Simple directional gradients

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Abstract

It is often useful to be able to compute the component of image gradient in a direction defined by a shape of some form, rather than relative to the image axis. This article introduces a simple method for doing this based on distance transforms that is potentially useful in a number of applications.

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1 Introduction

The gradient of a greyscale image is a vector pointing in the direction of maximum rate of change on intensity. It is often desirable to compute the component of this gradient relative to directions derived from image data, such as a mask representing domain knowledge. One simple and useful way of doing this is implemented in the *itkDirectionalGradientImageFilter*, introduced in this article.

2 Algorithm

Prior knowledge is represented by a mask, with direction being computed relative to the edges of the mask. This is achieved by computing the gradient of the distance transform of the mask, which provides a simple way of computing directions at positions away from the mask edges. The component of the gradient parallel to this direction can then be computed using an inner product.

3 Applications and Examples

The directional gradient can be useful in a number of situations, such as distinguishing interior and exterior edges of walls or computing gradients in the presence of clutter. Simple examples using the cthead1 image are illustrated in Figres 1 to 4. The mask used in this example is a small region near the middle of the image. The gradient of the distance transform of this mask is therefore pointing directly away from this region, with contours of the distance transform image forming circles around the image centre. Note that this mask could be a sinlge voxel, but has been enlarged for simpler visualization. This mask represents a very simple form of prior knowledge - points known to be inside the skull. Given this prior knowledge it is simple to separate light to dark transitions from dark to light transitions as we travel away from masked voxels. These images were generated using *testDirectional* and *label_overlay*, included with this package.

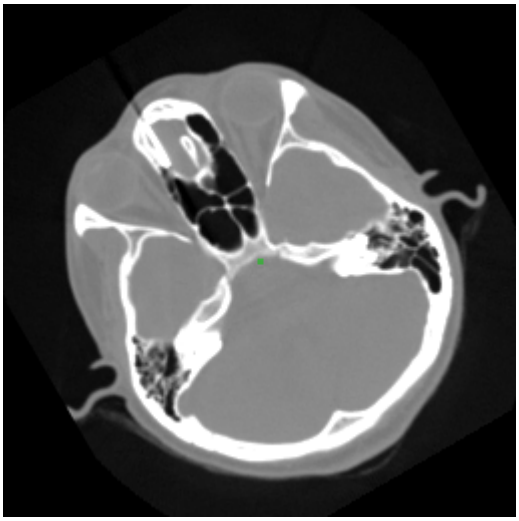

Figure 1: Raw image with mask representing prior knowledge (overlaid in green).

4 Usage

This algorithm is implemented in the *itkDirectionalGradientImageFilter* included with the article. It is a simple mini-pipeline filter that utilizes standard ITK gradient filters, a new inner product filter and the fast distance transform filters from an earlier InsightJournal publication [1]. The filter has a simple interface with only 3 control parameters:

- *SetOutsideValue*: controls the behaviour of the distance transform. The default (0), implies computing the distance to the nearest voxel with value 0. This is set to 1 for the example.

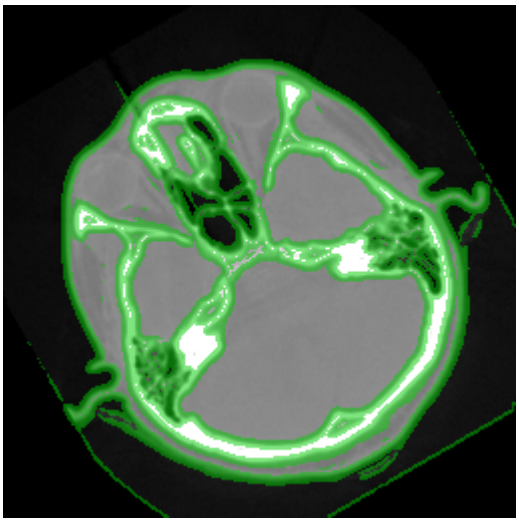

Figure 2: Standard linear gradient (thresholded).

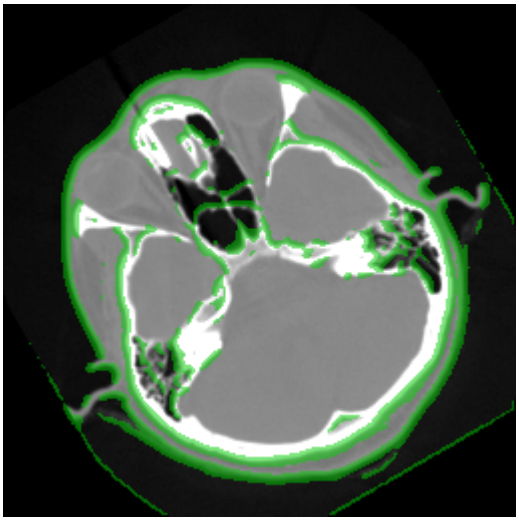

Figure 3: Light to dark transitions (thresholded).

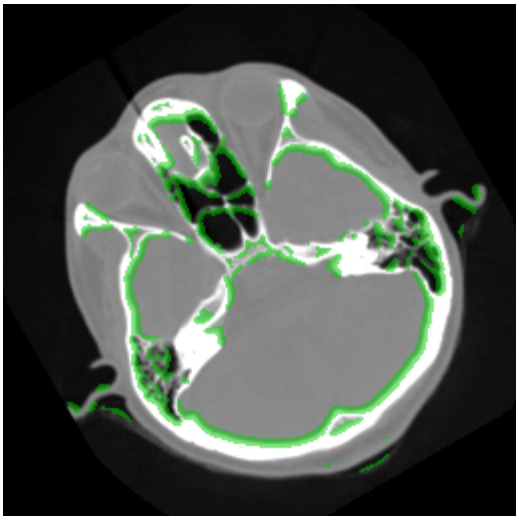

Figure 4: Dark to light transitions (thresholded).

- *SetSigma*: controls the size of the smoothing kernel used in computation of the gradient of the raw image.
- *SetScale*: controls a scaling factor using in the inner product. This is a convenient way of forcing the output gradient to always be positive.

Complete usage is illustrated in *testDirectional.cxx*.

5 Observations

The examples use extremely simple masks consisting of 1 voxel that lead to gradients being computed parallel to lines pointing away from the image centre. However arbitary masks can be used that allow much more complex shapes to be imposed on gradients. Examples include skeletons of linear structures, some form of approximate segmentation or a template.

6 Source code

Source code is available in with this article and latest versions are available from via git from `https://richardbeare@github.com/richardbeare/DirectionalGradient.git`.

7 Conclusion

This is a simple filter implementing a trick that I have found useful on a number of occasions. I hope the community finds it useful and/or interesting too.

References

[1] R. Beare. Morphology with parabolic structuring elements. *The Insight Journal*, May 2008. 4

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