SPADE: A Small Particle Detection Method Using A Dictionary Of Shapes Within The Marked Point Process Framework

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SPADE: A SMALL PARTICLE DETECTION METHOD USING A DICTIONARY OF SHAPES WITHIN THE MARKED POINT PROCESS FRAMEWORK

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ABSTRACT

We introduce SPADE (small particle detection), a novel method to detect and characterize objects only a few pixel large on microscopy images, based on the use of a dictionary of shapes (Figure 1).

It involves the minimization of an energy function embedding a prior and a data fidelity term to match shapes of the dictionary with patterns in images. The data fidelity term is a comparison between the pixels' intensities within a potential match and the surrounding pixels' intensities. It can be defined in different ways, from simple averages differences to formulas incorporating variance of the intensities. The prior forbids any overlap between the matched shapes. The sensitivity of the detector can be tuned using a minimal threshold on the data fidelity term.

Using synthetic images of increasing blur, *i.e.*, detection difficulty, we showed that, on certain images, SPADE can outperform widely used methods in this classical task of biological image processing (Figure 2). We also show that the data fidelity term must be adapted to the nature of the images in order to get the best results.

We then apply SPADE, in a real-case scenario, on confocal fluorescence microscopy images of *D. melanogaster* cultured cells where cytoplasmic ribonucleoproteic granules have to be detected and characterized (Figure 3). We demonstrate that our method can be calibrated for high-throughput screening imaging study, generating a F_1 detection score of 0.76 after cross-validation using a trained biologist expertise as ground truth (data not shown).

An open-source python implementation of SPADE has been released on the *Python Package Index*[1]. Different dictonaries of shapes and data fidelity terms could be used for different applications.

Index Terms— Image processing, Object detection, High-content (high-throughput) screening, Single cell & molecule detection

[1]https://pypi.python.org/pypi/small-particle-detection/

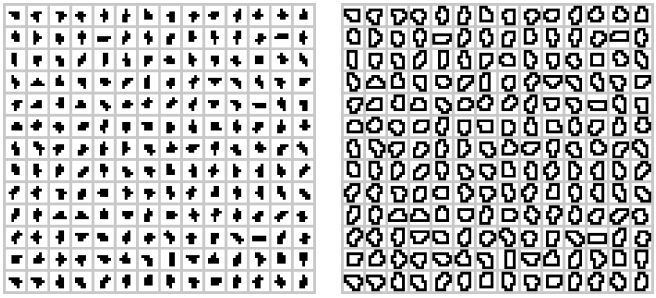

Fig. 1. SPADE default dictionary of shapes and their contours

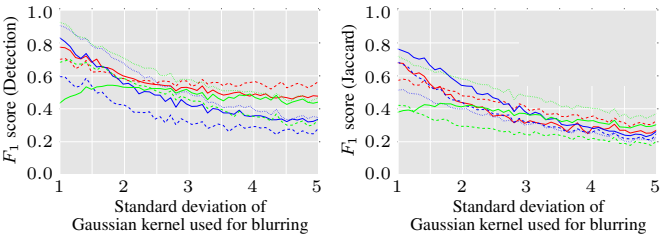

Fig. 2. Evaluation of SPADE (different data fidelity terms, green and blue) against a wavelet-based detector (- -) and simple intensity thresholding (——) on synthetic images

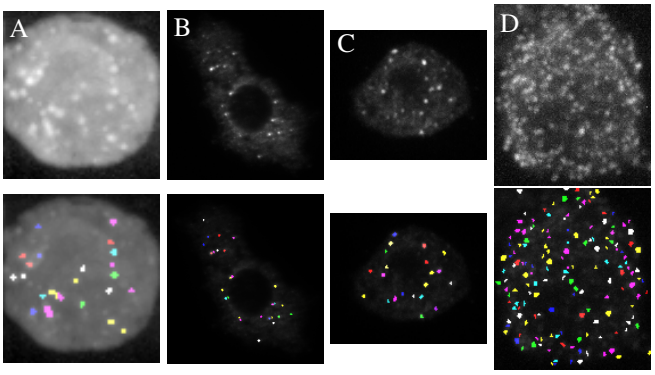

Fig. 3. Examples of real images (top) and the corresponding SPADE detections (bottom) Particles are fusion proteins (Green fluorescent protein-Imp), except (D): in situ hybridization with quasar 570-marked oligonucleotidic probes.