Unsupervised Segmentation of Mitochondria Using Model-based Spectral Clustering

Julia Dietlmeier, Ovidiu Ghita, Paul F. Whelan
Centre for Image Processing & Analysis, Dublin City University, Ireland

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Introduction

• Mitochondria are membrane-enclosed sub-cellular organelles that exhibit substantial morphological and structural variations.
• The current state of the art is manual segmentation which implies a laborious and subjective user-driven process.
• Prior research in the area of automatic mitochondria segmentation focused on the application of supervised machine learning approaches. These approaches proved impractical as they rely on the existence of large training datasets to accurately model the internal structures of mitochondria.
• A practical solution to this problem implies the inclusion of perceptual organization models such as Figure-Ground, Similarity, Proximity and Closure in the development of a foreground segmentation strategy that is based on multi-stage spectral clustering.

Proposed method

• Main Idea: We factored several perceptual organization principles into a joint model where a similarity matrix is used to reconstruct the 2D data via embedded kernel-PCA.
• In this low dimensional space the global salient structures are identified by means of multi-stage spectral clustering.
• To this end we propose a three-stage segmentation scheme where the first two steps (S1 and S2) involve the identification of dark contours that are given by the outer membrane of the mitochondrion, while the last step (S3) performs a contour post-processing that eliminates the pixels that are not consistent with a geometric model that is given by the inner and outer membranes of the mitochondrion.

Conclusions

• In our work we developed an unsupervised mitochondria segmentation algorithm that is based on the inclusion of perceptual organization principles that factor saliency, proximity and closure in a joint similarity model.
• Contrary to machine learning approaches, our method does not rely on subjective training procedures and proved robust to changes in the shapes and internal structures of mitochondria.
• Our future work will address the computational limitations associated with spectral clustering and with the generalization of this approach to multi-class segmentation tasks.

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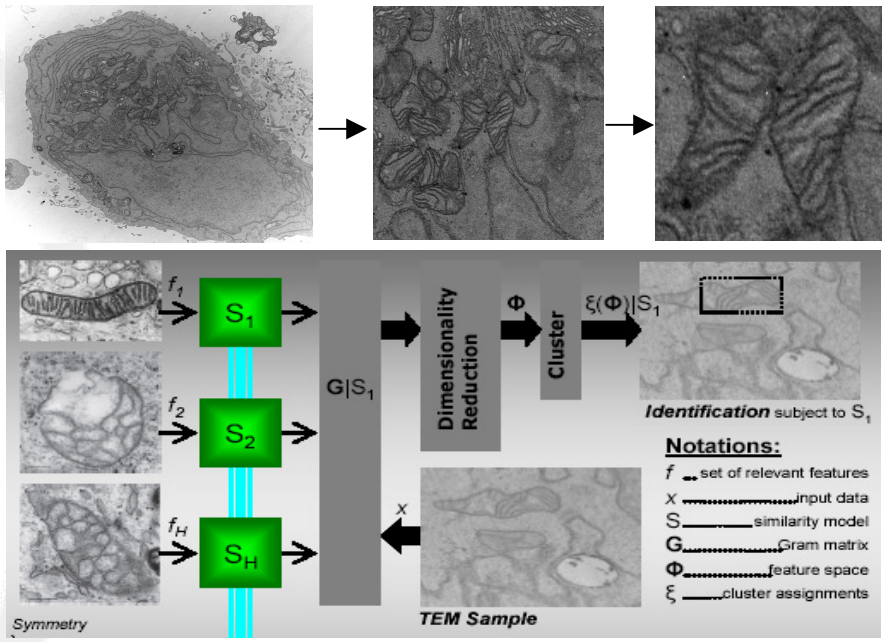
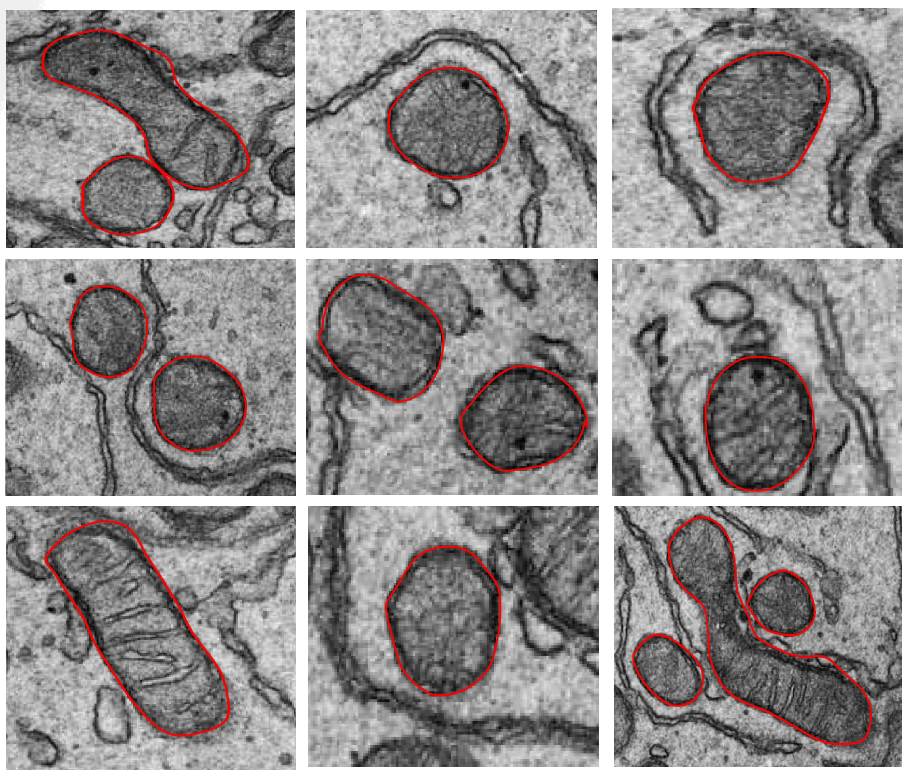
HEA Higher Education Authority An tÚdarás um Ard-Oideachas

NDP National Development Plan 2007 - 2013

Spectral Clustering-based Mithocondria Segmentation Framework



Experimental Results



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