

Discovering Connections!

Analysis of black ink sketches with Uniform Manifold Approximation and Projection

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Hyperspectral imaging (HSI) to study black ink

- **Black ink** is a typical artist medium for drawing and sketching
- Modern black ink formulations may be pigment based, dye based or a combination of both
- **Hyperspectral imaging (HSI)** is a **non-invasive analysis technique**, which is particularly useful in the identification of pigments and colourants on cultural heritage objects
- Capable of generating a reflectance image with the associated reflectance spectra at each pixel
- Result is a large datacube composed of millions of spectra
- Machine learning models have emerged to provide effective data dimensional reduction and visualization

Wu Guanzhong

- **Wu Guanzhong (1919-2010)** was a Chinese master painter of the twentieth century
- One of the first Chinese artists to have studied at the École Nationale Supérieure des Beaux-arts in Paris in 1947
- Renowned for his unique perspective and style that combines and unifies Chinese and Western art traditions, he inspired a new direction for **modern Chinese art**

Analysis of WGZ's black ink sketches

- A selection of **five black ink sketches** from the WGZ collection of the Hong Kong Museum of Art were studied to investigate the media used in these artworks
- Wu was well known for his habit of outdoor sketching, these artworks were created during his travels to **Paris and the USA in 1989**
- HSI data was collected on the sketches then their datasets processed within one unsupervised learning model - **Uniform Manifold Approximation and Projection (UMAP)**

Selected References

Reed, K. Savage, D. Edwards and N. N. Daeid, Hyperspectral imaging of gel pen inks: An emerging tools in document analysis, *Science and Justice* 54 (2014) 71-80.
 M. Vermeulen, K. Smith, K. Eremin, G. Rayner and M. Walton, Application of Uniform Manifold Approximation and Projection (UMAP) in spectral imaging of artworks, *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 252 (2021) 119547.
 M. Vermeulen, L. Burgio, N. Vandepierre, E. Driscoll, M. Viljoen, J. Woo and M. Leona, Beyond the connoisseurship approach: creating a chronology in Hokusai prints using non-invasive techniques and multivariate data analysis, *Heritage Science* 8 (62) (2020).

Data Acquisition

VNIR Data (400-800nm)



Data acquired with HySpex VNIR-1800 (400-1000nm)

Data Pre-treatment

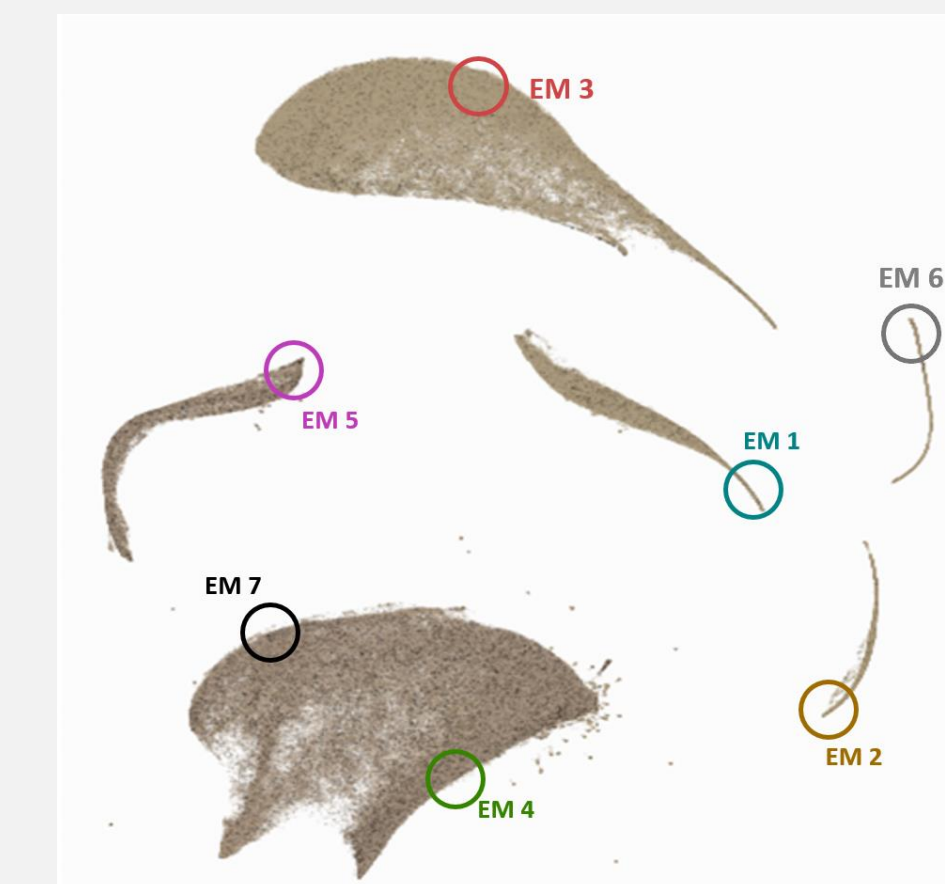
Masked Data



Masked areas are displayed in black against the unmasked areas

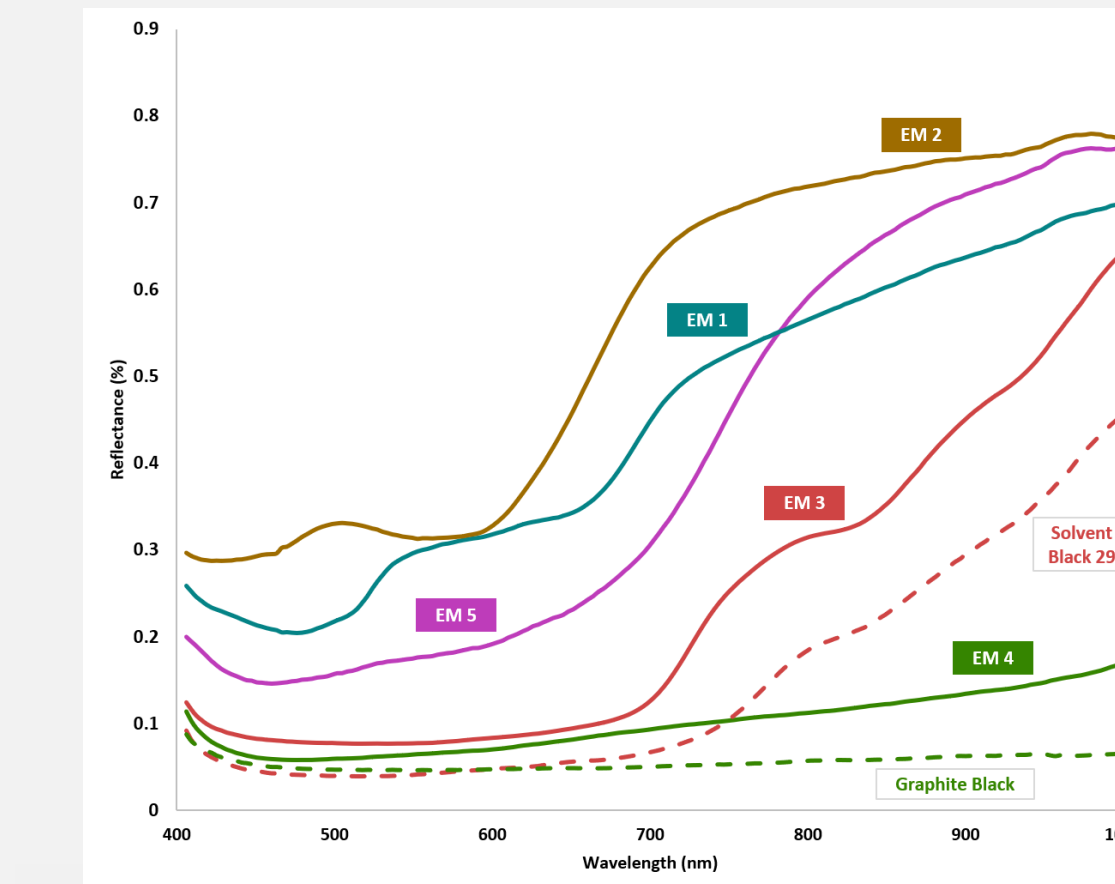
Data Clustering and Mapping

UMAP Scatter Plot



EM1-EM5: each cluster (endmember) represents a different black ink; EM6: the artist's signature red seal; EM7: remainder of the paper substrate

Endmember (EM) Spectrum



Reflectance spectra (EM1-5) of 5 different inks; in dashed lines are reference materials – Solvent Black 29 (Alfa Chemistry) and Graphite Black (Kremer 47710)

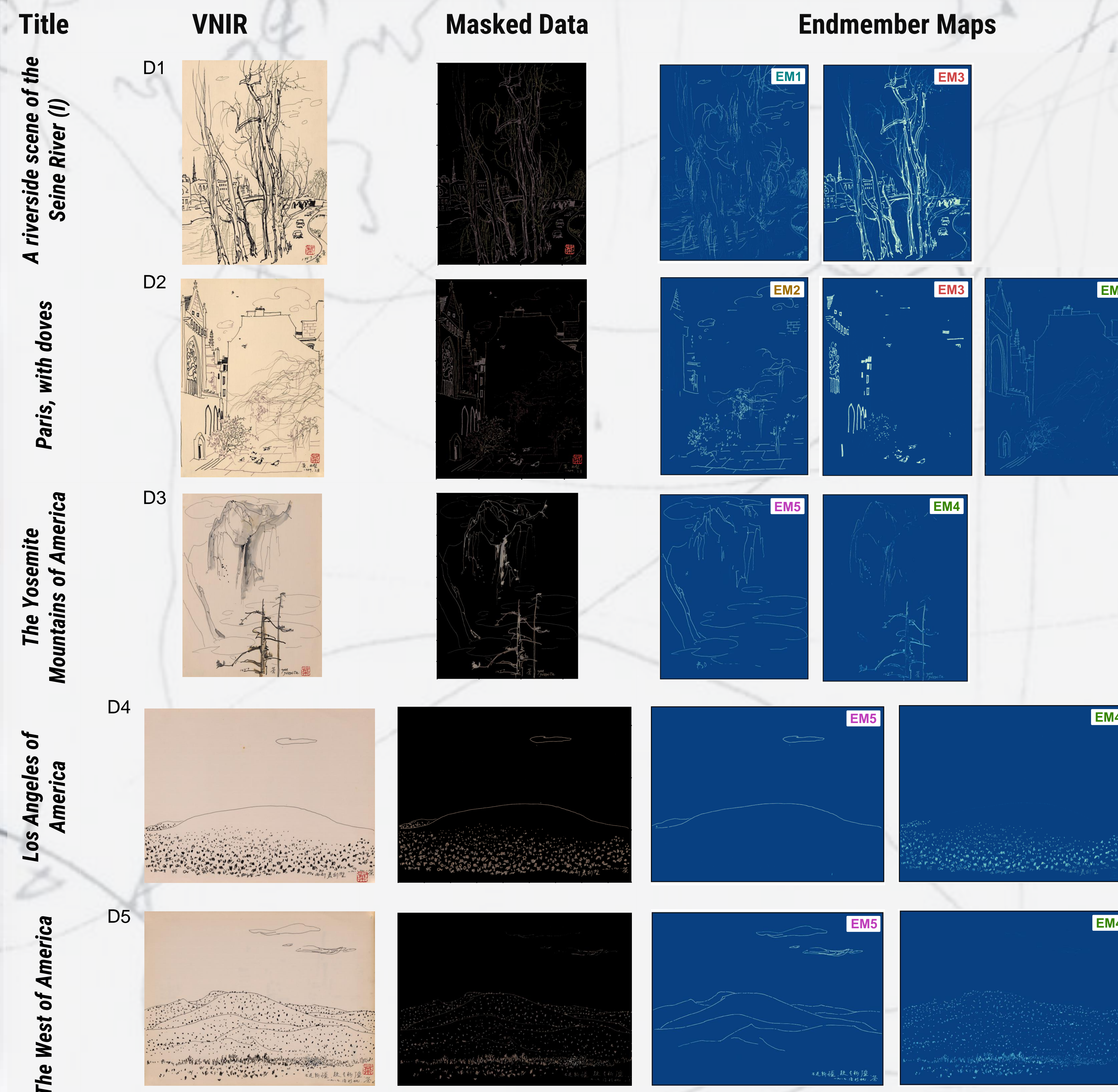
Workflow

EM Maps



Pixels (areas) corresponding to the EM spectra are highlighted in the respective maps

For the purposes of this study EM6-7 will not be discussed further



Results & Conclusion

- **EM1-3,5:** all **dye based black colourants**, their reflectance spectra all exhibit distinctive features with potential for identification
- Spectral features of **EM3** is consistent with that of **Solvent Black 29**
- **EM4:** flat and featureless reflectance spectrum is characteristic of **carbon black pigment**

Location Drawing	Paris, 1989		USA, 1989		
	D1	D2	D3	D4	D5
EM1	█				
EM2		█			
EM3	█	█			
EM4			█	█	
EM5					█

- **2 inks** (EM4-5) are consistently found in the **USA sketches D3-5**
- 4 types of inks (EM1-4) are found in the Paris sketches D1-2
- 1 particular ink (EM3) is present in both **D1-2**, observing these sketches and their **EM3 maps**, this ink was possibly delivered in the form of a **broad tip marker pen** which was used to create the effect of shadows and to emphasize the darker tones

Discussion

- **Data masking** step has proved to be crucial in this study to separate and remove the off-white paper substrate (background) from the black inked areas (subject), **distilling and reducing the size of datasets, processing power and time**
- Enables the processing of **multiple datasets within one UMAP model**
- HSI as a **fast screening** technique to discern between **pigment and dye based black inks**
- Differentiating the sketch lines has offered more insight into the **artistic creation process**
- UMAP has proved to successfully draw a **connection between artworks**
- Potential to develop into a **chronological study** of artist black ink drawings