

cence image of the same ROI, a medical practitioner can find and positively identify small or pre-cancerous lesions that may or may not be visible on a standard white-light image.

[0149] It is contemplated that one of the two displays might be a touch screen monitor that enables the medical practitioner to select (draw the outline) of an ROI for laser surgery. Since the image may be moving, the touch screen monitor will require the image to be captured and frozen in time. However, once this ROI is outlined, image segmentation and object recognition algorithms may be implemented to keep the ROI highlighted during real-time image acquisition and display. The touch screen monitor can provide sidebar menus for the practitioner to set parameters for the laser therapies, such as power level and duration of laser radiation exposure. The second display would not provide interactivity, but is preferably a high resolution monitor displaying the real-time optical image in full-color or grayscale. If IR photon detectors are integrated into the endoscope, the high resolution display with pseudo-color will allow the practitioner to monitor the progress of laser therapies, such as tissue heating and/or tissue irradiation in laser surgery.

[0150] The scanning optical fiber is positioned at a desired location within the patient's body, opposite ROI 486, using guide wires or a cannula (not shown) and a manual controller that facilitates tip navigation and stabilization, as indicated in a block 466. Within ROI 486, optical biopsy "spots" 485 illustrate the spatial and temporal distribution of single-point spectral measurements to diagnose for disease. These spots are distributed much like the current practice of invasively taking tissue samples for in vitro biopsy analysis. Each spot may be analyzed spectroscopically during a frame cycle of the optical scanner, separating t_1 and t_2 by, for example, about $\frac{1}{30}$ second. In addition to the image provided by the scanning optical fiber, IR thermal photodetectors (and an optional temperature monitor) as indicated in a block 468 could be included for receiving IR signals from the ROI.

[0151] To facilitate control of the motion of the scanning optical fiber or light waveguide, electrical power for microsensors and control electronics are provided, as indicated in a block 470. The signals provided by the control electronics enable amplitude and displacement control of the optical fiber when the actuator that causes it to scan is controlled by both electrical hardware and software within block 470. A spectrophotometer and/or spectrum analyzer 474 is included for diagnostic purposes, since the spectral composition of light received from ROI 486 and distribution of optical biopsy locations 485 can be used for screening and diagnosis for such diseases as cancer to a medical practitioner in evaluation of the condition of the ROI, based upon spectral photometric analysis. To illuminate the ROI so that it can be imaged, red, green, and blue light sources 476, 478, and 480 are combined and the light that they produce is conveyed through the optical fiber system to scanning optical fiber 484. The light source used for spectral analysis may be a high power pulse from one of the RGB light sources (e.g., lasers), or a secondary laser or white light source. Since signal strength, time, and illumination intensity are limiting, a repeated single-point spectroscopic method will be initially employed, using flash illumination. In addition, the same or a different high power laser source

482 can be employed to administer therapy, such as PDT, the laser ablation of tumors, and other types of therapy rendered with a high intensity source.

[0152] In using system 460, a medical practitioner navigates and maneuvers the flexible single scanning optical fiber component to an appropriate region of a patient's body while watching the high resolution color monitor displaying the standard, full-color endoscopic image. The search for tumors and/or pre-cancerous lesions begins by watching the monitor. A second monitor (not separately shown) included with spectrophotometer and spectrum analyzer 474 displays a fluorescence mapping in pseudo-color over a grayscale version of the endoscopic image. When an ROI is found, such as abnormal appearing tissue, the flexible endoscope is mechanically stabilized (as explained below). The ROI is centered within the FOV, then magnified using the multi-resolution capability provided by the present invention. The size of the ROI or tumor is estimated and a pixel boundary is determined by image processing either the visible image or the fluorescence image. If spectroscopic diagnosis is required, such as LIFS, the distribution of optical biopsy points is estimated along with illumination levels. The diagnostic measurements are performed by delivering the illumination repeatedly over many imaging frames automatically. The user can cease the diagnosis or have the workstation continue to improve signal-to-noise ratio and/or density of sampling until a clear diagnosis can be made. The results of diagnosis is expected to be in real-time and overlaid on top of the standard image.

[0153] If optical therapy is warranted, such as PDT, then an optical radiation exposure is determined and programmed into the interactive computer workstation controlling the scanning optical fiber system. The PDT treatment is an optical scan of high intensity laser illumination typically by high power laser source 482, pre-selected for the PDT fluorescent dye, and is controlled using dichroic filters, attenuators, and electromechanical shutters, as explained above. In a frame-sequential manner, both fluorescence images and visible images are acquired during PDT treatment. The medical practitioner monitors the progress of the PDT treatment by observing these acquired images on both displays.

[0154] With reference to FIG. 9B, an optical fiber system 460' is used for 3D imaging, biopsy, and monitoring endoscopic surgery. To enable 3D imaging in a pseudo-stereo view of the ROI, an HMD 490 is included. In addition, the system includes high resolution color monitor 464, which was described above in connection with FIG. 9A. Also, an IR optical phase detector 492 is included for range finding. High frequency modulation of IR illumination can be measured to determine phase shifts due to optical propagation distances on the order of a few millimeters. The distance between the distal end of the scanning optical fiber or light waveguide and ROI 486 can be important in evaluating the intensity of light that should be applied during endoscopic surgery, for mapping a specific ROI 487 to determine its boundary or size, and for determining the size and shape of features such as a volume of a tumor comprising the ROI. An UV-visible biopsy light source 494 enables an optical biopsy to be carried out at specific ROI 487. The spectrophotometer and spectrum analyzer in block 474 are useful in monitoring the status of the ROI during endoscopic surgery being carried out, since the condition of the ROI during the