Segmentation non-supervisée des IHS dans l'espace des matrices de covariance

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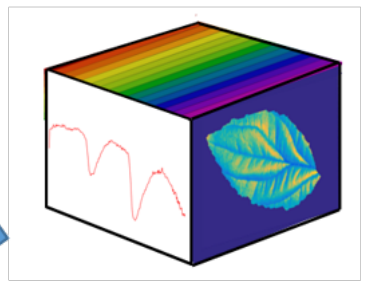
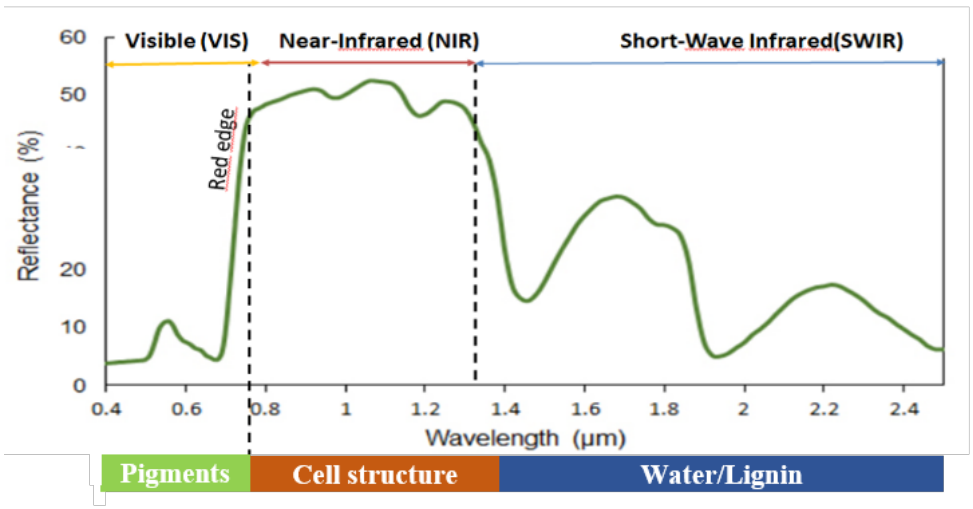
Préambule: Développer de nouveaux descripteurs spectro-spatiaux pour modeliser les images hyperspectrales

HSI

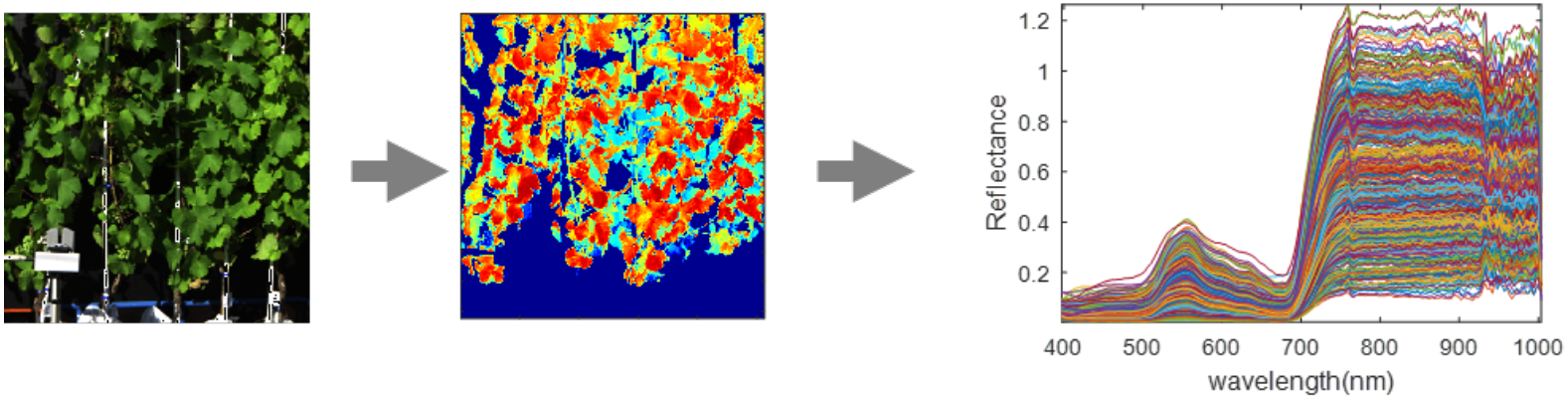


Spectral domain



Spatial patterns

Traitement des IHS

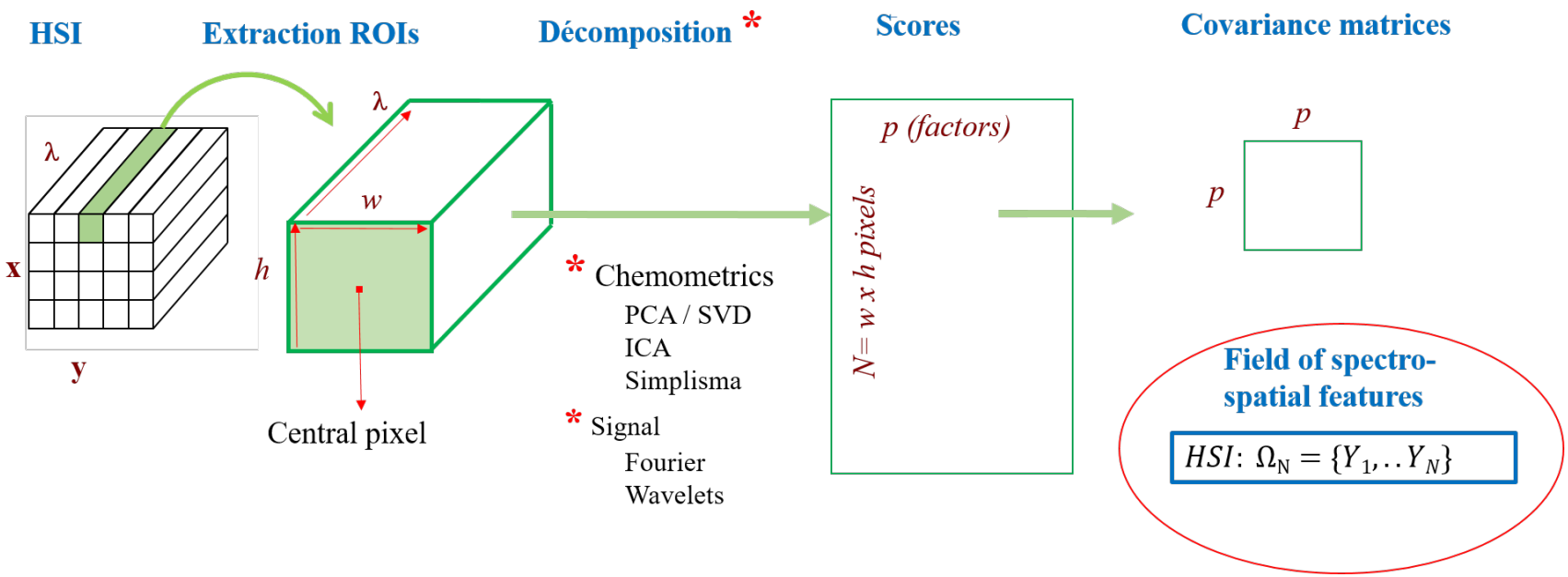


Approches existantes

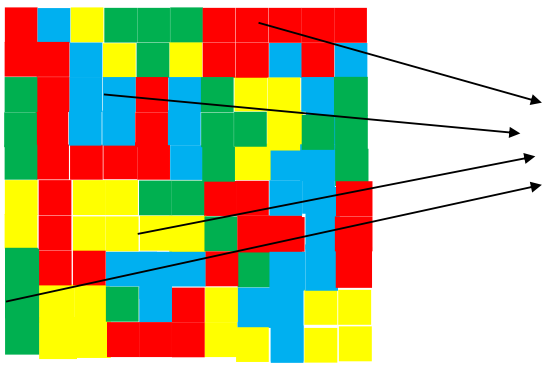
- Déplier + réduire: moyenne, bining, échantillonage (ESP, KS)
- Contraintes spatiales dans modèle spectrale (*e.g.* MCR)
- Séquentielles: réduction spectrale → imagerie monochromatique
- Hybrides: Fusion de données, Deep Learning, Co-clustering

Analyser les IHS dans l'espace des matrices de covariance

IHS décomposition ⟶ Champ de matrices de covariance



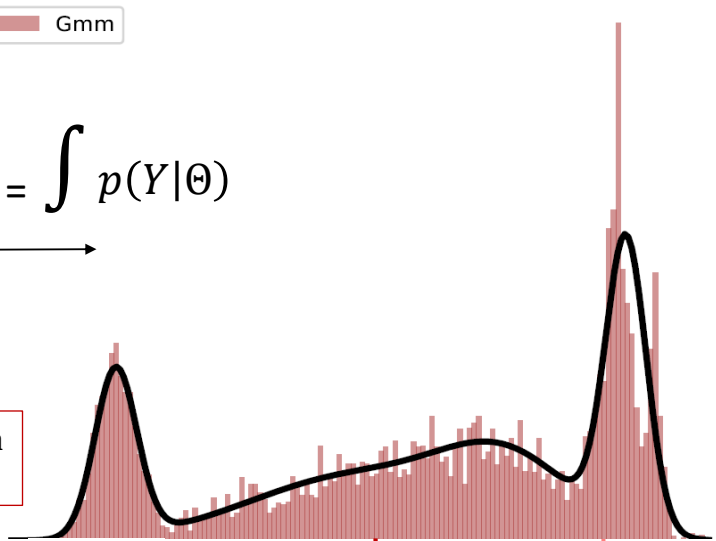
Approche proposée: Modèle mélange Gaussien (Riemannien) Maximum de vraisemblance (MLE)



$\{Y_{nk}\}$

Pdf observed

$$Y_n \sim F(Y, \Theta) = \int p(Y|\Theta)$$



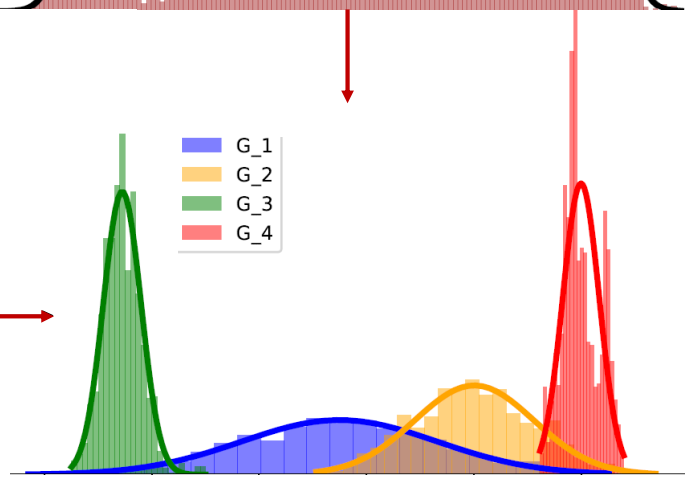
Expectation – Maximization Algorithm

K classes $\subset \Omega_N = \{Y_1, \dots Y_N\}$

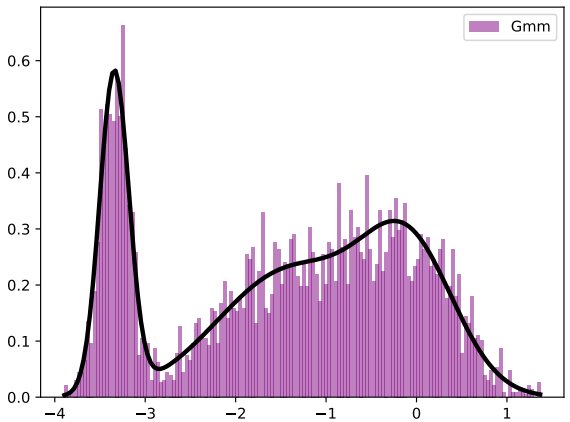
$$\hat{\Theta} = \{\theta_1, \dots, \theta_k\}$$

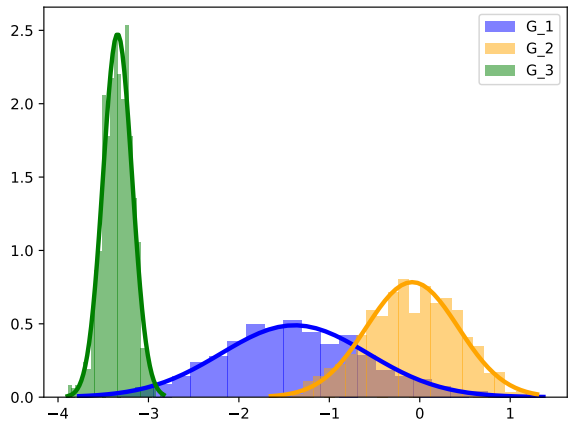
Mixture:

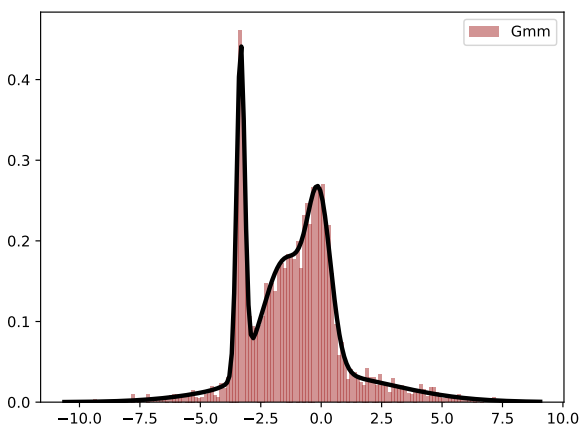
$$p(Y|\Theta) = \sum_k \omega_k \times p(Y = Y_k|\theta_k)$$

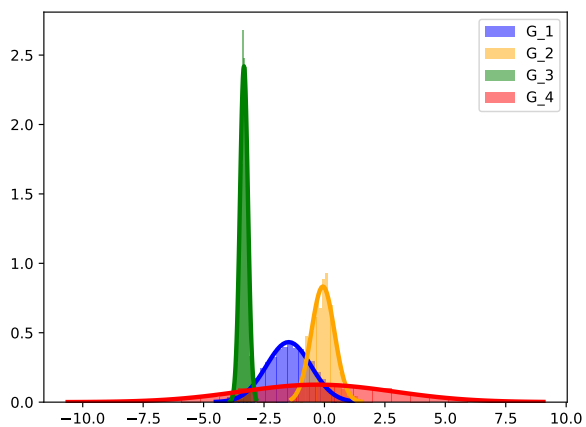


$\mathcal{G}$mm: représenter une grande diversité de distributions

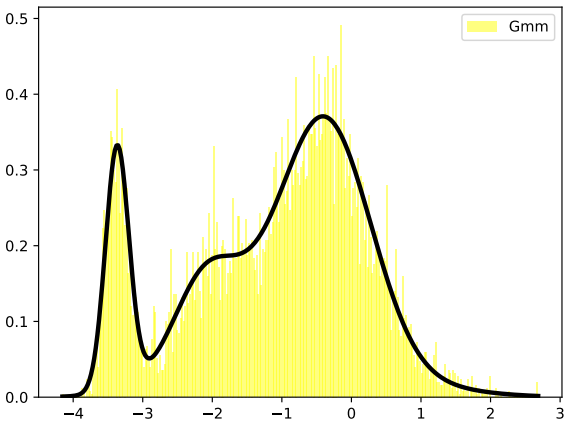


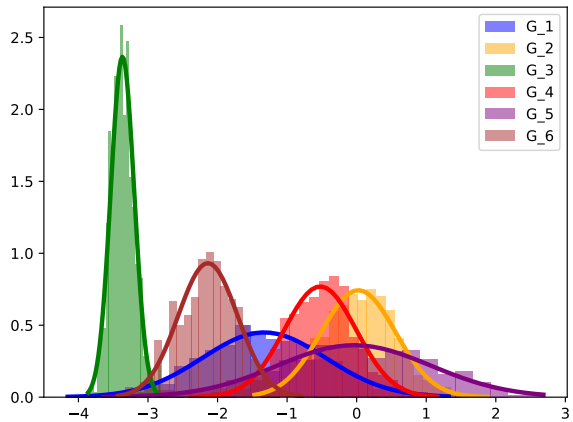


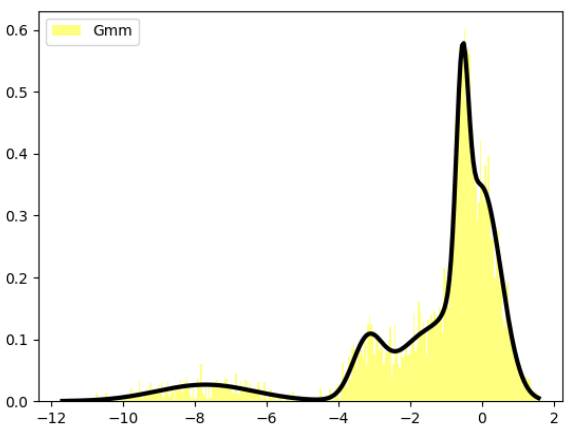


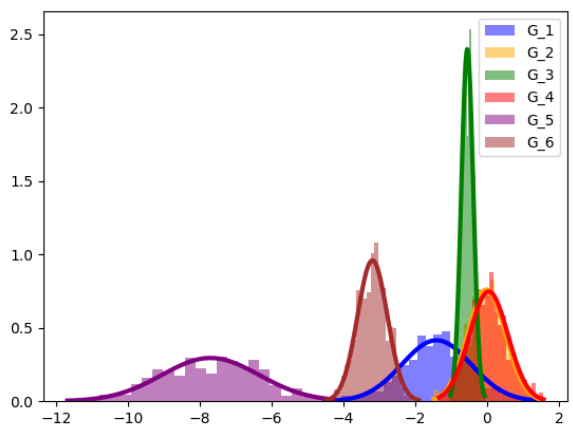


EM: démélanger des modèles complexes

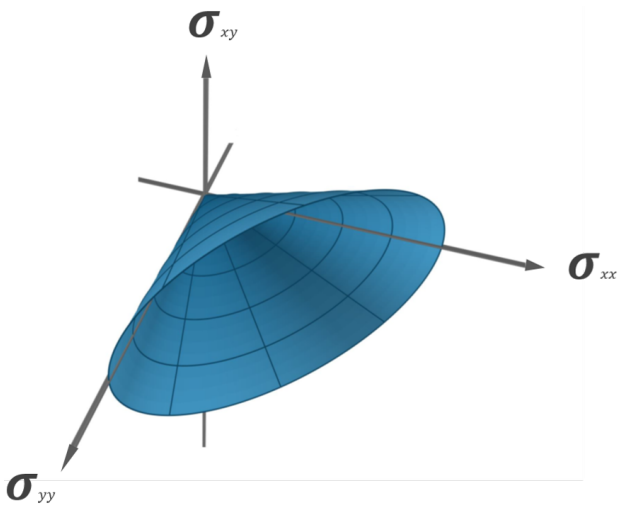








L'espace des matrices de covariances: un espace courbe particulier



$\mathcal{P}_2$ représentation 3-D

Variété Riemannienne

$Y - Y^T = 0$ (Symétrie)

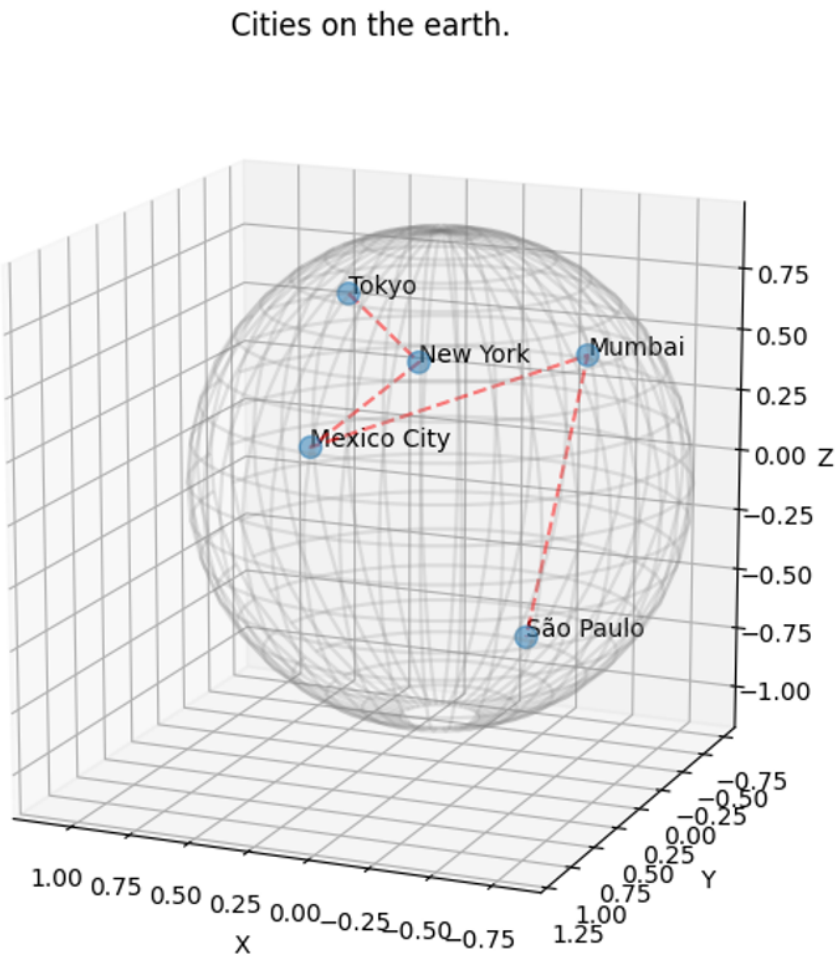
$x^T Y x \geq 0 \quad \rightarrow \quad det(Y) \geq 0$

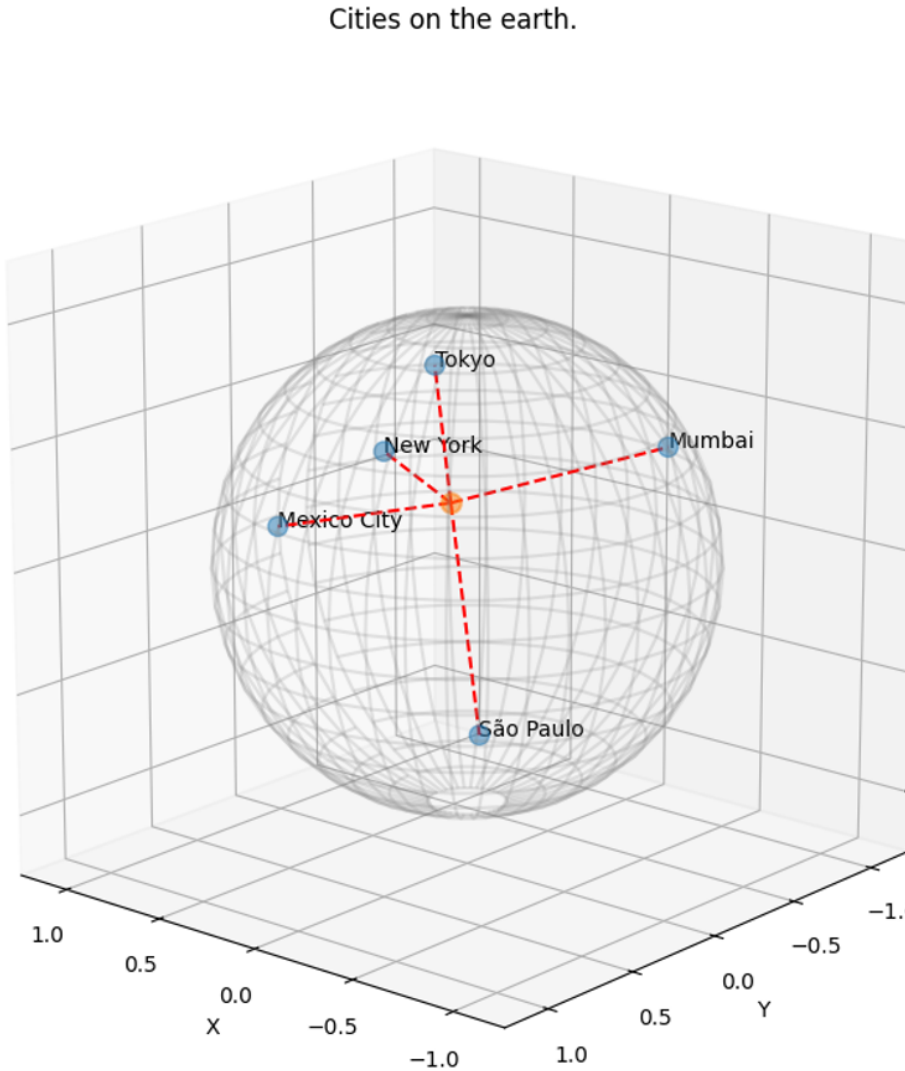
$x \neq 0$ column vector $\in \mathbb{R}_m$

(Valeures propres positives)

$$Y = \begin{bmatrix} \sigma_{xx} & \sigma_{xy} \\ \sigma_{yx} & \sigma_{yy} \end{bmatrix} \qquad |\sigma_{xy}| \leq \sigma_{xx}\sigma_{yy}$$

Visualise Manifold and Geodesic distance





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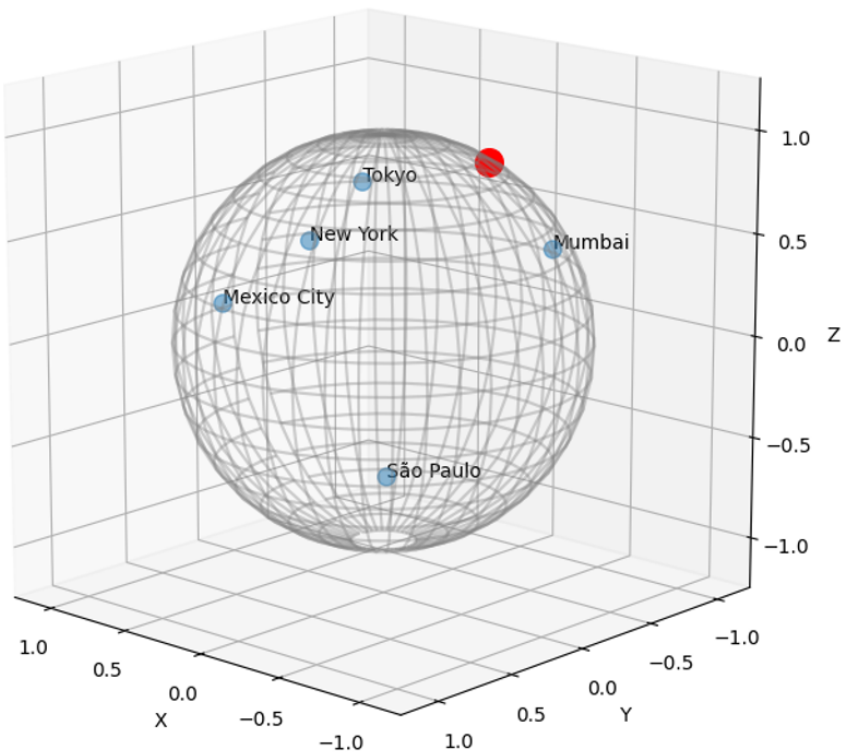
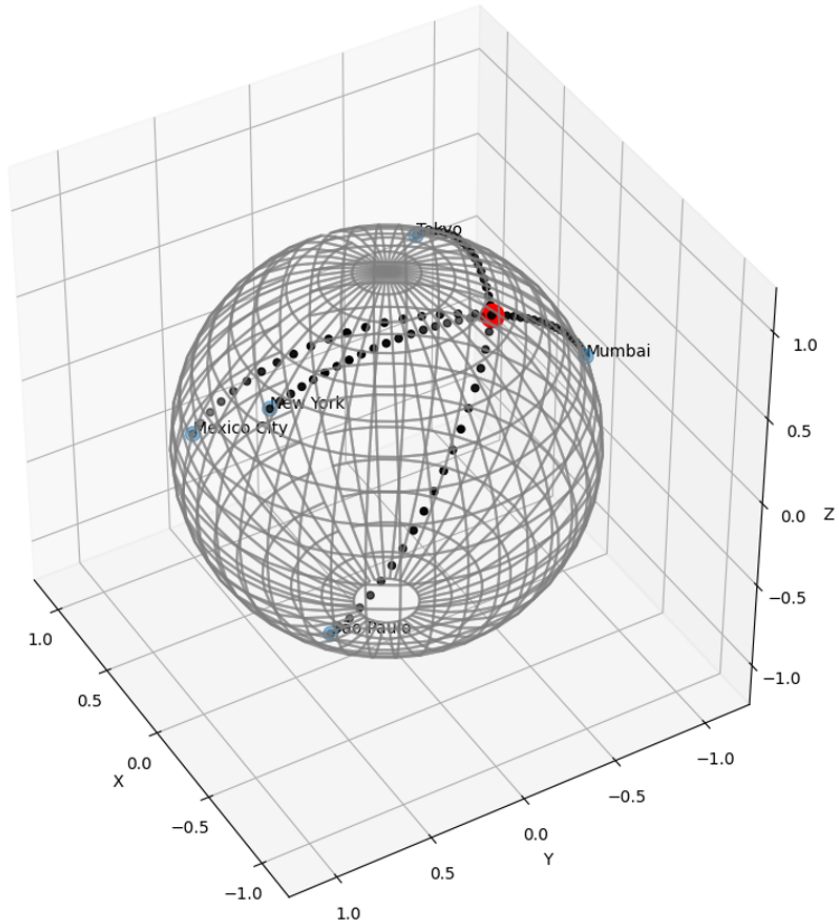
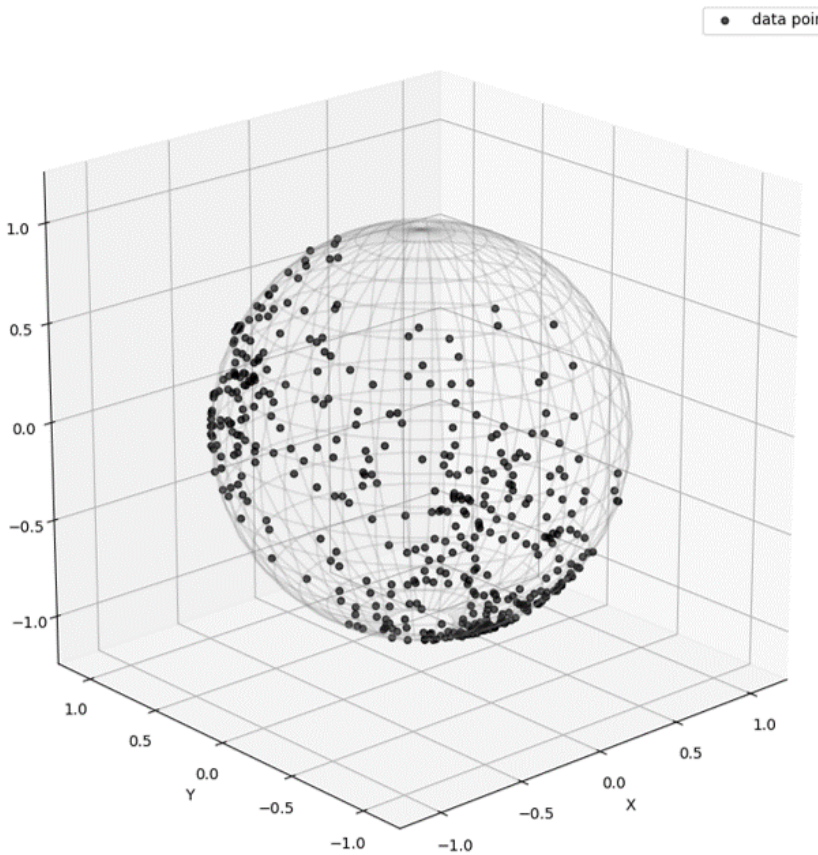
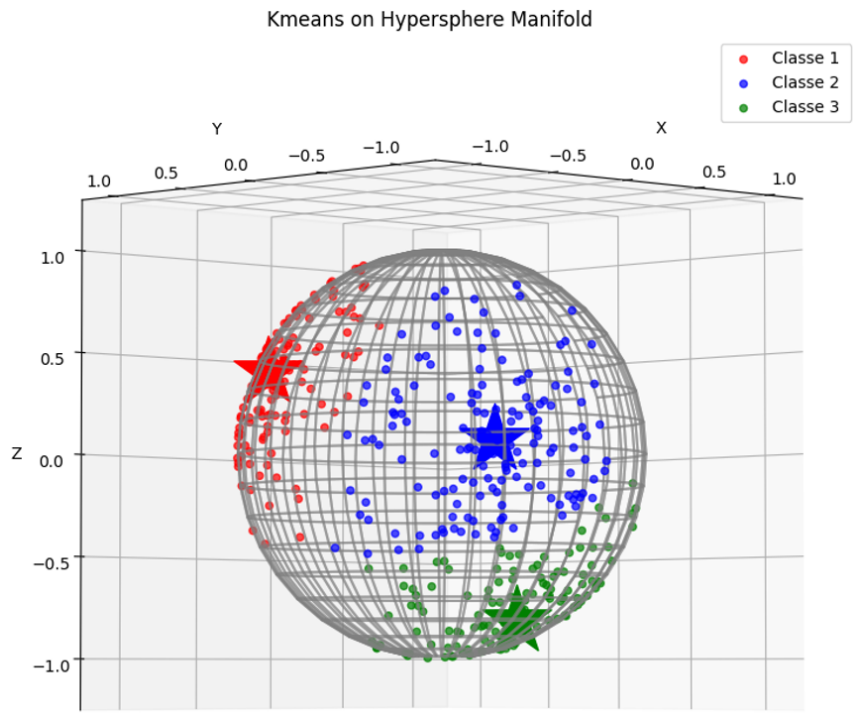


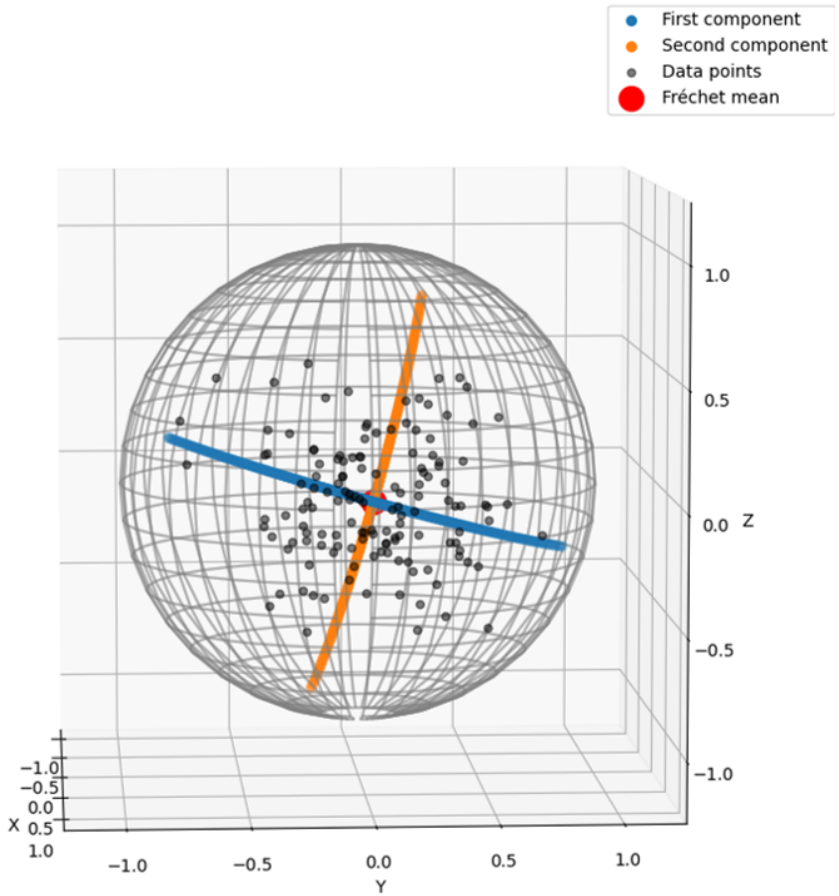


Kmeans on Manifolds

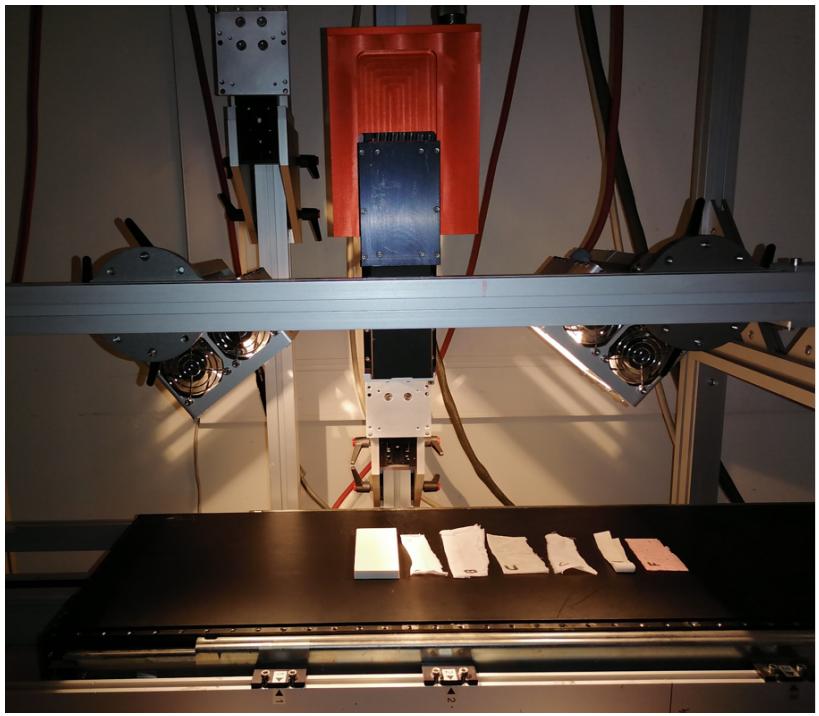


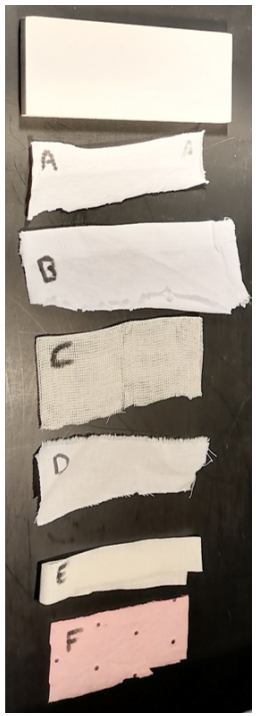


PCA on Manifolds



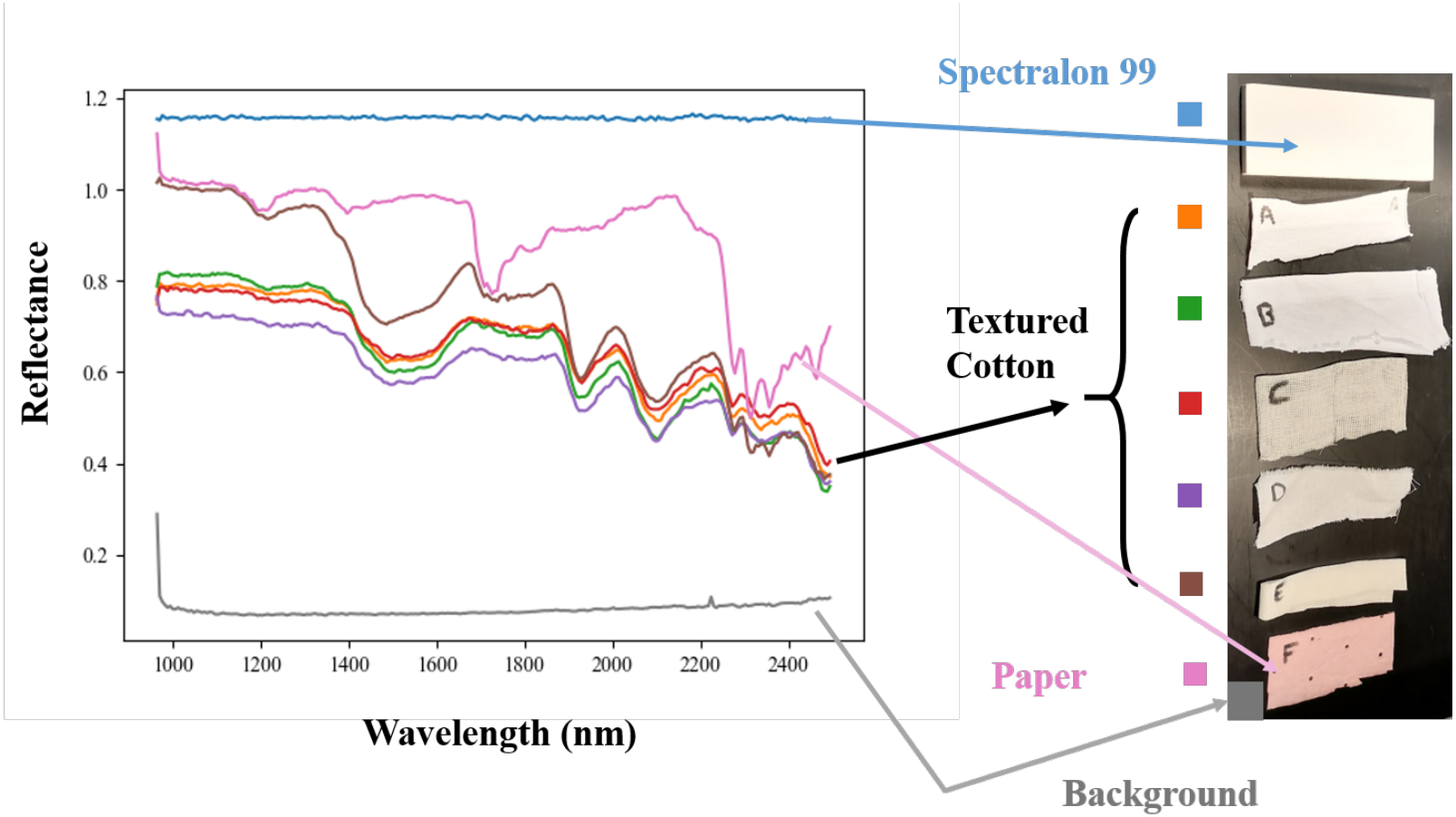
Application:Toy example



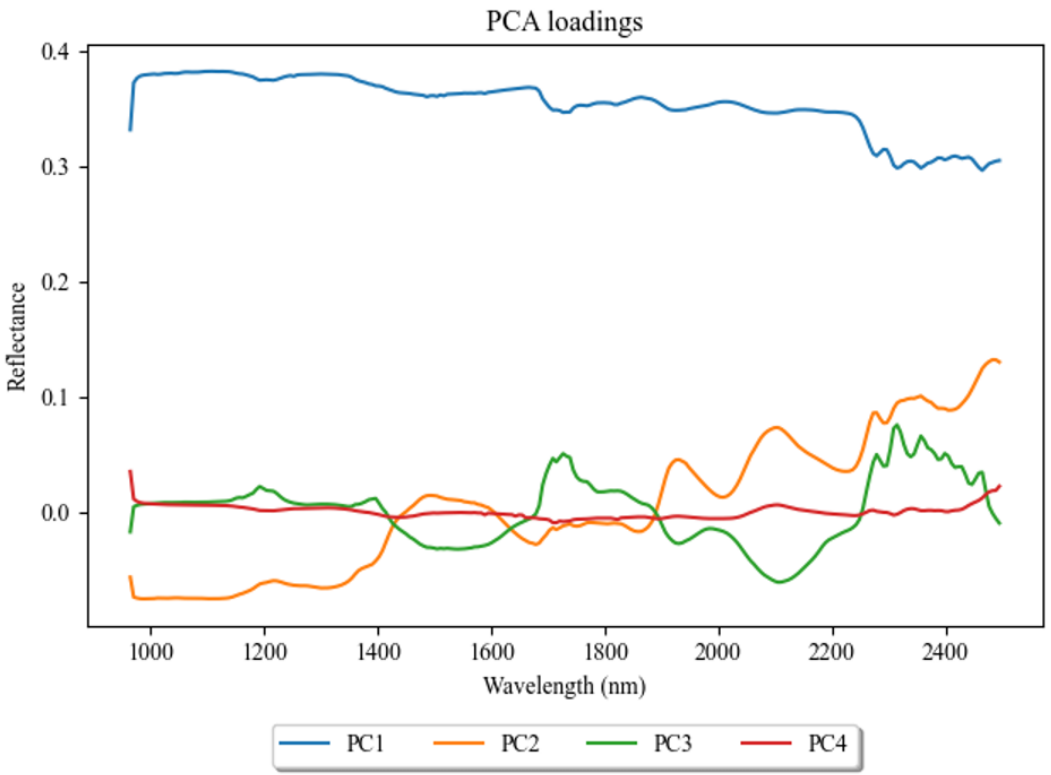


- Textured Cotton and paper
- Hyspex Neo SWIR [1000-2500]nm
- White ref 99%(Spectralon TiO_2)

Des objets chimiquements identiques



Analyse purement spectrale



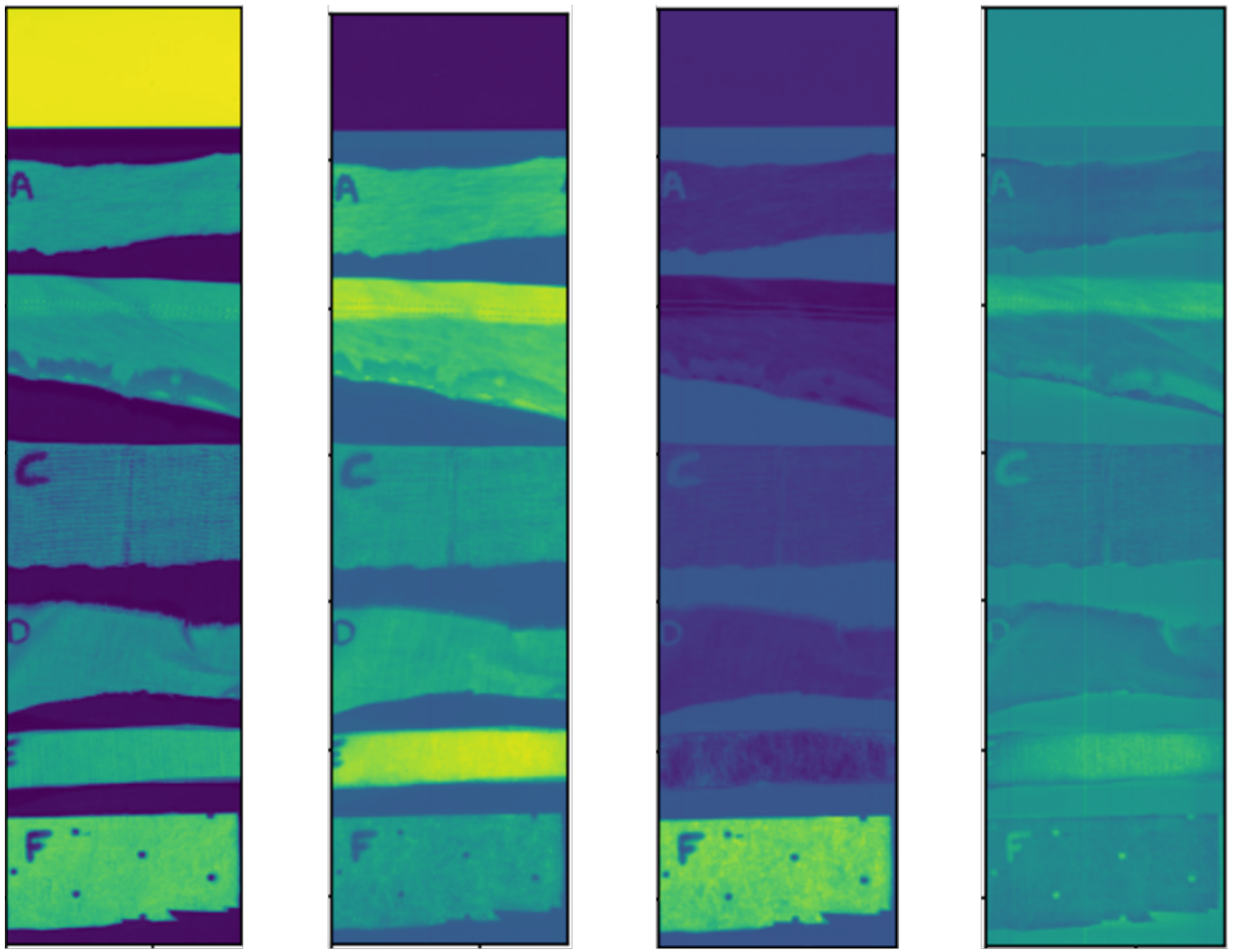
Spectralon

Cotton

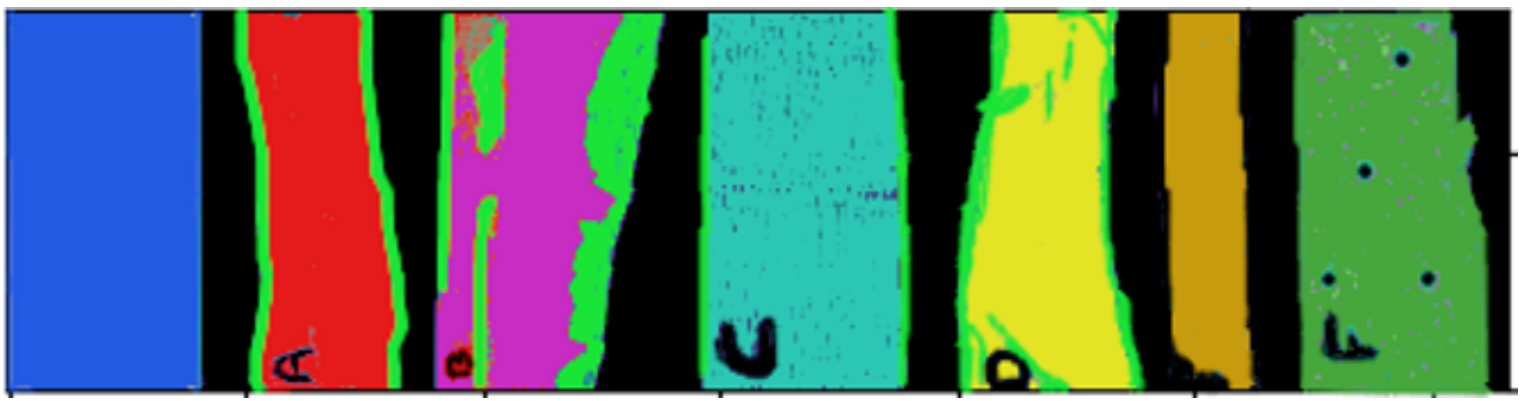
Paper

Background

Analyse purement spectrale : PCA scores



results with spectro spatial EM



Conclusion

- Taking into account jointly spectral and spatial properties
- New approach with tools of differential geometry
- Adapted statistics for multi-modal data

- Heavily computational
- Complex parametrisation
- Complex interpretation of features and models