
Grayscale morphological attribute operations

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Abstract

Morphological attribute openings and closings are connected set operations that are able to remove parts of an image that meet certain criteria without changing the rest. This article describes a number of classes that implement morphological area attribute operations using the methods described by Meijster and Wilkinson [].

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1 Introduction

A morphological attribute opening is probably best described by considering application to a binary image, in which case all blobs with attributes meeting specific criteria will be removed and all others retained. The most common and useful criteria is the number of voxels (i.e. area or volume) - an opening by area attributes with a threshold of 20 will remove all blobs containing fewer than 20 voxels. This operation can be implemented using connected component labelling approaches for binary images. Alternative attribute measures are possible, including perimeter and minimum enclosing rectangle (cite Breen and Jones). Some of these attributes are not increasing so the resulting operations aren't strictly openings, but are idempotent. There simplest way of extending this concept to gray scale images is to generate a series of binary images by thresholding at each distinct gray level. The binary image created by thresholding at gray level j will be

a subset of the image formed by thresholding at level $j - 1$. The binary area opening described above can then be applied independently to each binary image and the output grayscale image computed as a union of the results. An alternative description is to treat each peak independently. If the peak is smaller than the threshold area then form a region by collecting the all voxels with the next highest grey level that are connected to the peak. Repeat this process until the area exceeds the threshold. Set all pixels in the resulting region to the grey level of the most recently connected pixels.

2 Comparison of area attribute and traditional openings

The operation of traditional openings is based on the shape of a structuring element, with any feature where the structuring element doesn't "fit" being removed. Area attributes, on the other hand, are independent of shape and therefore can perform better in some circumstances. For example, an area attribute opening could retain long, linear structures and reject a range of compact objects. Connected set operations, such as area attribute openings, are dependent on connectivity. This can lead to undesirable results – e.g. a blob touching a linear structure would be retained in the previous example. In addition, breaks in connectivity could lead to parts of a linear structure being removed unexpectedly¹. The ability to remove some parts of an image while leaving the rest unchanged is especially useful in top hat filters.

2.1 Examples

Figures 1 and 2 illustrate a series of progressively larger area openings and closings applied to the cthead image. In Figure 1 progressively larger bright regions are removed from the image while progressively larger dark regions are removed in Figure 2. In both cases the rest of the image is left unchanged. It is especially important to note that contours are preserved.

If the peaks being removed were actually of interest then a top hat filter would be appropriate. The white top hat filter is the difference between the original image and the opened version, while the black top hat filter is the difference between the closed version of the image and the original.

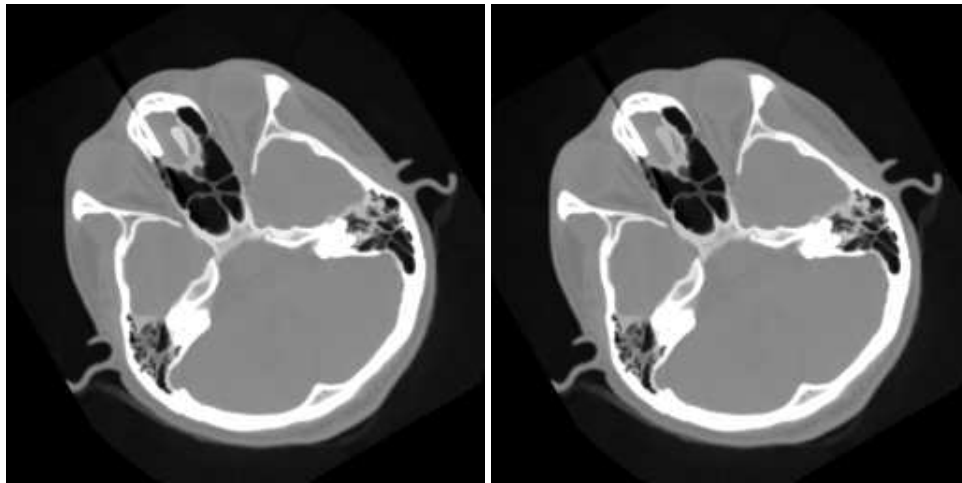
3 Filter documentation

The filters described here implement the area attribute opening or closing using the method described by Meijster and Wilkinson []. The base class is *itkAttributeMorphologyBaseImageFilter*. There are two sets of subclasses – *itkAreaOpeningImageFilter* and *itkAreaClosingImageFilter* and *itkPhysicalSizeOpeningImageFilter* and *itkPhysicalSizeClosingImageFilter*. The first two filters compute area/volume operations using units of voxel counts while the last two use physical units.

These classes are templated on input and output image type and are controlled by two methods:

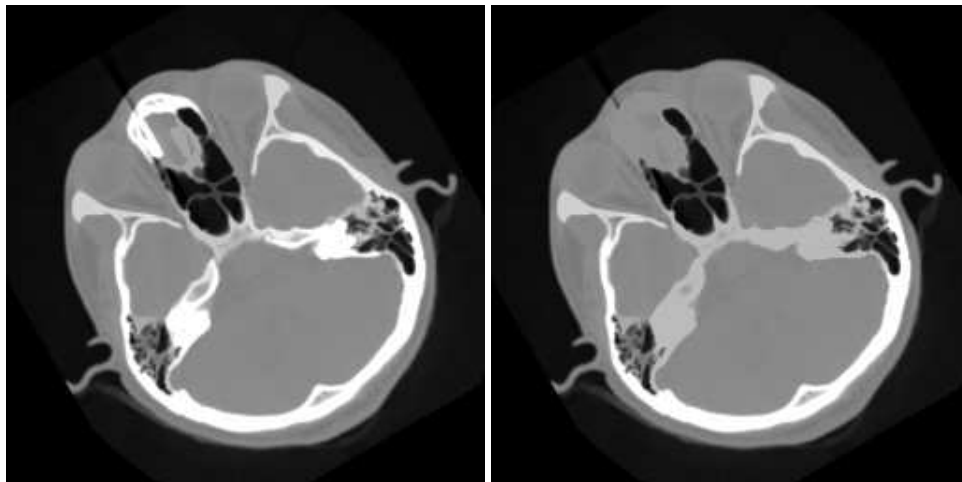
- **[Set/Get]FullyConnected** : define whether the neighborhood used to define a region is fully or face connected.
- **[Set/Get]Lambda** : set the area attribute.

¹Unexpected in the sense that a person probably wouldn't notice such breaks



(a) 50 pixel opening

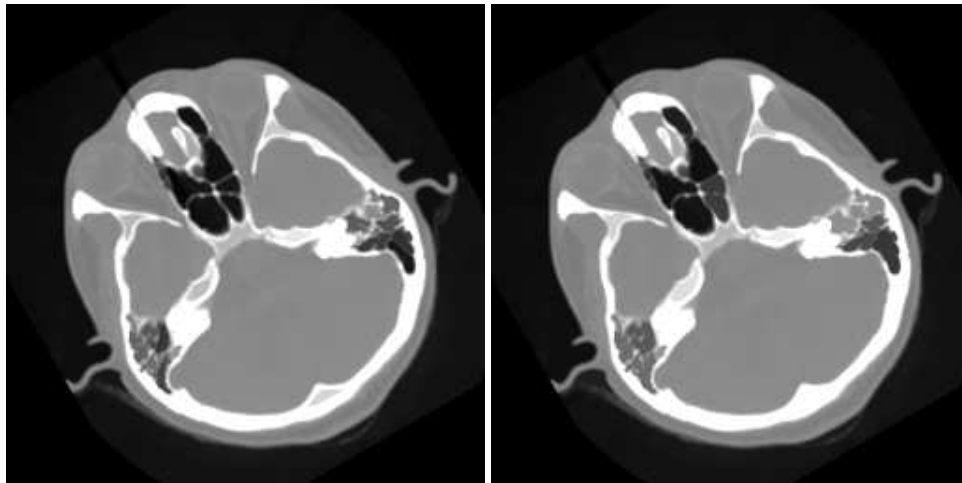
(b) 100 pixel opening



(c) 200 pixel opening

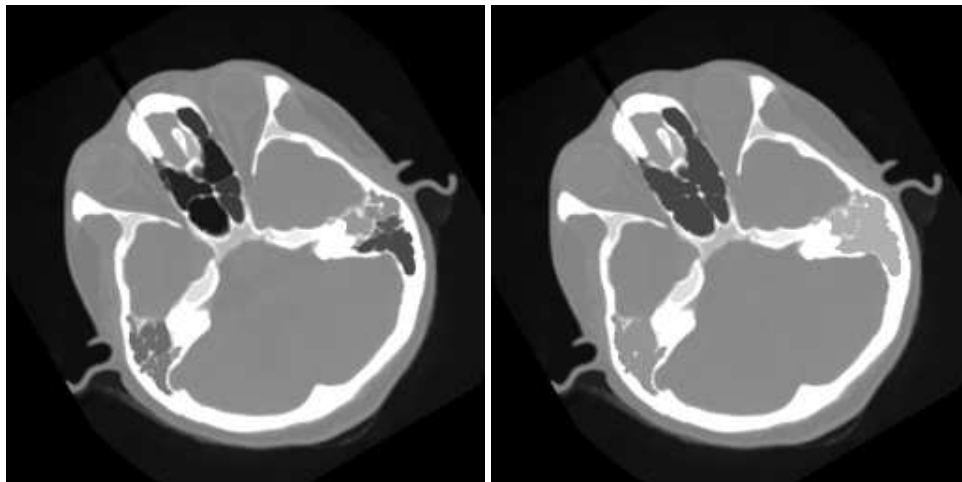
(d) 1000 pixel opening

Figure 1: A series of area openings applied to the cthead image



(a) 50 pixel closing

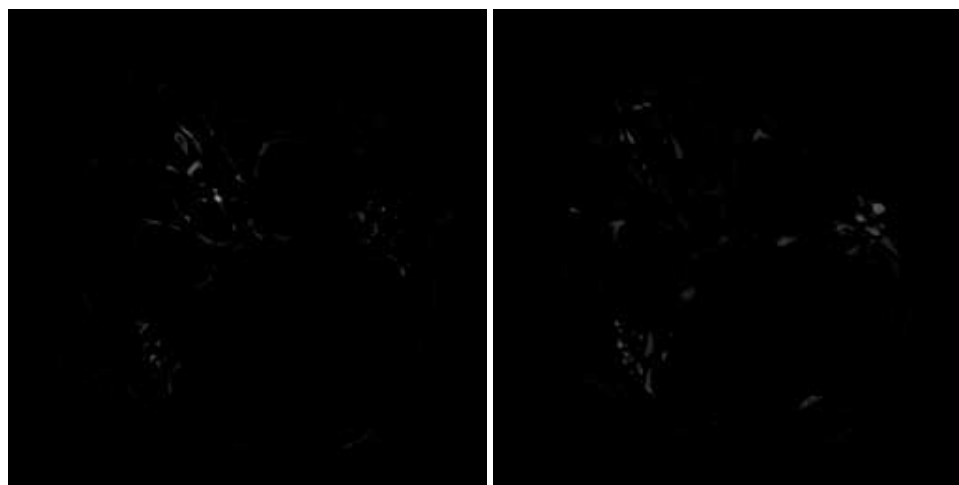
(b) 100 pixel closing



(c) 200 pixel closing

(d) 1000 pixel closing

Figure 2: A series of area closings applied to the cthead image



(a) White top hat of cthead1

(b) Black top hat of cthead1

Figure 3: White and black top hat filter results with area attribute of 50.

References

- [1] L. Ibanez and W. Schroeder. *The ITK Software Guide*. Kitware, Inc. ISBN 1-930934-10-6, <http://www.itk.org/ItkSoftwareGuide.pdf>, 2003.