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Hyperspectral imaging to detect and analyze the quality and authenticity of documents

Fluorescence Hyperspectral Imaging: Counterfeit Currency Detection and Analysis

Introduction

With significant advances in printing and production equipment, the production and circulation of inauthentic documents have become increasingly sophisticated. Although there are advanced detection and analysis methods for counterfeit documents and artifacts, most require expensive laboratory bench-top equipment that require detailed training, and are usually slow to collect and analyze data. Some of these need elaborate sample handling and positioning, and frequently cannot be taken into the field.

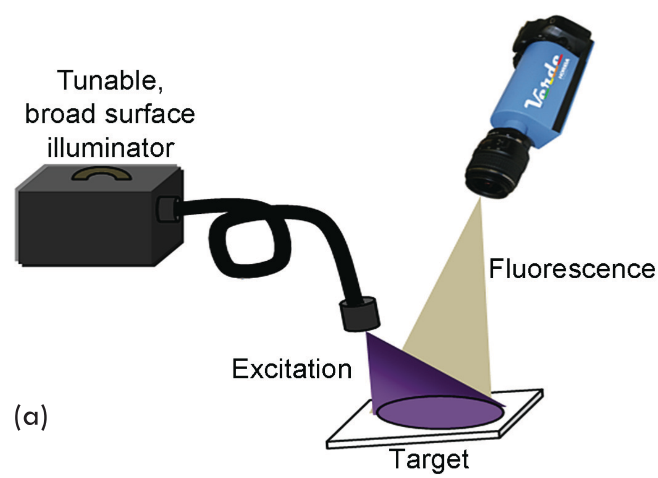
This technical note presents a simple fluorescence-based hyperspectral-imaging method of detecting and analyzing the quality or authenticity of documents and artifacts using the VERDE™ vis 300 Simultaneous Hyperspectral camera from HORIBA Scientific. This method requires no more training than that required to operate a consumer-grade point-and-shoot camera. All the image and spectral data are collected in one shot, a time-saving benefit.

Although the example shown here uses paper currency, the method is applicable to any targets that fluoresce or reflect characteristic radiation that can be used for the identification of specific features.

Experiment

A broad surface wavelength tunable illuminator was used to excite the target while the imaging lens of the VERDE™ camera was focused on the target to image the resultant fluorescence from the excitation [Fig. 1(a)].

The excitation source is important for this set-up, for not only must it provide sufficient power-density for excitation, it also has to be tunable to different wavelengths, and provide broad, uniform illumination over the target. For this purpose, the HORIBA CrimeScope CS16-500 high-powered tunable light source [Fig. 1(b)] was used. The illuminating wand is a liquid light-guide that provides uniform illumination of over 1 ft. (30 cm) diameter from about 2 ft. (61 cm) away.



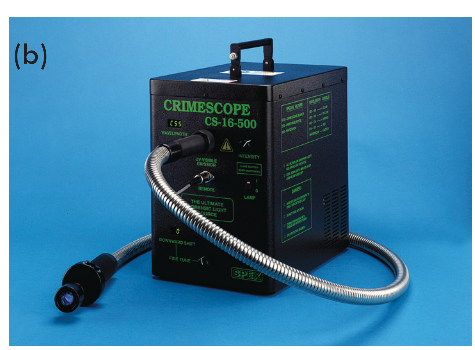


Fig 1. (a) Broad surface tunable illuminator excites the sample while the VERDE camera images the fluorescence. (b) CrimeScope CS16-500 was used as a the illuminator.

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Results and Discussion

For this test we investigated three $5 bills of different provenance (Samples 1, 2, and 3). Under ambient room-light, the authenticity of each bill was difficult to determine because they all looked genuine (Fig. 2). Using the set-up in Fig. 1(a), the samples were illuminated with a uniform beam of near-UV light (λ_{exc} = 365 nm). The resulting fluorescence image was captured by the VERDE™ hyperspectral camera (Fig. 3a).

Genuine currency is printed on parchment, which shows a very small but characteristic background fluorescence pattern.[1] Counterfeit currency is often printed on bleached paper, which shows much stronger fluorescence [Fig. 3(b)]. From these results, Sample 2 is probably genuine while Sample 1 is clearly counterfeit. Sample 3 is not determinable.

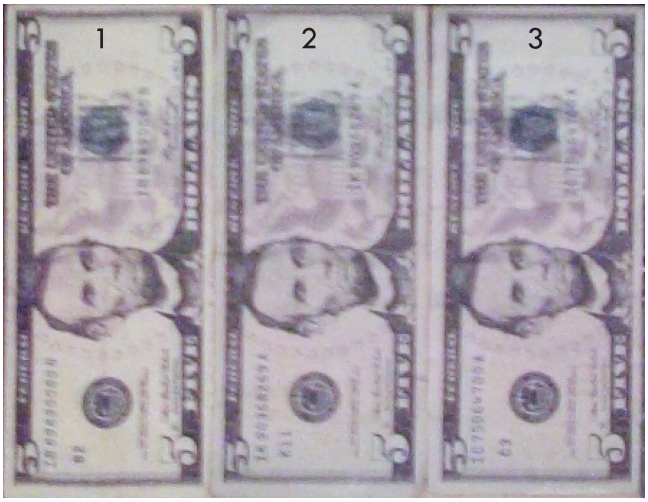

Fig. 2. Three different $5 bills (Samples 1, 2, and 3), as they appear in ambient room-light.

The sample bills were next excited with blue light (λ_{exc} = 415 nm). The image in Fig. 4(a) was collected by the VERDE™ camera though a blocking filter intended to prevent the excitation light from reaching the camera. (Spectra were not corrected for the filter-transfer function.) The spectra in figure 4b once more show the background fluorescence-response of the different bills collected at a region shown by the square box on each bill. Note how the two potential counterfeits (1 and 3) show a shifted peak at ~520 nm compared to peak from the genuine bill at ~550 nm. Sample 3, although suspect, may just be a variant of a genuine bill, in which case the procedure described here can be used for quality control during production.

Finally the samples were excited at 445 nm and the results shown in Fig. 5. The distinct behaviors of the different samples are obvious. Here, interest

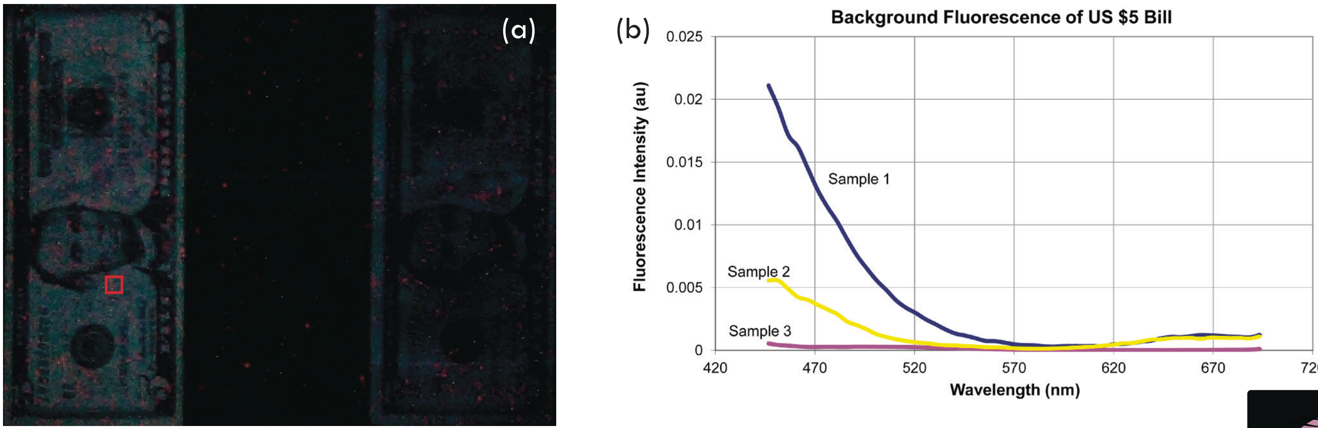

Fig. 3. (a) Fluorescence image of samples under UV illumination at 365 nm. As a hyperspectral image, every pixel in the image has an associated spectrum. (b) Average spectra of a rectangular region close to Abraham Lincoln's right ear as shown in Fig. 3(a). Genuine currency (parchment) has a very small but characteristic fluorescence spectrum while counterfeit currency (bleached paper) has much stronger background fluorescence.[1]

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in the behavior of particular features on the bills: the green insignia of the U.S. Department of the Treasury. On Sample 1, the insignia is black, completely absorbing the excitation light, while in Samples 2 and 3, the insignia fluoresces green (not reflection) [Fig. 5(b)].

Conclusions

The spectra and images presented here highlight the rich set of analysis and authentication possibilities that can be realized with our compact portable VERDE™ Simultaneous Hyperspectral Imaging Camera. Its ease of use certainly recommends it as a first-line instrument before detailed analytical measurements need to be taken on larger, more elaborate, bench-top instruments.

[1] Fluorescence Detection of Counterfeit US Currency http://www.jascoinc.com/Libraries/Product_Spec_Sheets/FP_01_02.sflb.ashx

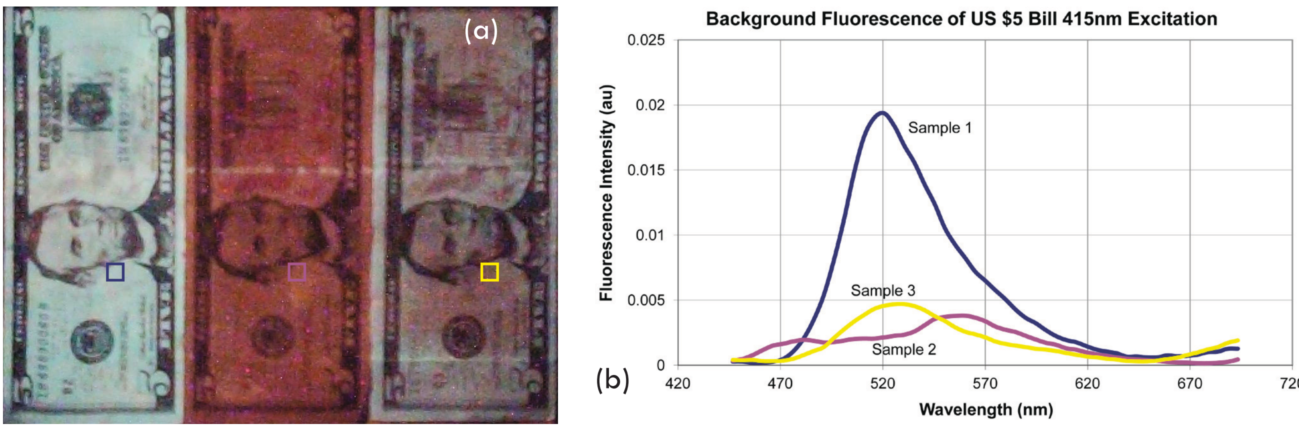

Fig. 4. (a) Image of fluorescent samples following excitation at 415 nm. (b) Average spectra over region within the box in each image, collected at a similar location on each bill. Note how the peak positions for the potentially fake bills are the same (~520 nm), while the genuine bill shows a different peak at 550 nm.

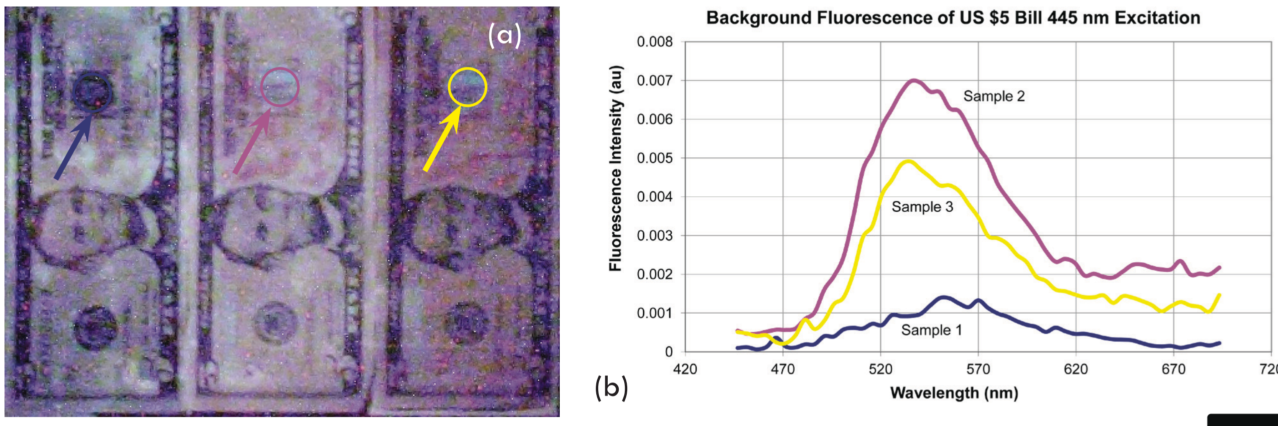

Fig. 5. (a) Fluorescence image of samples under 445 nm excitation. The target is fluorescence spectra from the insignia of the U.S. Department of the Treasury) within circles shown by arrows. (b) Spectra from areas indicated by circles and arrows in (a).

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