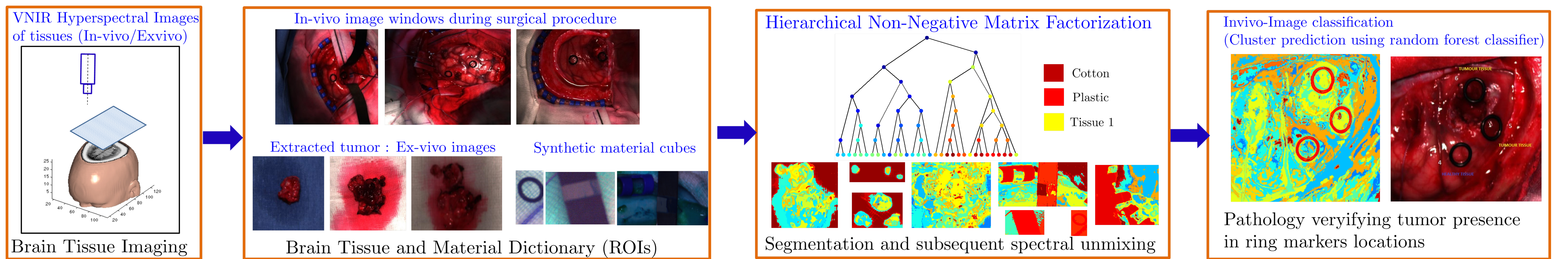


UNSUPERVISED CLUSTERING OF HYPERSPECTRAL IMAGES OF BRAIN TISSUES BY HIERARCHICAL NON-NEGATIVE MATRIX FACTORIZATION

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Problem overview and workflow



Inputs : VNIR-HSI images of In-vivo brain tissue surface during surgery and Ex-vivo extracted tumor are provided.

Goals : Identify the spectrum of the different brain tissues synthetic surgical materials and eventually spectral delineation of tumors.

Issues : Noisy & uncalibrated image, severe illumination variation, variability across patients & tumors. No ground truth labels for tumors. Specular reflections prominent in many images.

Methodology : Unsupervised clustering or segmentation and subsequent training of random forest classifier to predict subspace clusters.

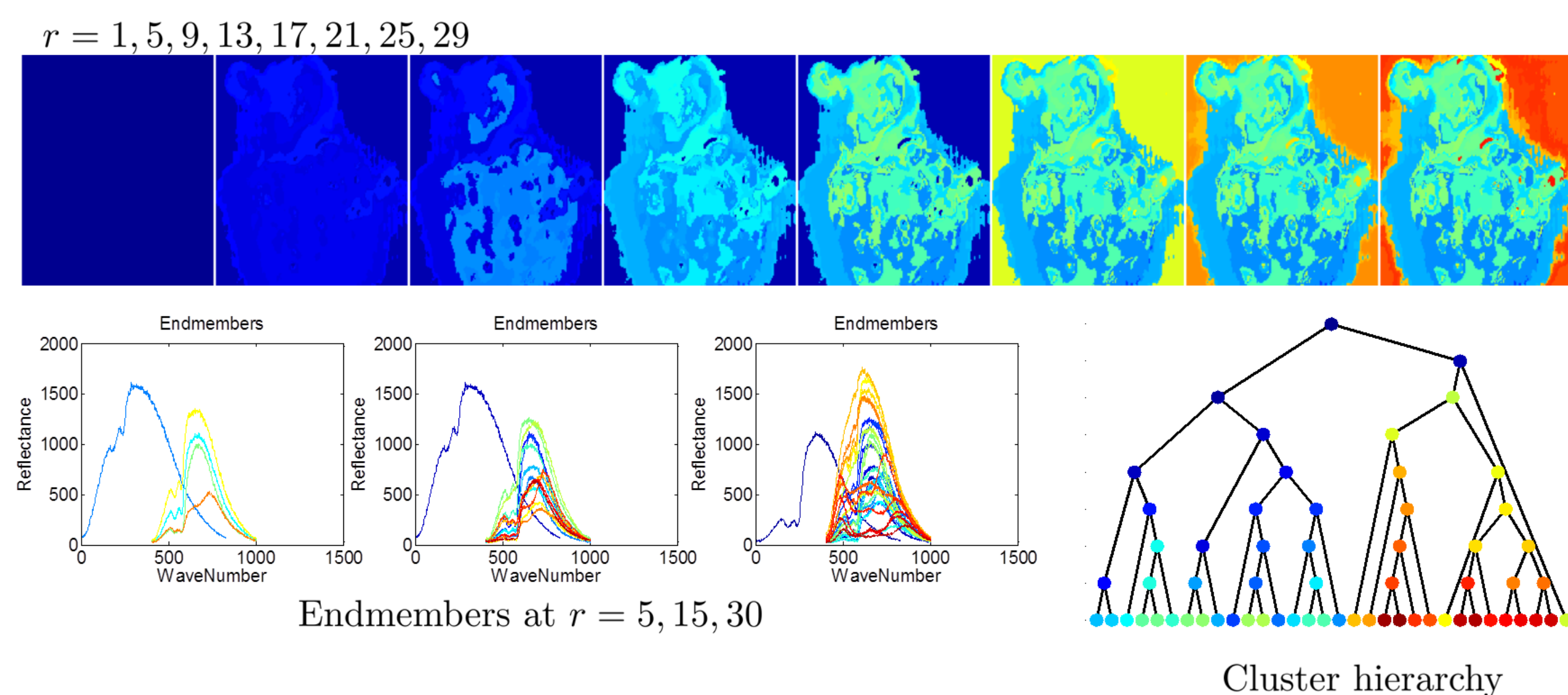
Hierarchical Rank-2 NMF clustering (H2NMF)

1. Select cluster with least approximation error : $\arg \min E_k$ in (1)
2. Split the cluster by projecting the data points onto the first two eigen vectors, by SVD.
3. Iterate (1,2) till r-clusters are reached.

This yields pure-pixels in the HSI cube approximating the first principle component.

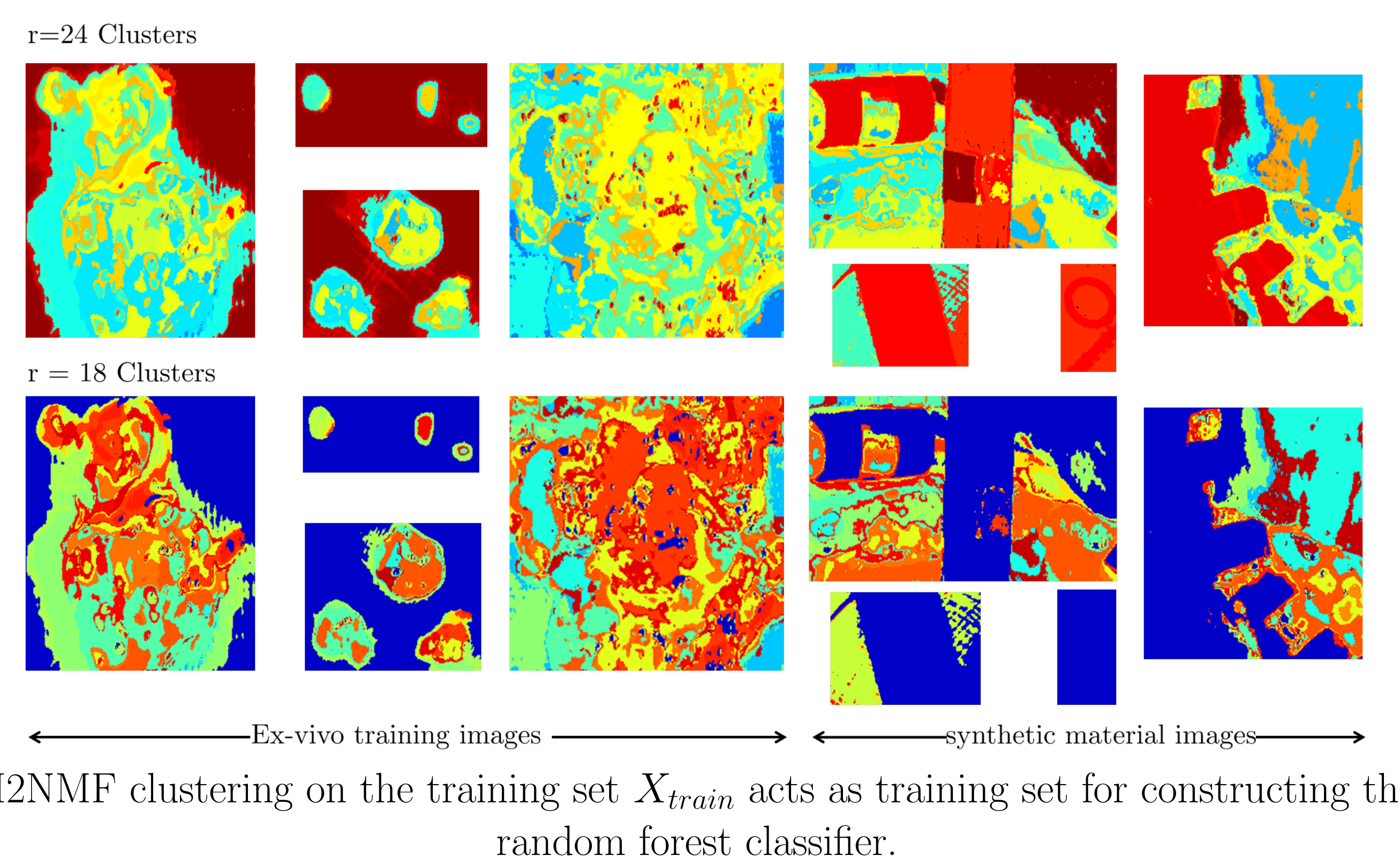
$$E_k = \sigma_1^2(X(:, K_i^1)) + \sigma_1^2(X(:, K_i^2)) - \sigma_1^2(X(:, K_i)) \quad (1)$$

Use (H2NMF) to cluster different materials and tissues based on homogeneity of spectral signature.

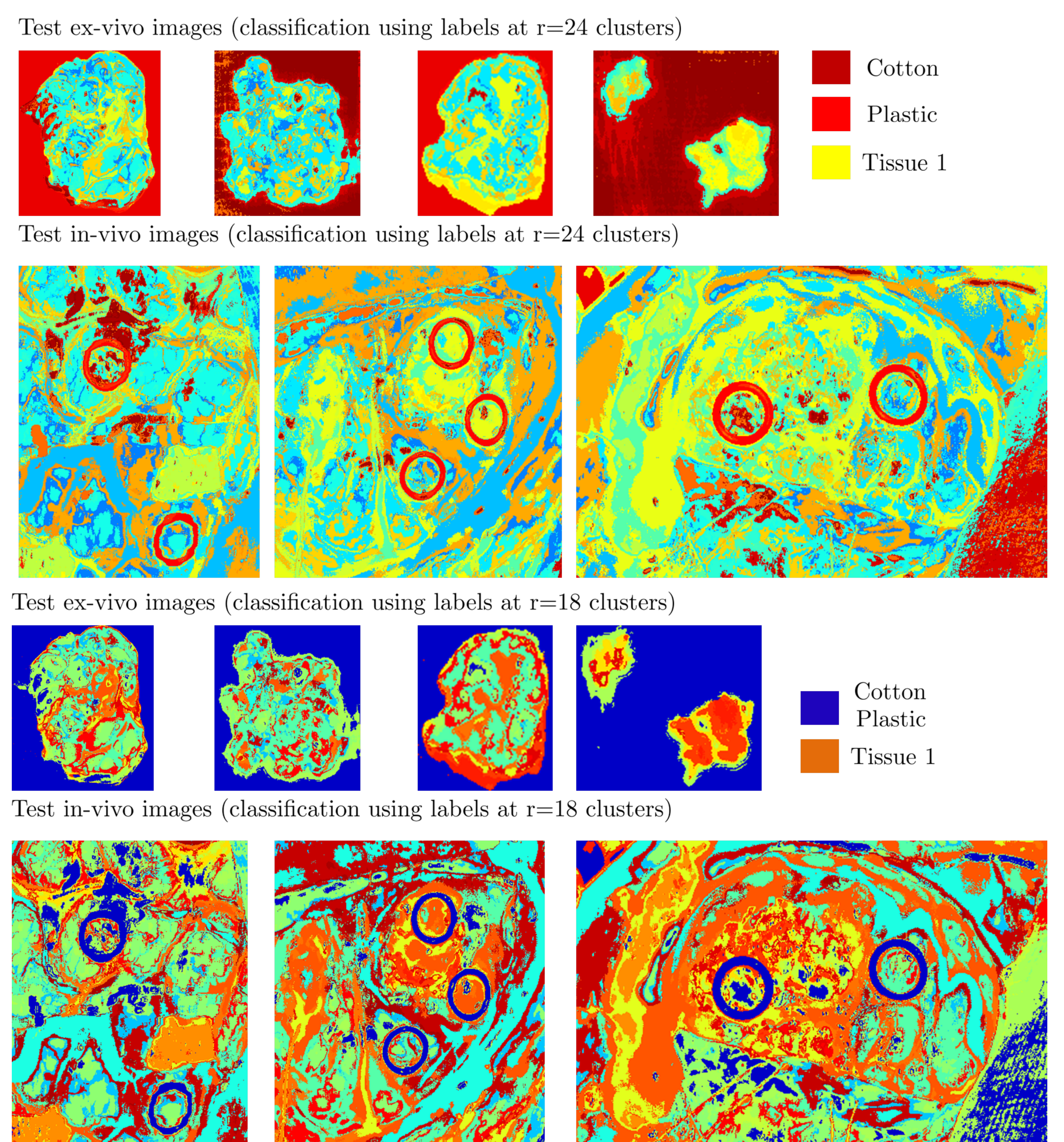


By viewing the endmembers (spectra) at different levels, we can infer visually that blood is a dominant material in the scene (blue peak around 400nm).

Learning on levels of (H2NMF) hierarchy



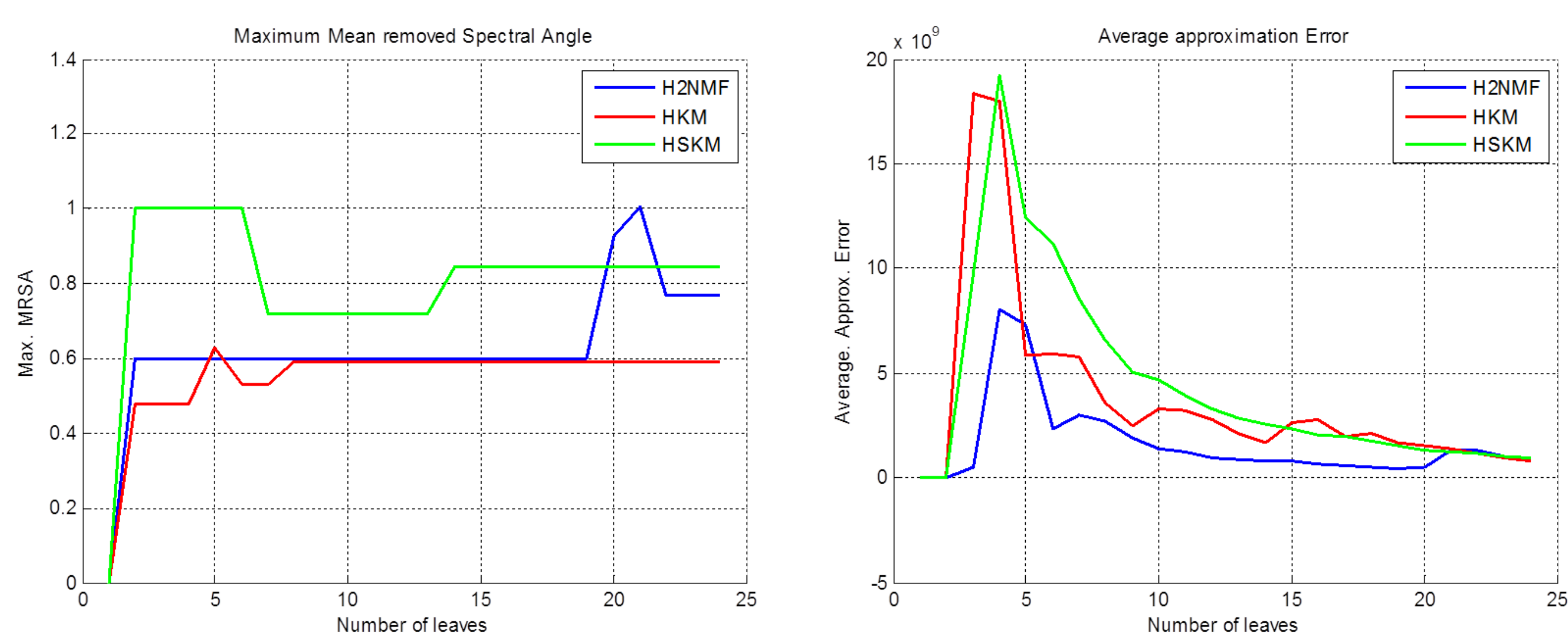
Classification on Test images (Invivo and Exvivo)



Number of Clusters

Mean removed spectral angle (MSRA) between two spectra is defined as :

$$\phi(\mathbf{x}, \mathbf{y}) = \frac{1}{\pi} \arccos \left(\frac{(x - \bar{x})^T (y - \bar{y})}{\|x - \bar{x}\| \|y - \bar{y}\|} \right) \in [0, 1] \quad (2)$$



Left: Variation of the maximum MRSA eq. (2) w.r.t number of clusters to evaluate the homogeneity of clusters w.r.t endmember signature. Right: Variation approximation error in (1) with increasing leaves.