Histogram-based thresholding - some missing methods

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Abstract

Using intensity histograms to estimate image thresholds is a long established practice in image processing and image analysis and a wide variety of techniques have been developed. Different techniques are appropriate for different intensity distributions. This article implements a number of standard techniques not currently available in ITK.

Contents

1 Introduction

This contribution includes classes for threshold estimation using the following methods: Huang[1], Intermodes[8], Minimum[8], IsoData[9], Li[5, 6], MaxEntropy[2], KittlerIllingworth[3], Moments[11], Yen[12], RenyiEntropy[2], Shanbhag[10] and Triangle[13].

All classes are largely derived from the AutoThresh [4] package for ImageJ. The brief outline below is taken from the presentation associated with the HistThresh[7] matlab toolbox, which was also a source of information for the AutoThresh package. The exception is the triangle method, that was written before discovery of the AutoThresh packge and before this project got slightly out of hand.

Latest version of this contribution is available via github: `git clone git://github.com/richardbeare/HistThresh.git`

2 Thresholding algorithms

The histogram of the standard cthead image, and the thresholds estimated by the various methods are shown in Figures 1 and 2

2.1 Huang

Huang's fuzzy thresholding using Shannon's entropy function.

2.2 Intermodes

Iteratively smooths histogram until only 2 peaks remain. Threshold is the midpoint of the two peaks. Not good for histograms with very unequal peaks.

2.3 Minimum

Same as Intermodes, except that threshold is the mimimum point between the peaks, rather than midway. This method is part of the *itkIntermodeThresholdImageFilter* and is selected using the *UseIntermodeOff* method.

2.4 IsoData

Computes average of voxels below initial threshold and above initial threshold. Threshold is set to the average of the two. Repeat until the threshold is larger than the composite average.

2.5 Li

Li's minimum cross entropy.

2.6 MaxEntropy

Choose threshold such that the entropies of distributions above and below threshold is maximised. One of several entropy-based approaches.

2.7 KittlerIllingworth

Similar to the Otsu method. Assumes a Gaussian mixture model. Minimizes the number of misclassifications between the two normal distributions with the given means, variances and proportions.

2.8 Moments

Choose threshold such that the binary image has the same first three moments as the grey level image.

2.9 Yen

Maximum correlation criterion.

2.10 RenyiEntropy

Similar to MaxEntropy, but using a different entropy measure.

2.11 Shanbhag

Extenstion of the Kapur method.

2.12 Triangle

The triangle method constructs a line between the histogram peak and the farthest end of the histogram. The threshold is the point of maximum distance between the line and the histogram. This implementation uses robust (default is 1% and 99%) estimation of histogram ends.

3 Usage

The new classes are:

- *itkHuangThresholdImageFilter*
- *itkIntermodesThresholdImageFilter*

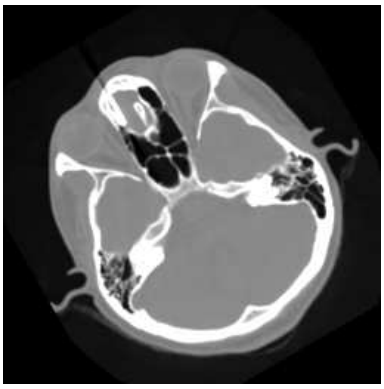

Figure 1: The input image.

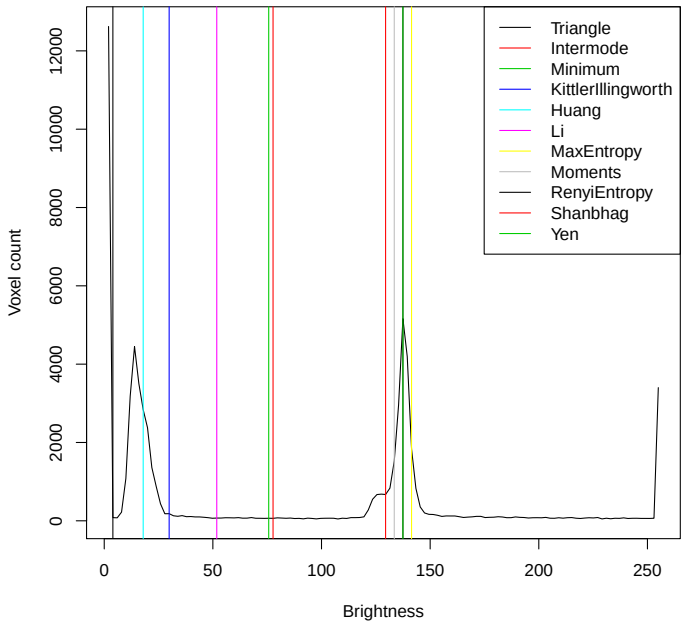

Figure 2: Image histogram and thresholds selected by implemented methods.

- *itkIsoDataThresholdImageFilter*
- *itkKittlerIllingworthThresholdImageFilter*
- *itkLiThresholdImageFilter*
- *itkMaxEntropyThresholdImageFilter*
- *itkMomentsThresholdImageFilter*
- *itkRenyiEntropyThresholdImageFilter*
- *itkShanbhagThresholdImageFilter*
- *itkTriangleThresholdImageFilter*
- *itkYenThresholdImageFilter*

All classes have methods to set the number of histogram bins. Intermodes has a method to select the intermodes or minimum selection option.

Simple test functions are provided for all classes.

4 Future improvements

All classes in this package were based on the existing ITK implementation of the Otsu method. This class does not make use of the rich ITK histogram structure, and hence the new classes do not utilize it either. There is also a moderate amount of repeated code between the different filter and calculator classes. Future work should look at refactoring the classes and making better use of the ITK histogram tools.

More informative examples would also be a great advantage.

5 Conclusions

This contribution is a set of standard thresholding methods available in other packages. The implementation is derived from both the ImageJ java plugin and the ITK Otsu classes. The classes are being made available to the user community in a relatively untested and poorly documented state. I hope that someone finds them useful. Additional documentation is welcome.

References

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