DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF COPENHAGEN

CENTRE FOR STOCHASTIC GEOMETRY AND ADVANCED BIOIMAGING

Distance map based analysis of organelle distributions

Hans JT Stephensen, hast@di.ku.dk
Jon Sporring, sporring@di.ku.dk

Summary

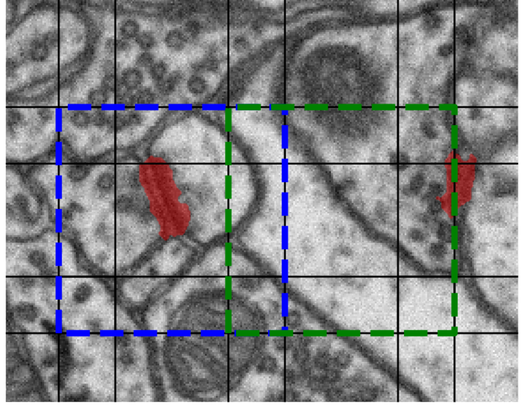
Analyzing the distribution of ultrastructures accurately across cells is a fundamental problem. We produce volume statistics of ultrastructures using a combination of neural network classification and calculated membrane-bounded distance maps in full 3D. The result is an insight into the distribution of organelles, which follows the morphology of the cells.

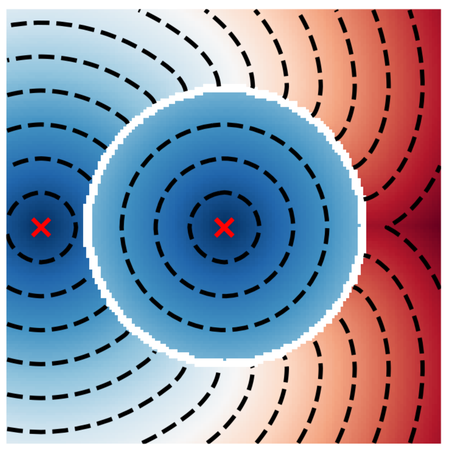
Method Overview

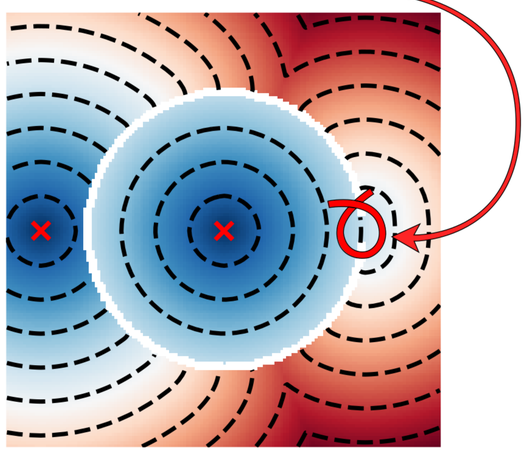
1. Predict the nerve structures using a CNN.
2. Clean up classifications by a connected component analysis. We either threshold on the size of the organelle or use the organelle location as a discriminator.
3. Choose organelles as distance map source (here synapse).
4. Choose organelles as distance map boundary (here membrane).
5. Compute the distance function using the fast marching method.
6. Combine the final organelle classif - cation and calculated distance map to generate distributions of the organelle volume in the distance map.

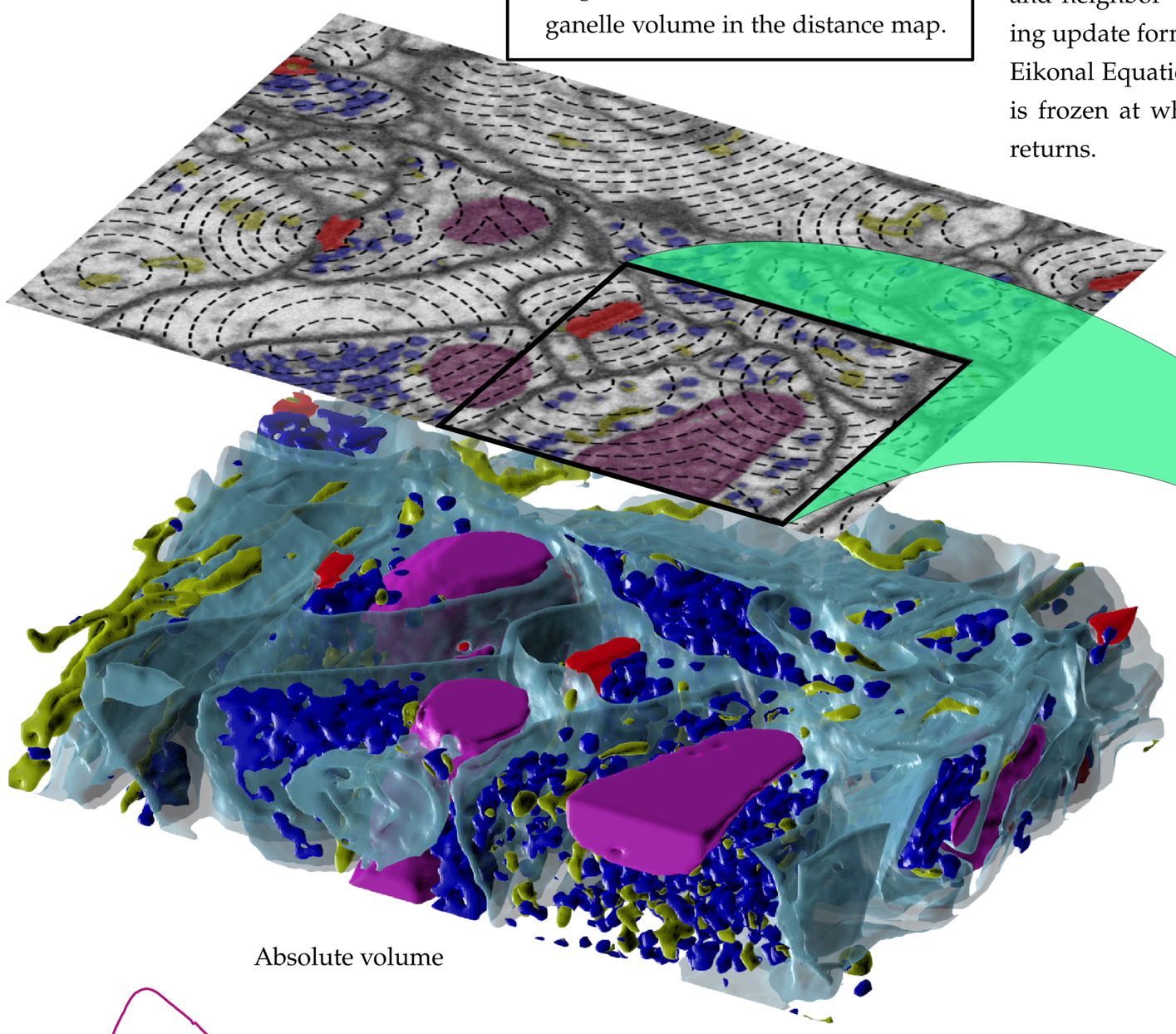
Calculating Distance Maps

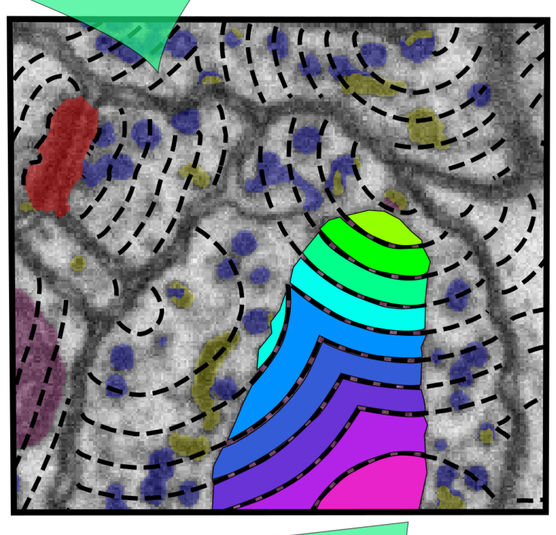
Calculating distance maps was done solving the Eikonal Equation using the Fast Marching Method. Our implemented Fast Marching Method works by initializing each point of a 3D Cartesian grid either (1), by ∞ if that point has to be calculated, (2) placeholder values if that point marks the boundary of the distance map (3) precalculated 'known' values if the distance has already been calculated from a previous iteration or (4) zero if it marks a source of the distance map. The minimum values are then marked as frozen one at a time, and neighbor values are updated using update formulas derived from the Eikonal Equation until the entire grid is frozen at which point the method returns.

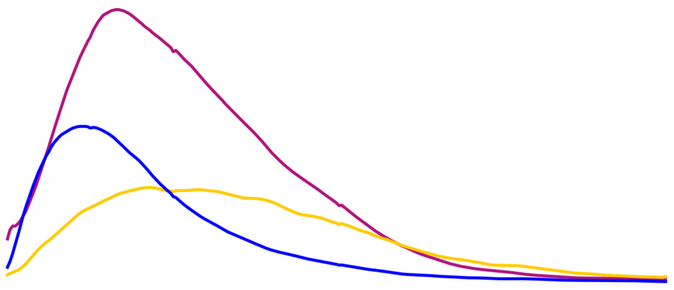


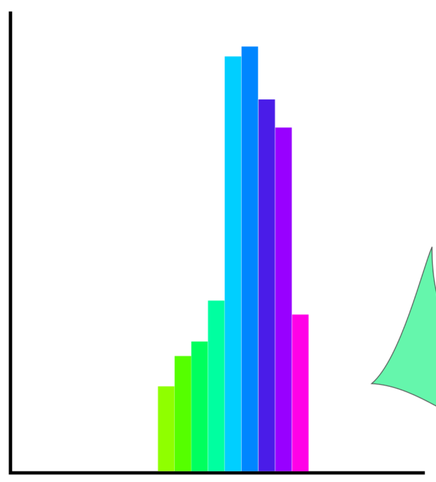












Conclusion & Future

We here show how the distribution of the volume in the synapse distance map of the mitochondria, endoplasmic reticulum and vesicles are distinctly different because of their location. Both mitochondria and vesicles are usually closer to the active zone, while the endoplasmic reticulum spans the neurons. In the future, we hope to use this to assess morphological differences in cells with and without disease conditions.