Utilizing Deep Learning for Cellular cryo-tomography

Niels Volkmann
Sanford Burnham Prebys Medical Discovery Institute
NRAMM Deep Learning Workshop, April 2018
ARTIFICIAL INTELLIGENCE
Engineering of making Intelligent Machines and Programs

MACHINE LEARNING
Ability to learn without being explicitly programmed

DEEP LEARNING
Learning based on Deep Neural Network
Cellular Tomography
Cellular Tomography

Cortex
- crosslinked networks

Stress fibers
- antiparallel contractile structures

Lamellipodium
- branched and crosslinked networks

Filopodium
- parallel bundles

Blanchoin et al. (2014)
Traditional Machine Learning Approach

Input data (pixels) -> feature representation (hand-crafted) -> Learning Algorithm (e.g., SVM)

- SIFT
- Spin image
- HoG
- Textons
Template-based Approaches

from Frangakis et al. PNAS 2002

Xu et al. LNCS 2015
Deep Neural Network

Input Layer

Hidden Layer 1

Hidden Layer 2

Hidden Layer 3

Output Layer

IT'S EINSTEIN!

edges

combinations of edges

object models
Universal Approximation Theorem

THAT'S NOT EINSTEIN!!
Cellular Tomography

- **Cortex**: crosslinked networks
- **Stress fibers**: antiparallel contractile structures
- **Lamellipodium**: branched and crosslinked networks
- **Filopodium**: parallel bundles

Blanchoin et al. (2014)
The "volume percentage" is not completely accurate because of the elongation in Z. Estimate from comparing XY with Z is that it is ~1.5 X smaller. Corrected numbers are in brackets. A (corrected) fraction of 0.25 approximately translates to an average distance between filament centers of ~3 times its diameter (~30 nm).

- volume fraction of actin filaments in bundles:
  - wt: 0.233 +/- 0.073 (0.153)
  - mut: 0.362 +/- 0.116 (0.242)

- volume fraction of actin filaments in protrusions:
  - wt: 0.287 +/- 0.095 (0.191)
  - mut: 0.384 +/- 0.084 (0.256)

T-tests indicate p << 0.0001 for wt versus mut protrusion versus bundle.

Mut: p = 0.0863 (-> statistically no difference)

Wt: p << 0.0001

Anderson et al. 2016
Mordvintsev et al. 2015
Acknowledgements:

Volkmann Lab:
Xiao-Ping Xu
Chris Page

Hanein Lab:
Karen Anderson
Mark Swift