

# Hierarchical forest attributes for multimodal tumor segmentation on FDG-PET/contrast-enhanced CT

Francisco Javier Alvarez Padilla<sup>1</sup>, Barbara Romaniuk<sup>1</sup>, Benoît Naegel<sup>2</sup>, Stéphanie Servagi-Vernat<sup>1,3</sup>, David Morland<sup>1,4</sup>, Dimitri Papathanassiou<sup>1,4</sup> and Nicolas Passat<sup>1</sup>

<sup>1</sup>Université de Reims Champagne-Ardenne, CReSTIC, France, <sup>2</sup>Université de Strasbourg, CNRS, ICube, France,

<sup>3</sup>Radiotherapy Department and <sup>4</sup>Nuclear Medicine Department, Institut Jean-Godinot, Reims, France



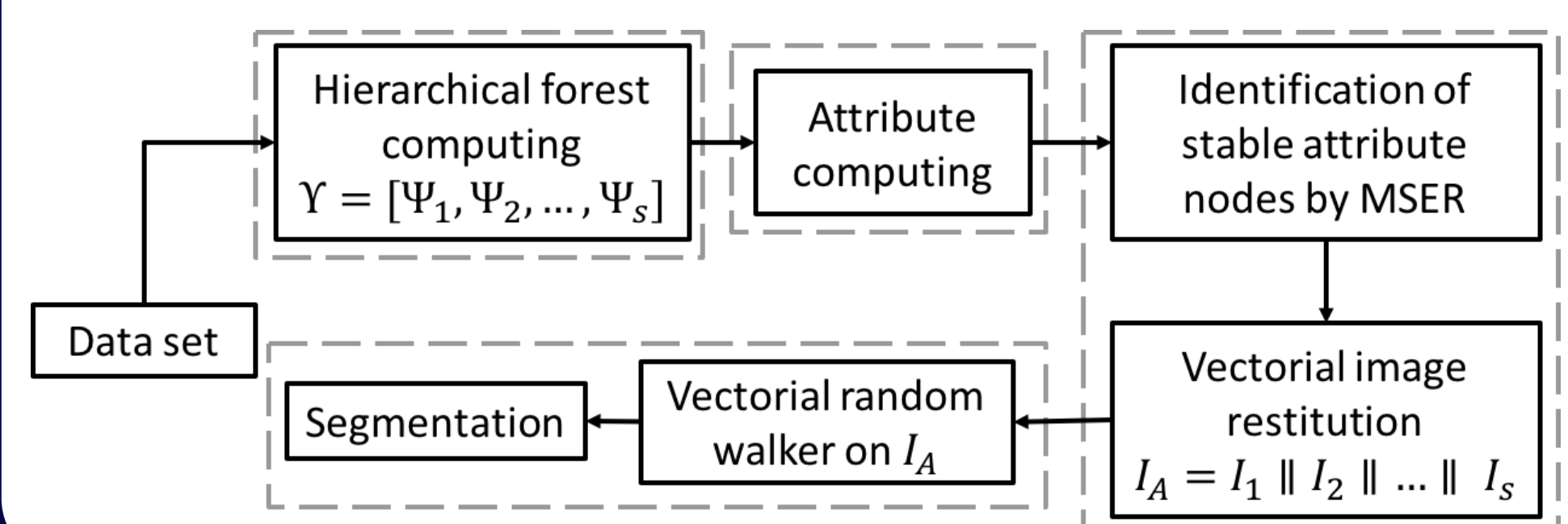
## 1. Abstract

Accurate tumor volume delineation is a crucial step for disease assessment, treatment planning and monitoring of several kinds of cancers. However, this process is complex due to variations in tumors properties. Recently, some methods have been proposed [1] for taking advantage of the spatial and spectral information carried by coupled modalities (e.g., PET-CT, MRI-PET). Simultaneously, the development of attribute-based approaches has contributed to improve PET image analysis. In this work, we aim at developing a coupled multimodal / attribute-based approach for image segmentation. Our proposal is to take advantage of hierarchical image models for determining relevant and specific attribute from each modality. These attributes then allow us to define a unique, semantic vectorial image. Sequentially, this image can be processed by a standard segmentation method, in our case a random-walker approach, for segmenting tumors based on their intrinsic attribute-based properties. Experimental results emphasize the relevance of computing region-based attributes from both modalities.

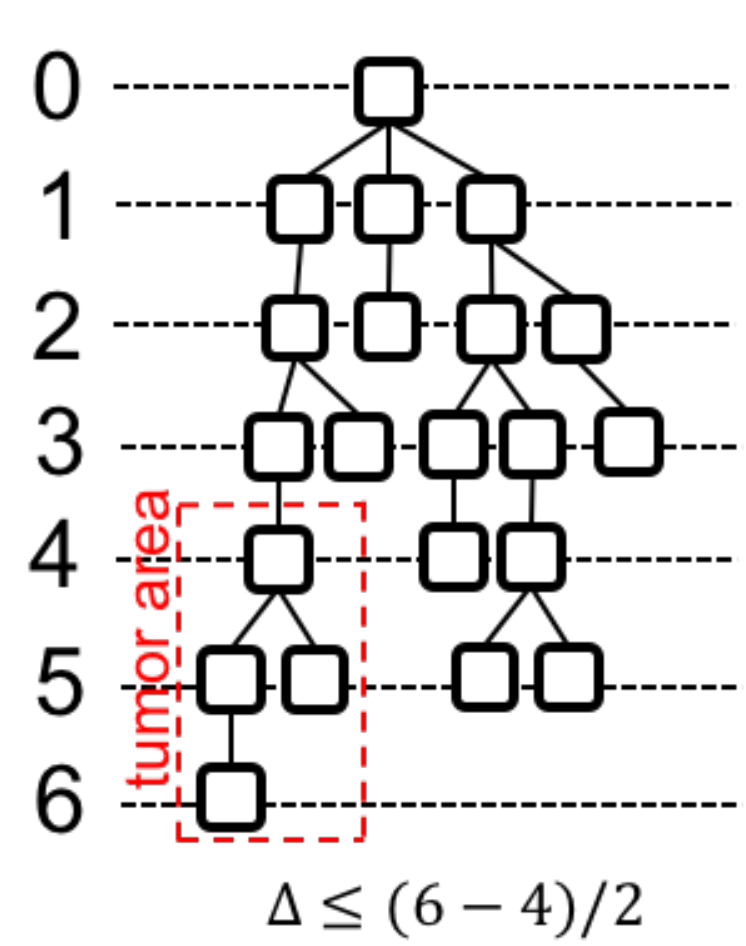
## 2. Context concepts

1. A hierarchical structure is a graph representation of an image formed by nodes  $k \in \Theta$  that are hierarchically linked by edges  $e \in E$  via an order relation, e.g. the inclusion relation [2], or the nested relation of their frontiers.
2. A node  $k$  is an image region formed by connected pixels/voxels.
3. An attribute  $h$  is a value (usually scalar) that characterizes a node. An attribute can, for example, be based on notions of form, spectrality, geometry, etc.

## 4. Method



## 5. MSER



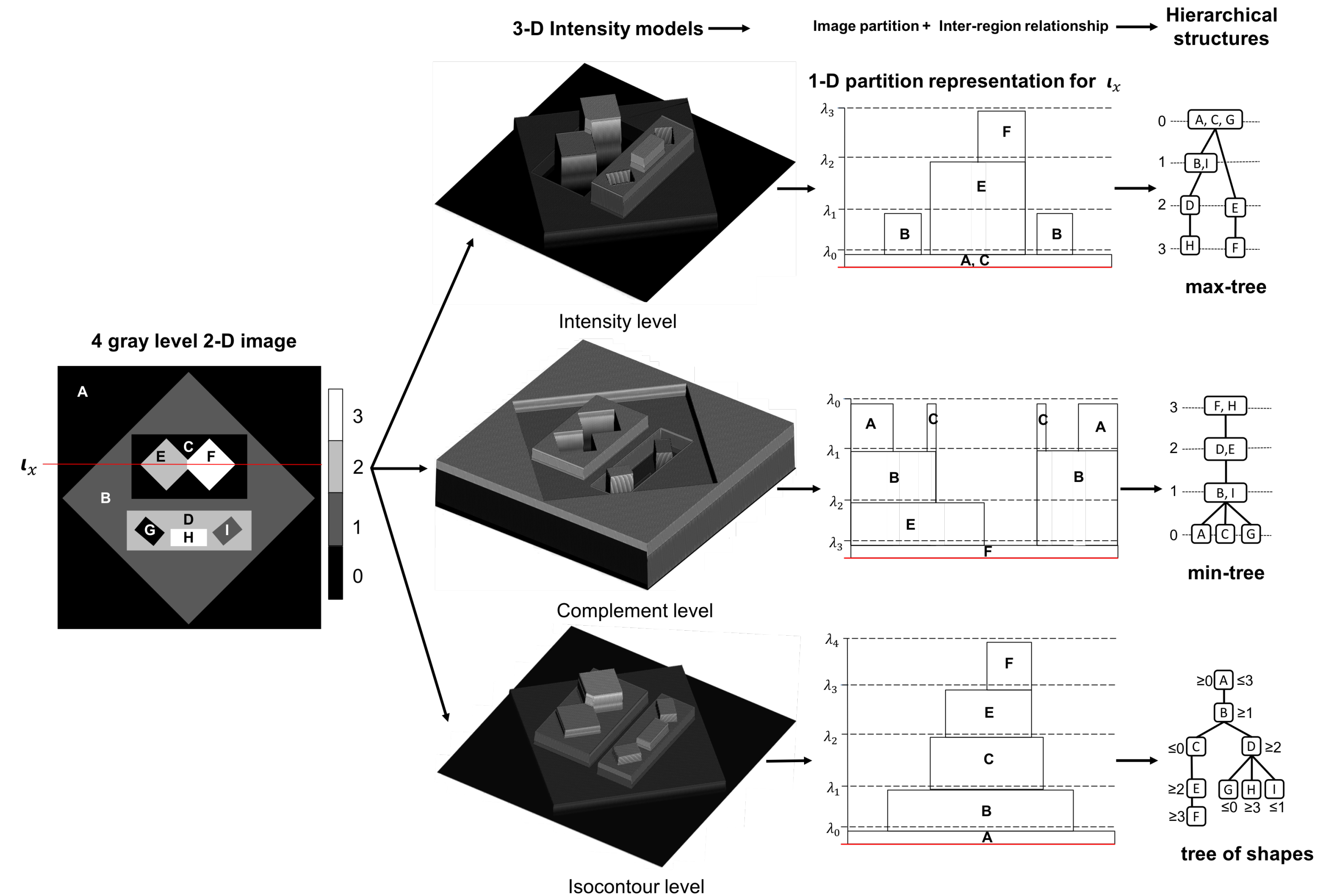
This analysis process begins from the extremal nodes  $k_{i*}$  (leaves of  $\Psi$ ), up to the root, through the branches, pruning instable nodes. The stability state is achieved if and only if the estimator  $s(k_i) = |k_{i+\Delta}(h) - k_{i-\Delta}(h)|$  has a local minimum at  $k_i$  where  $\Delta \in \mathbb{N}$  denotes the evaluation range.

## 8. Conclusions

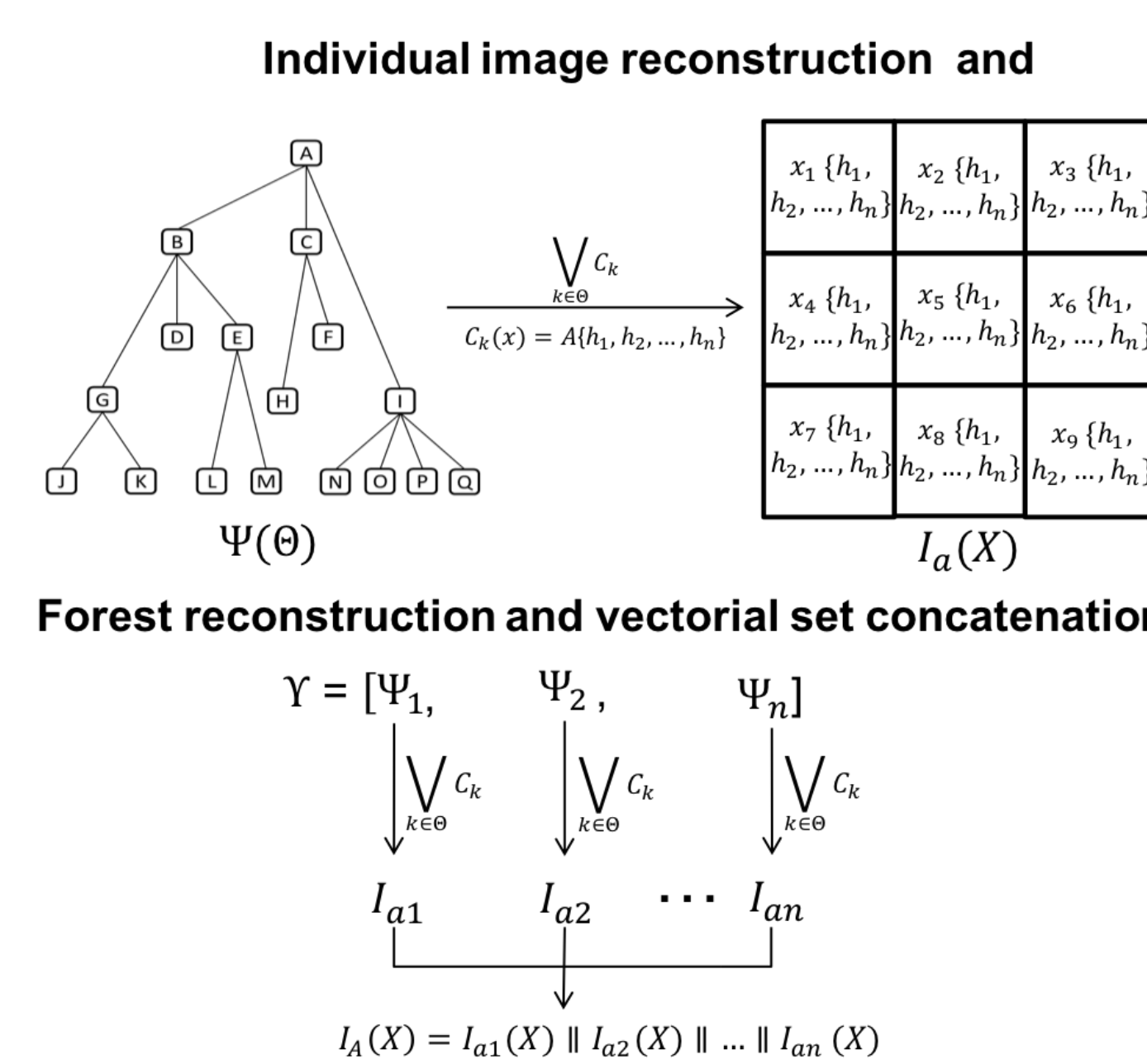
1. Multimodality and region-based attributes improved our results (literature corroboration). Their functional / morphological complementarity allows for a better delineation of tumors.
2. Vectorial image framework can be exploited by other methodologies.
3. Versatility of relevant attributes and imaging modalities selection with its preferable type of hierarchical structure, allow to adapt the algorithm according to inherent target properties.

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## 3. Hierarchical structures



## 6. Vectorial image reconstruction and vectorial Random Walker



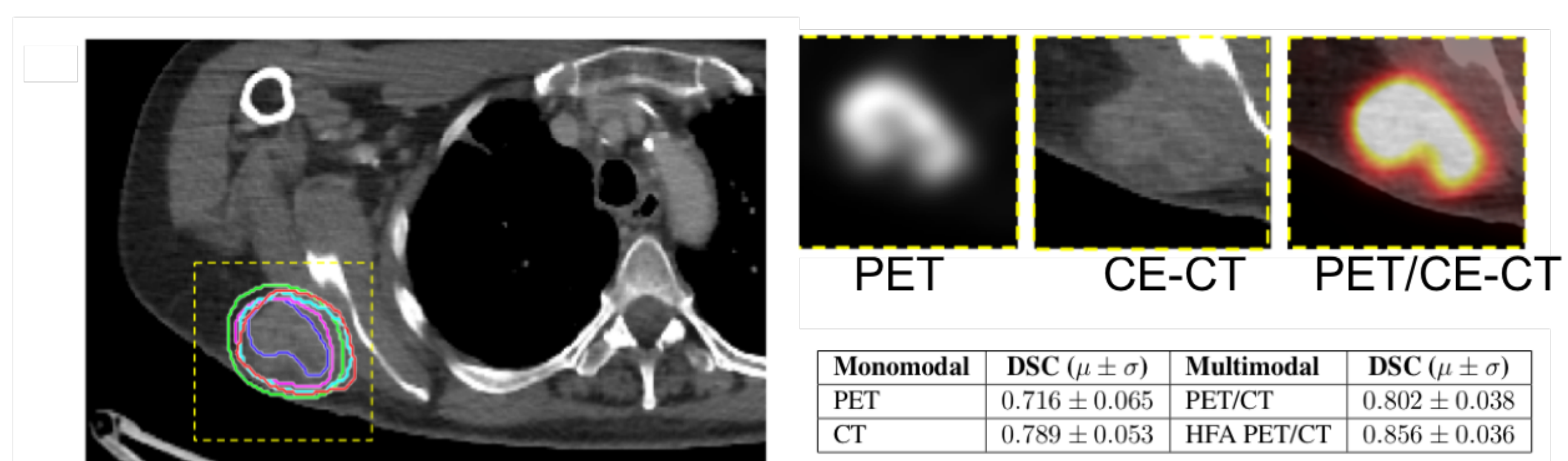
The random walker algorithm seeks the shortest path between a non-class node and the provided markers [3]. First,  $I_A$  is model as a graph: Markers  $m$  are set by a  $t$  threshold protocol for background  $b$  and foreground  $f$ , respecting:  $t_b < U < t_f$ .

PET for  $m_b$  (blue),  $m_f$  (red) and  $U$  (gray values)

Edges  $E$  are weighted:  $\omega_{ij} = \exp(-\beta \|v_i(A) - v_j(A)\|^2)$ ; this norm is represented by a Mahalanobis distance between the inter-node vectors of attributes  $A$ , for normalization.

## 7. Results

A max-tree  $\tau$  was built from PET and a ToS  $\Phi$  from CE-CT for the forest  $\Upsilon = [\tau_{PET}, \Phi_{CE-CT}]$ .



## 9. References

- [1] Foster B., Bagci U., Mansoor A., Xu Z. and Mollura D. *A review on segmentation of positron emission tomography images*. Comput Biol Med, 50:76–96, 2014.
- [2] Salembier P., Oliveras A. and Garrido L. *Anti-extensive connected operators for image and sequence processing*. IEEE T Image Process, 7:555–570, 1998.
- [3] Grady L. *Random walks for image segmentation*. IEEE T Pattern Anal, 28:1768–1783, 2006.