sensor located proximal to a first wall portion of the radial wall, the first radial sensor configured to transmit a first radial illumination towards the environment and to detect a first radial reflectance from the

environment resulting from the first radial illumination; and a second radial sensor located proximal to a second wall portion of the radial wall, the second radial sensor configured to transmit a second radial illumination towards the environment and to detect a second radial reflectance from the environment resulting from the second radial illumination, the second wall portion being spaced from the first wall portion by at least 60 degrees along a circumference of the radial wall, and the second radial illumination being in a different radial direction from the first radial illumination; or the axial optical sensing sub-unit comprises an infrared Light-Emitting Diode (LED); or the radial optical sensing sub-unit comprises a LED emitting light having a wavelength of approximately 571nm; or the radial optical sensing sub-unit comprises a RGB LED package; or the housing is capsule-shaped.

[0002B] In a first aspect of the invention, there is provided a method for identifying a location within a gastrointestinal (GI) tract of a body, the method comprising: providing an ingestible device having a sensing unit to collect reflectance data, the sensing unit comprising: an axial optical sensing sub-unit operable to transmit an axial illumination towards an environment external to the ingestible device and to detect an axial reflectance from the environment resulting from the axial illumination; and a radial optical sensing sub-unit operable to transmit a radial illumination towards the environment external to the ingestible device and to detect a radial reflectance from the environment resulting from the radial illumination, the radial illumination being substantially perpendicular to the axial illumination; operating the sensing unit to collect, at least, a reflectance data series as the ingestible device transits through the body, the reflectance data series comprising an axial reflectance data series and a radial reflectance data series, each of the axial reflectance data series and the radial reflectance data series including one or more reflectance values corresponding to the respective axial reflectance and radial reflectance detected by the sensing unit during at least a portion of the transit; and operating a processing module to identify the location using the reflectance data series, the processing module being in electronic communication with the sensing unit, the processing module being configured to: determine a quality of the environment external to the ingestible device based on the axial reflectance data series and the radial reflectance data series; and indicate the location based on the determined quality of the environment external to the ingestible device; wherein: the sensing unit further comprises a temperature sensor for collecting a temperature data series as the ingestible device transits through the body; and prior to associating the quality of the environment as homogenous, the method further comprises: determining whether a portion of the temperature data series includes a temperature change exceeding a temperature threshold;

and in response to determining the portion of the temperature data series does not include the temperature change exceeding the temperature threshold, associating the quality of the environment as homogenous.

[0002C] In an example, there is provided a computer readable medium comprising a plurality of instructions executable on a processing module of a device for adapting the device to implement a method of identifying a location within a gastrointestinal (GI) tract of a body, the method being for identifying a location within a gastrointestinal (GI) tract of a body, the method comprising: operating an axial optical sensing sub-unit to transmit an axial illumination towards an environment within the GI tract and to detect an axial reflectance from the environment resulting from the axial illumination; operating a radial optical sensing sub-unit to transmit a radial illumination towards the environment within the GI tract and to detect a radial reflectance from the environment resulting from the radial illumination, the radial illumination being substantially perpendicular to the axial illumination; and operating a processing module to identify the location using the detected axial reflectance and the detected radial reflectance, the processing module being configured to: determine a quality of the environment within the GI tract based on the detected axial reflectance and the detected radial reflectance; and indicate the location based on the determined quality of the environment within the GI tract.

[0003] In further examples, an ingestible device for identifying a location within a gastrointestinal (GI) tract of a body is provided herein. The ingestible device includes a housing defined by a first end, a second end substantially opposite from the first end, and a radial wall extending longitudinally from the first end to the second end; a sensing unit inside the housing, the sensing unit including: an axial optical sensing sub-unit located proximal to

What is claimed is:

1. A method for identifying a location within a gastrointestinal (GI) tract of a body, the method comprising:

providing an ingestible device having a sensing unit to collect reflectance data, the sensing unit comprising:

an axial optical sensing sub-unit operable to transmit an axial illumination towards an environment external to the ingestible device and to detect an axial reflectance from the environment resulting from the axial illumination; and

a radial optical sensing sub-unit operable to transmit a radial illumination towards the environment external to the ingestible device and to detect a radial reflectance from the environment resulting from the radial illumination, the radial illumination being substantially perpendicular to the axial illumination;

operating the sensing unit to collect, at least, a reflectance data series as the ingestible device transits through the body, the reflectance data series comprising an axial reflectance data series and a radial reflectance data series, each of the axial reflectance data series and the radial reflectance data series including one or more reflectance values corresponding to the respective axial reflectance and radial reflectance detected by the sensing unit during at least a portion of the transit; and

operating a processing module to identify the location using the reflectance data series, the processing module being in electronic communication with the sensing unit, the processing module being configured to:

determine a quality of the environment external to the ingestible device based on the axial reflectance data series and the radial reflectance data series; and

indicate the location based on the determined quality of the environment external to the ingestible device;

wherein:

the sensing unit further comprises a temperature sensor for collecting a temperature data series as the ingestible device transits through the body; and

prior to associating the quality of the environment as homogenous, the method further comprises:

determining whether a portion of the temperature data series includes a temperature change exceeding a temperature threshold; and

in response to determining the portion of the temperature data series does not include the temperature change exceeding the temperature threshold, associating the quality of the environment as homogenous.

2. The method of claim 1, wherein determining the quality of the environment external to the ingestible device based on each of the axial reflectance data series and the radial reflectance data series comprises:

generating an axial standard deviation for the axial reflectance data series and a radial standard deviation for the radial reflectance data series;

determining whether each of the axial standard deviation and the radial standard deviation satisfies a corresponding deviation threshold; and

in response to determining the axial standard deviation and the radial standard deviation satisfy the deviation threshold, defining the quality of the environment as homogenous.

3. The method of claim 2, wherein the deviation threshold comprises an axial deviation threshold for the axial reflectance data series and a radial deviation threshold for the radial reflectance data series, the radial deviation threshold having a different value from the axial deviation threshold.

4. The method of any one of claims 2 and 3, further comprising, in response to determining that the axial standard deviation and the radial standard deviation satisfy the deviation threshold and prior to defining the quality of the environment as homogenous:

generating an axial average from a portion of the axial reflectance data series and a radial average from a portion of the radial reflectance data series;

determining whether the radial average is less than the axial average; and

in response to determining the radial average is less than the axial average, defining the quality of the environment as homogenous.

5. The method of claim 4, wherein determining whether the radial average is less than the axial average comprises determining whether the radial average is less than the axial average by a minimum difference value.

6. The method of any one of claims 4 and 5, wherein generating the axial average from the portion of the axial reflectance data series and the radial average from the portion of the radial reflectance data series comprises:

selecting a number of reflectance values from each of the axial reflectance data series and the radial reflectance data series, the number of reflectance values being selected from a most recent portion of the respective axial reflectance data series and the radial reflectance data series.

7. The method of any one of claims 1 to 6, wherein the processing module is operated to indicate the location is the small intestine in response to determining the quality of the environment external to the ingestible device is homogenous.