Shape-based analysis on component-graphs for multivalued image processing
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The extension of mathematical morphology to multivalued images is an important issue. In this context, connected morphological operators based on hierarchical image models have been increasingly considered to provide efficient image segmentation and filtering tools in various application fields, e.g. (bio)medical imaging, astronomy or remote sensing.

We propose a preliminary study that describes how component-graphs (that extend the component-tree from a spectral point of view) and shapings (that extends the component-tree from a conceptual point of view) can be associated for the effective processing of multivalued images.

**Component-graphs** [1]: Component-trees and multivalued images

A (discrete) image \( I : \Omega \rightarrow V \) (canonically equipped with an order relation \( \leq \)) can be modeled as a valued graph \((G, V, \leq)\). If \( (V, \leq) \) is no longer a total order, the Hasse diagram associated to \( I \) is no longer a tree:

- We extend the notion of connected component to valued connected component: \( \Theta = \bigcup_{v \in V} C(G,v) \times \{v\} \)
- We define an order relation \( \preceq \) on \( \Theta \) as:
  \[
  (X_1, v_1) \preceq (X_2, v_2) \iff \left\{ \begin{array}{l}
  (X_1 \subseteq X_2) \lor \\
  (X_1 = X_2 \land v_1 \leq v_2)
  \end{array} \right.
  \]
- The component-graph \( CG \) of the valued graph \((G, V, \leq)\) is the Hasse diagram of the partially ordered set \( (\Theta, \preceq) \).
- Each node of \( CG \) can contain an attribute value, interpreted as a function \( A : \Theta \rightarrow \mathbb{R} \). Such enriched component-graph is also interpreted as a valued graph \((C(G, \mathbb{R}, A)\).

**Shapings**

We consider the paradigm of shapings, proposed by Xu et al. [2], to extend the filtering capabilities of tree-based representation to non-monotonic attributes.

- The shaping framework consists of using a two-layer component-tree, i.e. a tree on a tree, that transforms any attribute into a monotonous one. This allows us to embed additional information. In particular it facilitates user interaction and real-time threshold-based node selection.
- The first tree is the component-tree of the image: it models its successive binary level-sets. The second is the component-tree of this first tree, considered as an image whose points are the nodes, while intensities correspond to attribute values.
- Limited use to grey-level images considering a tree as intermediate data-structure.

**Coupling component-graphs and shapings**

We propose to associate the shaping and component-graph in a common framework for developing connected operators on multivalued images.

- We use vertex-valued graphs as a unified formalism to describe images, component-trees and component-graphs.
- The inner layer of shape-space filtering only requires a graph, not necessarily a tree.
- Generalization of the initial shaping paradigm: it can be used not only to build a “tree on a tree” but also a “tree on a graph”.
- Any images can be processed via shape-based filtering:

**Advantages of the framework**

- Avoids the complex selection of nodes directly in \( CG \).
- Extends the initial shaping approach to multivalued images.
- Inherits the good properties of shape-space filtering from increasing attributes: real-time and interactive node selection at higher semantic level.

**Application to PET/CT image filtering**

**Illustrative proof of concept**:

We illustrate the potential usefulness of this framework by filtering coupled PET and CT images. The criterion considered for filtering is the compactness factor [3], defined as the ratio between the extremal eigenvalues of the matrix of inertia.

**References**