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Title: Dendritic Spine Classification using Shape and Appearance Features based on Two-Photon Microscopy

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PII: S0165-0270(16)30292-8
DOI: http://dx.doi.org/doi:10.1016/j.jneumeth.2016.12.006
Reference: NSM 7641

To appear in: *Journal of Neuroscience Methods*

Received date: 27-8-2016
Revised date: 9-12-2016
Accepted date: 13-12-2016

Please cite this article as: Muhammad Usman Ghani, Fitsum Mesadi, S*ddotu*meyra Demir Kanik, Ali Özg*ddotu*r Argunşah, Anna Felicity Hobbiss, Inbal Israely, Devrim Ünay, Tolga Taşdizen, M*ddotu*jdat Çetin, Dendritic Spine Classification using Shape and Appearance Features based on Two-Photon Microscopy, *<![CDATA[Journal of Neuroscience Methods]]>* (2016), http://dx.doi.org/10.1016/j.jneumeth.2016.12.006

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# Dendritic Spine Classification using Shape and Appearance Features based on Two-Photon Microscopy

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**Abstract**

*Background:* Neuronal morphology and function are highly coupled. In particular, dendritic spine morphology is strongly governed by the incoming neuronal activity. The first step towards understanding the structure-function relationships is to classify spine shapes into the main spine types suggested in the literature. Due to the lack of reliable automated analysis tools, classification is mostly performed manually, which is a time-intensive task and prone to subjectivity.

*New Method*: We propose an automated method to classify dendritic spines using shape and appearance features based on challenging two-photon laser scanning microscopy (2PLSM) data. Disjunctive Normal Shape Models (DNSM) is a recently proposed parametric shape representation. We perform segmentation of spine images by applying DNSM and use the resulting representation as shape features. Furthermore, we use Histogram of Oriented Gradients (HOG) to extract appearance features. In this context, we propose a kernel density estimation (KDE) based framework for dendritic spine classification, which uses these shape and appearance features.

*Results*: Our shape and appearance features based approach combined with Neural Network (NN) correctly classifies 87.06% of spines on a dataset of 456 spines.

*Comparison with Existing Methods*: Our proposed method outperforms standard morphological feature based approaches. Our KDE based framework also enables neuroscientists to analyze the separability of spine shape classes in the

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