an image processing module, coupled to the imaging module, to receive information corresponding to the time-resolved fluorescence emission spectra, time-resolved reflectance, and time-resolved transmittance spectra, the image processing module can include: an image processor to perform spatial and temporal resolution of the time-resolved fluorescence emission spectra, time-resolved reflectance, and time-resolved transmittance spectra to obtain a plurality of spectral parameters; and a library database comprising a set of standard spectral parameters identifiable with reference pathogens, wherein the image processing module can be configured to compare each of the plurality of spectral parameters with the set of standard spectral parameters to detect and classify the pathogen; and

a display module to display a result based on the comparison.

[0002B] In one aspect, there is provided a method for non-invasive, automatic, and in-situ detection and classification of pathogens. The method can include:

exposing a sample comprising a plurality of pathogens to an excitation radiation at a predetermined range of wavelengths from a plurality of light sources for a predetermined duration at a predetermined periodicity;

synchronously capturing, by a detector, a time-resolved fluorescence emission spectra, time-resolved reflectance, and transmittance spectra at multiple spectral bands from the sample;

performing, by an image processing module, spatial and temporal resolution of the time-resolved fluorescence emission spectra, time-resolved reflectance, and time-resolved transmittance spectra from the sample to obtain a plurality of spectral parameters;

accessing, by an image processor, a library database, wherein the library database comprises a set of standard spectral parameters associated with reference pathogens;

I/We claim:

1. A device for non-invasive, automatic, and in-situ detection and classification of pathogens, the device comprising:

an imaging module comprising:

a plurality of light sources to emit excitation radiation at a predetermined range of wavelengths;

an optical switch to expose a sample comprising pathogens to the excitation radiation for a predetermined duration at a predetermined periodicity; and

a detector to synchronously capture time-resolved fluorescence emission spectra, time-resolved reflectance, and time-resolved transmittance spectra at multiple spectral bands from the sample;

an image processing module coupled to the imaging module to receive information corresponding to the time-resolved fluorescence emission spectra, time-resolved reflectance, and time-resolved transmittance spectra, the image processing module comprising:

an image processor to perform spatial and temporal resolution of the time-resolved fluorescence emission spectra, time-resolved reflectance, and time-resolved transmittance spectra to obtain a plurality of spectral parameters; and

a library database comprising a set of standard spectral parameters identifiable with reference pathogens,

wherein the image processing module is to compare each of the plurality of spectral parameters with the set of standard spectral parameters to detect and classify the pathogen; and

a display module to display a result based on the comparison.

2. The device as claimed in claim 1, wherein the image processing module is to compare each of the plurality of spectral parameters with the set of

standard spectral parameters based on a first image processing model and wherein the library database is to receive a new set of standard spectral parameters identifiable with a new reference pathogen, wherein the device comprises:

a model builder ensemble to provide a plurality of image processing models based on the new set of standard spectral parameters identifiable with the new reference pathogen and the set of standard spectral parameters identifiable with reference pathogen; and

a cross-validator to fix a second image processing model from the plurality of image processing models, wherein the second image processing model is to replace the first image processing model.

3. The device as claimed in claim 1, wherein the plurality of light sources comprises at least one of the following: a light emitting diode, a laser, a colored light source, a configurable light source, ambient light, or any combination thereof.

4. The device as claimed in claim 1, wherein the detector is to capture at least one of a steady state fluorescence spectrum, fluorescence lifetime spectrum, photobleaching spectrum, time-resolved reflectance spectrum, time-resolved transmittance spectrum, and a combination thereof.

5. The device as claimed in claim 4, wherein the detector is to capture fluorescence life time spectra, wherein the excitation radiation has the predetermined duration in the range from about 1 ps to about 1 s and the predetermined periodicity in the range from about 0.01 ns to about 1 s.

6. The device as claimed in claim 4, wherein the detector is to capture photobleaching spectra, wherein the excitation radiation has the predetermined duration in the range from about 1 ms to about 10 s and the predetermined periodicity in the range from about 0.01s to about 1 min.

7. The device as claimed in claim 1, wherein the image processing module

is to classify the pathogen based on family, genus, species and strain based on the comparison.

8. The device as claimed in claim 1, wherein the image processing module is to quantify pathogens present in the sample, wherein the image processing module is to receive an intensity of the time-dependent fluorescence of the sample and compare the intensity with a fluorescence intensity data provided in the library database to quantify pathogens.

9. The device as claimed in claim 1, wherein based on the detection and classification of pathogens, the device is to monitor wound healing and wound closure, wherein the device is to calculate at least one of the following: wound size, wound depth, wound temperature distribution, tissue classification, biofilm information, degree of contamination, tissue oxygenation and blood flow.

10. The device as claimed in claim 1, wherein the plurality of spectral parameters comprises ratios of amplitude of fluorescence emission spectra, ratios of amplitude of reflectance spectra, ratios of amplitude of transmittance spectra, bandwidth of the fluorescence emission spectra, full width half maxima of the fluorescence emission spectra, and combinations thereof.

11. The device as claimed in claim 1, wherein the library database comprises at least one of excitation emission matrix spectra, excitation emission matrix fluorescence spectra, reflectance spectra, transmittance spectra, fluorescence life times, photobleaching times, absorption coefficients, reflection coefficients, transmission coefficients, scattering coefficients, normalized intensity data, intensity ratios, or any combinations thereof, identifiable with various reference pathogens.

12. The device as claimed in claim 1, wherein the device is a handheld device.

13. The device as claimed in claim 1, wherein the image processor is to obtain at least one of the following: fluorescence decay times, fluorescence emission signal amplitude, photobleaching times, or any combination thereof.

14. The device as claimed in claim 1, wherein the result comprises at least one of the following: detection of presence of various pathogens on the sample, pathogen spatial distribution data, pathogen growth state data, co-colonization data, biofilm information, biomarker information, pathogen quantification data, a treatment protocol, or any combination thereof.

15. A method for non-invasive, automatic, and in-situ detection and classification of pathogens comprising:

exposing a sample comprising a plurality of pathogens to an excitation radiation at a predetermined range of wavelengths from a plurality of light sources for a predetermined duration at a predetermined periodicity;

synchronously capturing, by a detector, a time-resolved fluorescence emission spectra, time-resolved reflectance, and transmittance spectra at multiple spectral bands from the sample;

performing, by an image processing module, spatial and temporal resolution of the time-resolved fluorescence emission spectra, time-resolved reflectance, and time-resolved transmittance spectra from the sample to obtain a plurality of spectral parameters;

accessing, by an image processor, a library database, wherein the library database comprises a set of standard spectral parameters associated with reference pathogens;

comparing, by the image processing module, each of the plurality of spectral parameters with the set of standard spectral parameters to detect and classify the pathogens; and

displaying, by a display module, a result based on the comparing.

16. The method as claimed in claim 15, wherein the method comprises:

computing, by the image processing module, real time spatial distribution data of the pathogens across a wound region;

combining, by the image processing module, the real time spatial distribution data of the pathogens across the wound region with fluorescence intensity data at a plurality of spectral bands of the corresponding pathogens contained in the library database; and

quantifying, by the image processing module, amount of each pathogen across the wound region.

17. The method as claimed in claim 15, the method comprising:

receiving, by the library database, a new set of standard spectral parameters identifiable with a new reference pathogen;

providing, by a model builder ensemble, a plurality of image processing models based on the new set of standard spectral parameters identifiable with the new reference pathogen and the set of standard spectral parameters identifiable with reference pathogen; and

fixing, by a cross-validator, a second image processing model from the plurality of image processing models, wherein the second image processing model is to replace a first image processing model, wherein the first image processing model is associated with the set of standard spectral parameters and the second image processing model is associated with the set of standard spectral parameters and the new set of standard spectral parameters.