

光画像工学

Optical imaging and image processing (XII)

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Multispectral image by LANDSAT

- Band 1 (0.45~0.52 μm) : Blue-green
- Band 2 (0.52~0.60 μm) : Green-Yellow
- Band 3 (0.63~0.69 μm) : Red
- Band 4 (0.76~0.90 μm) : Near infrared
- Band 5 (1.55~1.75 μm) : Middle infrared
- Band 7 (2.08~2.35 μm) : Middle infrared
- Band 6 (10.4~12.5 μm) : Thermal infrared



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6 Multispectral imaging

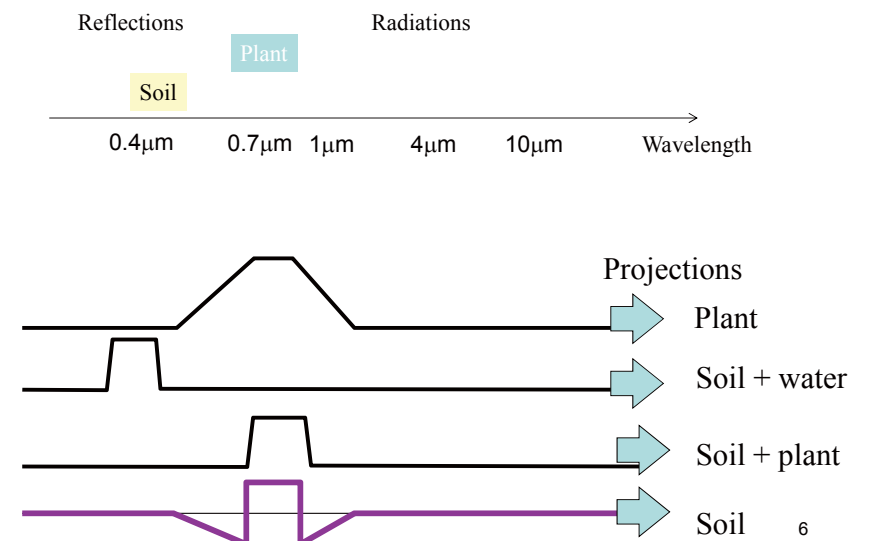
- Satellite image, remote sensing
- Object discrimination
- Color reproduction

LANDSAT image
(Land satellite by US)

Landsat/TMデータによる1988年10月14日の関東地方の土地被覆分類画像です。
赤色、桃色が市街地、住宅地で、黄色や朱色が農地、黄緑色が草地、荒地、緑色が森林、青色が水域を示します。

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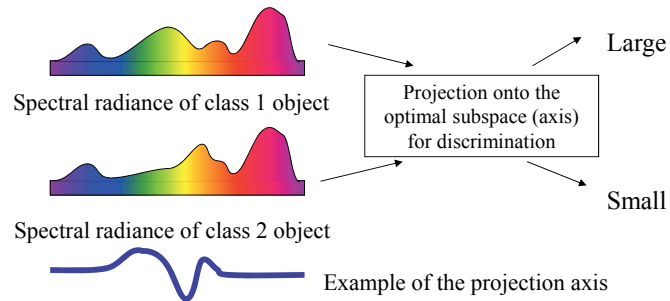
Extraction of specific features



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Object recognition using multispectral images

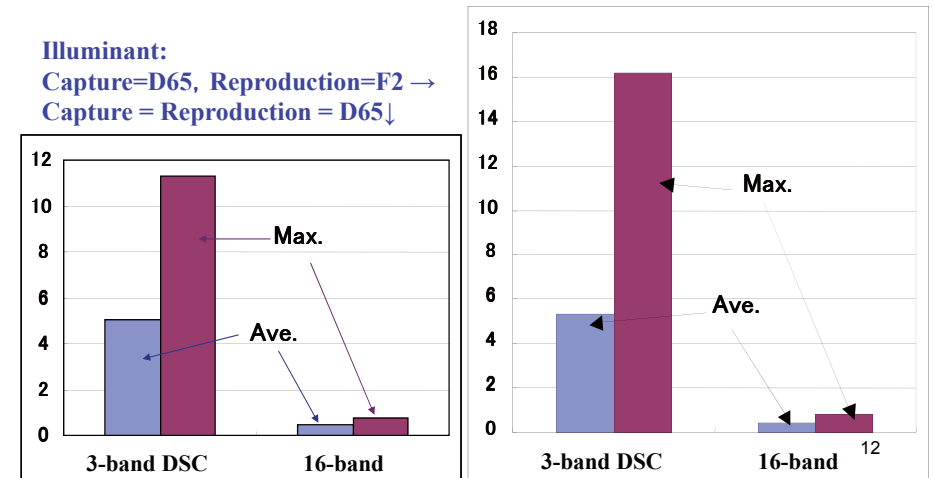
- Multispectral image acquisition
- Statistical classification of spectral data
 - Linear classification, PCA, ICA (independent component analysis), Canonical discriminant analysis
- Optimal design of the spectral sensitivities of imaging systems
 - Color imaging can be considered as the projection in the spectral space



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Accuracy of color estimation

- CIELAB color difference of GretagMacbeth ColorChecker (24 color patches) - Experimental results



Multispectral imaging for color reproduction

Why RGB Imaging is not enough?

- RGB does not represent the color attribute of an object.

- Spectral sensitivity of conventional color imaging device is not equivalent to human vision
- Color reproduction under different illumination environment
- Is not "Quantitative" information for image analysis
- The color gamut of display does not cover all the existent colors
- Observer Metamerism: Color matching for different observers

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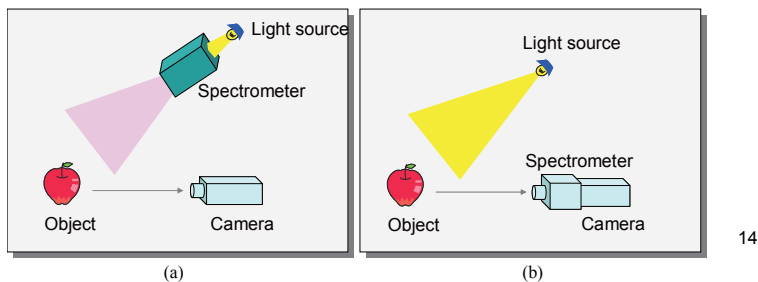
Examples of application

- Medicine
 - Dermatology, Pathology, Endoscopy (ex. Narrow band imaging),
 - Dentistry, Telemedicine, Surgery, Ophthalmology
- Printing
 - Image acquisition for merchandize catalog printing
- Electronic commerce
 - Textile: Hi-fi color reproduction, expanded color gamut
 - Virtual prototyping by multispectral BRDF measurement and multispectral rendering
- Digital archive, digital museum
 - Multispectral image archive of artworks and cultural heritage
 - Reproduction of woodprints by Shiko Munakata
 - Capture and reproduction of natural scene, ex., Aurora
- CG
 - New expression in computer graphics
 - Spectral rendering

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Methods for spectral imaging

Location of dispersive element or spectral filter	Bandwidth	Acquisition methods	Optical device
Between object and sensor	•Narrow	•Point sequential •Line sequential •Band sequential	•Diffraction grating •Interference filter •Absorption filter
Between illuminant and object	•Wide	•Mozaic filter •Others	•Dichroic prism •Fourier transform spectroscopy •Emission •Others



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Spectral imaging device using interference filter

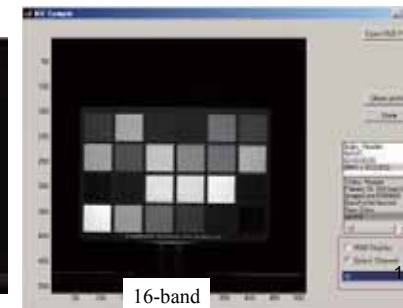


16-band filter-wheel multispectral camera (TAO/NICT, Japan)

16-band image



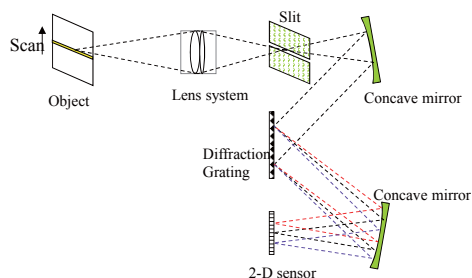
Color reproduction



16-band

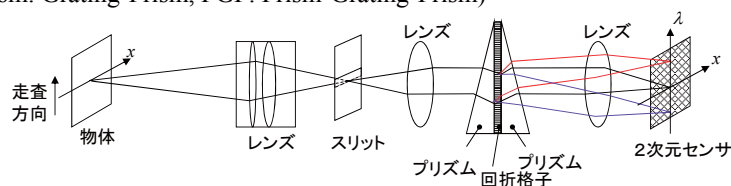
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Spectral imaging device using diffraction grating



Spectral data of a line can be acquired; a spectral image is captured with scanning of the object or the optical system.

The optical system for direct vision spectral imaging (Grism: Grating-Prism, PGP: Prism-Grating-Prism)



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ref. フィンランド, Specim社 <http://www.specim.fi/>

Spectral imaging device using absorption filter



Fig. 3. Camera system for multiband imaging

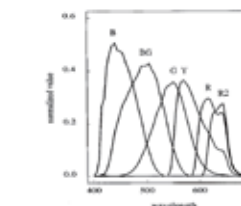
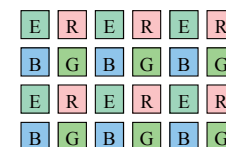


Fig. 4. Spectral sensitivity functions for the six sensors. R, red; B, blue; G, green; Y, yellow.

The system for 6-band image capture*1)



4-color filter DSC*2)

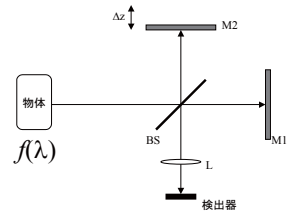
Wider bandwidth
Spectral reconstruction is required → S/N decreased
Optimization of spectral sensitivity is important

*1) S. Tominaga, J. Opt. Soc. Am. A Vol. 13, No. 11/November 1996/ 2163-2173

*2) 加藤直哉, 日本写真学会誌, Vol.67別冊1, pp.14-16 (2004)

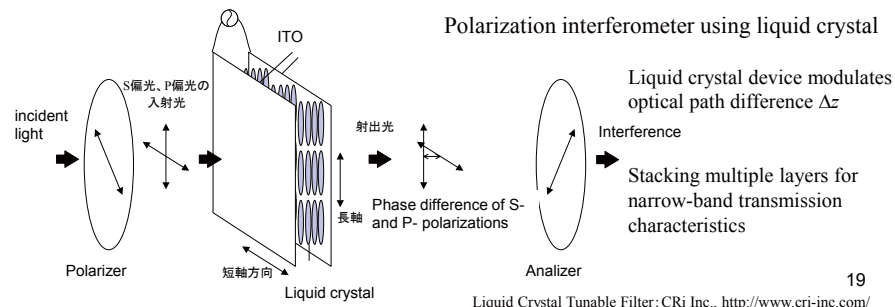
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Spectral imaging device using Fourier transform spectroscopy



Michelson interferometer

$$\text{Sensor output} \propto \int \frac{f(\lambda)}{2} \{1 + \cos(\frac{2\pi}{\lambda} \Delta z)\} d\lambda$$



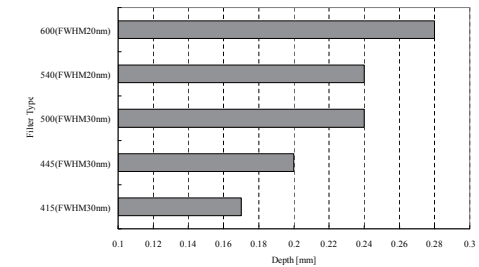
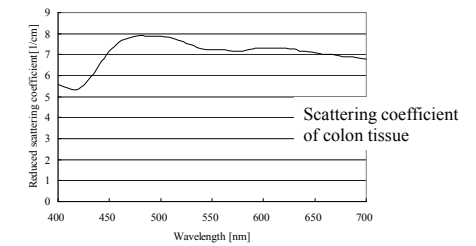
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Liquid Crystal Tunable Filter: CRI Inc., <http://www.cri-inc.com/>

Light scattering in mucosal tissue

mucosa

Structure of colon surface

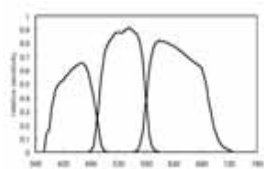
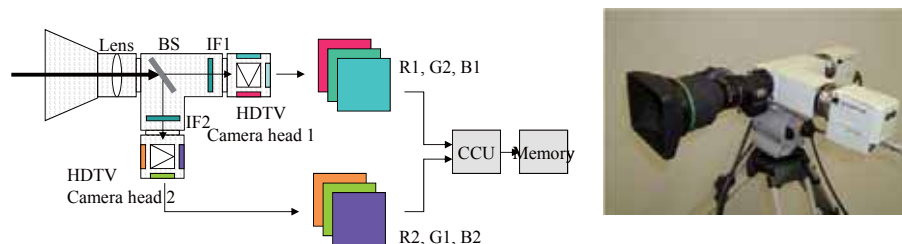


Penetration depths dependency to wavelength
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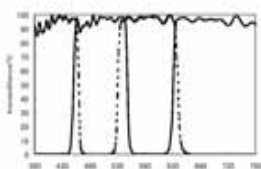
後野, 観察機能強化を目的とした内視鏡マルチバンドイメージングに関する研究
東京工業大学博士論文, 2003

Spectral imaging device using hybrid method

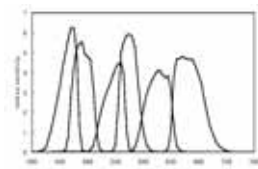
- 6-band HDTV camera (NICT)



Spectral sensitivity of 3-camera



Spectral transmittance of filters IF1 and IF2

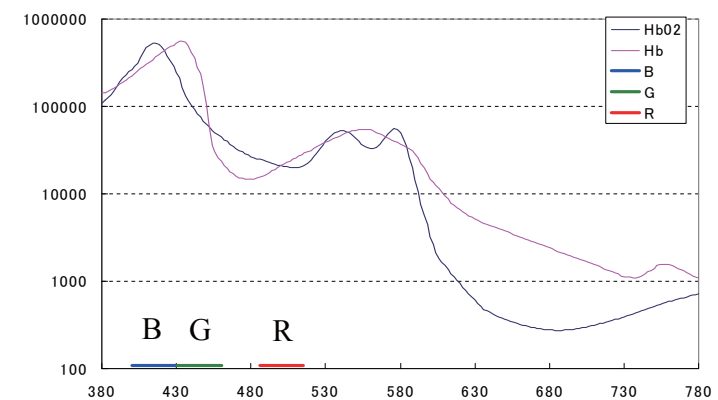


Spectral sensitivity of 6-band camera

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Ref. K. Ohsawa, T. Ajito, et. al., J. Imag. Sci. and Tech., Vol.48, No.2; pp.85-92 (2004)

Color image by narrow-band light



→ Narrow Band Imaging (NBI)

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