VideometerLab 3 Multi-Spectral Imaging
Rapid Non-destructive Surface Analysis

• Light reflectance at separate colours
• Statistical image processing
• Chemical, physical and spatial properties
• Differentiate | Quantify | Report

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Normal Colour Imaging

Traditional colour imaging uses three broad bands of colour:

**Red, Green and Blue**
Normal Colour Imaging

- RGB photographs have limited spectral resolution
- Chlorophyll a and b give almost the same RGB signal and are not spectrally separated
Multispectral Imaging

- Using just 4 wavelength bands with tightly defined ranges, Chlorophyll a and b can easily be distinguished.
- VideometerLab 3 uses 19 wavelength bands.

<table>
<thead>
<tr>
<th>Chloro-a</th>
<th>High</th>
<th>Low</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloro-b</td>
<td>Med</td>
<td>High</td>
<td>Med</td>
<td>Low</td>
</tr>
</tbody>
</table>
Multispectral Imaging

- Many images obtained at selective wavelength bands
- Each image pixel contains spectral data points
- Spectral signature reveals chemo-specific information
- See spatial location of surface chemical variation
Why use Multispectral Imaging?

- Nuanced, human-like analysis of heterogeneous samples
- Objective, accurate, repeatable measurements
- Non-destructive analysis allows further sample assay work
- No sample preparation is required
- Rapid data acquisition and analysis enables high throughput screening
Multispectral Imaging with VideometerLab 3

- Hybrid between spectroscopy, image analysis and statistics
- Allows rapid, accurate and reproducible analysis of spectral AND spatial features including shape, colour, texture, size, frequency, surface chemistry and chemical composition
- The flexibility of the VideometerLab software unlocks many different application possibilities with the same hardware
- Advanced signal processing and statistical analysis allows fast, objective, repeatable, non-destructive analysis of any heterogeneous surface
Multispectral Imaging Application Examples

- Grain and seed sorting, disease detection, malting, germination and hydration
- Contaminant detection and identification in foods and ingredients
- Coatings and API concentration distribution in tablets
- Corrosion quantification and grading of materials and surfaces
- Agar plate colony counting of multiple species simultaneously
- Forensic analysis of fingerprints, bloodstains, inks, powder residues and questioned documents
- CIELab colour quantification and sRGB simulation under specified lighting conditions
Multispectral vs Hyperspectral

- **Hyperspectral datacubes** are a 2D image at each wavelength of a spectral range – third image datacube dimension is light wavelength.

- Hundreds of images with fine spectral resolution, each spatial pixel has full spectral information contained inside.

- Complex equipment, algorithm optimisation, heavy computing and trained personnel to collect and analyse data.

- **Multispectral datacubes** are a 2D image at a selection of narrow wavelength bands along the spectrum.

- Vastly reduced complexity while retaining most analysis power.

- Data collection, computing power and interpretation much more simple.
Multispectral vs Hyperspectral

- **Hyperspectral systems** use a broadband illumination source with a fixed output intensity at each wavelength, like the sun or a halogen bulb.
- Detector sensitivity can’t be changed, forcing a **compromise** that doesn’t use the optimal sensitivity at any wavelength and results in poor signal to noise.
- They’re also very expensive!!
- **VideometerLab 3** provides 90% of the performance of a hyperspectral imaging system at a **fraction of the cost** and with more **flexibility**.
- VideometerLab’s **patented LED illumination** system ensures **high signal to noise ratio** across the UV-Vis-VNIR spectrum (375nm-970nm at spaced intervals).
- LED illumination allows **precise control of lighting** conditions at each chosen wavelength, allowing tuneable illumination on any given sample surface for **optimal image acquisition**.
- VideometerLab’s **powerful software** brings advanced image processing and multispectral analysis techniques to the **average user**.
VideometerLab 3 Schematic

- Narrowband illumination provided by 19 LEDs between 375nm-970nm (UV-Vis-VNIR)
- Integrating sphere diffuses light onto sample
- 2056x2056 CCD camera captures reflectance at each LED wavelength for each pixel
- Emission filter wheel for longpass/bandpass filtering
- Bright-field or dark-field lighting for translucency or diffuse scatter imaging
VideometerLab 3 Schematic

- Precise lighting control for optimal illumination of each sample across whole spectrum
- Diffuse light on sample ensures even lighting from all directions
- Broadband camera spectrally and spatially calibrated (NIST)
- Emission filters enable multispectral reflectance and fluorescence imaging abilities
- Powerful, user-friendly image analysis and quantification software for data and modelling
VideometerLab 3 Schematic
Multispectral Image Analysis

• A variety of image processing tools are available in VideometerLab’s analysis software

• Analysis protocols and models can be saved and applied to new samples for routine analysis

• Multiple analysis models can be run on the same image data to quantify separate parameters

• Analysis can be batch-run to aid in high-throughput data acquisition

• Image archiving provides a record of samples for future data mining and regulatory compliance
Hardware and Software Options

- **Hardware options**
  - Emission filter wheel (4 x 25mm Ø) for fluorescence macro-imaging
  - Dark- or Bright-field backlighting for scattering or translucency analysis
  - Vibratory feeder for automatic presentation of granular samples
  - Bespoke solutions available

- **Software options**
  - Image Processing Toolbox for filtering and segmentation of image data in individual spectral bands
  - Multispectral Imaging Toolbox for multivariate image analysis and modelling
  - Blob Toolbox for granular object separation, analysis and data output reporting
  - Matlab multispectral imaging toolbox integration
Post Sales Support Options

- Hardware warranty guarantee included with purchase for one year
- Software support service included with purchase for one year, helps guide you through simple image analysis and model development
- Complex protocol development services available
- Software updates and improvements released regularly
- Annual on-site service visits
- On-site repair response in 3 days
Banknote Analysis Security Windows

- Australian 10 Dollar note at RGB and UV wavelengths.
Banknote Analysis Security Windows

- Australian 10 Dollar note at RGB and UV wavelengths. Note the security window, displaying a windmill image
Banknote Analysis Security Windows

- This window at different wavelengths

![RGB](image1)
![375nm](image2)
![385nm](image3)
The Bruneian 50 Ringit note has an additional interesting security feature, in addition to the security window which we see at 405nm.
In the 870nm region we see a ‘face’ appear (boxed in blue) which functions as an additional security feature.
Banknote Analysis  Contamination

• By using statistical transformations built into the VideometerLab software package, identifying the contamination on this note is very quick.
Banknote Analysis Contamination

- This is especially useful when identifying ‘marginal’ spots of contamination where it is unclear if the mark is contamination or printing
Banknote Analysis Polymer Identification

- Fisher discriminant analysis performed for Australian and New Zealand banknotes, designed to identify the polymers used by each mint. Below are two example images:
Banknote Analysis  Polymer Identification

- Table of scores for both sets of banknotes. The interpretation of this table is that if the model has worked the Australian scores should cluster around +1 and the New Zealand scores should cluster around -1. The Australian $100 throws the results slightly, but overall we see that we could – for example - easily identify a counterfeit Australian note made on a stolen New Zealand press.

<table>
<thead>
<tr>
<th>Name</th>
<th>Australian CDA Score</th>
<th>New Zealand CDA Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10</td>
<td>1.07</td>
<td>-0.78</td>
</tr>
<tr>
<td>$20</td>
<td>1.34</td>
<td>-0.88</td>
</tr>
<tr>
<td>$50</td>
<td>0.95</td>
<td>-1.02</td>
</tr>
<tr>
<td>$100</td>
<td>0.39</td>
<td>-0.80</td>
</tr>
</tbody>
</table>

Sdev for Australian notes ~ 0.4, Sdev for New Zealand notes ~0.1
Security Document Features Watermarks

- Birth certificate under different lighting. UV shows only the faint printing behind the text visible in RBG.
Security Document Features Watermarks

- Whereas NIR shows up a ‘crowns’ watermark on the left of the image and some printed letters on the right.
Security Document Features Microprinting

- ‘Simple’ microprinting (dots) on Greek residency permit.
Security Document Features Microprinting

- ‘Complex’ microprinting (words) on Greek passport and statistical transformation (nCDA) to make them clearer.
Security Document Features Microprinting

- Spectrum obtained from ‘red’ microprint lines and ‘blue’ microprint lines on eight 50 Lei Romanian banknote. A single misprinted line would show up by having a different spectrum to these inks.
Security Document Features Hidden

- Credit card under different lighting – note the security ‘V’ watermark (boxed in red) which is invisible under RGB lighting becomes visible in the UV
This cheque has been altered by a forger, and there are a number of ways we can prove this in a routine setting.
Questioned Document Routine Analysis

- These images show the VideometerLab automatically detecting a difference between the ink used to write “One hundred pounds” and “and sixty”.

![Image of sample text on banknotes]
VideometerLab can remove noise to make analysis easier using segmentation analysis. The example on the right is a binary image where every pixel is either white (‘forged’) or black (‘everything else’).
The spectral signatures of the two inks. The ink used for the forgery is in red.
The VideometerLab could also be used as an aid for forensic handwriting examination – as a quick demonstration the image below proves that the forger bunches their letters.

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Name</th>
<th>Letters</th>
<th>Distance from first letter to last (mm)</th>
<th>Average size of letter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Genuine</td>
<td>‘ndred’</td>
<td>5</td>
<td>14.1</td>
<td>2.8</td>
</tr>
<tr>
<td>2 - Faked</td>
<td>‘and’</td>
<td>3</td>
<td>15.6</td>
<td>1.9</td>
</tr>
<tr>
<td>3 - Faked</td>
<td>‘sixty’</td>
<td>5</td>
<td>6.8</td>
<td>1.4</td>
</tr>
<tr>
<td>4 - Genuine</td>
<td>‘pounds’</td>
<td>6</td>
<td>19.3</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Questioned Document Faintness

- Five samples, gradually increasing in faintness and the false-colour image generated by the VideometerLab
Questioned Document Faintness

• Detail of sample five
Questioned Document Obliteration

- Five samples, increasing in faintness, then rubbed twenty times with a rubber
Questioned Document Obliteration

• Detail of sample four
Questioned Document Obliteration

• Detail of sample five
Questioned Document Overwriting

- Five samples, increasing in faintness, then written over in a different ink
Questioned Document Overwriting

• Side-by-side comparison of VideometerLab’s false colour images
Fingerprints

This image shows the first sample, various fingerprints on different purple\red backgrounds. The image is displayed in RGB.
Fingerprints

Detail from the last slide, the top right fingerprint. The arrow points to a faint print that could be missed in RGB images.
Fingerprints

The same image transformed using the most powerful statistical software onboard the VideometerLab, known as ‘nCDA’ (normalised Canonical Discriminant Analysis).
Fingerprints

For comparison, the statistical transformation from the last two slides has been applied to the whole image.
Miscellaneous Shotgun Shells

- Two shotgun shells and statistical transformations on the shell looking for features which could be used to identify the weapon they were fired from.
Miscellaneous Animal Hair

- Two slides with animal hair on them

- Rabbit hair
- Cat hair and nylon fibres
Miscellaneous Animal Hair

- Statistical transformation of the above slides to show up hair better against background
Miscellaneous Metameric Materials

- Metameric panels under different illuminants
Miscellaneous Counterfeit Drugs

• We can use the VideometerLab’s in-built chemometrics to show that the drug on the left is counterfeit, because it is spectrally distinct from known samples of ‘genuine’ (one example of which is on the right of the image)
Notwithstanding that we already know that drug is a counterfeit, we could use additional information to put this conclusion beyond doubt; the counterfeit on the left is longer and fatter than the three orange ‘genuine’ samples, for example.

<table>
<thead>
<tr>
<th></th>
<th>Length (mm)</th>
<th>Width (mm)</th>
<th>Ratio</th>
<th>Area (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15.17</td>
<td>14.48</td>
<td>0.72</td>
<td>117.0</td>
</tr>
<tr>
<td></td>
<td>14.48</td>
<td>10.58</td>
<td>0.73</td>
<td>110.1</td>
</tr>
<tr>
<td></td>
<td>14.48</td>
<td>10.58</td>
<td>0.73</td>
<td>109.6</td>
</tr>
<tr>
<td></td>
<td>14.48</td>
<td>10.58</td>
<td>0.73</td>
<td>109.5</td>
</tr>
</tbody>
</table>
Miscellaneous Counterfeit Drugs

- The texture of the packaging of this counterfeit breaks down at 700nm
VL3 Multispectral Imaging

- Nuanced, human-like analysis of heterogeneous samples
- Sophisticated data analysis tools for the novice and power user
- Objective, repeatable data collection with easy export
- Rapid, non-destructive testing with no sample preparation

Multispectral imaging at Analytik.co.uk
VL3 Datasheet PDF
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