SUPPLEMENTARY MATERIAL

Smartphone based multispectral imager and its potential for point-of-care test

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S1. The detail of the smartphone based multispectral imager

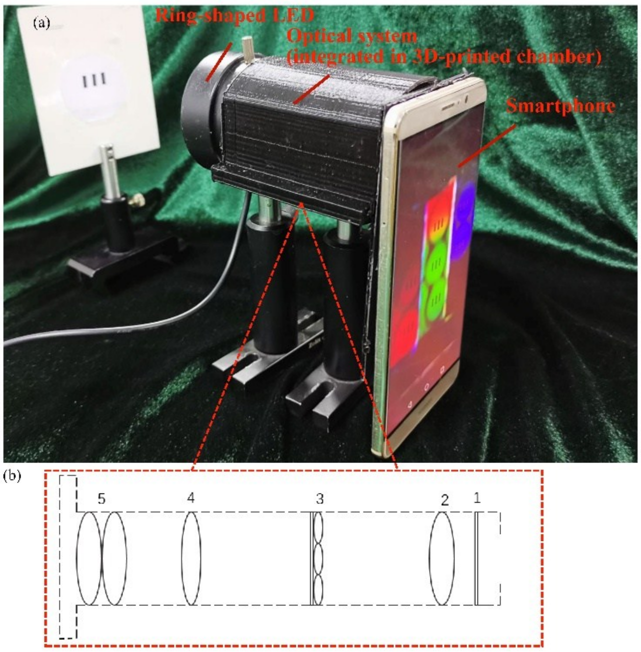

Figure S1. Illustration of the smartphone based multispectral imager. (a) A real photograph of the smartphone based multispectral imager during testing. (b) Schematic diagram of the optical components, including: 1. Linear polarizer (Ø25.4 mm); 2. Doublet lens(Ø25.4 mm, f 65mm); 3.MSI chip; 4. Doublet lens(Ø25.4 mm, f 32mm); 5. The lens of the smartphone camera.

① More information on the optical system. As shown in Fig.S1. (a), a real photograph of the smartphone based MSI system during experimenting is demonstrated. The optical assembly is positioned within a 3D printed enclosure designed in 3D Builder and optimized for a Huawei Mate9 smartphone (20 MP camera, SNR ~ 55 dB). The assembly is attached to the rear facing camera such that it is suitable for hand-held operation. When multispectral imaging, the target is illuminated by the ring-type LED light and then multispectral imaged by the smartphone MSI. As we can see, the single-band image of the target under different wavelength are recorded by the smartphone simultaneously.

The schematic diagram of the optical components is shown in Fig.S1 (b). Here, the component 1 is a linear polarizer (Ø25.4 mm). Component 2 and 4 are Doublet lens (Ø25.4 mm) with focus length of 65 mm and 32 mm respectively. Components 3 is the devised compound-eye MSI chip and Components 5 is the lens of smartphone camera. It should be addressed that the compound-eye multispectral imaging system is an off-axis imaging system array. In order to make all the sub-images could be captured by the smartphone camera, the exit pupil of the MSI chip should be precisely matched to the entry pupil of the smartphone camera (~3 mm).

②The smartphone camera setting. When multispectral imaging, the ISO value and exposure time are fixed via a home-made Andriod APP. It should be noticed that, it is infeasible to get the real pixel response of the CMOS directly from the digital photo, owing to the pre-process by manufacturer to offset the nonlinear response of human eyes, such as white balance calibration, color calibration, Gamma calibration. To survey the effect, the RAW image of the camera is first utilized to obtain the photon intensity of each pixel. RAW data is the output from the original red, green and blue sensitive pixels of the CMOS sensor, which reflects the true information of the photon intensity with no pre-process or compression.

S2. The optical resolution of the proposed MSI system

To examine the optical resolution of the smartphone based multispectral imager, the highest frequency line set which the system is capable of resolving in a resolution target was measured. Figure1(a) shows the image of the resolution target, and the scale bar indicates ~500 um. Figure S2 (b) and Fig.S2. (c) illustrates the profiles of the intensities along the horizontal direction (line A) and vertical direction (line B). As we can see, the lines in the vertical (A') and horizontal (B') directions are clearly distinguished, the resolution of the proposed system is about 100 um.

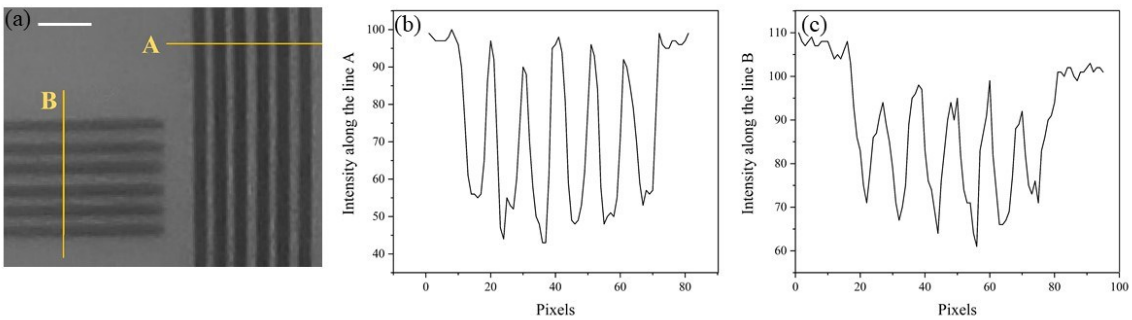

Figure S2. Resolution of a smartphone-based multispectral imaging system: (a) cropped image of a resolution target, (b) intensity variations along the line of A' (horizontal direction) in the image acquired using the proposed system, and (c) intensity variations along the line of B' (vertical direction) in the image acquired using the developed system. The scale bar indicates ~300 μm.

S3. Spectral classification

Fisher linear discrimination was adopted to solve the pattern recognition problem. We utilize the optical density OD (550) and OD (640) are selected as the principle components for the discrimination analysis. The program flow chart is shown as follows:

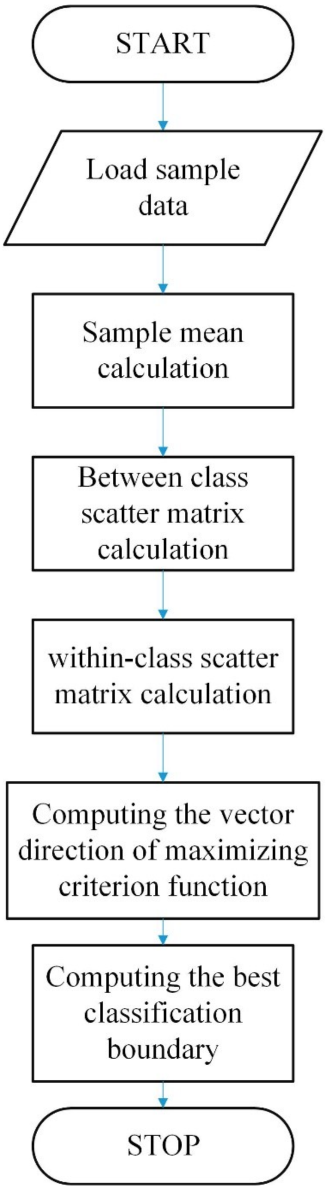

Fig.S3 The program flow chart of spectral classification.

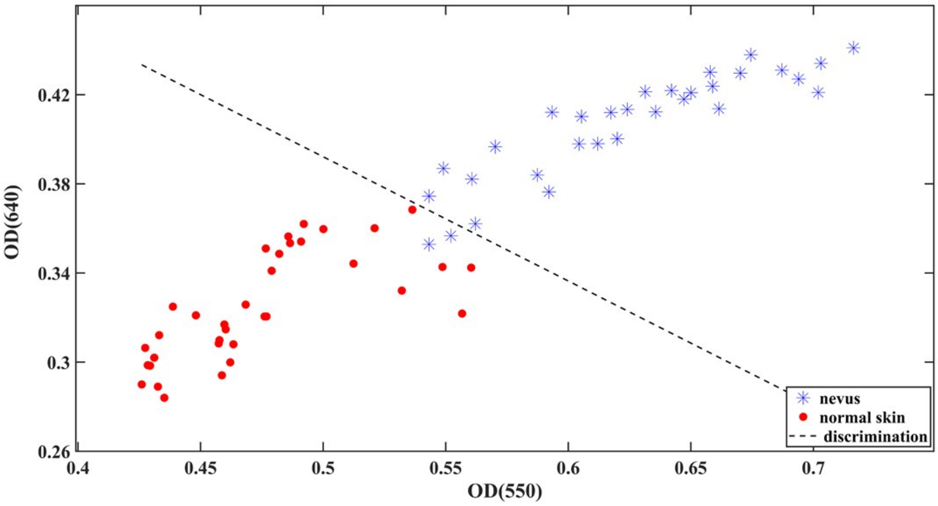

Fig.S4. Discriminant analysis in OD550 – OD640 plane