Digital Color Imaging
HANDBOOK

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1.11.5.1 Principal-component recording

- Color recording device
  - Sample spectra of image with visual information
  - Extremely slow and expensive

- Scanner Visual Space
  - In the absence of noise
  - Karhunen-Loeve Transformation (Hotelling Trans.)
  - Obtain the best spectra by K principal components of the reflectance spectra
Smooth function of wavelength
  – Spectra represented by three and seven principal components
  – Significant reduction in dimensionality in comparison with spectrophotometric

Linear model based of the PCA
  – Recover illuminant and reflectance
  – Commercial color measuring devices by sensor
  – Analyzing multispectral satellite imagery
1.11.6 Quantization and coding

- Scalar and vector quantization
  - RGB channels with 8 to 12 bits per channel
  - Uniform quantization
  - Companded quantization (gamma correction)
  - Vector quantization
    - 8, 12, or 16 bits of video memory
Coding color image
- Transmission and storage
- Luminance-chrominance space is better than RGB
- Exploit the properties of human vision by allocating fewer bits to the high-frequency chrominance components
- JPEG for still image, MPEG for video data by DCT
- YCbCr space similar to L*a*b* space
1.11.7 Device color space

- Standard color space
  - Need standard color space for communicating between device's color spaces
  - sRGB
    - Based on the characteristics of CRT monitors
    - Using the CRT phosphor as primaries for determining the CMFs
    - Limitation in some respects
      - Cyan and bright yellow region in common printers
  - Standardized CMYK
    - Varying by SWOP, Euroscale and Japan Color
1.12 Color management and calibration

- Calibration in closed-loop configuration

Fig. 1.35. Closed-loop system calibration.
◆ Severe limitation
  – Increase of the number of devices
  – Difficult to construct and maintain each input-output device pair
  – Specific to one output device

◆ Device-independent color space (DVI)
  – Exchange of date between different devices
Fig. 1.36. Device-Independent color calibration.
1.12.1 Calibration and profiles

- Calibration
  - Input device
    - Mapping from device measurement value to DVI color descriptors
  - Output device
    - Mapping from DVI color descriptors to device control values
1.12.1.1 Input device calibration

◆ To calibrate a scanner
  – Select a collection of color patches
    • Span the gamut of interest
    • Avoid metamerism
  – Measure patches by measurement instrument
    • Spectrophotometer and colorimeter
    • Get the device-independent color values in CIELAB space
  – Measure patches by scanner
– Determine the CIE values for measured patch
  • Interpolating function and mapping from the space of scanner measurement values to the chosen DVI
  • Complicated and computationally
  • Using lookup table (LUT)

◆ Digital camera and video camera
  – Using similar fashion to scanner
  – Additional one-dimensional transform
    • Gray/white balancing
1.12.1.2 Output device calibration

- Forward and backward transformation
  - Printer characterization
    - Transform from printer control values to DVI color values
    - Using forward transform to determine the inverse mapping from DVI color values to device control values
  - CRT monitor
    - Represent by parametric models with forward transform
    - Simple matrix transformation by one dimensional transform for the gamma correction
Forward characterization of printer
- Selecting a set of printer control values
- Measuring the corresponding DVI color values
- Forward mapping with interpolation
  - From control value to DVI color values
- Get sampled LUT by interpolating function
- Under color removal (UCR)
  - Due to four degrees of freedom by CMYK
  - Reduce total colorant amounts and using of CMY colorants
1.12.1.3 Device profiles

- Calibration transformation
  - Available to different application
  - Store the device profile

- International color consortium (ICC)
  - Specifying a wide variety of input and output device profiles suitable for efficiently representing the color calibration information
1.12.2 Color management systems

- Color management system (CMS)
  - Interpreting the device profiles
  - Performing the appropriate transformations to and from the device-independent space
  - Perform at several different phases
    - In the devices (e.g., Adobe’s Postscript level 2/3 for printers), in device drivers (e.g., Cannon Colorgear), applications (e.g., Adobe’s Photoshop), or in the operating system (e.g., Apple’s ColorSync / Microsoft Windows)
Difficult to transfer color information
- Significant differences in gamuts of different devices
- Difference in typical viewing conditions for different media
  - Simple colorimetric mach does not give an appearance match

Need gamut mapping and appearance match
1.12.3 Gamut mapping

- Process of mapping the displayable colors from one media to those of another media
- Image dependent method
  - Different strategies for different images
  - Better results, but significantly slow
- Image independent method
  - Clipping in the space of device control values
  - Gamut compression algorithm
1.12.4 Appearance matching

- Different color reproduction media have different viewing condition

- White-point matching
  - Von Kries transformation
  - Converts tristimuli into a space of cone responses

- Characterize psychophysical effects
  - Apparent contrast of an image decreases in a dark surround in comparison to a bright surround
  - Gamma correction