THINKING AND MAKING COLOR REPRODUCTION OF ARTWORKS IN A SPECTRAL WAY

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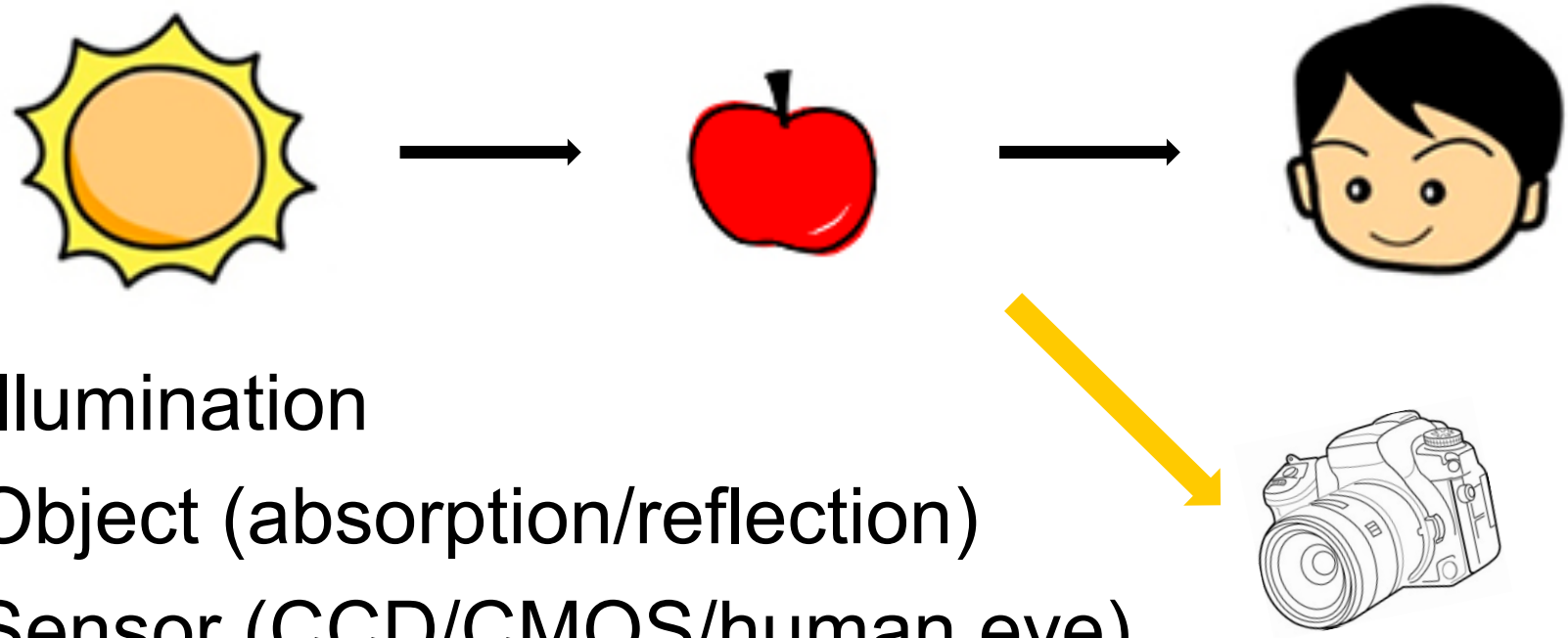
Overview

- Objectives of Image Reproduction
- Multi-spectral Imaging System
  - Theory in behind
  - System configuration
  - Results
- Implications to ICC workflow
- Summary

About True Image Reproduction

- Are they the same?

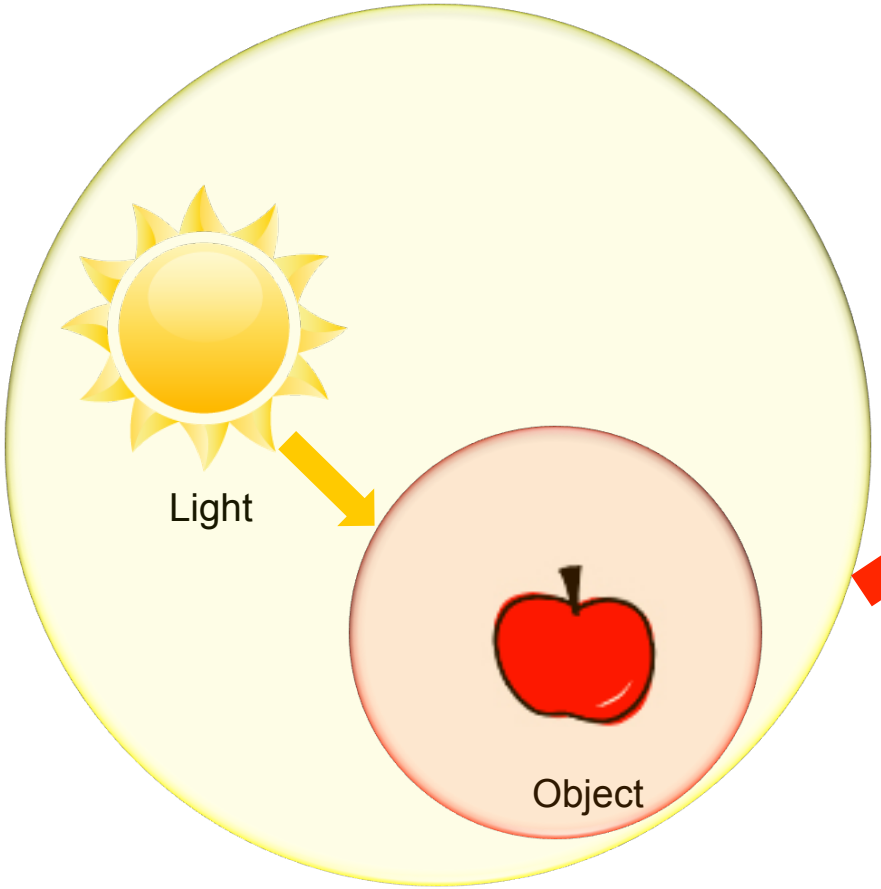
The Way Color Image Is Captured



- Illumination
- Object (absorption/reflection)
- Sensor (CCD/CMOS/human eye)

- Light that reaches the eye is captured and recorded

Problem in Regular RGB Image



Regular camera records image with Sensor's RGB sensitivities.

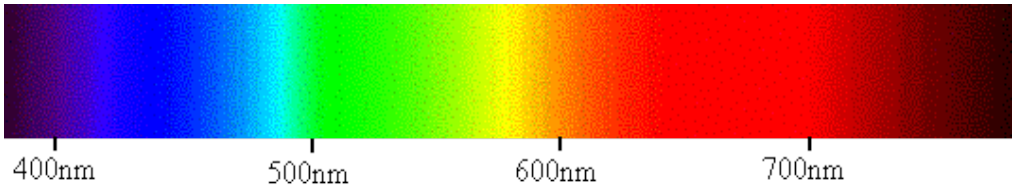
Two problems:

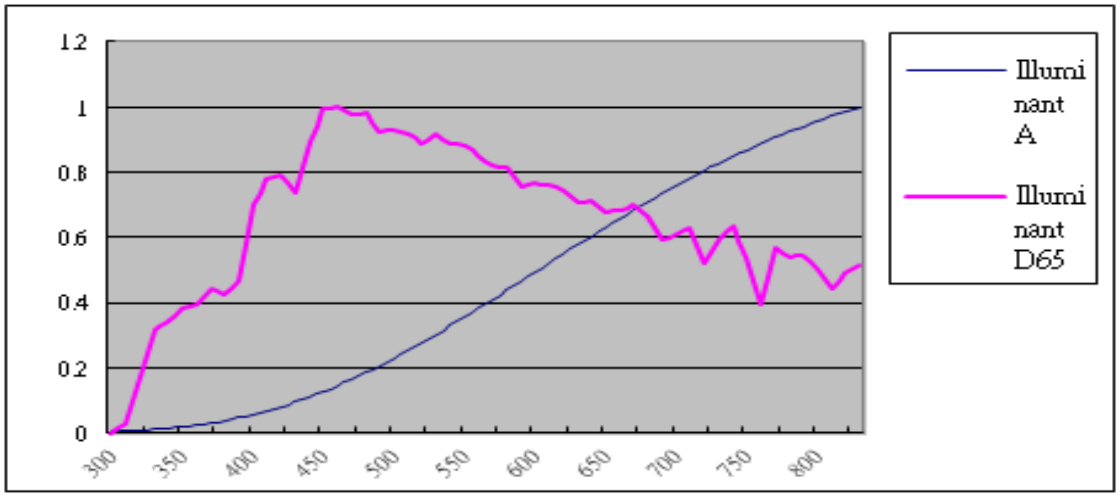
1. Are R, G, and B colors good enough to represent the combinations of all the colors ?

2. Objects might appear differently under different lighting (metamerism). What exactly is the object's color property?

Colors: Lights in Different Spectrum

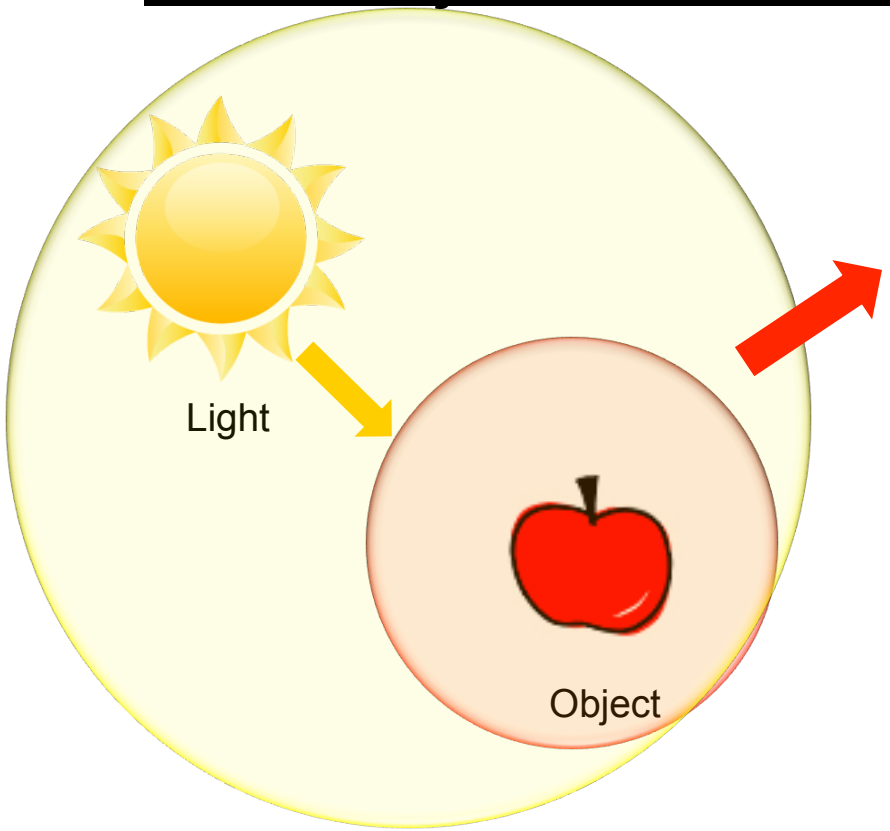
- Electro-Magnetic Radiation includes gamma ray, X-ray, UV, Visible band, IR, radio way …
- Human visible band 400nm~700nm
- Narrow band of wavelength corresponds to certain color hue

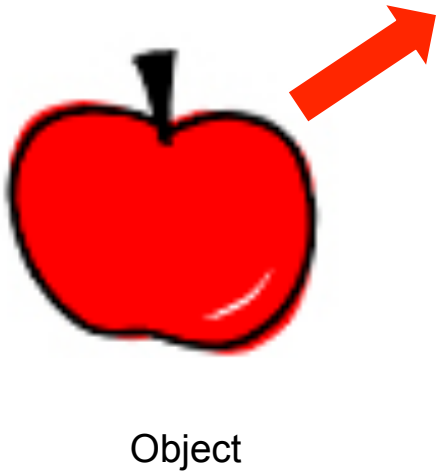




Digital Archive for Culture Heritage

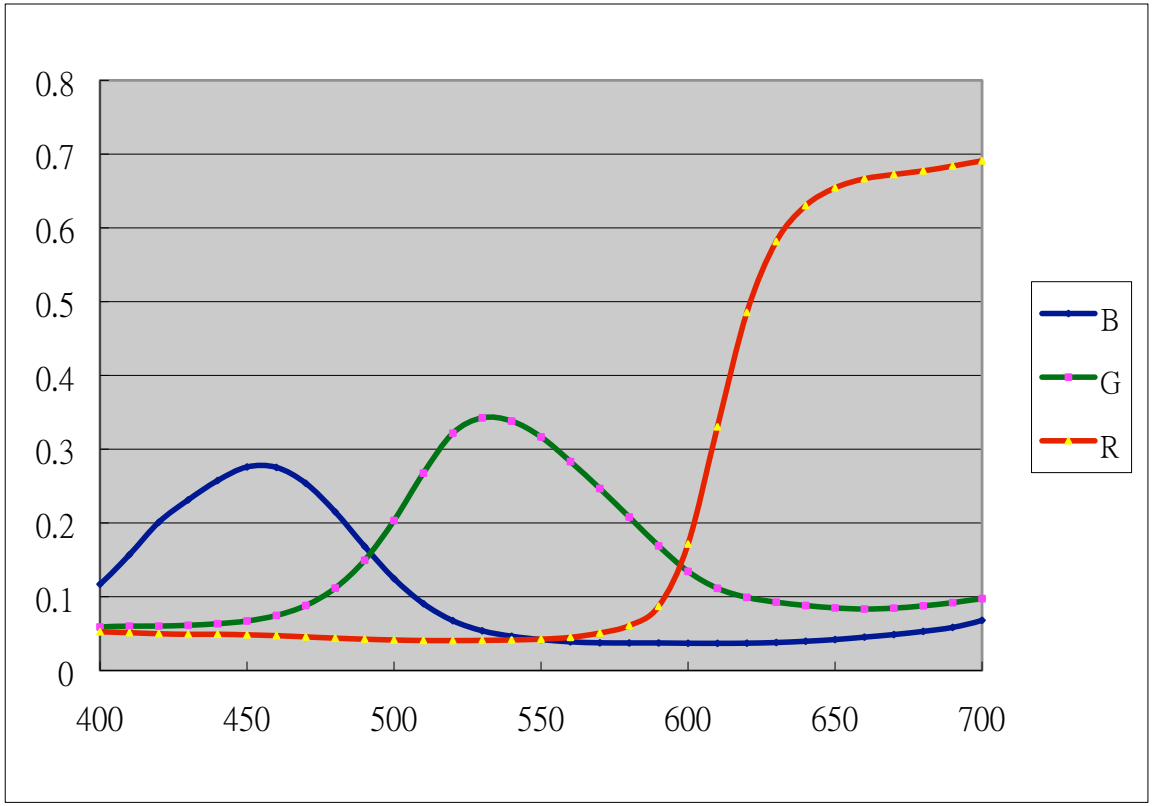
- Do we record the object as how it is appeared under specific illumination?
- Can we just record the object property only?





Spectral Reflectance Ratio Due to Absorption

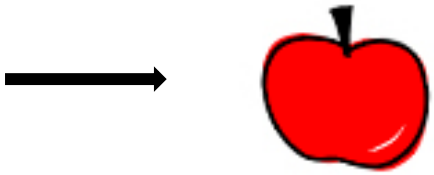
- $R(\lambda) = I(\lambda)_{output} / I(\lambda)_{input}$

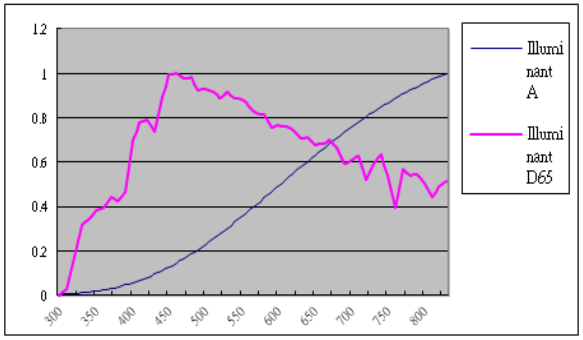


Computing Colors

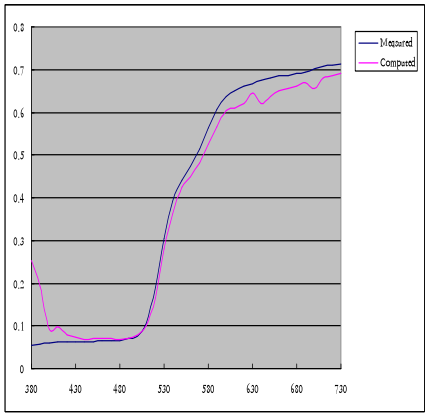
- Visible band (400-700 nm)

CIE Color Values

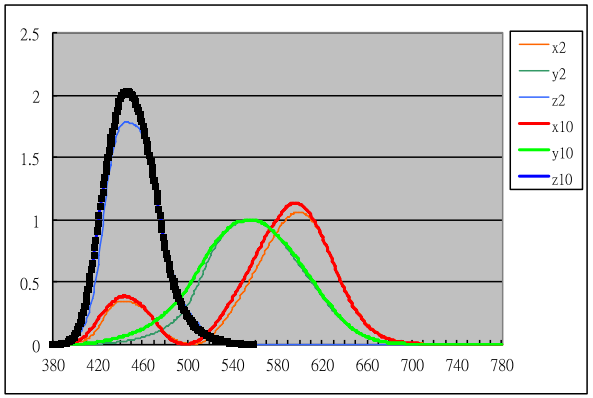




Light Source
(Spectral distribution / Color Temperature)



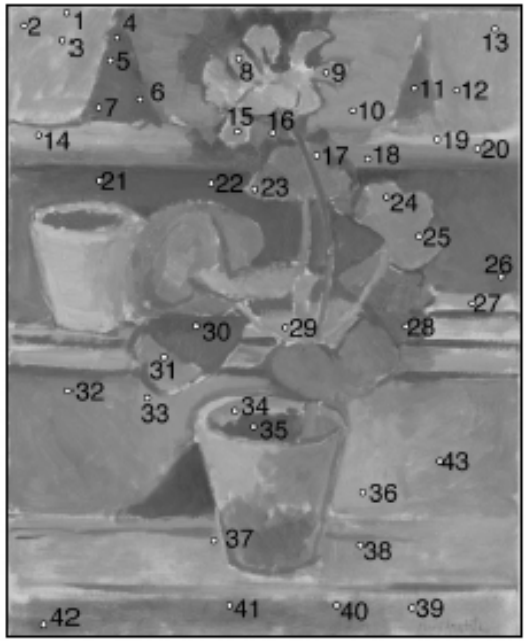
Object
(Reflectance factor)

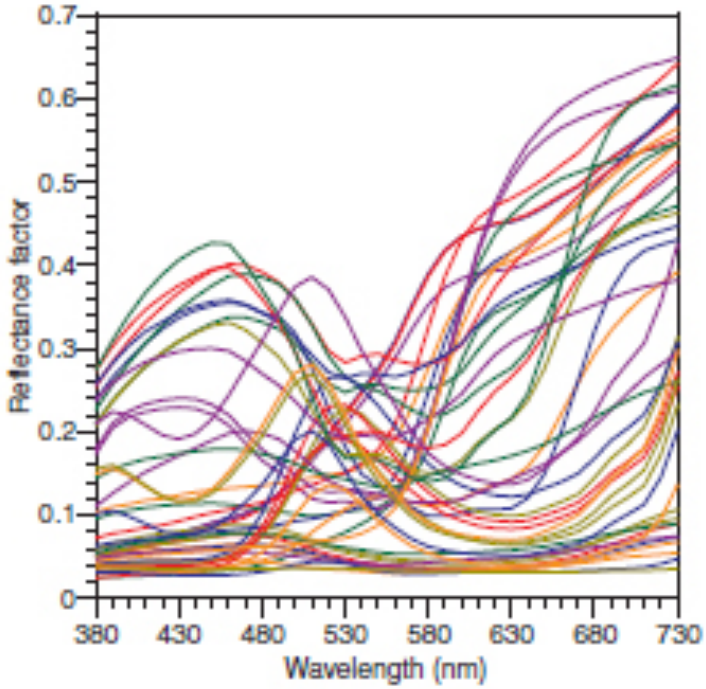


Visual System
(Color Matching Functions)

Early Study of Spectral Imaging

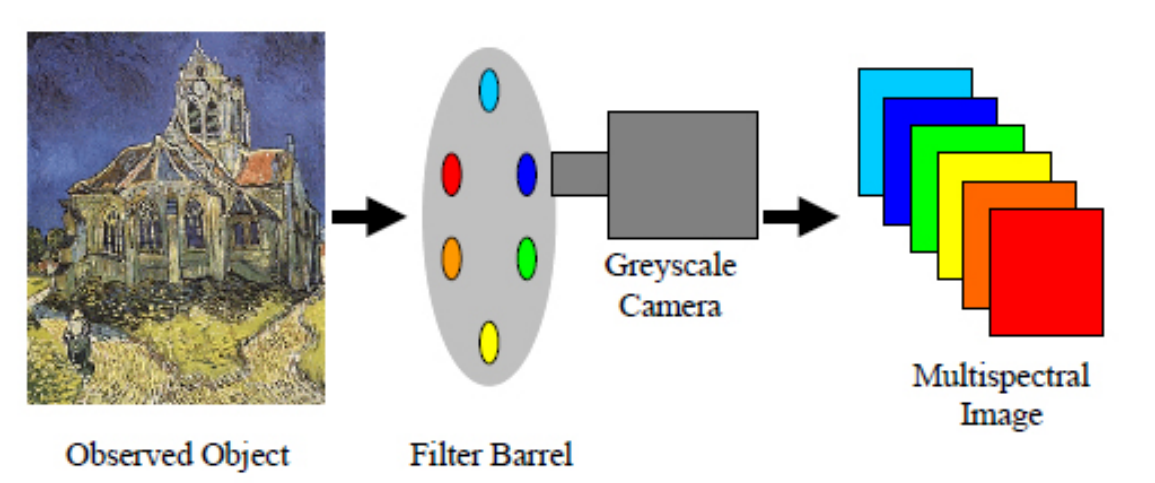
- Roy S. Berns, Lawrence A. Taplin, Francisco H. Imai
- Spectral Imaging of Matisse's Pot of Geraniums: A Case Study, IS&T 2003 Color Imaging Conference.

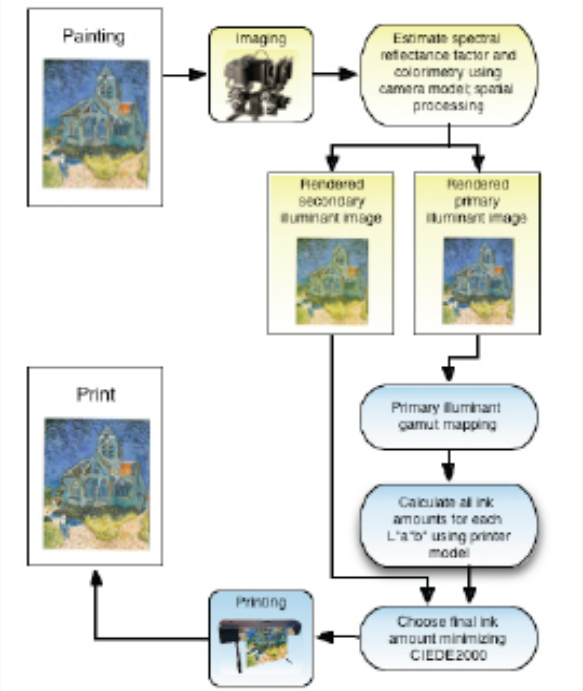




Prior Spectral Imaging System

- Berns, Roy S.; Taplin, Lawrence A.; Urban, Philipp; Zhao, Yonghui
- Spectral color reproduction of paintings, CGIV 2008 Final Program and Proceedings, pp. 484-488(5)
- 6 wide-band filters

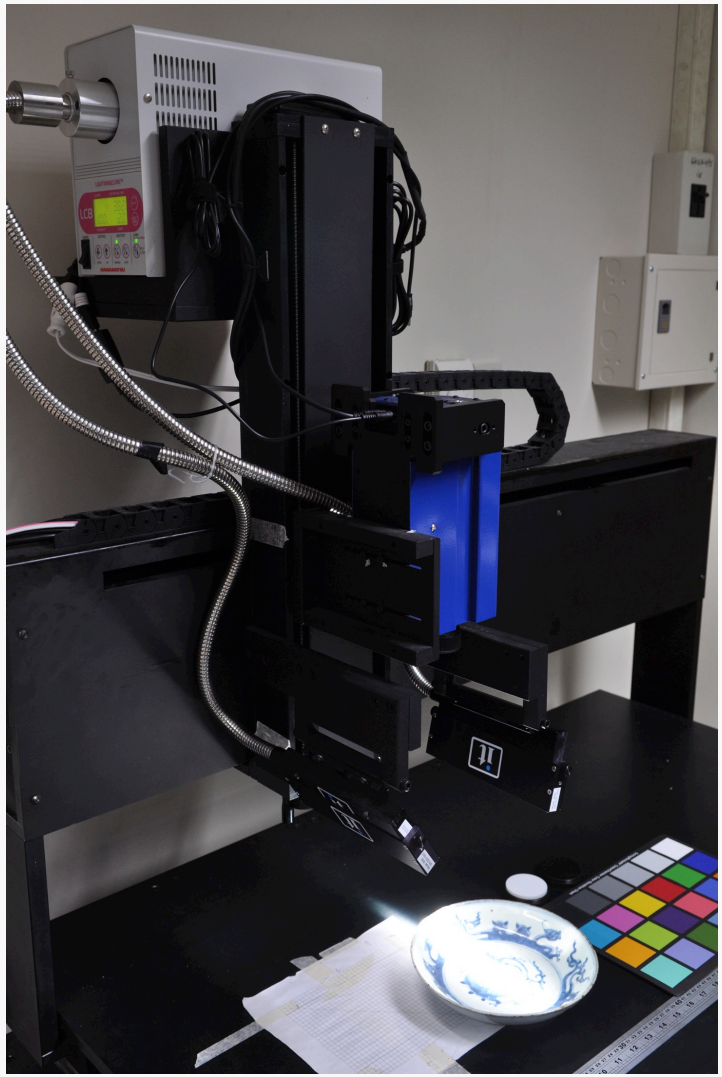




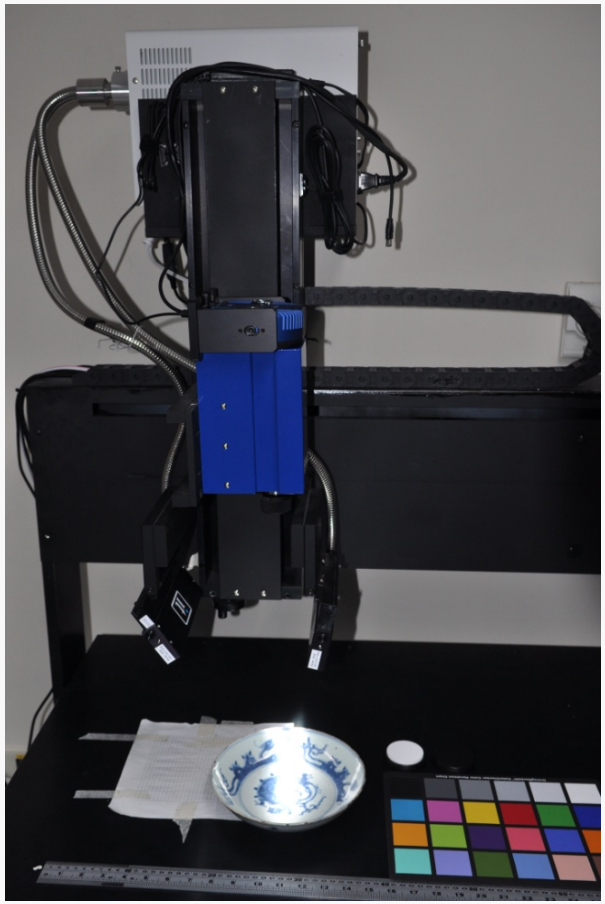
Spectral Imaging System at CCU

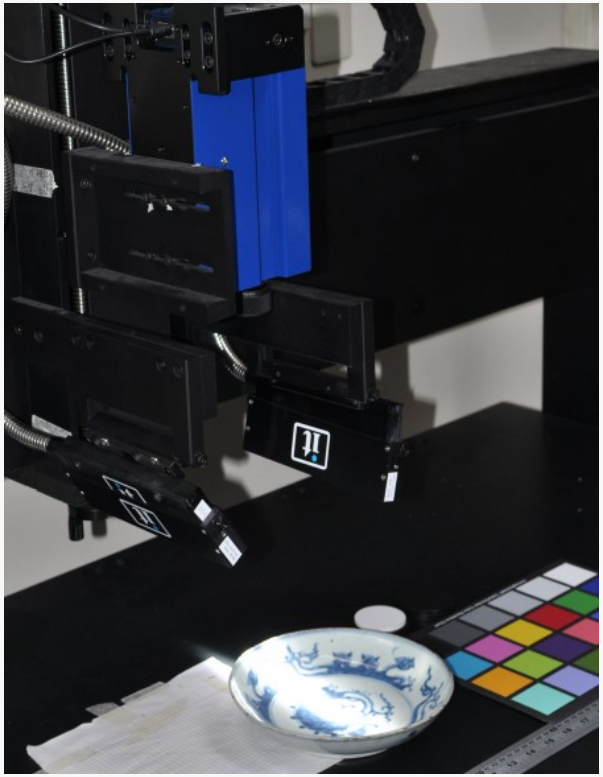
- Light Source
- Lens
- Spectrograph
- CCD camera (1600 pixels x 800 channel per line scan)
- X-Y scan bed
- Computer
- NAS Storage

- 10 times more color information than RGB image



CCU's Spectral Imaging System in Details

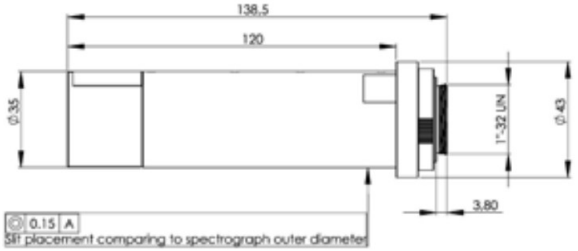




ImSpector Imaging Spectrographs

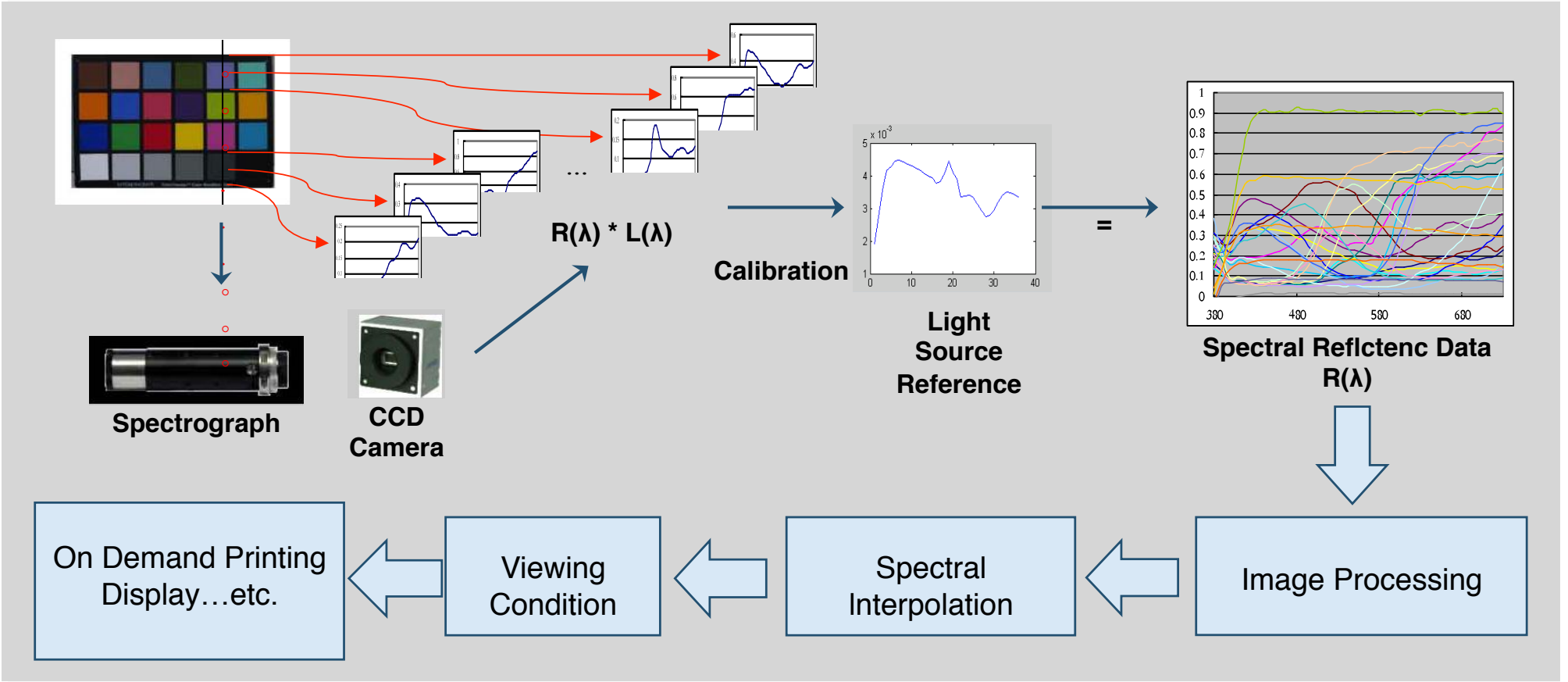
ImSpector V10

- Spectral range : 400 - 1000 NM
- Dispersion : 139 NM/mm
- Image size : 4.3 (spectral) x 6.6 (spatial) mm
- Spectral resolution : rms spot radius < 40 µm
- Numerical aperture : F/2.8



Workflow of Spectral Imaging

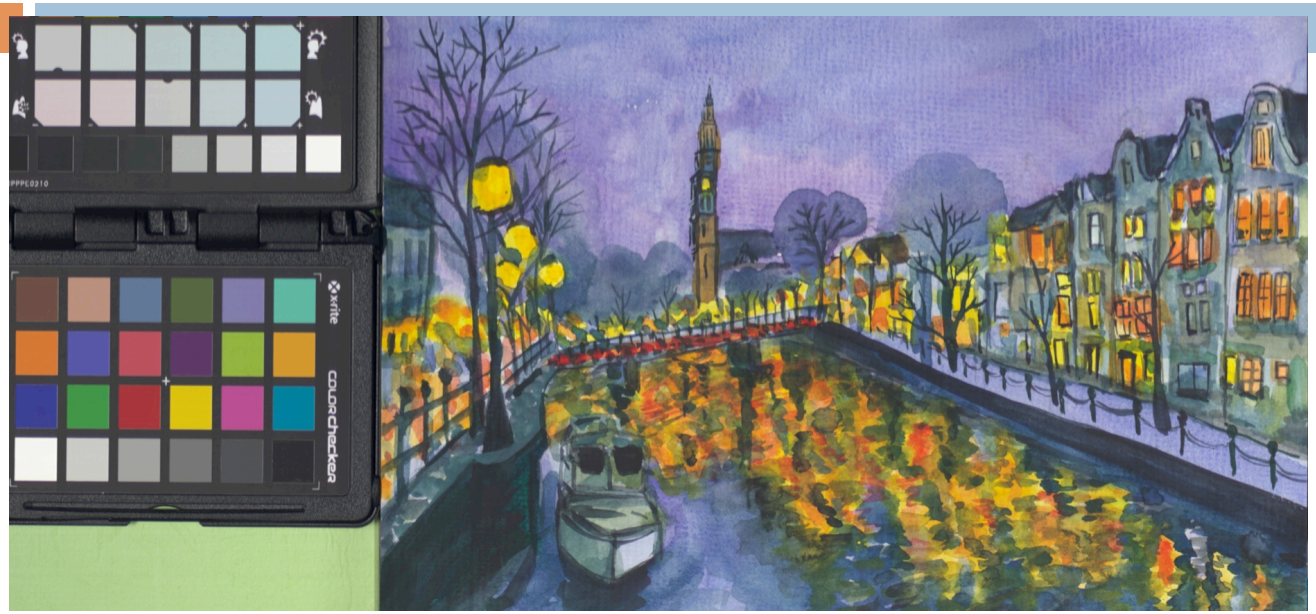
Workflow



Actual Reprint from Spectral Data

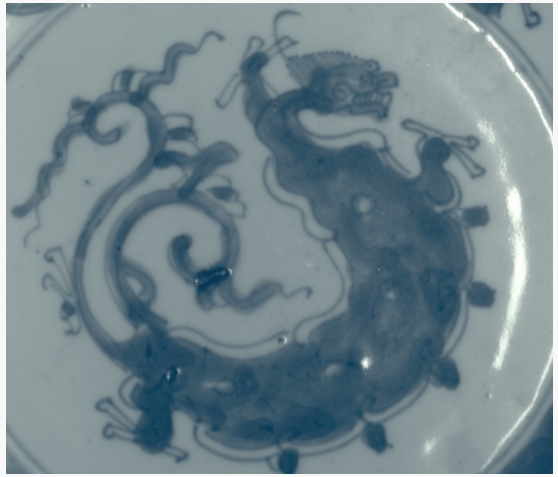
- Ink Jet Print ->
- Original ->

Simulated Reprint

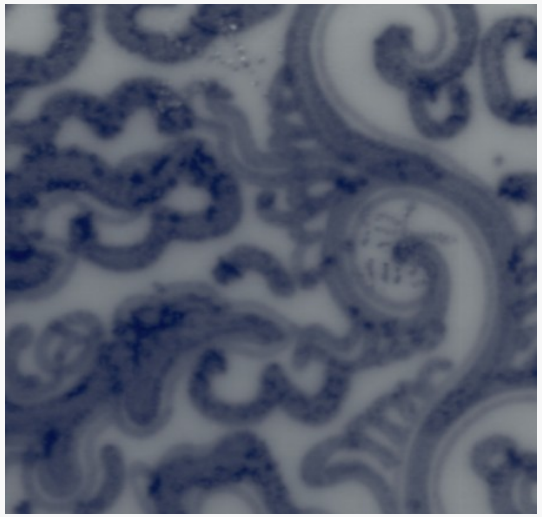


- CCT 6500K and CCT 3100K

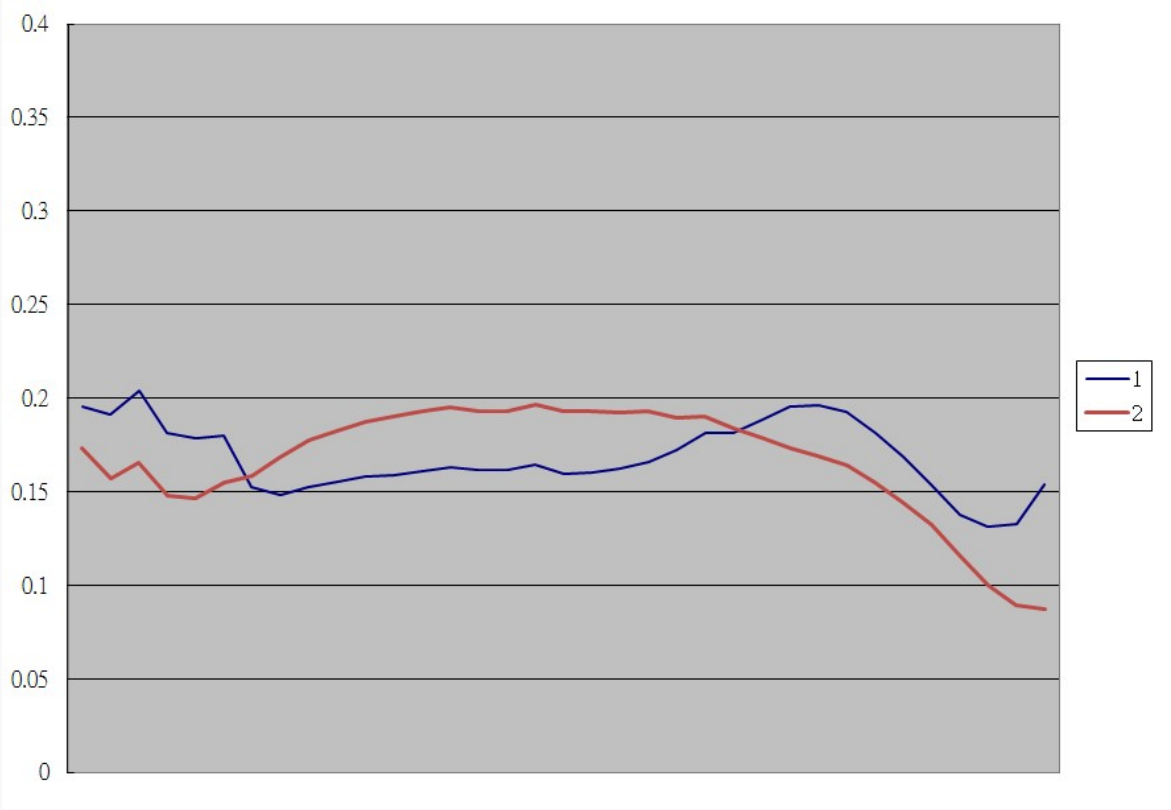
Spectral Analysis on Primary Colors



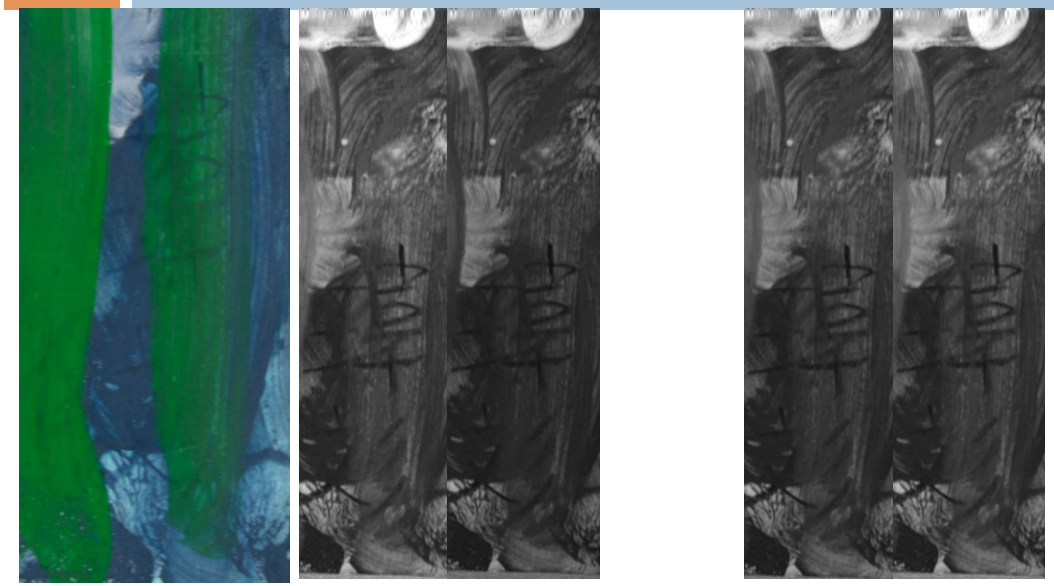
1



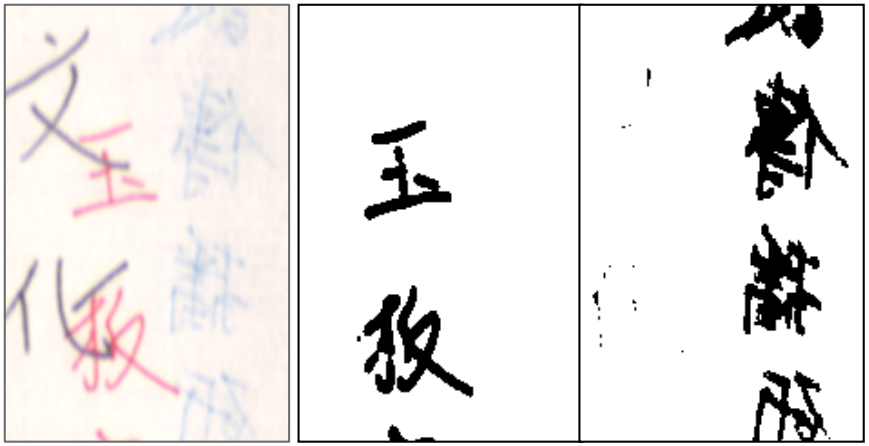
2



Monochromatic Analysis (Filtering)



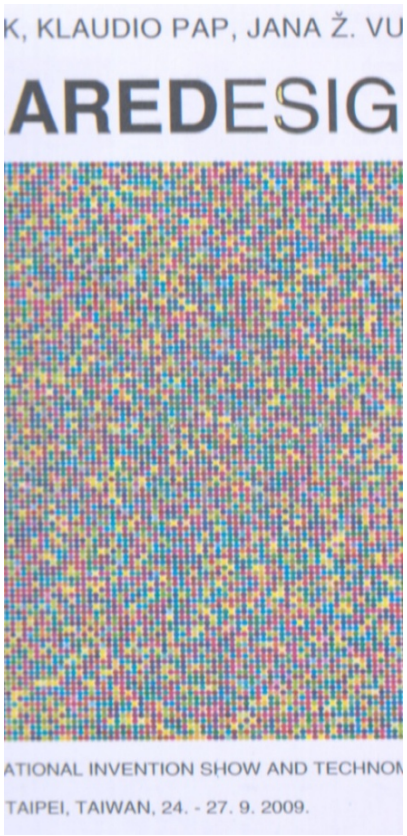
The signature can be identified better in narrow-band images in 830mm~870mm (IR range 830 nm from left in 10nm apart)

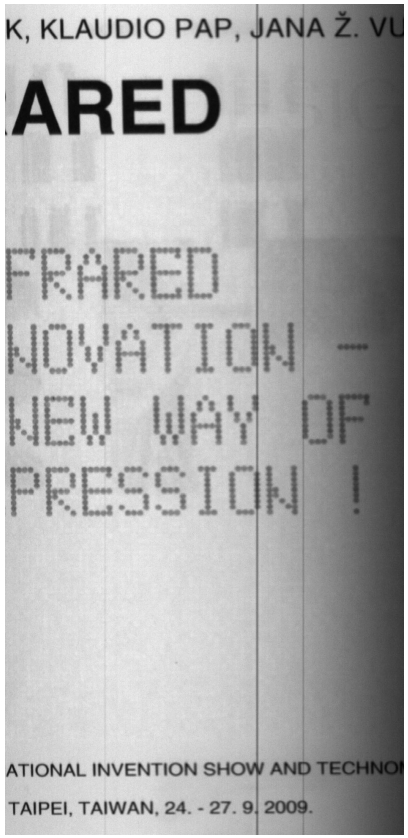


The see-through image on both sides of a paper (left) can be separated into two images (center and right).

Showing IR Watermarks

IR Analysis





Current Reproduction Workflow

- Get spectral reflectance values
- Define illuminant (D65)
- Compute CIELAB values

- Output with ICC printer profile
  - Rendering intent – absolute colorimetric

- Semi-close-loop reproduction

Implication for ICC Profile

- Being spectral…
- What should be embedded in the spectral image file for ICC tag ?
  - Which file format?
  - Dynamically allocated light source?
  - Selectable color matching functions?
- Considering gamut mapping in spectral form?
- Possible new rendering intent?

Summary

- Capture image in spectral form becomes popular.
- Currently CIELAB profile connection space is used.
- What can be done to fully utilize the power of spectral data with ICC structure?
- …

Q&A

THANKS FOR YOUR ATTENTION