

Tensor Anisotropic Nonlinear Diffusion for Hyperspectral Image Enhancement 🤌



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Abstract

Using Hyperspectral Imaging (HSI) with its capacity of sampling the electromagnetic spectrum using hundreds of narrow and contiguous spectral bands is a valuable remote sensing technology for many defense and security applications. Noise introduced by the Hyperspectral sensor and the interfering medium, in addition to the natural spectral variability of the materials, make information difficult. Pre-processing extraction more methods for image enhancement that take full advantage of available spectral information are proposed here to enhance spatial features of interest and denoising. Tensor Anisotropic Nonlinear Diffusion (TAND) is one way to deal with the problem of denoising a HSI. The idea is to use the structure tensor to find the direction where the edges that separate the regions in the scene are. The tensor information is then used either to prevent diffusion from happening across edges (Edge Enhancement Diffusion (EED)) or to enhance or complete the edges or other linear structures (Coherence Enhancement Diffusion (CED)). A new structure tensor is proposed here that gives higher weight to spectral bands with edge information. This variable weighting improves EED and CED enhancement. Results of this method are presented for HSI images of different spatial characteristics to demonstrate the potential capabilities of the method. The proposed image enhancement algorithm can be an integral part of a target detection system using HSI.

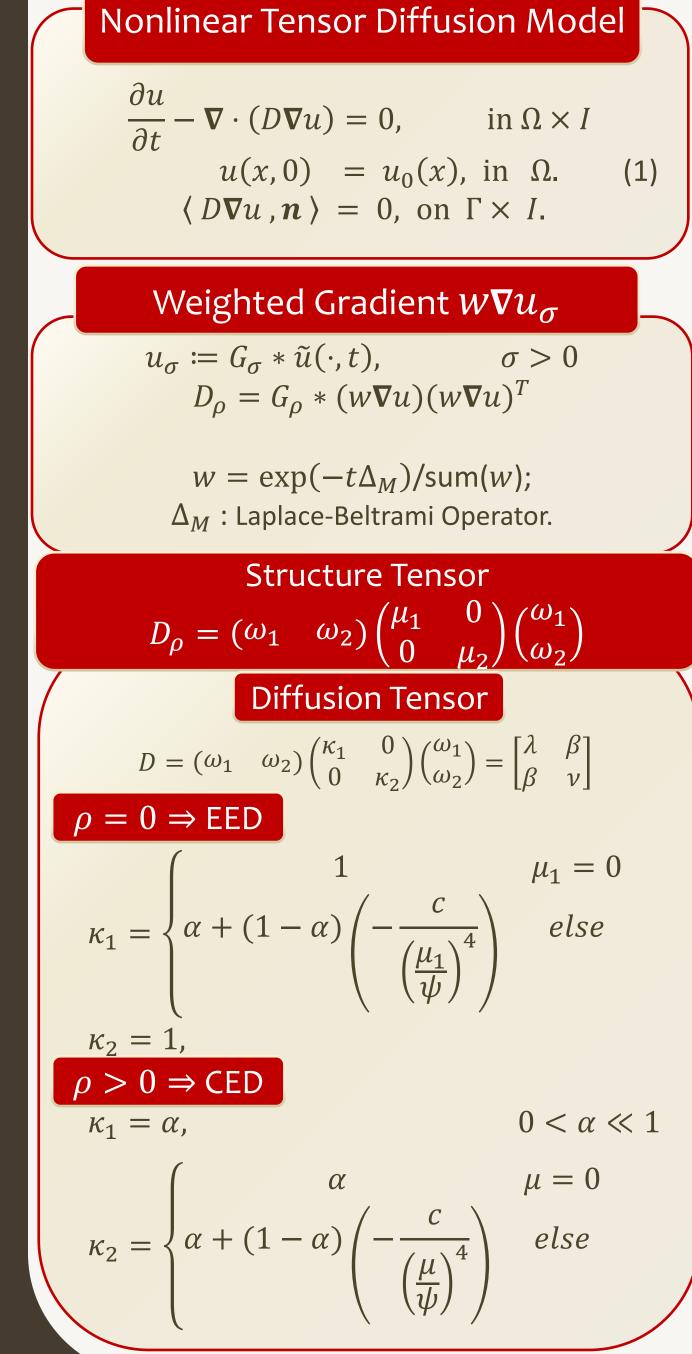
Relevance

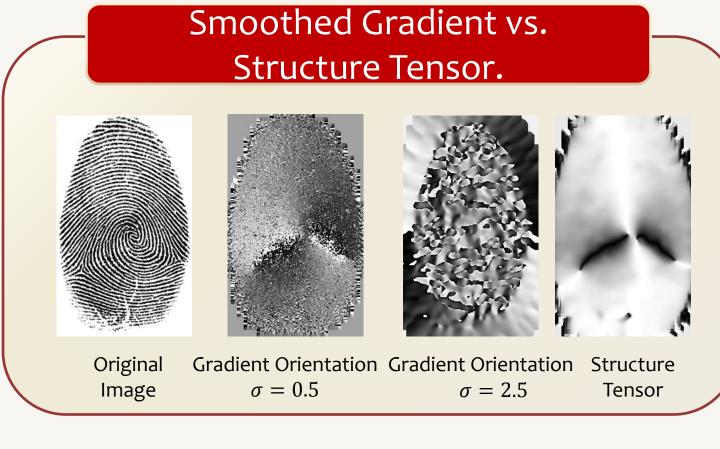
Advances to the State of the Art

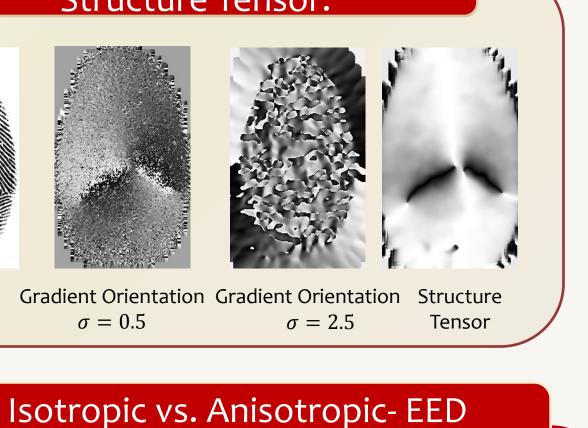
- Defines a new weighted structure tensor
 - Weights depend on data
 - They are based on the heat operator
- Proposing a more versatile function to define the eigenvalues of the CED tensor This work is based on TAND proposed by [4]

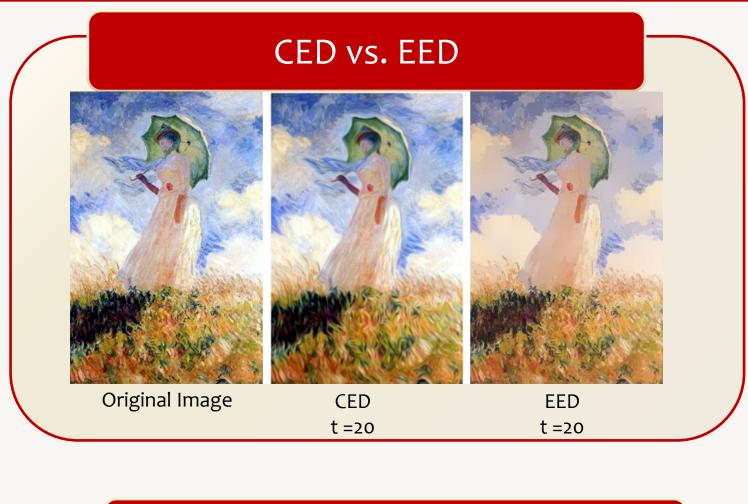
The proposed enhancement improves the capability of image analysts and machinebased detection of threads and regions of interest in surveillance systems.





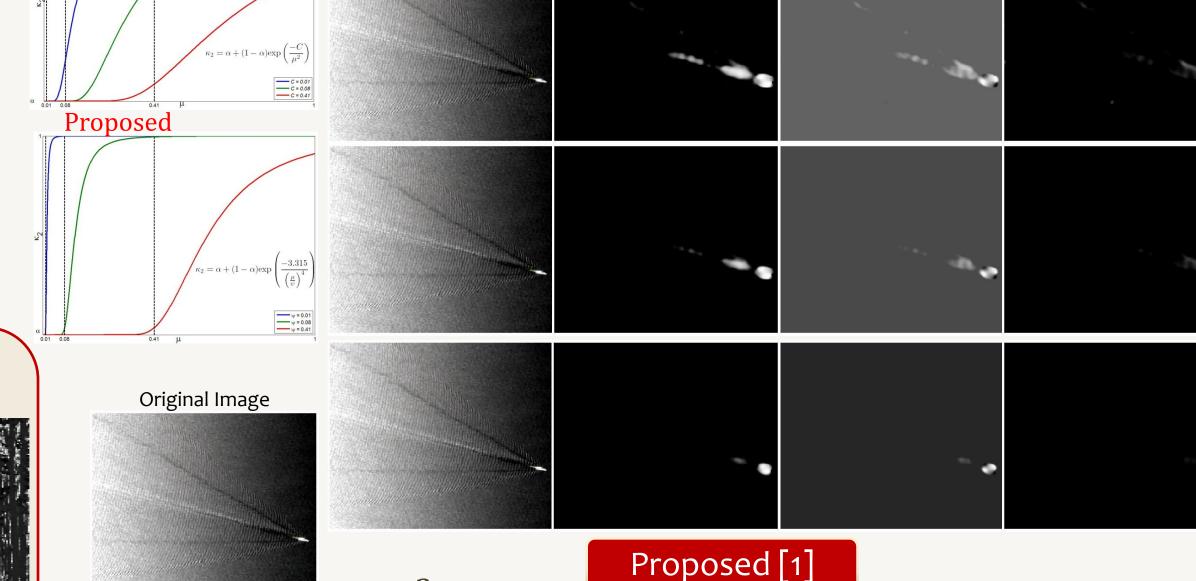






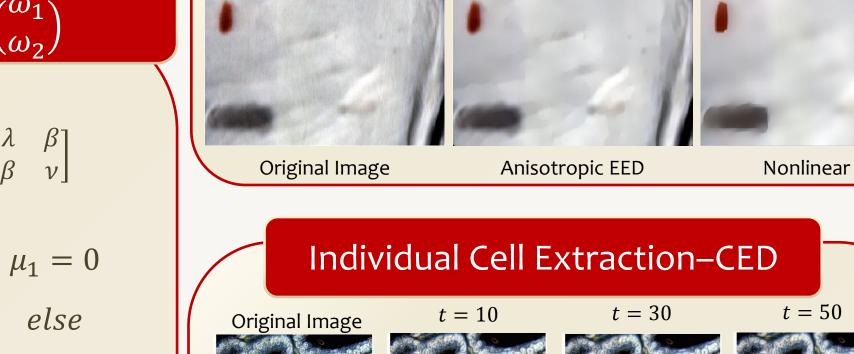
Enhancement for Target Detection

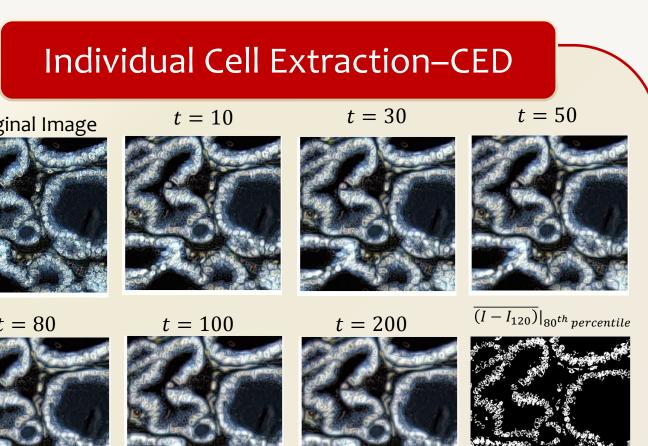
State of the art



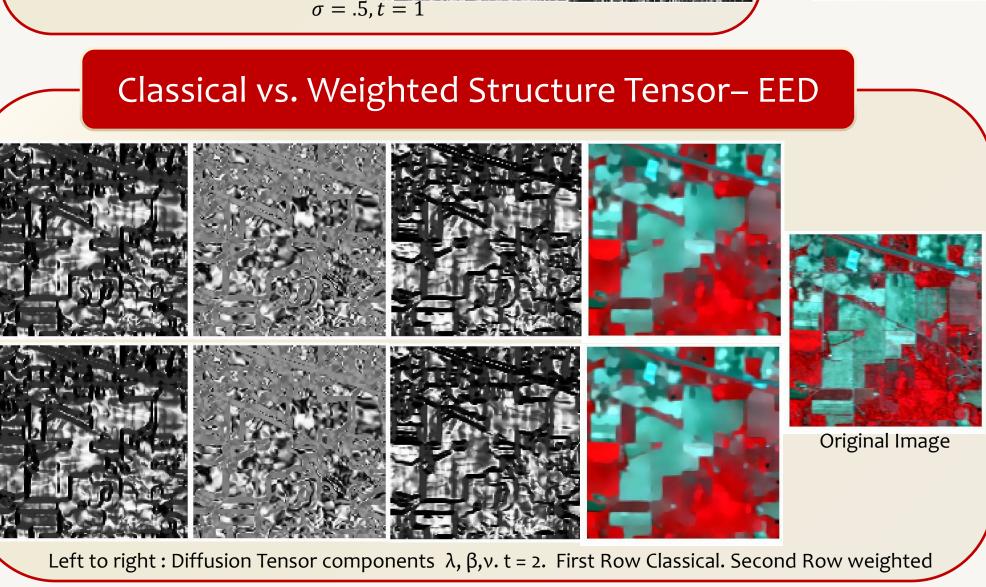
Eigenvalue-function with contrast parameter for CED

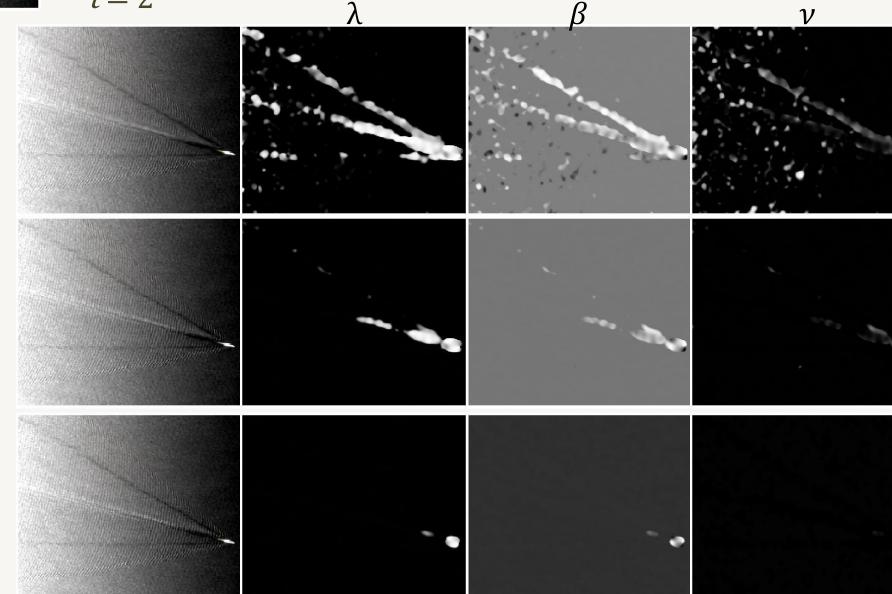
State of the art [3]





for Detection of Traces of Materials





Accomplishments Through Current Year

A TAND algorithm based on a weighted structure tensor has been developed. Weights are defined using the heat operator.

Diffusion algorithms have been implemented in MATLAB.

Experiments with HS data of different spatial characteristics have been performed and analyzed. Two papers have been published.

Future Work

Develop a method to combine CED and EED diffusion for further image enhancement.

Work on the transition to the UPRM Hyperspectral Image Analysis Toolbox.

Improve computational efficiency. Finish dissertation in Spring 2012.

Opportunities for Transition to Customer

Algorithms developed in MATLAB can be used as a basis to transition algorithms for companies interested in incorporating the Hyperspectral approach into Detection Systems.

Incorporation into the UPRM HSI Analysis Toolbox will facilitate access to algorithms in an easy to use environment to evaluate the technology.

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Publications Acknowledging DHS Support

- M. Marin-McGee and M. Velez-Reyes, "Enhancement of Flow-Like Structures in Hyperspectral Imagery Using Tensor Nonlinear Anisotropic Diffusion," in Proc. SPIE 8048, 2011, p. 80480E-80480E-9.
- 2. M. Marin-McGee and M. Velez-Reyes, "A Structure Tensor for Hyperspectral Images," in Proceedings of the 3rd IEEE Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing, Lisbon, 2011.

Other References

- J. Weickert, "Coherence-Enhancing Diffusion Filtering," International Journal of Computer Vision 31, 111-127 (1999).
- 4. J. Weickert, Anisotropic Diffusion in Image Processing, Teubner-Verlag (1998).

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