Claims

WE CLAIM:

1. A portable, handheld imaging system, comprising:

at least one excitation light source configured to emit excitation light during fluorescent imaging;

a fluorescent image sensor;

a first filter configured to permit passage of optical signals, responsive to illumination of a target surface with the excitation light and having a wavelength corresponding to one or more of bacterial fluorescence, bacterial autofluorescence, tissue fluorescence, and tissue autofluorescence, to be detected by the fluorescent image sensor;

a white light source configured to emit white light during white light imaging;

a first white light image sensor and a second white light image sensor;

a second filter and a third filter, each of the second and third filters being configured to permit passage of optical signals, responsive to illumination of the target surface with the white light and having a wavelength in the visible light range, to be detected by a respective one of the first and the second white light image sensors;

a thermal sensor configured to detect thermal information regarding the target surface; and

a processor configured to receive the detected fluorescent and white light optical signals and the thermal information detected by the thermal sensor and to output a representation of the target surface to a display based at least in part on the detected optical signals and detected thermal information, wherein the representation, based in part on the optical signals detected by the first and second white light image sensors, is a stereoscopic or three-dimensional image of the target surface and, wherein the representation, based in part on the optical signals detected by the fluorescent image sensor, provides an indication of a bacterial load of the target surface.

2. The system of claim 1, wherein the at least one excitation light source is configured to emit excitation light having a wavelength of 350 nm – 400 nm, 400 nm – 450 nm, 450 nm – 500 nm, 500 nm – 550 nm, 550 nm – 600 nm, 600 nm – 650 nm, 650 nm – 700 nm, 700 nm – 750 nm, 750 nm – 800 nm, 800 nm – 850 nm, 850 nm – 900 nm, and/or combinations thereof.

3. The system of claim 1 or claim 2, wherein the at least one excitation light source is configured to emit excitation light having a wavelength of 400 nm to 450 nm.

4. The system of any one of claims 1-3, wherein the at least one excitation light source is configured to emit excitation light having a wavelength of 405 nm ± 10 nm.

5. The system of any one of claims 1-4, wherein the at least one excitation light source is coupled to a housing of the portable, handheld imaging system.

6. The system of any one of claims 1-5, wherein the first filter is further configured to block the passage of optical signals having a wavelength of 405 nm ± 10 nm.

7. The system of any one of claims 1-6, wherein the first filter is configured to permit optical signals having a wavelength between 500 nm and 550 nm and/or optical signals having a wavelength between 600 nm and 660 nm to pass through the first filter to the first image sensor.

8. The system of any one of claims 1-7, wherein the at least one excitation light source includes first and second violet/blue LEDs, each LED configured to emit light having a wavelength of 405 nm ± 10 nm.

9. The system of any one of claims 5-8, further comprising a display on a front side of the housing.

10. The system of claim 9, wherein the at least one excitation light source is positioned on a rear side of the housing.

11. The system of any one of claims 1-10, wherein the at least one excitation light source includes first and second violet/blue LEDs, each LED configured to emit light having a wavelength of 405 nm ± 10 nm.

12. The system of claim 11, wherein the first and second violet/blue LEDs are positioned on opposite sides of a longitudinal axis of the housing, wherein the longitudinal axis passes through and top and bottom of the housing.

13. The system of claim 10, wherein the housing is a modular housing comprising a display unit and an optical unit.

14. The system of claim 13, wherein the optical unit is releasably attached to the display unit.

15. The system of claim 14, wherein the at least one excitation light source is contained in the optical unit.

16. The system of claim 15, wherein the white light source is contained in the optical unit.

17. The system of claim 16, wherein the display unit includes an interface configured to releasably receive an optical unit.

18. The system of claim 17, wherein the interface is defined, at least in part, by a heat sink of the system.

19. The system of claim 18, wherein the heat sink surrounds an opening configured to releasably receive the optical unit.

20. The system of any one of claims 1-19, further comprising an ambient light sensor configured to indicate when ambient lighting conditions are sufficient to permit fluorescent imaging.

21. The system of any one of claims 1-20, further comprising a range finder.

22. The system of any one of claims 1-21, further comprising a Wi-Fi and/or Bluetooth antenna.

23. The system of any one of claims 1-22, wherein the processor is configured to wirelessly transmit and/or receive data.

24. The system of any one of claims 1-23, further comprising a power source.

25. The system of any one of claims 1-24, wherein the excitation light source includes a first excitation light source and a second excitation light source.

26. The system of claim 25, wherein the first excitation light source is configured to emit excitation light having a wavelength of 350 nm – 400 nm, 400 nm – 450 nm, 450 nm – 500 nm, 500 nm – 550 nm, 550 nm – 600 nm, 600 nm – 650 nm, 650 nm – 700 nm, 700 nm – 750 nm, 750 nm – 800 nm, 800 nm – 850 nm, 850 nm – 900 nm, and/or combinations thereof.

27. The system of claim 26, wherein the first excitation light source is configured to emit excitation light having a wavelength of 400 nm to 450 nm.

28. The system of claim 27, wherein the first excitation light source is configured to emit excitation light having a wavelength of 405 nm ± 10 nm.

29. The system of claim 25, wherein the second excitation light source is configured to emit excitation light having a wavelength of 350 nm – 400 nm, 400 nm – 450 nm, 450 nm – 500 nm, 500 nm – 550 nm, 550 nm – 600 nm, 600 nm – 650 nm, 650 nm – 700 nm, 700 nm – 750 nm, 750 nm – 800 nm, 800 nm – 850 nm, 850 nm – 900 nm, and/or combinations thereof.

30. The system of claim 29, wherein the second excitation light source is configured to emit excitation light having a wavelength of 750 nm – 800 nm.

31. The system of claim 30, wherein the second excitation light source is configured to emit excitation light having a wavelength of between 760 nm and 780 nm.

32. The system of claim 31, wherein the second excitation light source is configured to emit excitation light having a wavelength of 760 nm ± 10 nm.

33. The system of claim 31, wherein the second excitation light source is configured to emit excitation light having a wavelength of 770 nm ± 10 nm.

34. The system of claim 31, wherein the second excitation light source is configured to emit excitation light having a wavelength of 780 nm ± 10 nm.

35. The system of any one of claims 1-34, wherein the first and second image sensors each comprise a complementary metal-oxide-semiconductor (CMOS) sensor.

36. The system of any one of claims 1-35, wherein the first filter is fixed to the first image sensor.

37. The system of any one of claims 1-36, wherein the second filter is fixed to the first white light image sensor and the third filter is fixed to the second white light image sensor.

38. The system of any one of claims 1-37, further comprising an infrared radiation source.

39. The system of claim 38, wherein the system is configured to project infrared radiation onto the target surface and detect infrared radiation reflected from the target surface as well as any infrared fluorescence emitted by the target when excited by the appropriate excitation wavelength.

40. The system of claim 39, wherein the processor is further configured to generate a three-dimensional map of the target surface based on the detected reflected infrared radiation.

41. The system of claim 40, wherein the processor is further configured to generate a three-dimensional fluorescence image of the target surface based on the three-dimensional map, a two-dimensional white light image of the target surface, and a two-dimensional fluorescence image of the target surface.

42. A portable, handheld imaging system, comprising:

at least one excitation light source configured to emit excitation light during fluorescent imaging;

a fluorescent image sensor;

a first filter configured to permit passage of optical signals, responsive to illumination of a target surface with the excitation light and having a wavelength corresponding to one or more of bacterial fluorescence, bacterial autofluorescence, tissue fluorescence, and tissue autofluorescence, to be detected by the fluorescent image sensor;

a white light source configured to emit white light during white light imaging;

a first white light image sensor and a second white light image sensor;

a second filter and a third filter, each of the second and third filters being configured to permit passage of optical signals, responsive to illumination of the target surface with the white light and having a wavelength in the visible light range, to be detected by a respective one of the first and the second white light image sensors;

a processor configured to receive the detected fluorescent and white light optical signals and to output a representation of the target surface to a display based at least in part on the detected optical signals,

wherein the system comprises a modular housing including an optical unit detachably connected to a display unit,

wherein the optical unit includes the at least one excitation light source, the fluorescent image sensor, the white light source, and the first and second white light image sensors, and

wherein the display unit includes the processor and a display.

43. The system of claim 42, wherein the representation, based in part on the optical signals detected by the first and second white light image sensors, is a stereoscopic or three-dimensional image of the target surface and, wherein the representation, based in part on the optical signals detected by the fluorescent image sensor, provides an indication of a bacterial load of the target surface.

44. The system of claim 42 or 43, wherein the system further comprises a thermal sensor configured to detect thermal information regarding the target surface.

45. The system of claim 44, wherein the processor is further configured to receive the detected thermal information and to output a representation of the target surface based on the thermal information.

46. The system of any one of claims 42-45, further comprising an infrared radiation source.

47. The system of claim 46, wherein the system is configured to project infrared radiation onto the target surface and detect infrared radiation reflected from the target surface as well as any infrared fluorescence emitted by the target when excited by the appropriate excitation wavelength.

48. The system of claim 47, wherein the processor is further configured to generate a three-dimensional map of the target surface based on the detected reflected infrared radiation.

49. The system of claim 48, wherein the processor is further configured to generate a three-dimensional fluorescence image of the target surface based on the three-dimensional map, a two-dimensional white light image of the target surface, and a two-dimensional fluorescence image of the target surface.

50. A portable, handheld imaging system, comprising:

at least one excitation light source configured to emit excitation light during fluorescent imaging;

a fluorescent image sensor;

a first filter configured to permit passage of optical signals, responsive to illumination of a target surface with the excitation light and having a wavelength corresponding to one or more of bacterial fluorescence, bacterial autofluorescence, tissue fluorescence, and tissue autofluorescence, to be detected by the fluorescent image sensor;

a white light source configured to emit white light during white light imaging;

a first white light image sensor and a second white light image sensor;

a second filter and a third filter, each of the second and third filters being configured to permit passage of optical signals, responsive to illumination of the target surface with the white light and having a wavelength in the visible light range, to be detected by a respective one of the first and the second white light image sensors;

an infrared radiation source, wherein the system is configured to project infrared radiation onto the target surface and to detect infrared radiation reflected from the target surface as well as any infrared fluorescence emitted by the target when excited by the appropriate excitation wavelength; and

a processor configured to receive the detected fluorescent and white light optical signals and to output a representation of the target surface to a display based at least in part on the detected optical signals, and

wherein the processor is further configured to generate a three-dimensional fluorescence image of the target surface based at least in part on the detected reflected infrared radiation.

51. The system of claim 50, wherein the processor is further configured to generate a three-dimensional map of the target surface based on the detected reflected infrared radiation.

52. The system of claim 51, generating a three-dimensional fluorescence image of the target surface with the processor is based on the three-dimensional map, a two-dimensional white light image of the target surface, and a two-dimensional fluorescence image of the target surface.

53. The system of any one of claims 50-52, wherein the representation, based in part on the optical signals detected by the first and second white light image sensors, is a stereoscopic or three-dimensional image of the target surface and, wherein the representation, based in part on the optical signals detected by the fluorescent image sensor, provides an indication of a bacterial load of the target surface.

54. The system of any one of claims 50-53, wherein the system further comprises a thermal sensor configured to detect thermal information regarding the target surface.

55. The system of claim 54, wherein the processor is further configured to receive the detected thermal information and to output a representation of the target surface based on the thermal information.

56. An imaging system kit, comprising:

the imaging system of any one of claims 1-55; and

a sterile drape configured to create a sterile barrier between the imaging system and an environment the imaging system is used in.

57. The kit of claim 56, further comprising an imaging drape configured to reduce ambient light in an imaging environment of the imaging system.

58. The kit of claim 57, wherein the imaging drape includes a connector element configured to receive an optical housing of the imaging system.

59. The kit of any one of claims 56-58, further comprising one or more imaging agents or contrast agents.