

# How to Modify the Tree of Shapes of an Image: Connected Operators Without Gradient Inversion

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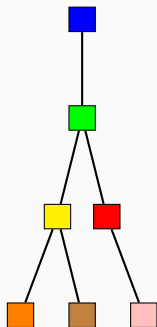
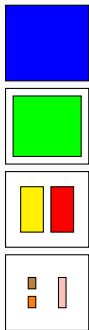
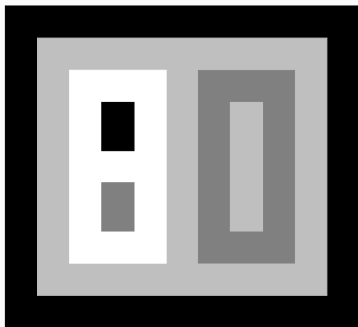
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# The tree of shapes

The tree of shapes models the inclusion of the **level lines** of an image.

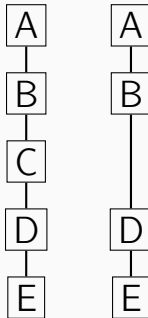
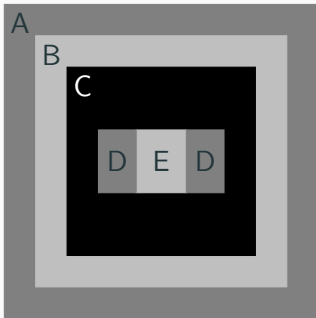


# Modifying a tree of shapes

## Possible issues

Uncarefully modifying a node of the tree of shapes can have the following effects:

- the resulting structure **may not be the ToS of the modified image**
- the resulting image may present **differential inconsistencies**.

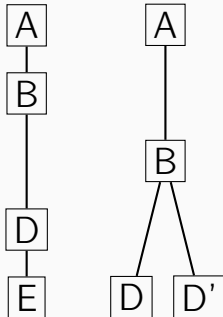
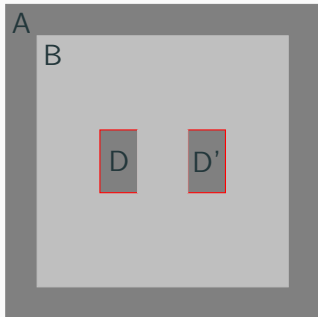


# Modifying a tree of shapes

## Possible issues

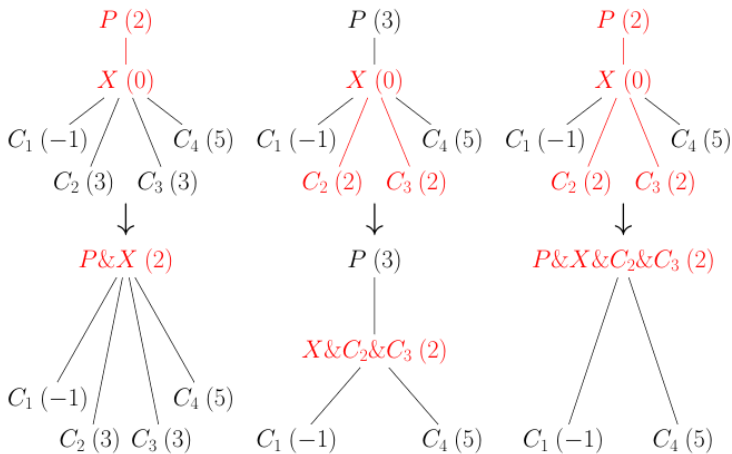
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# Contributions

Set of rules to modify a node to any new altitude

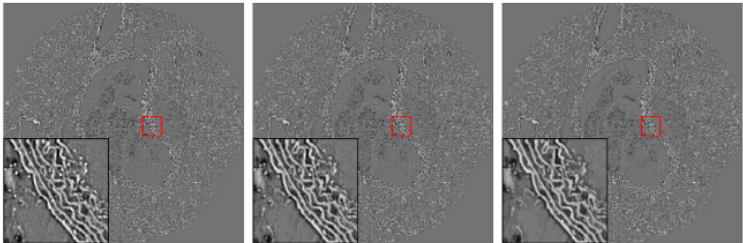


# Contributions : application

Application to denoising and tree of shapes simplification



Application to denoising and tree of shapes simplification



## HOW TO MODIFY THE TREE OF SHAPES OF AN IMAGE: CONNECTED OPERATORS WITHOUT GRADIENT INVERSION

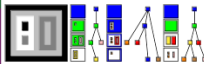
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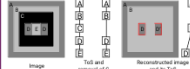


### Motivations

The tree of shapes (ToS) [E] is a **hierarchical data structure** that models a gray-level image via the inclusion of its **level lines**. It is often described as the self-dual version of the min- and max-trees.



- The **modification** (shifting of the altitude of one or several nodes) of the tree of shapes allows to design **connected operators**.
- It carried out **unusually**, the resulting structure **may not be the ToS of the modified image** and this **image may present differential inconsistencies**.



The proposed modifications rules guarantee that:

- the modified tree of shapes is **still the tree of shapes** of the modified image;
- the **range of the graytone** of the resulting image are not inverted.

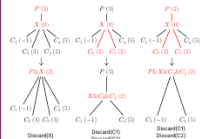
### Short range altitude shifting

The **Discard** function is the **atomic operation** merging a node to its parent.



**Short range shift**: modify the altitude of a node to a target altitude within that of its nearest neighboring node (parent and children).

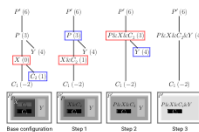
The short range shifting of node  $X$  with a target altitude of 1 can lead to the following configurations:



### Long range altitude shifting

**Long range shift**: modify the altitude of a node to **any target altitude** within the gray level range of the image.

- Gradually** progress toward the target altitude by applying **successive short range shifts** until the target altitude is reached.
- Results in the **progressive flattening** of the surrounding regions.



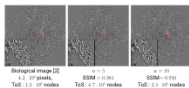
### Applications

Defining a **filtering criterion** allows the modification of specific nodes of the tree.

- Depending on the **filtering strategy**, the defined operators can satisfy specific properties (anisotropy, anisotropy, quantification, etc.)
- Example of an **area opening**, removing nodes of the image with **small perimeter**.



- One can define strategies to **simplify** a tree of shapes.
- Each node is assigned the **mean altitude** value of its neighboring nodes.
- Apply this **mean filtering** - times:



[E] Caselles, V. and S. Morel, J. "Topographic maps and local contrast changes in natural images. International Journal of Computer Vision, 2(5): 27-37 (1986).  
 [1] J. Mendes-Forte, N. Passat, Y. Kenmochi, "A new approach for image opening and closing based on the tree of shapes", in Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2014, pp. 1405-1412.  
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