

Visual Feature Exploration for ssTEM Image Segmentation

Masterstudium:
Visual Computing

Ivan Maricic

Technische Universität Wien
Institut für Computergraphik und Algorithmen
Arbeitsbereich Computergraphik
Betreuung: Ao.Univ.Prof. Dipl.-Ing. Dr.techn. Eduard Gröller
Mitwirkung: Dipl.-Inf. Hendrik Schulze

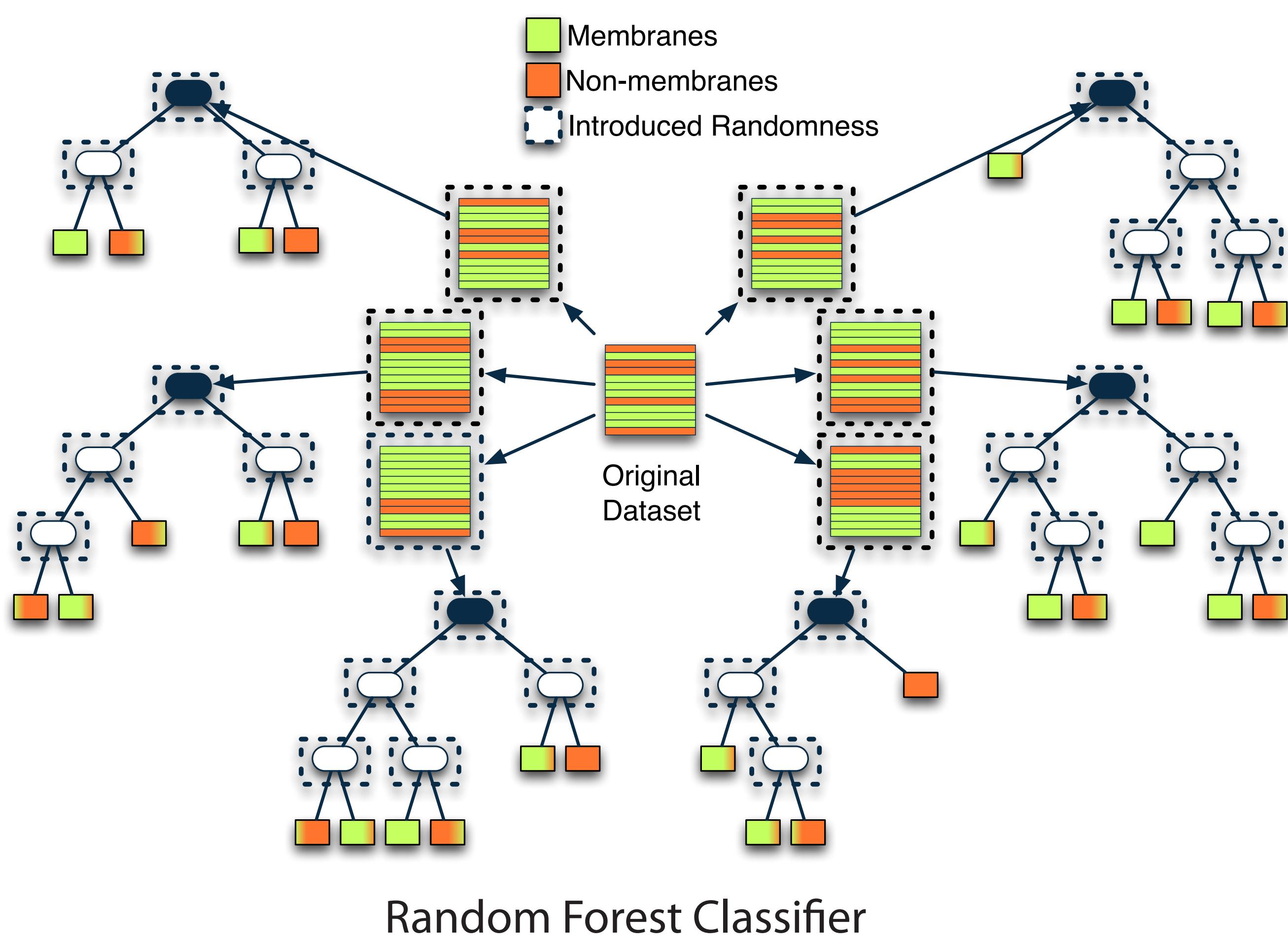
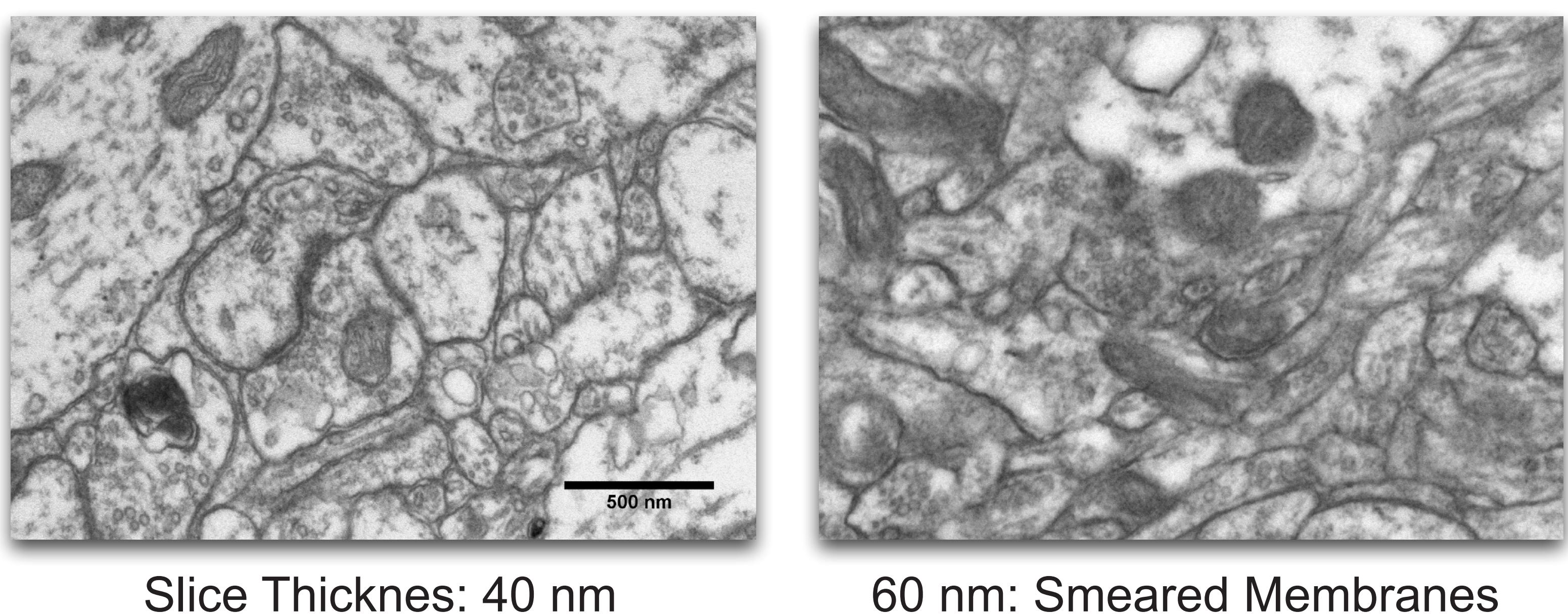
Problem Statement/Motivation

Serial-section Transmission Electron Microscopy (ssTEM)

Problem 1 Large Volumes 1 cm^3 require 1776 Petabyte

Problem 2 Artifact-afflicted Images

Goal Machine Learning-based Membrane Segmentation,
use Visualization and Interaction to Improve Segmentation



Method

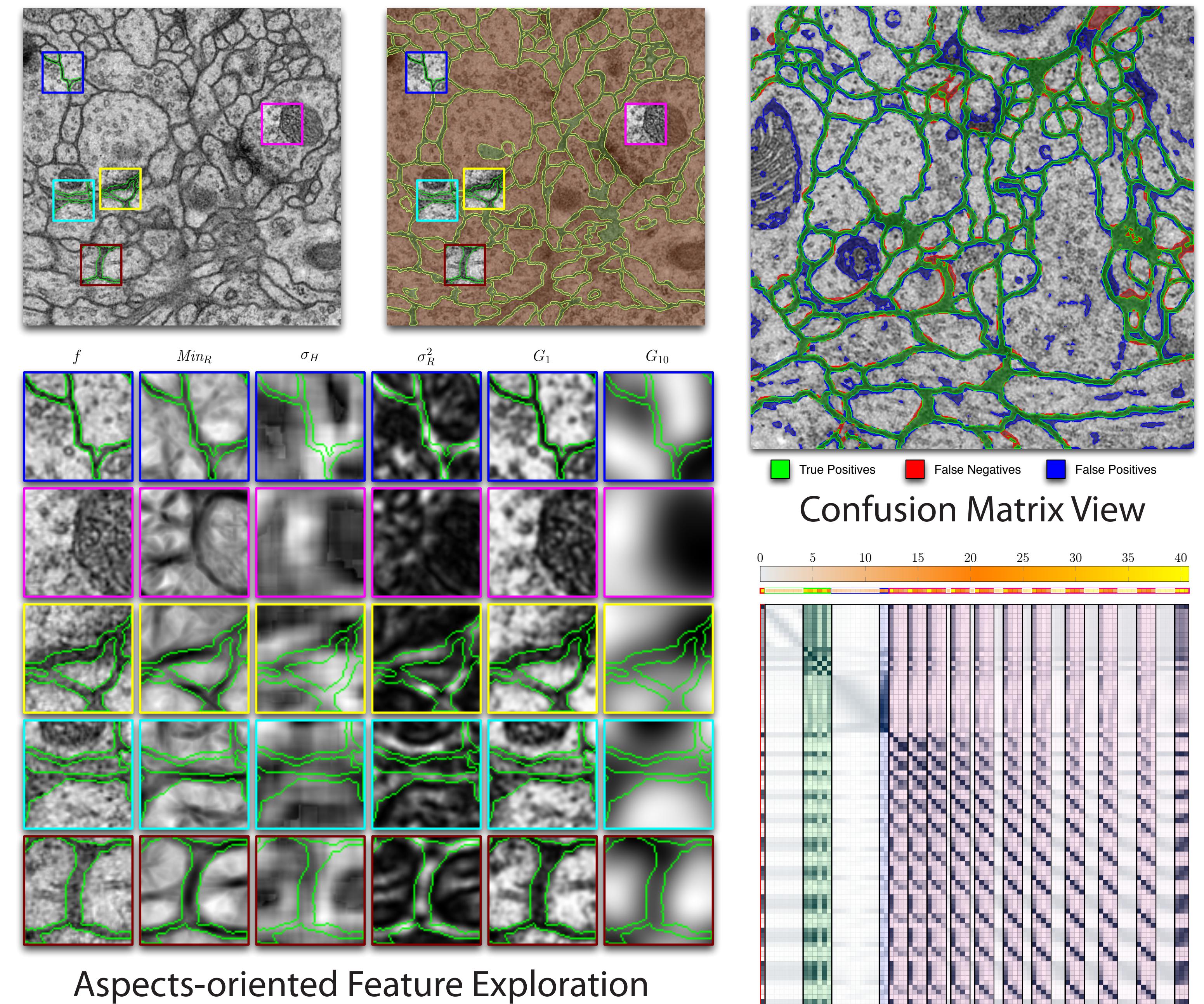
Iterative Training Sample Construction (**Q1**)
Create Aspects (=Image Patches) from Segmentation Results (**Q2**)
 based on representative membrane examples
 based on problematic regions
Use Aspects (**Q2**)
 to guide creation of new feature images
 to define anchors for proof reading of segmentation
Use Correlation-based Feature Selection with Intra-class Covariance Check (**Q2**)
Aspect Visualization (**Q3**)
 use confusion matrix view to show type of errors made by segmentation

Segmentation Results			Timing Results (sec)		
	T_i	T_{i+1}	T_{GT}		
# Positives	1,358	1,613	61,451		
# Negatives	1,636	2,350	200,691		
Size in %	0.04	0.05	3.33		
Error	0.1513	0.1270	0.1464		
\mathcal{F}_{90} Precision	0.6731	0.7914	0.6294		
Recall	0.6528	0.5910	0.8300		
Error	0.1505	0.1277	0.1448		
\mathcal{F}_{52} Precision	0.6784	0.7893	0.6349		
Recall	0.6457	0.5910	0.8302		
Error	0.1560	0.1305	0.1472		
\mathcal{F}_{49} Precision	0.6601	0.7822	0.6297		
Recall	0.6510	0.5831	0.8308		
Error	0.1353	0.1248	0.1464		
\mathcal{F}_{90+1} Precision	0.7333	0.8053	0.6290		
Recall	0.6307	0.5834	0.8316		
Error	0.1497	0.1298	0.1473		
\mathcal{F}_{52+1} Precision	0.6792	0.7918	0.6285		
Recall	0.6451	0.5736	0.8282		
Error	0.1558	0.1336	0.1479		
\mathcal{F}_{49+1} Precision	0.6607	0.7778	0.6277		
Recall	0.6472	0.5690	0.8287		

Evaluation Results of Six Feature Sets

Scientific Questions

(Q1) How to Organize Training Sample Creation?
(Q2) How to Construct Feature Sets for Learning a Concept?
(Q3) How to Compare Prediction Models?
(Q4) Can Segmentation be Improved (Accuracy, Memory, Time)?



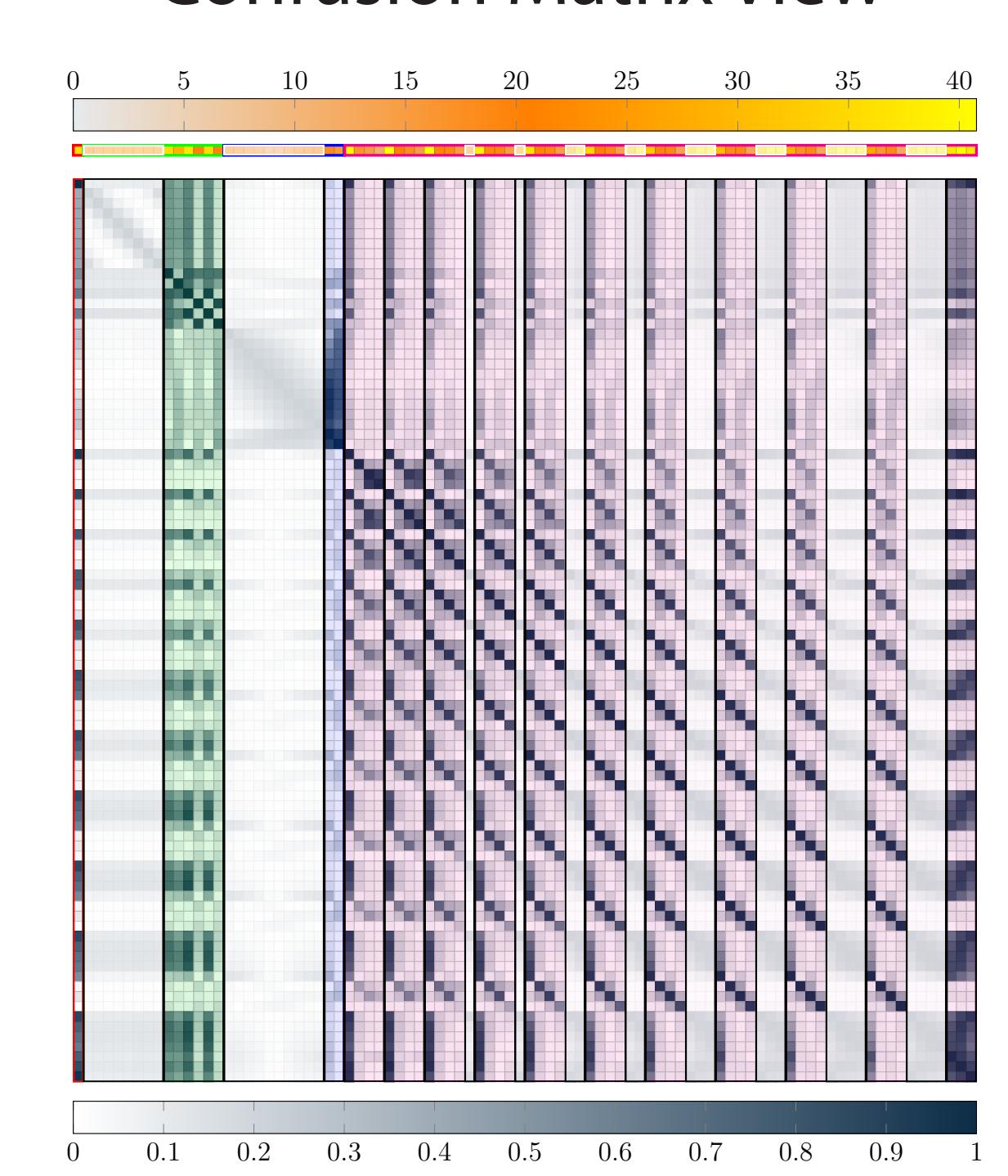
Results

Reduced Feature Set (Q4) \mathcal{F}_{52}
▷ reduced by 42.22 %
▷ similar prediction error 12.70 % vs. 12.77 %

Additional Feature
▷ from 12.70 % to 12.48 % error rate for \mathcal{F}_{90+1}
▷ no improvement for \mathcal{F}_{52+1}

Processing Time (Q4)
improvement only noticeable for large training and testing samples

Feature Correlation Coefficient Matrix View



References

- [1] V. S. Kaynig-Fittkau. *Machine learning approaches for neuron geometry extraction and synapse detection in electron microscopy images*. PhD thesis, ETH Zürich, Zürich, 2011.
- [2] Guyon and A. Elisseeff. *An introduction to variable and feature selection*. J. Mach. Learn. Res., 3:1157–1182, Mar. 2003.
- [3] L. Breiman. *Random forests*. Mach. Learn., 45(1):5–32, Oct. 2001. ISSN 0885-6125.