HYPERSPECTRAL MICROSCOPE

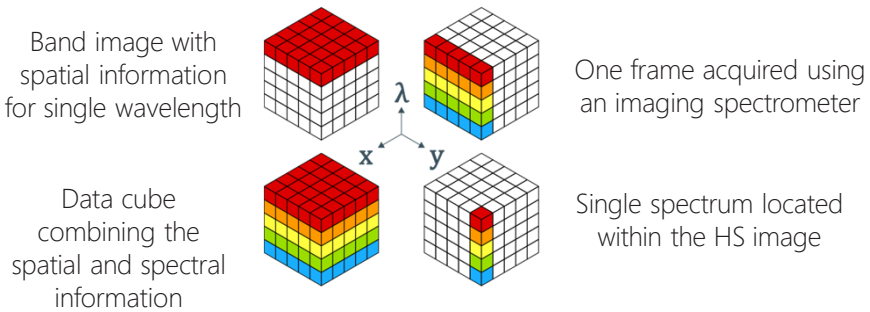
Applied and Integrated Photonics Group

ISI CAS Institute of Scientific Instruments The Czech Academy of Sciences

Application Note

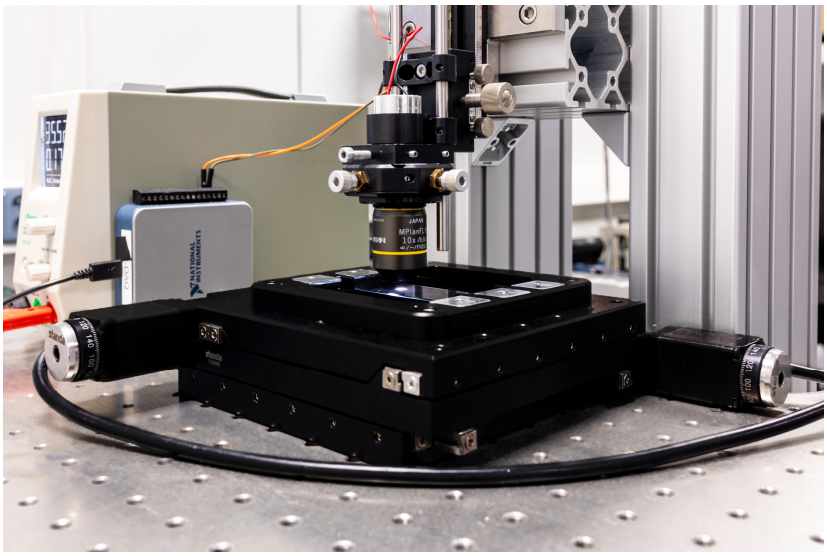
Hyperspectral (HS) imaging is an advanced technology that combines traditional imaging with spectroscopy to detect, identify, and classify materials based on their spectral signatures. Unlike conventional RGB cameras that capture only three spectrally wide color bands, hyperspectral cameras capture hundreds of narrow contiguous spectral bands, allowing detailed analysis and identification of materials and surfaces.

Hyperspectral Data Cube Structure



How does it work?

HS sensors acquire spatio-spectral images where each spatial pixel contains a detailed reflectance or transmittance spectral information. The result is a data cube (also known as a hypercube), with two spatial dimensions and one spectral dimension. This enables precise identification of materials based on how they reflect or absorb specific wavelengths of light.



Institute of Scientific Instruments
of the CAS, v. v. i.
Czech Academy of Sciences
Královopolská 147, 612 64 Brno,
Czech Republic
aip.isibrno.cz

Head: Dr. Mojmír Šerý
Phone: +420 541 514 534
E-mail: sery@isibrno.cz

Head of the Department:
Prof. Pavel Zemánek
Phone: +420 541 514 202
E-mail: zemanek@isibrno.cz

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Applications and Features

Application areas

– Agriculture – phenotyping, plant stress monitoring
– Food industry – safety screening, contamination detection
– Pharmaceuticals – homogeneity testing, quality control
– Medical imaging – tissue analysis, histopathology

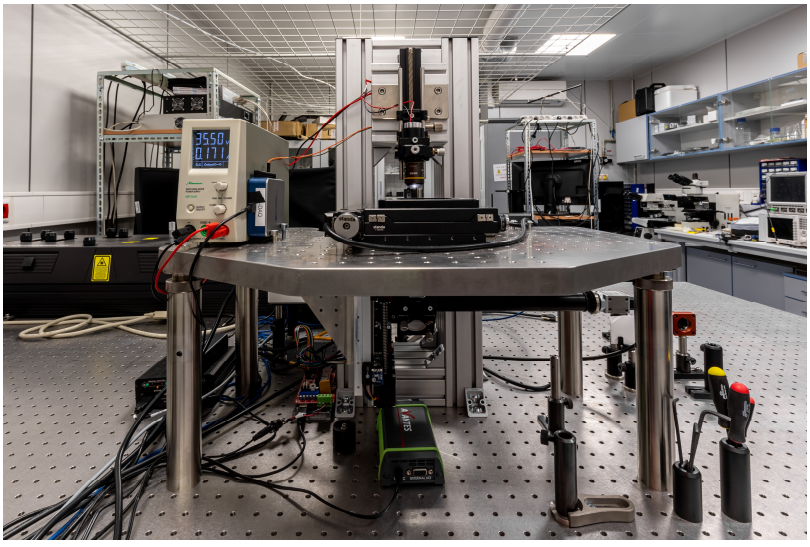
Key features

– Non-destructive material analysis
– Detection of chemical composition, moisture content, contamination, or defects
– High accuracy in distinguishing visually similar substances
– Enables real-time, automated inspection and classification

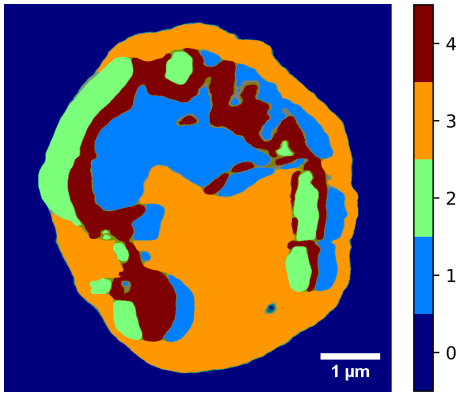
Benefits over traditional imaging

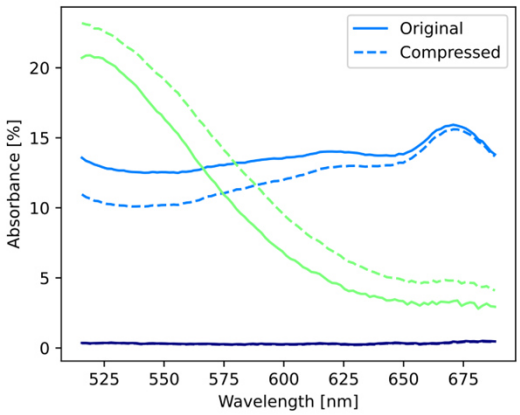
– More information compared to RGB imaging
– Works with unstained samples
– Contactless and non-invasive analysis
– Ability to distinguish spectral features beyond the visible range
– Higher flexibility in image and data analysis

Technical parametres of HS microscope at ISI

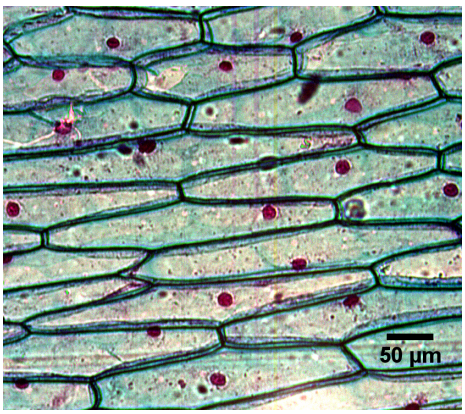


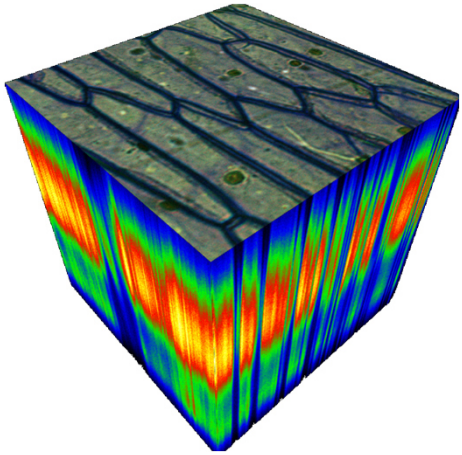
- Inverted microscope configuration
- Transmission spectrum measurement
- Push-broom scanning mode
- 120 nm bandwidth tunable in 400 nm to 1000 nm spectrum range
- 0.1 nm spectral resolution (FWHM)
- Up to 100× magnification





Trachydiscus minutus with identified areas with a similar spectral response. The clustering was performed on data that were reduced in spectral dimension using autoencoder neural network, the plot shows difference between original and compressed data.





Onion skin cells as RGB image composed from HS data with a HS data cube preview as 3D object.

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