The XYZLMS interim connection space for spectral image compression and reproduction

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Spectral image reproduction

- Advantages
  - No information loses
  - Avoiding metamerism
  - ...
- Questions
  - Large data storage
  - Not easy for spectral image processing, gamut description, gamut mapping in spectral space
  - ...

Spectral image reproduction

- Solution - ICS (Dimensionality Reduction of the spectral space)
  - With the constraints
    - Phsical meanings
    - Positive
    - Uniform
    - Compromise with PCS of ICC
    - …

Research

- PCA
- XYZXYZ
- LabPQR
- LabRGB
- ...

My Solution

- phenomenon

Spectrum → XYZ → Spectrum

60 Munsell chips　　Matrix R

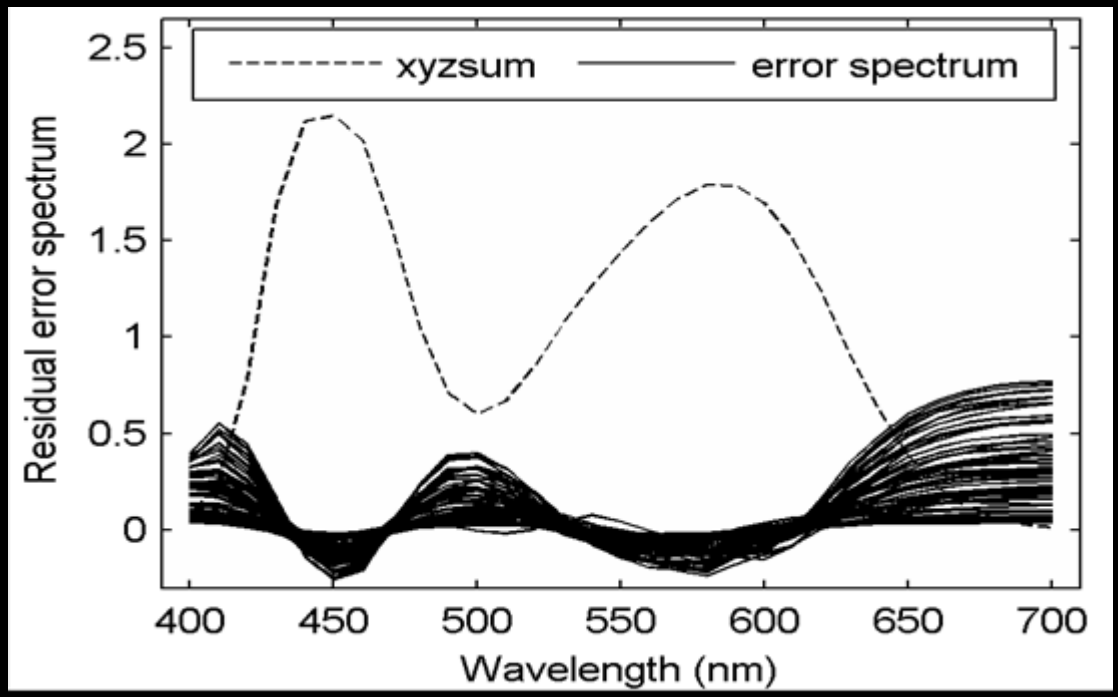


Fig.1 Comparison between the error spectrums and the visual sensitivity functions.

My Solution

- More importance should be shed on the visual insensitive region

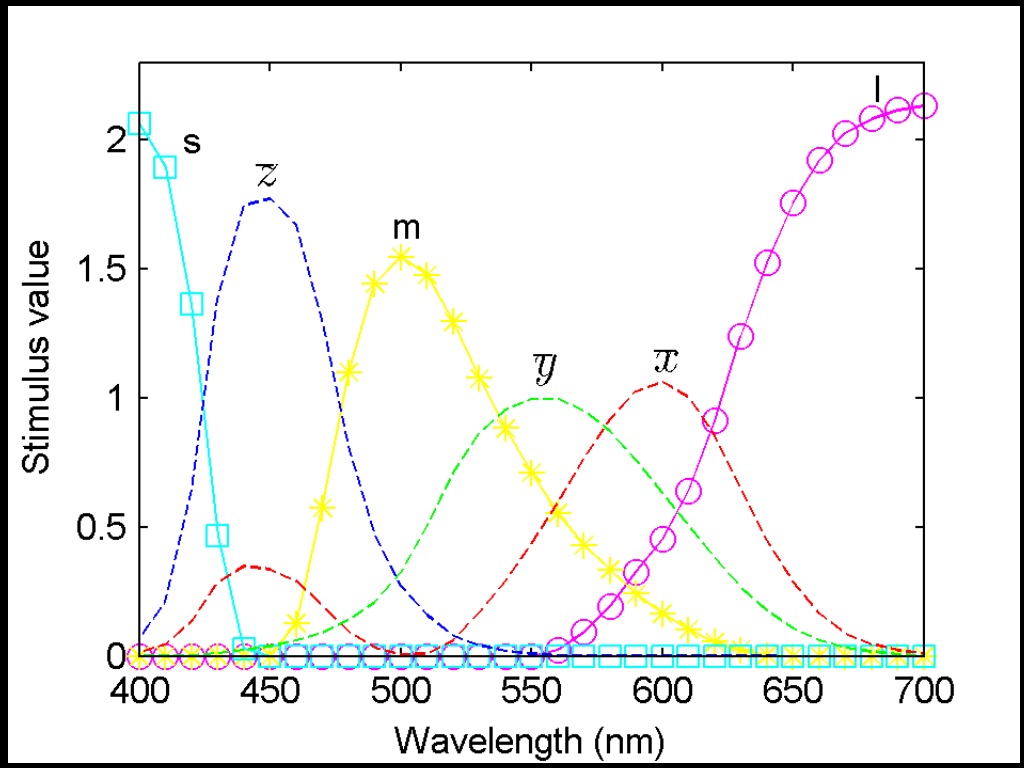
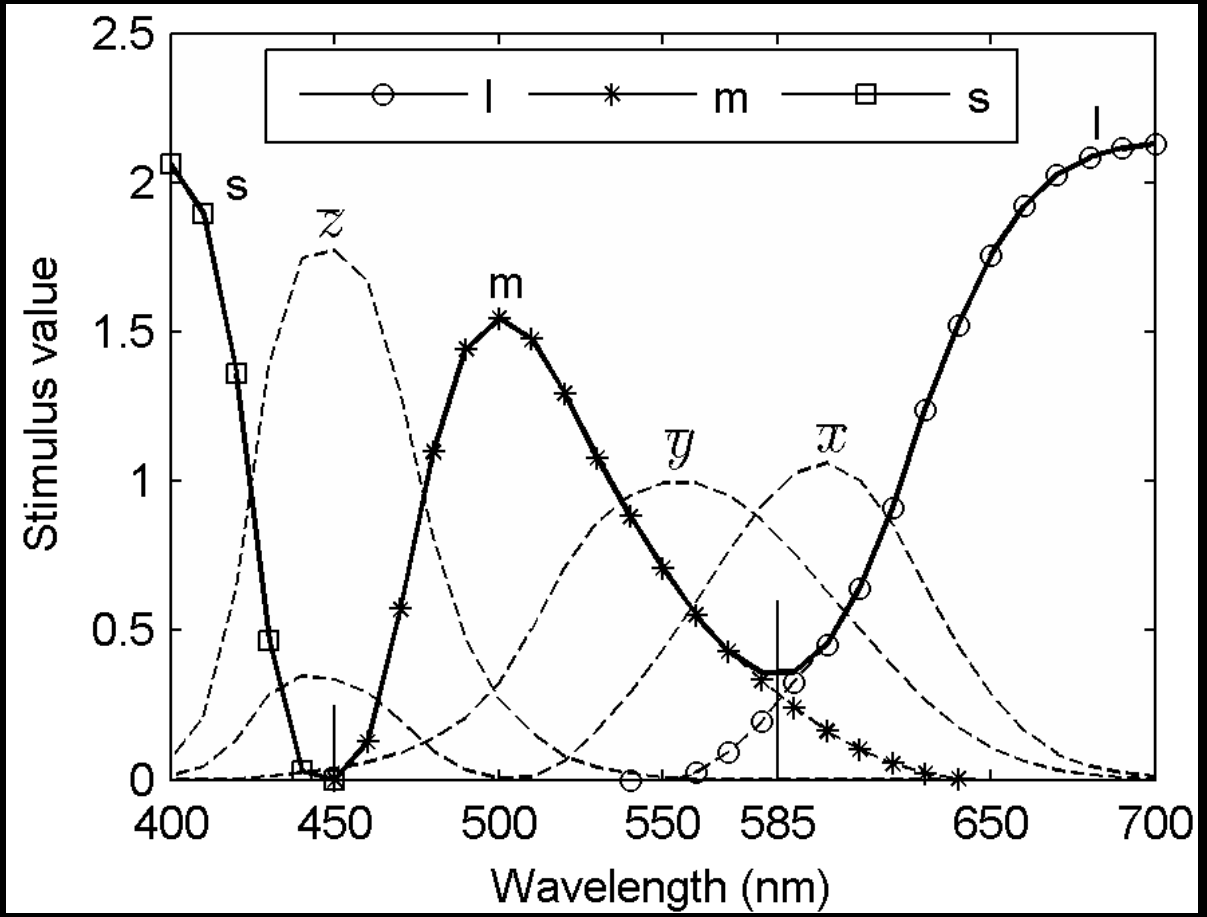


Fig.2 the CIE1931XYZ and constructed LMS functions.

How ?

$$v_{offset}(\lambda) = v_s(\lambda)_{\max} - v_s(\lambda)$$



Spectrum To XYZLMS

- To XYZ – traditional method
- To LMS

$$\mathbf{r_b} = \mathbf{r} - \mathbf{A}(\mathbf{A}'\mathbf{A})^{-1}\mathbf{t_1}$$

$$\mathbf{t_2} = k\mathbf{V_o}'\mathbf{P}\mathbf{r_b}$$

$$k = 100/\mathbf{m'i}$$

XYZLMS To Spectrum

1. $\tilde{\mathbf{r}}_c = \mathbf{A}(\mathbf{A}'\mathbf{A})^{-1}\mathbf{t}_1$

2. $\tilde{\mathbf{r}}_b = \mathbf{W}\mathbf{t}_2$

   $\mathbf{W} = \mathbf{N}_t \times \mathbf{PINV}(\mathbf{T}_{2t})$

3. $\tilde{\mathbf{r}} = \mathbf{r}_c + \tilde{\mathbf{r}}_b$

Verification

- Data sets
  - Training samples: Munsell atlas
  - Testing samples:

    (1) Munsell atlas

    (2) Mixed spectrum sets (NCS, IT8.7/2, Lumber and Forest)

    (3) Two spectral images

$$\text{Spectrum} \Rightarrow \left\{ \begin{array}{c} \text{LabPQR} \\ \text{LabRGB} \\ \text{XYZLMS} \end{array} \right\} \Rightarrow \text{Spectrum}$$

Results - RMSE

- Table 1. The RMSE statistics of the three ICS.

Testing samples	XYZLMS		LabPQR		LabRGB	
	Mean	Max.	Mean	Max.	Mean	Max.
Munsell	0.0095	0.0569	0.0110	0.0571	0.0405	0.0919
Mixed sets	0.0103	0.0775	0.0108	0.0779	0.0344	0.1348
Image1	0.0124	0.0340	0.0144	0.0346	0.0530	0.1010
Image2	0.0180	0.0670	0.0196	0.0677	0.0303	0.1037

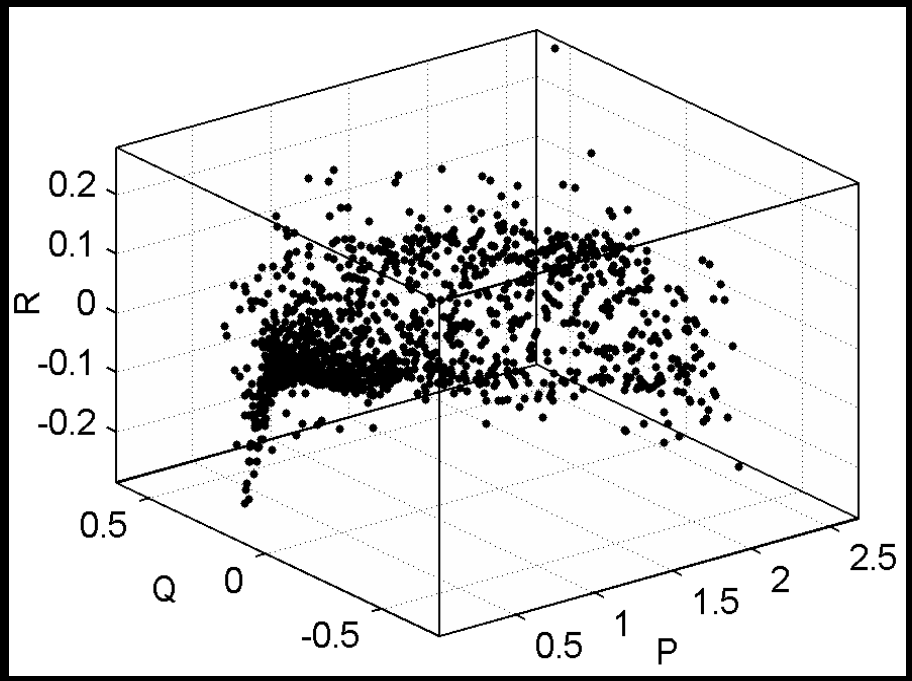
Results – ΔE^*_{ab}

- Under A, D50, D65, D90, F2, F7, F11, four actual LED light sources

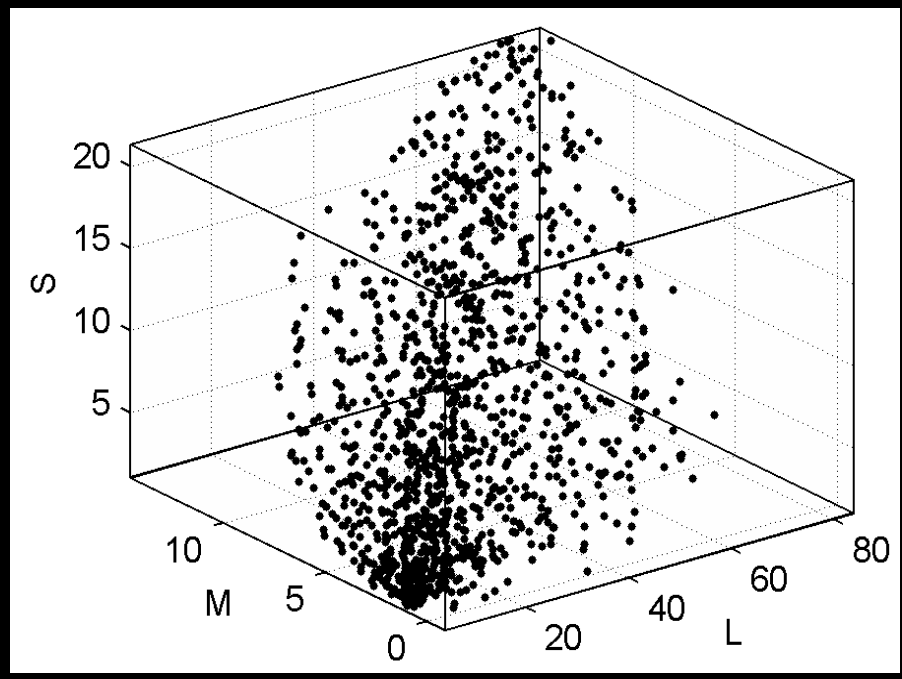
Table 2 The CIELAB color difference statistics of the three ICS.

Testing samples	XYZLMS		LabPQR		LabRGB	
	Mean	Max.	Mean	Max.	Mean	Max.
Munsell	0.155	2.148	0.230	2.640	0.323	1.498
Mixed sets	0.164	2.082	0.210	2.974	0.312	1.920
Image1	0.210	0.594	0.310	1.171	0.671	1.266
Image2	0.601	3.255	0.671	4.166	0.748	4.136

Distribution comparison between PQR and LMS values of Munsell Altas



PQR



LMS

Conclusion

- New ICS (XYZLMS) was defined;
- With higher competitive for spectral image compression and reproduction

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Thanks for your attention!
Welcom to Hangzhou!