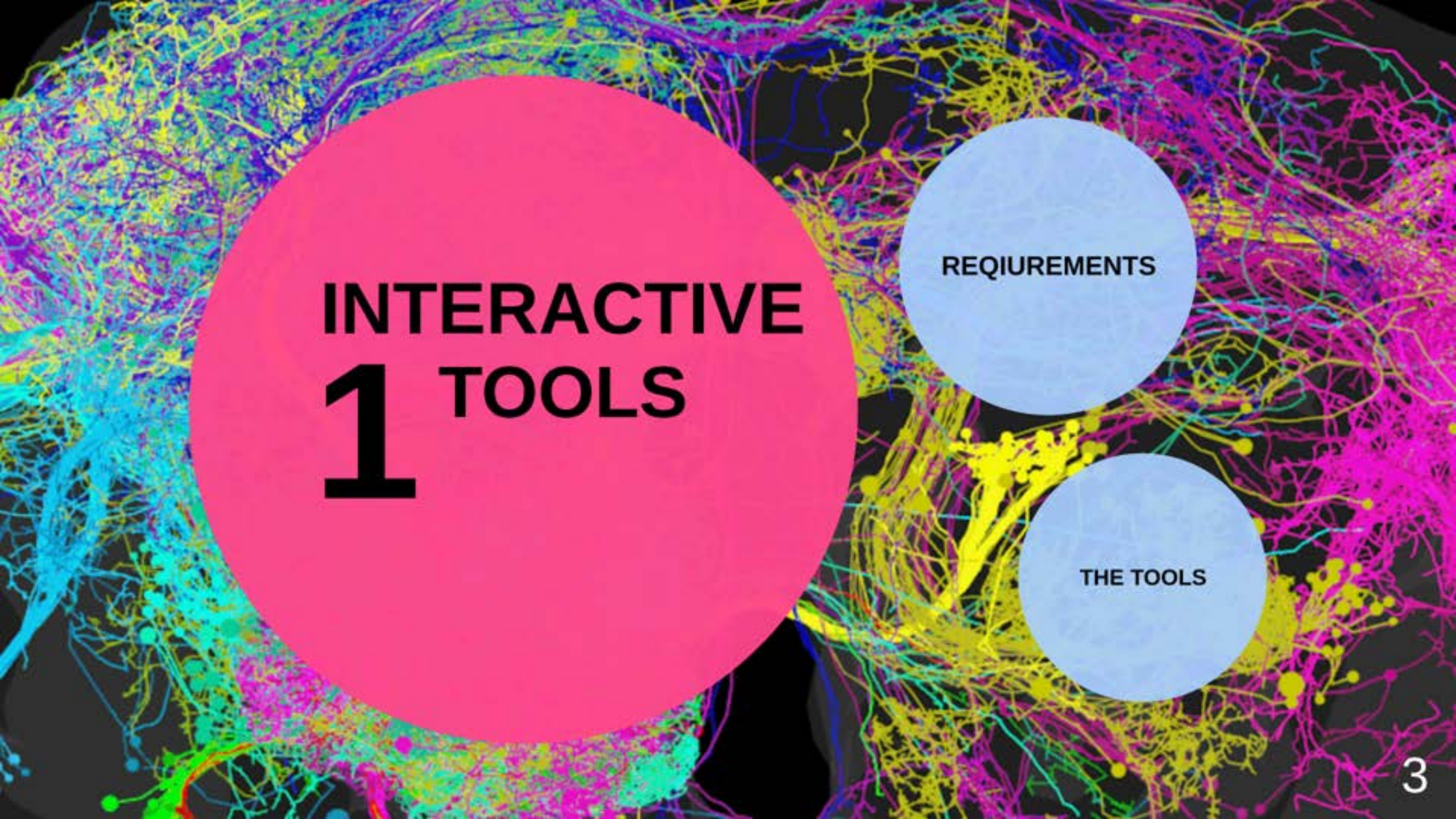
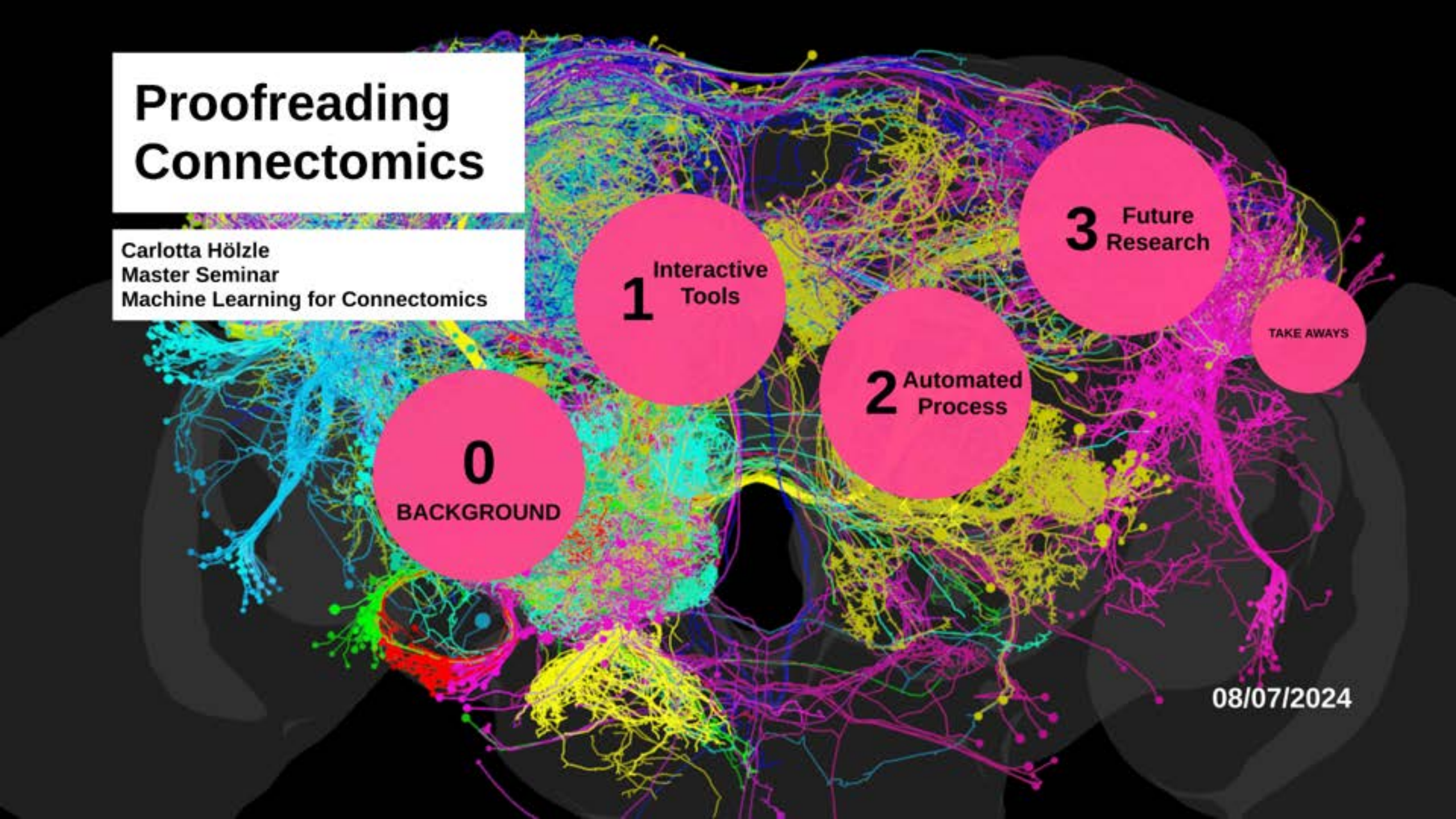
Explanation:

This presentation is built with animations; therefore, the slide numbering might be a little bit confusing, but I hope that with the presentation it becomes clear. As there was no specification oft he format the slides should be uploaded with, I hope this pdf format is okay.

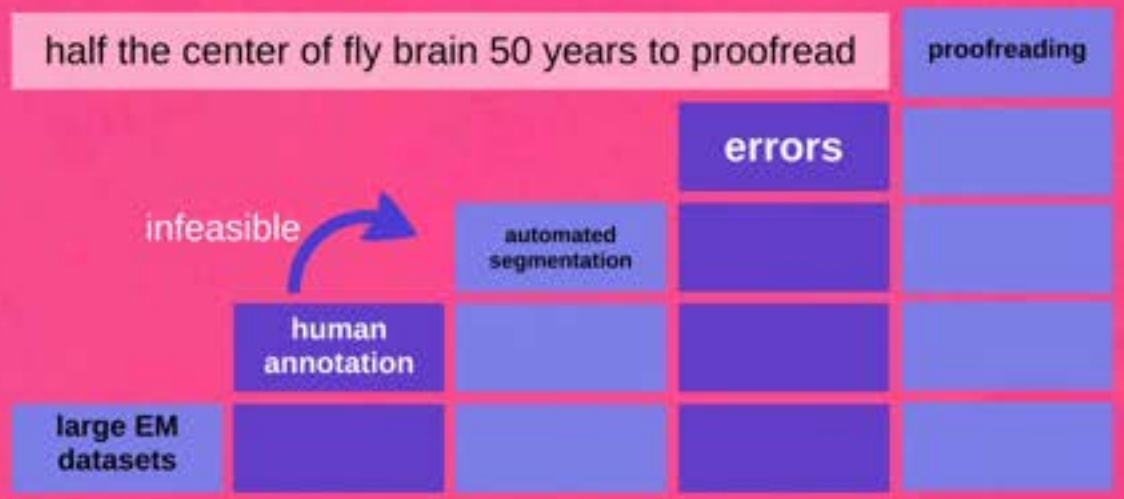

INTERACTIVE
1 TOOLS
REQIUREMENTS
THE TOOLS

Proofreading Connectomics

Carlotta Hölzle
Master Seminar
Machine Learning for Connectomics



BACKGROUND

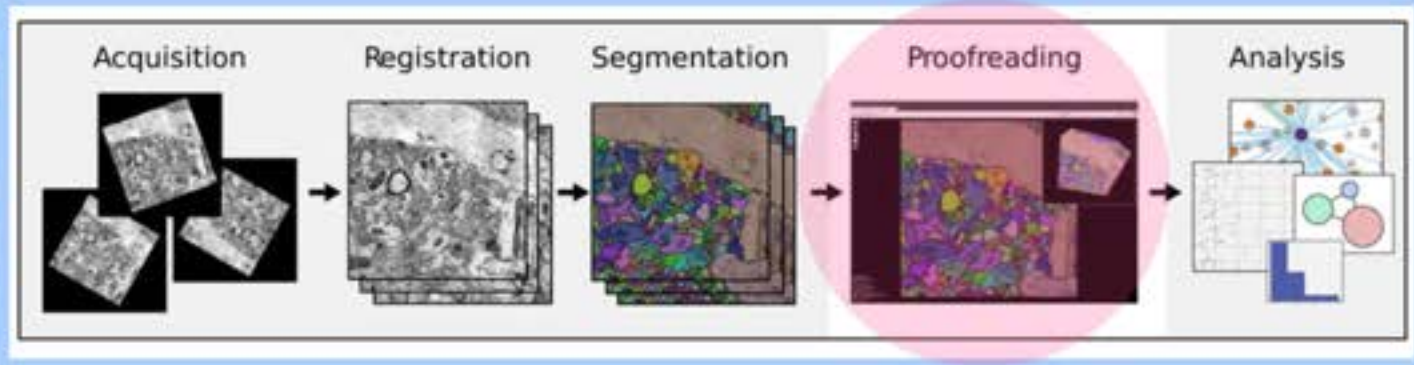


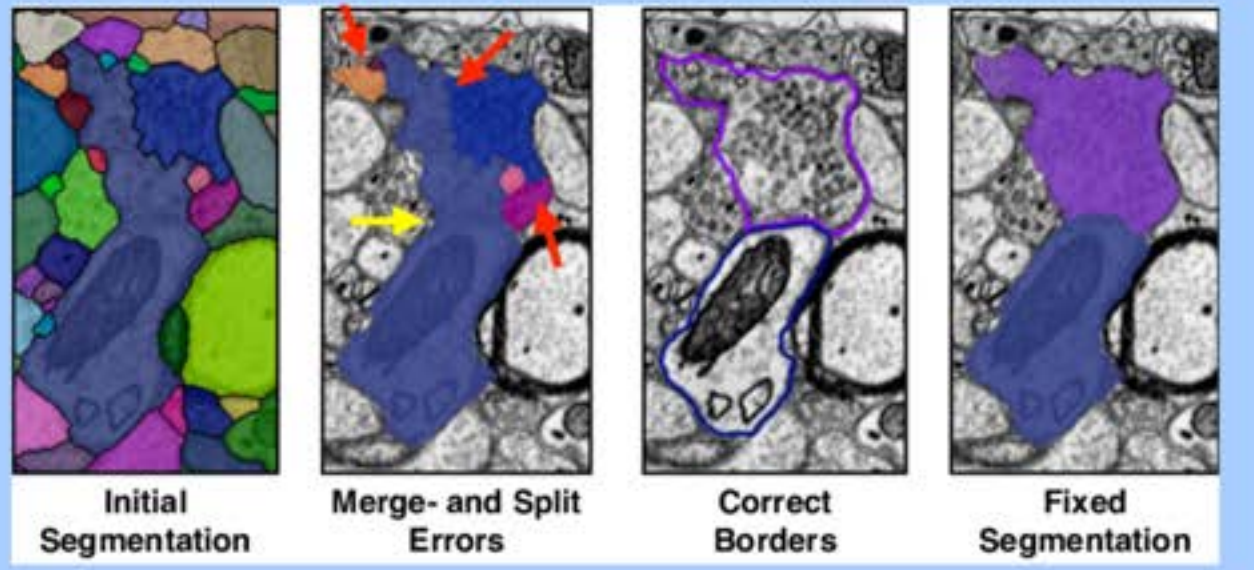
proofreading = main bottleneck

- crowd-sourcing?
- automated error detection & correction?
- standardized workflows?

Scheffer, L. K., Xu, C. S., Januszewski, M., Lu, Z., Take- mura, S.-y., Hayworth, K. J., Huang, G. B., Shinomiya, K., Maitlin-Shepard, J., Berg, S., et al. A connectome and analysis of the adult drosophila central brain. elife, 9: e57443, 2020.

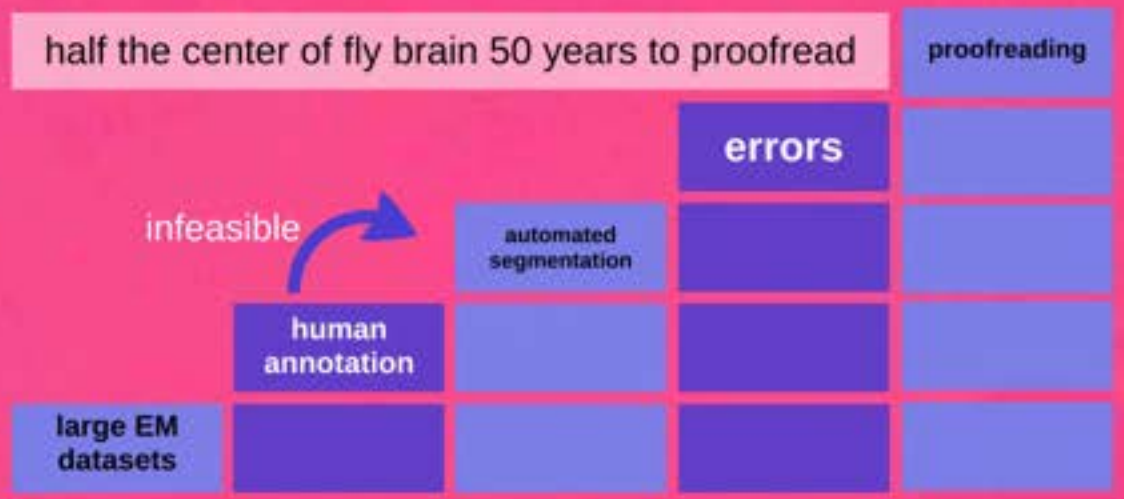
WORKFLOW





https://www.researchgate.net/publication/273394468/figure/fig1/AS:689257886801920@1541343294157/Proofreading-as-part-of-the-Connectome-workflow-Electron-microscopy-data-of-the.jpg
https://www.researchgate.net/publication/329750899/figure/fig1/AS:712800884236288@1546956382107/The-most-common-proofreading-corrections-are-fixing-split-errors-red-arrows-and-merge.png

BACKGROUND



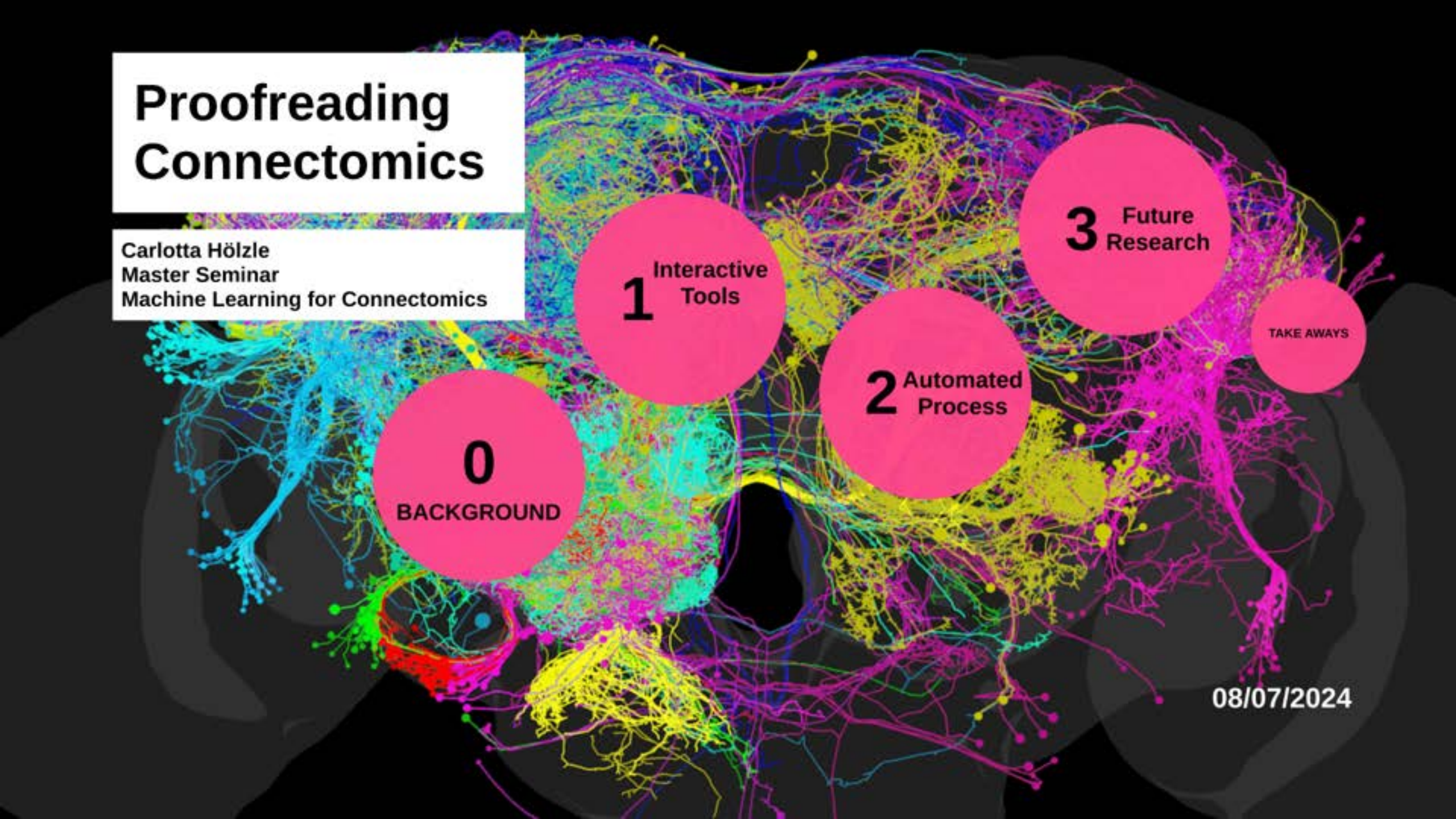
proofreading = main bottleneck

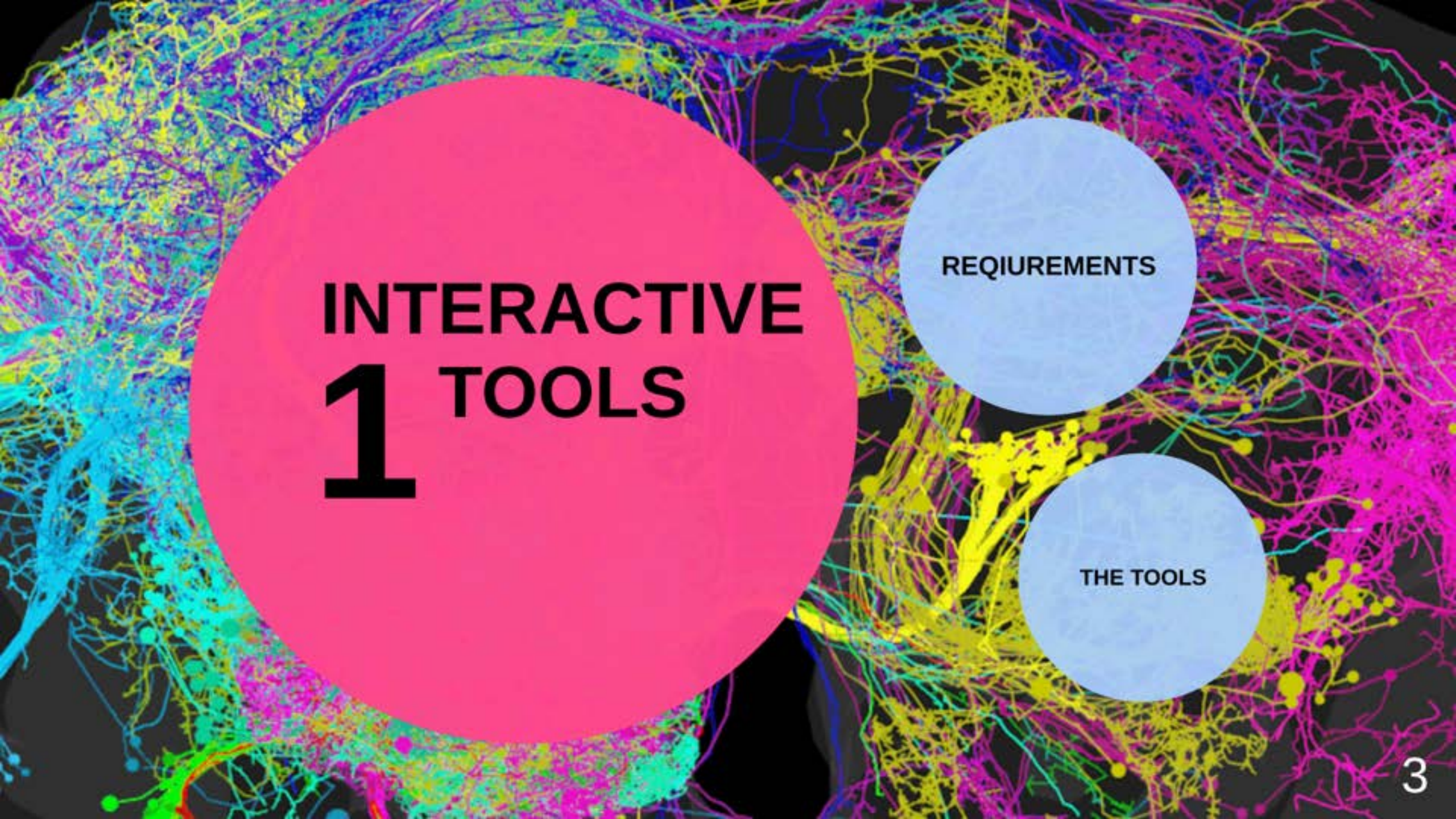
- crowd-sourcing?
- automated error detection & correction?
- standardized workflows?

Scheffer, L. K., Xu, C. S., Januszewski, M., Lu, Z., Take- mura, S.-y., Hayworth, K. J., Huang, G. B., Shinomiya, K., Maitlin-Shepard, J., Berg, S., et al. A connectome and analysis of the adult drosophila central brain. elife, 9: e57443, 2020.

Proofreading Connectomics

Carlotta Hölzle
Master Seminar
Machine Learning for Connectomics




INTERACTIVE
1 TOOLS
REQIUREMENTS
THE TOOLS

Requirements

0 = no reduction, 1 = minimal, 2 = advanced, 3 = extensive, 4 = full, * = advanced features

Collaboration/
Accessibility 4.1

Interface/Tools 4.4

Scalability 4.7

Visualisation 4.2

Progress/History Tracking 4.5

Standard Input/Output 4.8

Error Automation 4.3

Computational Expense 4.6

multi vs. single user

control mechansim

web-based vs. installation

Collaboration/ Accessibility

2D

↓

3D

↓

OTHER:

- SEG. SKELETON
- GRAPH

Visualisation

Semi:
1. automated hints
   - confidence level
   - verification status
2. highlighting inconsistencies
3. yes/no questions

Automated:
1. max-flow min-cut for neuron splits
2. heuristics
3. volume & synaptic threshold

Error Automation

1. **GUI**
   MINIMALISTIC & INTUITIVE > COMPLEX

2. **TOOLS**
   EASY > COMPLEX

3. **EXPERT LEVEL**
   LAYPERSON > HIGH EXPERTISE

Interface/Tools

PROGRESS:
- "TO-DO"; "DONE"

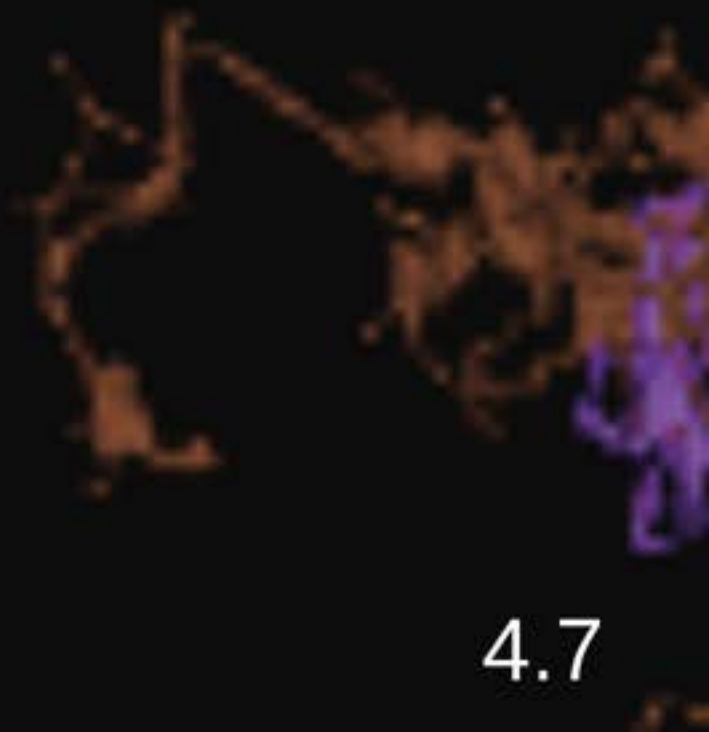
MAINTAIN HISTORY

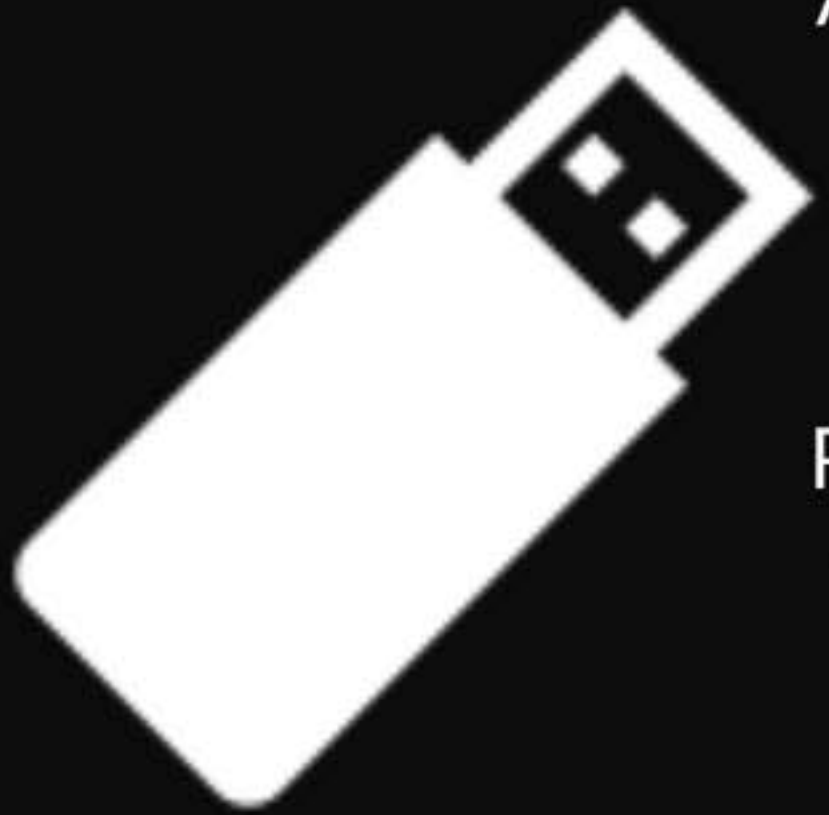
Progress/History Tracking

- OVERHEAD COST
- PARALLELIZABLE
- CONSTRAINTS
- EFFICIENCIE

Computational Expense

Scalability





AUTOMATIC SEGMENTATION

PROOFREAD SEGMENTATION
+ GRAPH

Standard Input/Output

Requirements

0 = no reduction, 1 = minimal, 2 = advanced, 3 = extensive, 4 = full, * = advanced features

Collaboration/
Accessibility

Interface/Tools

Scalability

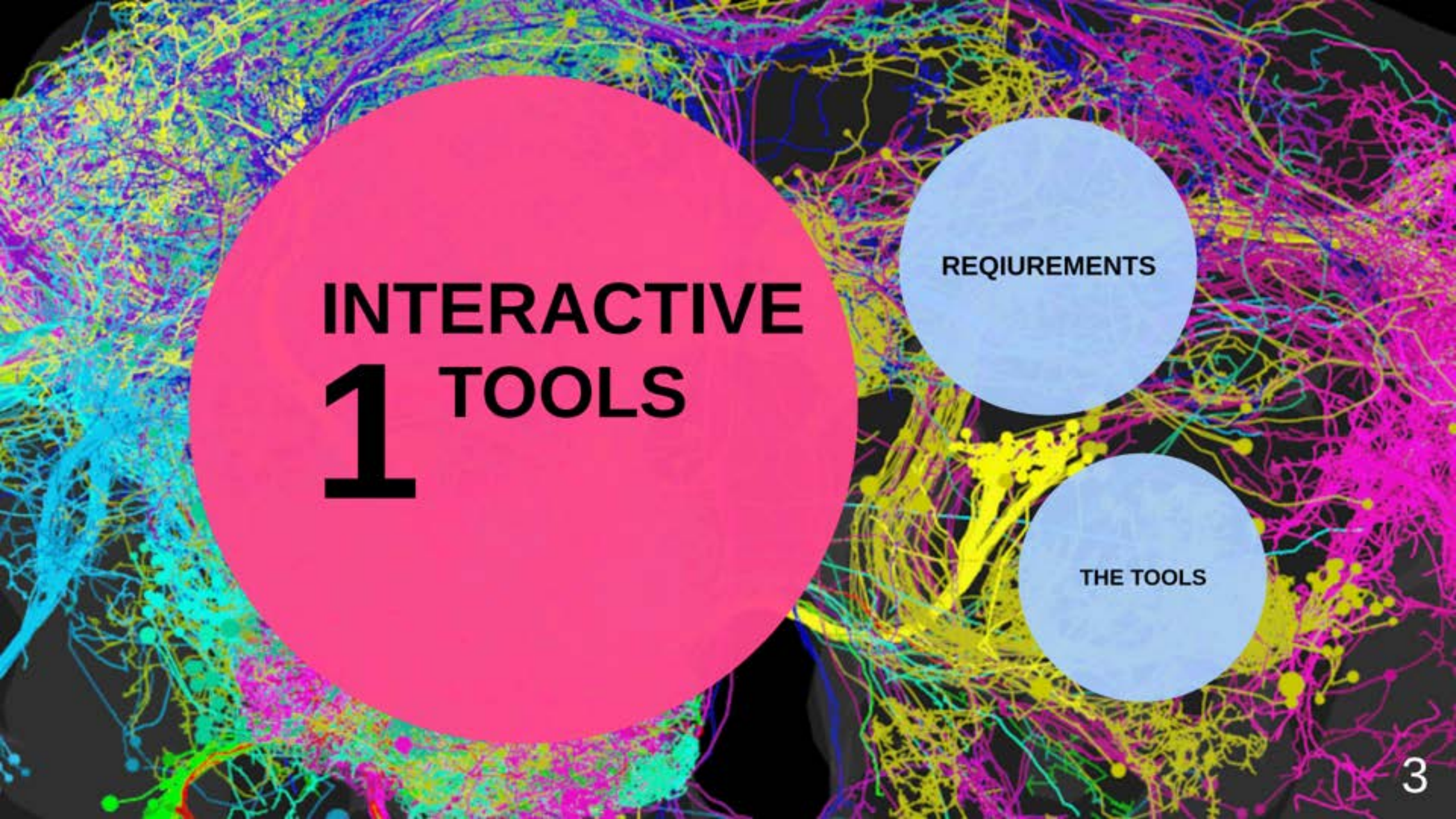
Visualisation

Progress/History
Tracking

Standard Input/Output

Error Automation

Computational Expense


INTERACTIVE
1 TOOLS
REQIUREMENTS
THE TOOLS

Tools

0 = no reduction, 1 = minimal, 2 = advanced, 3 = extensive, 4 = full, * = advanced features

	Raveler	Mojo	Graph	Dojo	VICE	NeuroProof	Flywire	NeuTu
User	1	0	0	3	1	0	2	2
Visualisation	1	0	1	3	3	0	3	3
Automation	0	0	1	0	3	3	3	3*
Interface	1	1	3	3	2	3	3	3
Tracking	0	0	0	0	0	0	2	3*
Computation	1	2	0	2	3	3	2	3
Scalability	1	3	1	3	3	3	3	2
Input/Output	2	2	2*	2	2	2	2	1
Reduction	1	1	1	2	2	2	2.5	3

6

Collaboration/
Accessibility

Interface/Tools

Scalability

Visualisation

Progress/History
Tracking

Standard Input/Output

Error Automation

Computational Expense

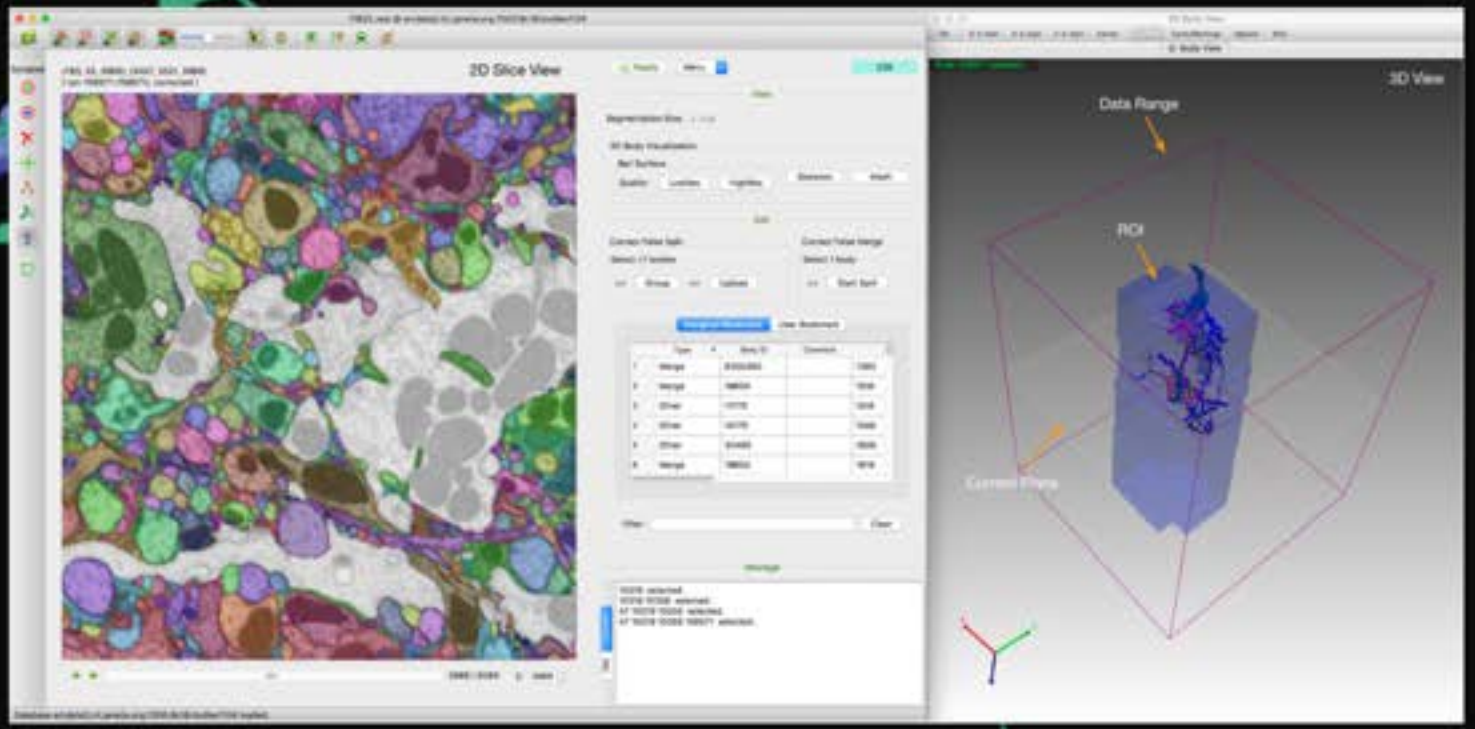
0 = no reduction, 1 = minimal, 2 = advanced, 3 = extensive, 4 = full, * = advanced features

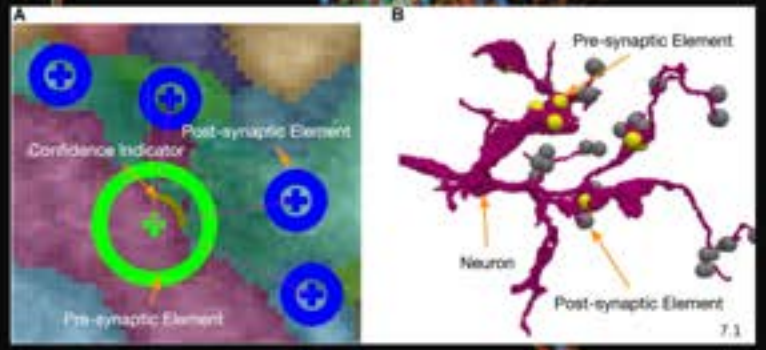
	Raveler	Mojo	Graph	Dojo	VICE	NeuroProof	Flywire	NeuTu
User	1	0	0	3	1	0	2	2
Visualisation	1	0	1	3	3	0	3	3
Automation	0	0	1	0	3	3	3	3*
Interface	1	1	3	3	2	3	3	3
Tracking	0	0	0	0	0	0	2	3*
Computation	1	2	0	2	3	3	2	3
Scalability	1	3	1	3	3	3	3	2
Input/Output	2	2	2*	2	2	2	2	1
Reduction	1	1	1	2	2	2	2.5	3

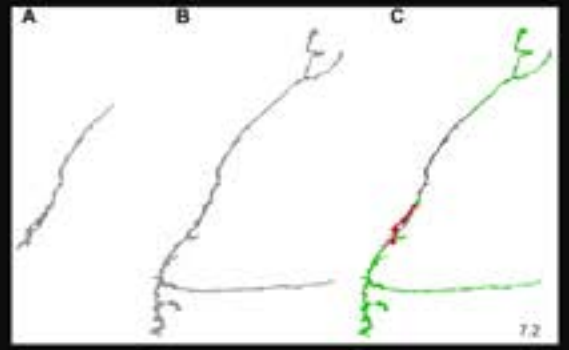
NeuTU

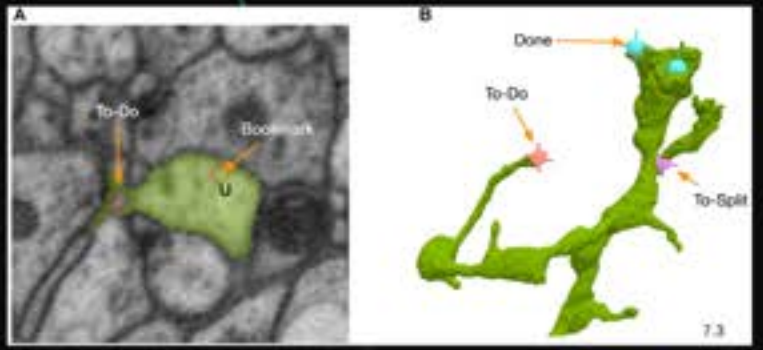
2 3 3* 3

3* 3 2 1

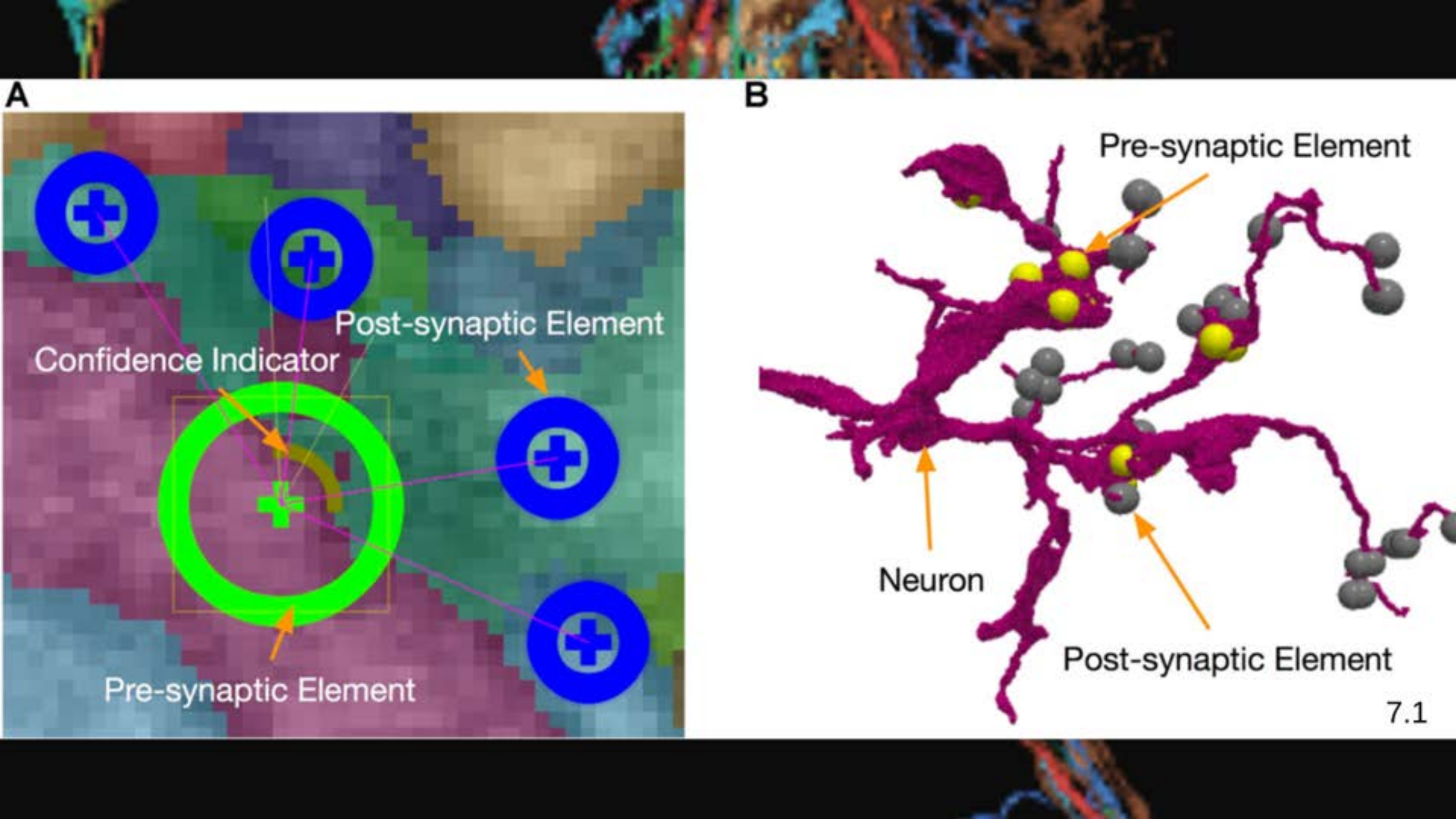


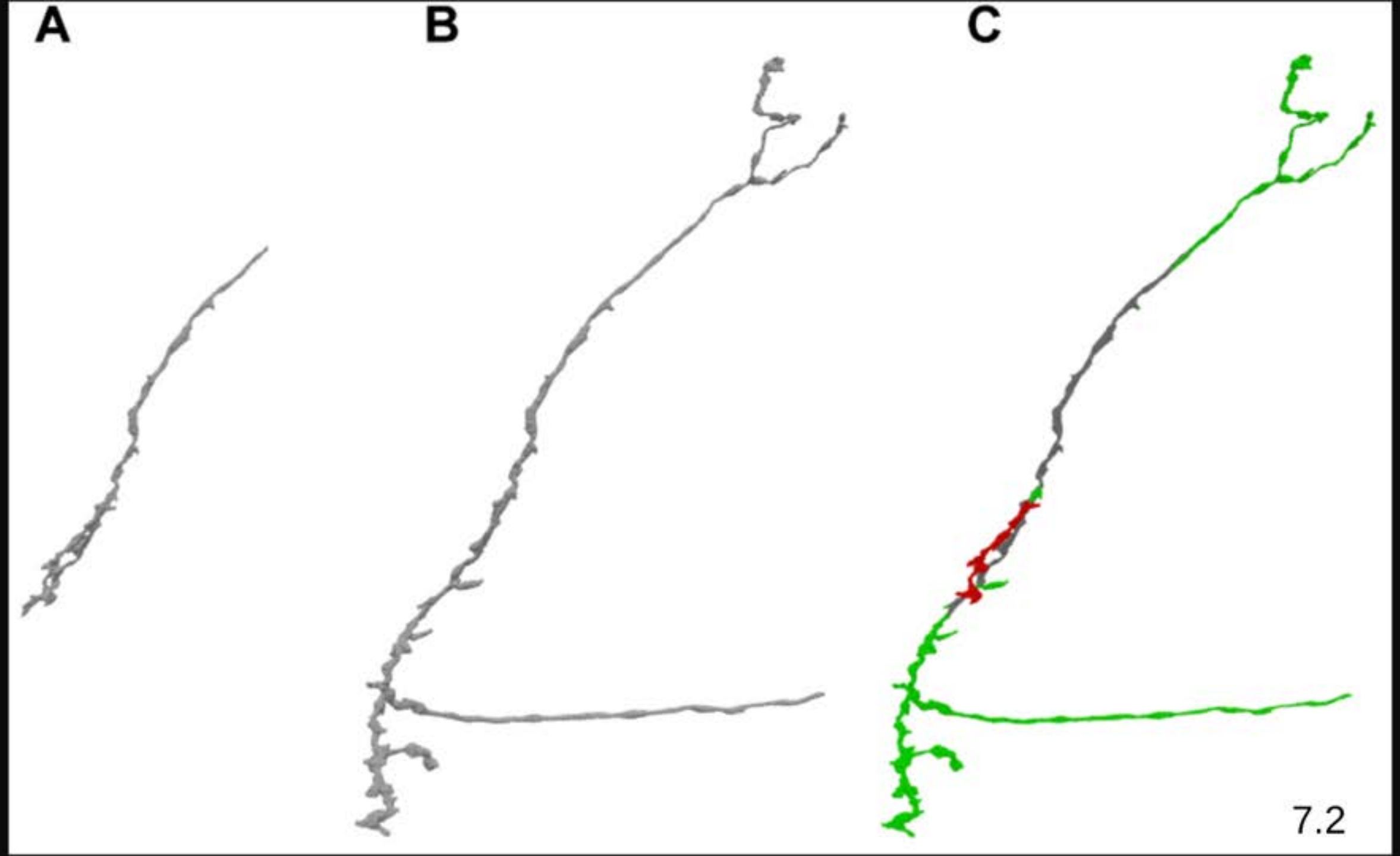


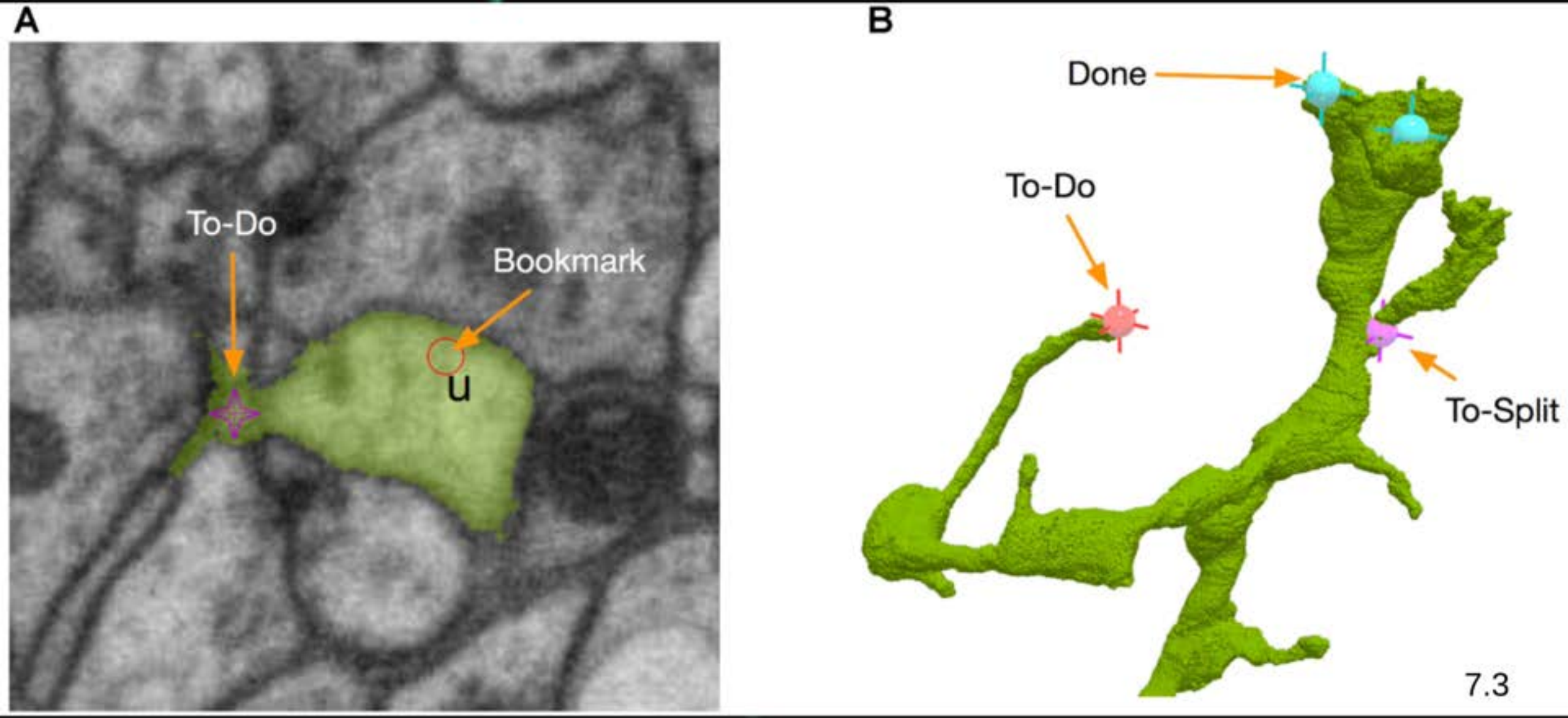




Zhao, T., Olbris, D. J., Yu, Y., and Plaza, S. M. Neutu: software for collaborative, large-scale, segmentation-based connectome reconstruction. Frontiers in Neural Circuits, 12:101, 2018

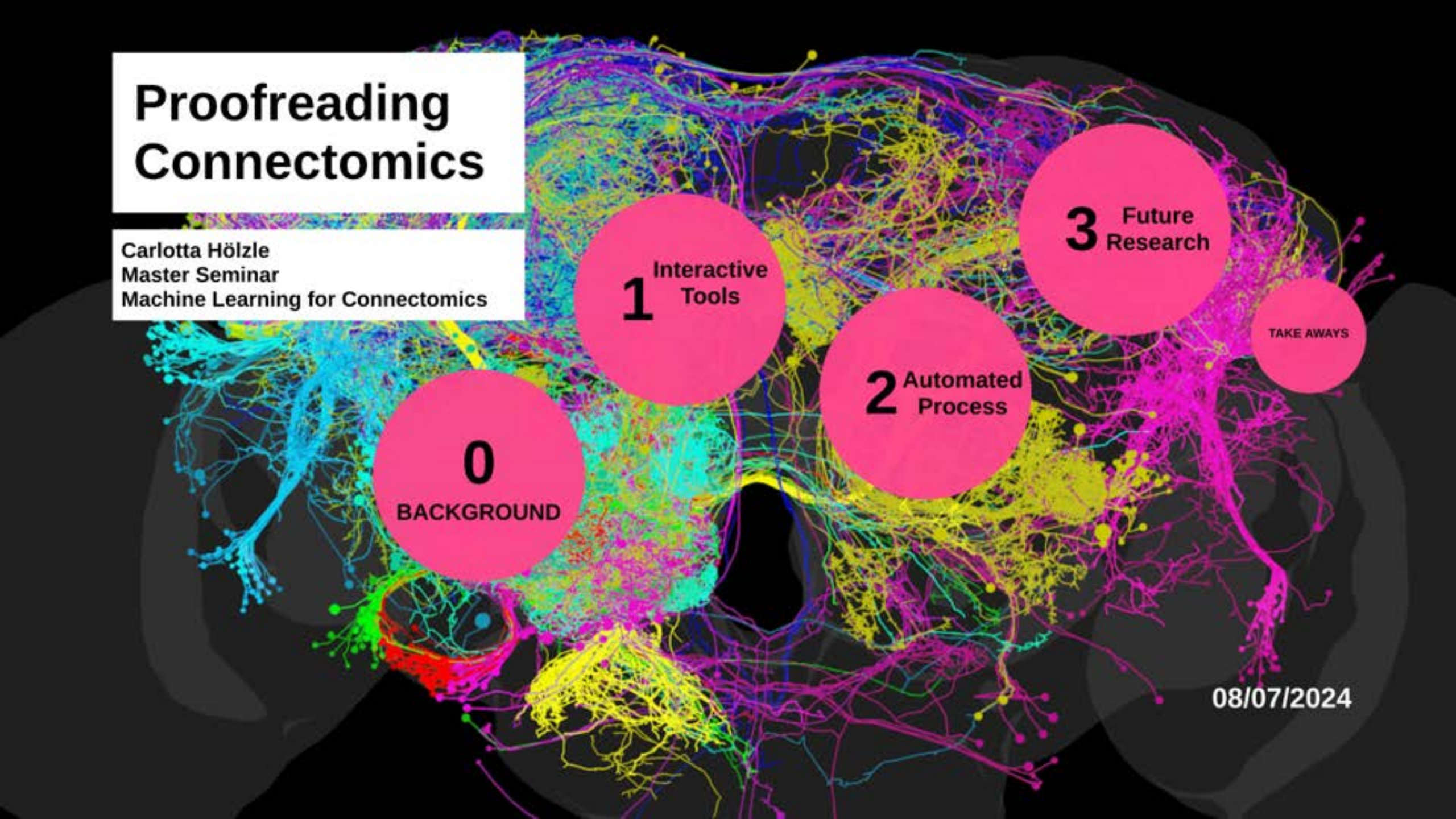

A
Post-synaptic Element
Confidence Indicator
Pre-synaptic Element
B
Pre-synaptic Element
Neuron
Post-synaptic Element
7.1


A
B
C
7.2


A
To-Do
Bookmark
u
B
Done
To-Do
To-Split
7.3

Proofreading Connectomics

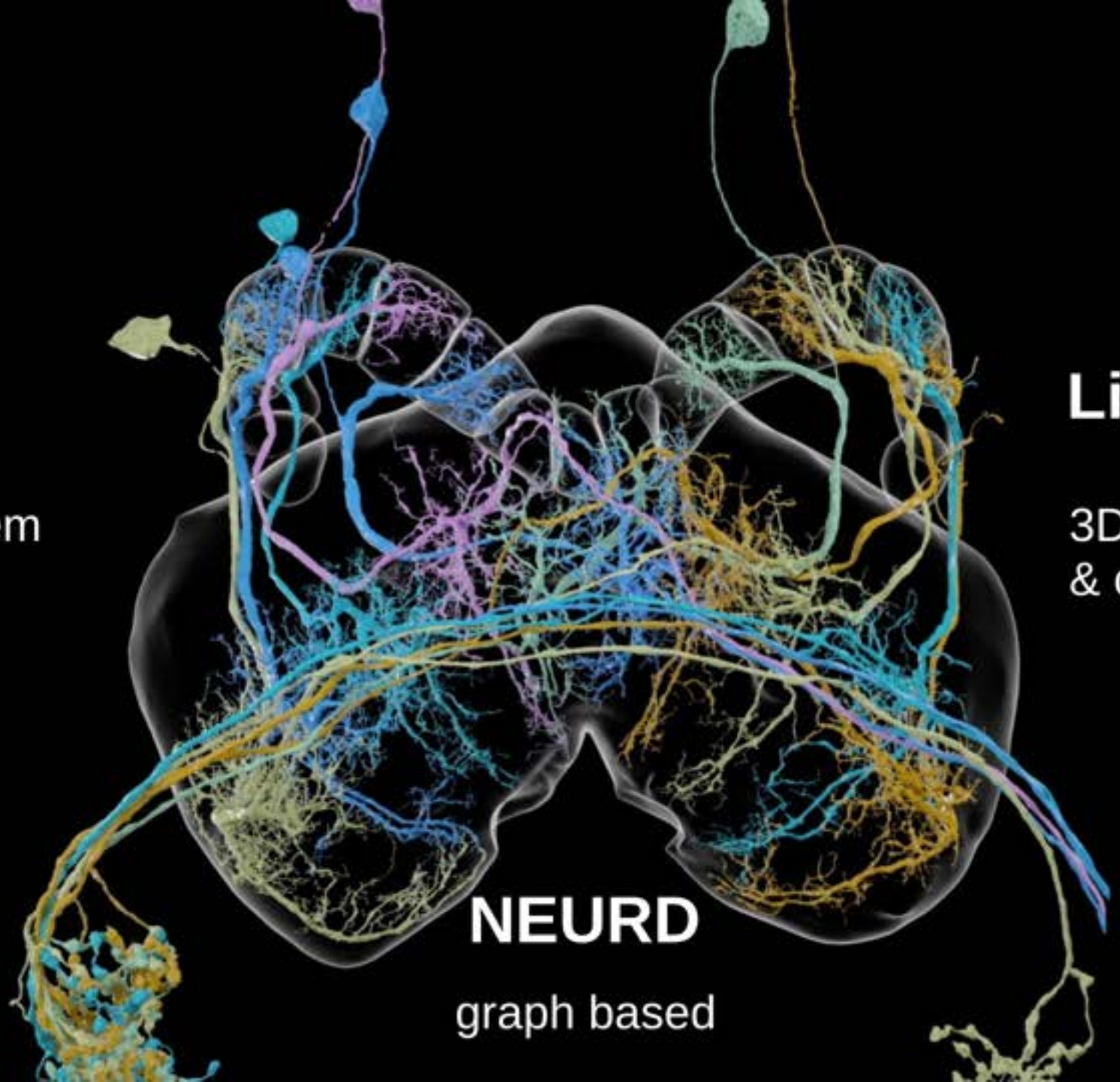
Carlotta Hölzle
Master Seminar
Machine Learning for Connectomics




2 Automated Process
APPROACH
LIMITATIONS

RoboEM

3D Flight system



Lie et al.

3D voxel classification
& consistency scores

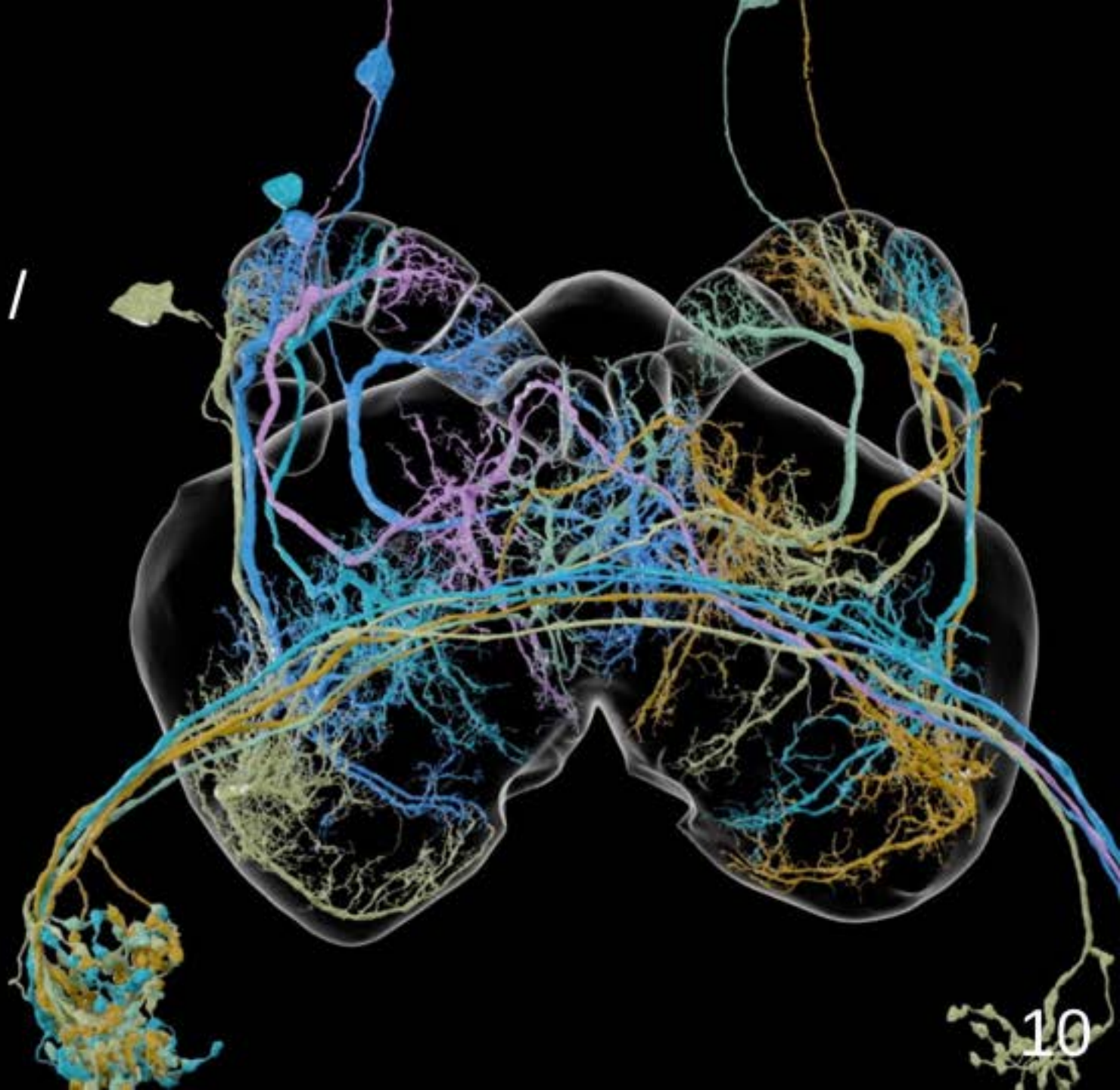
NEURD

graph based


2 Automated Process
APPROACH
LIMITATIONS

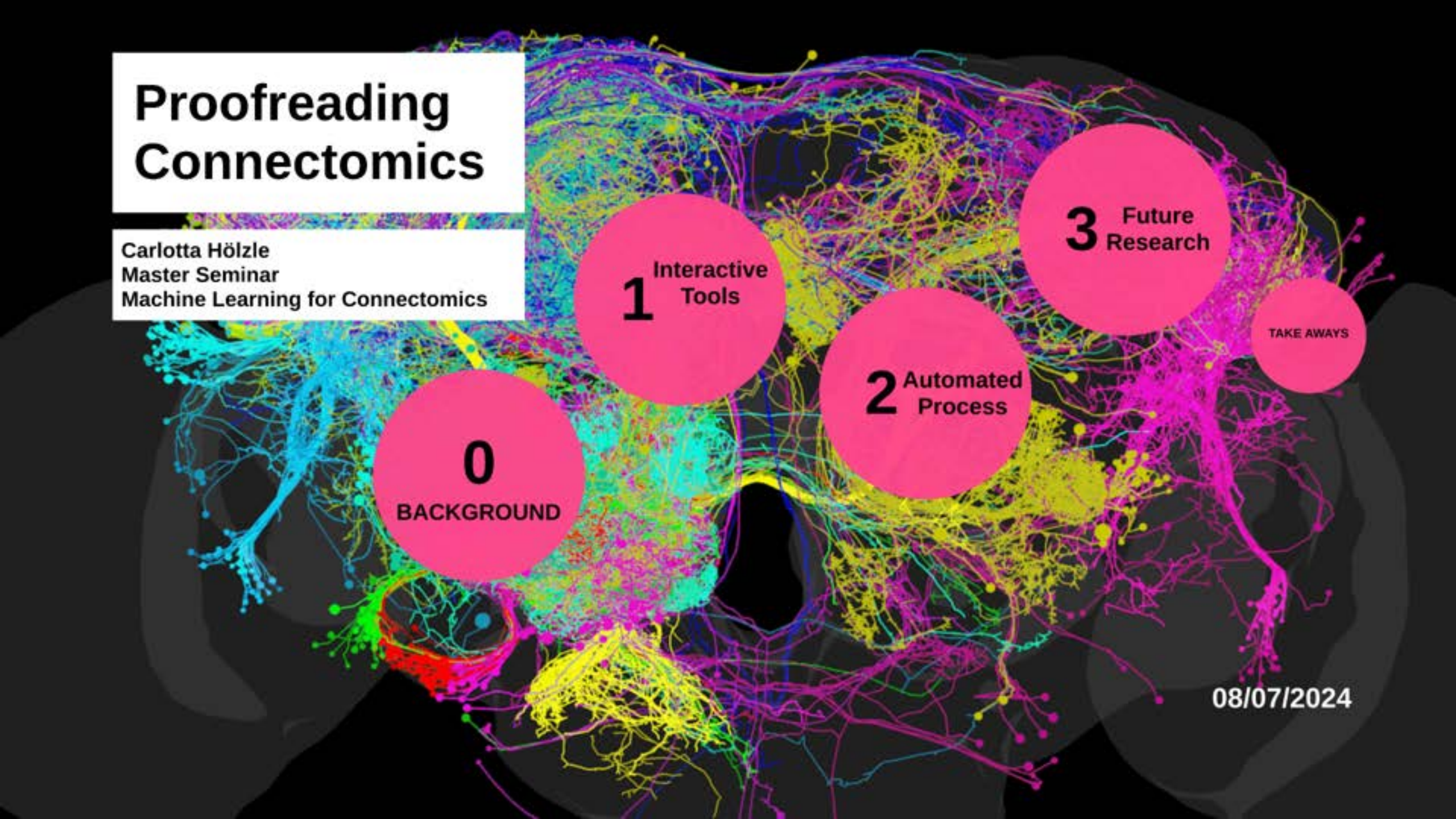
Limitations

- non-standardized input / output
- limited scalablility
- high computational complexity
- mostly merge errors
  - some split errors



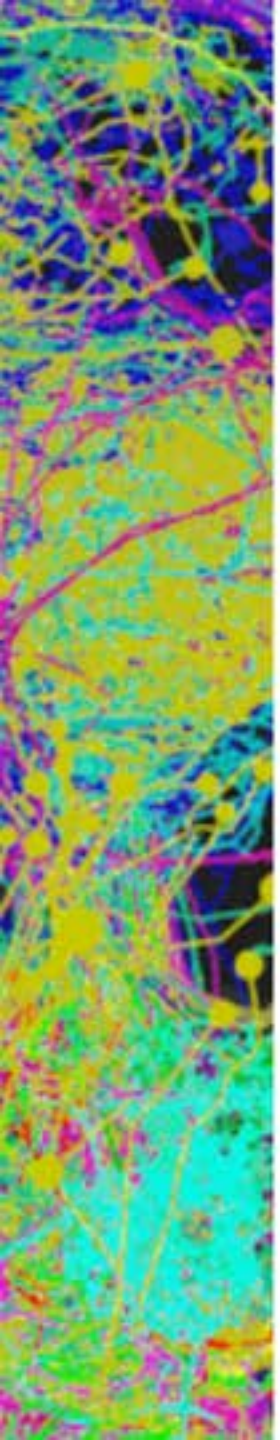
Proofreading Connectomics

Carlotta Hölzle
Master Seminar
Machine Learning for Connectomics

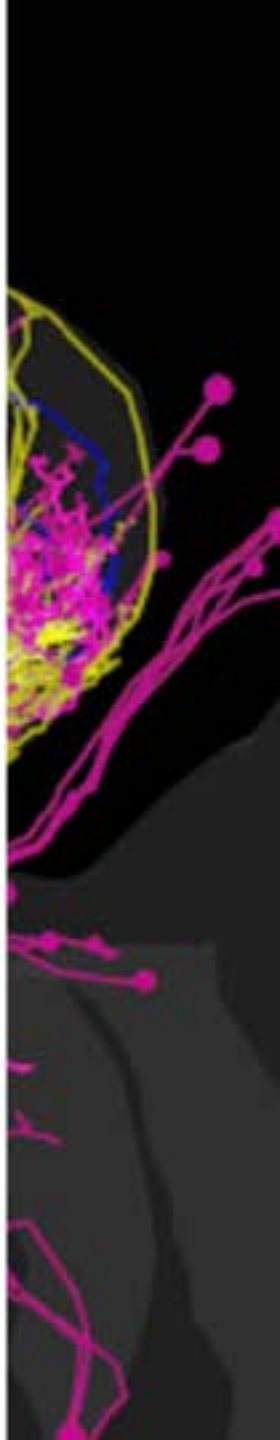



3 FUTURE RESEARCH
SCALE FULLY AUTOMATED METHODS TO LARGE DATASETS & ALL ERRORS
MERGE INTO ONE WORKFLOW
GAMIFICATION

SCALE FULLY AUTOMATED METHODS TO LARGE DATASETS & ALL ERRORS



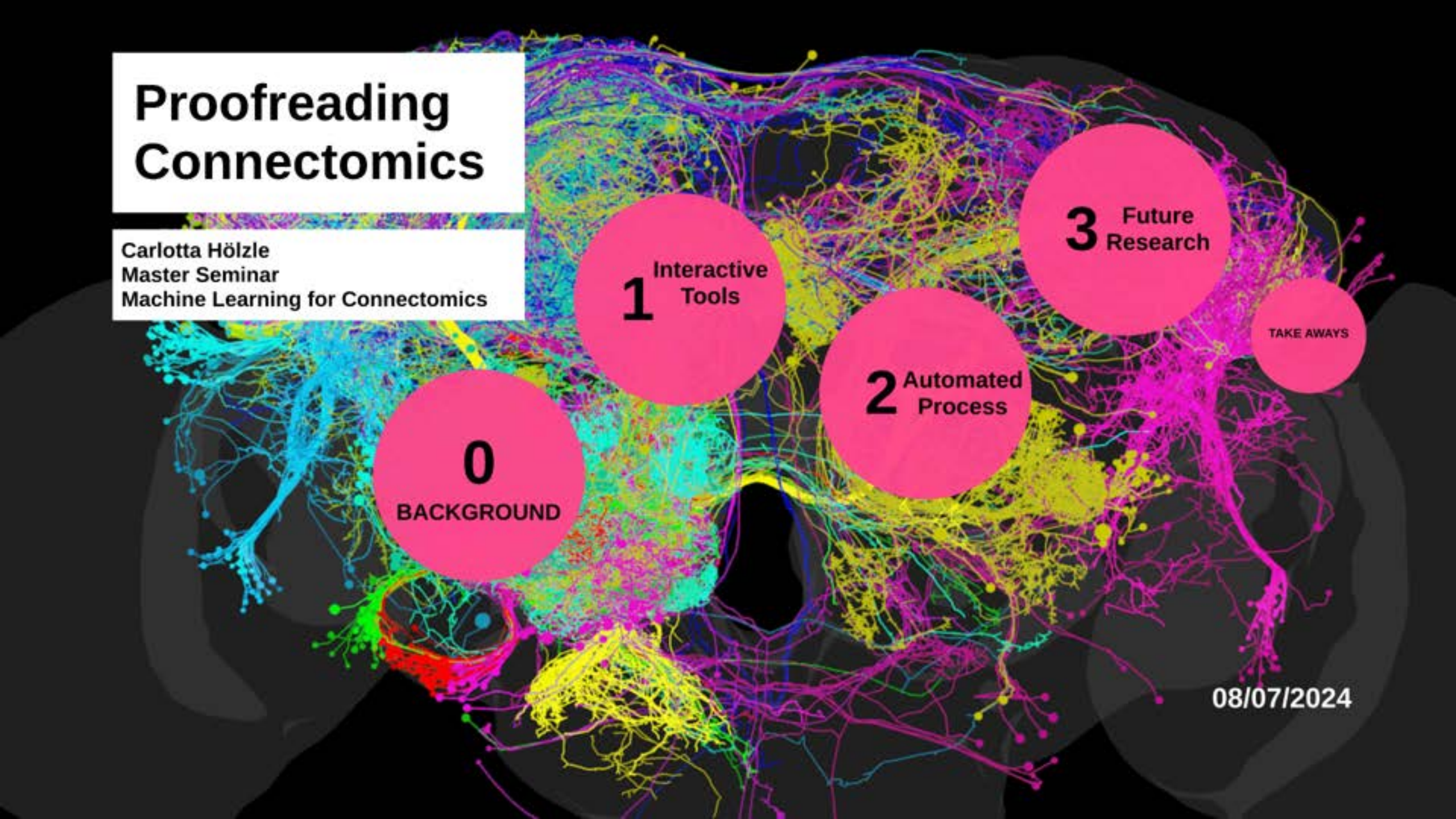
MERGE INTO ONE WORKFLOW



GAMIFICATION

Proofreading Connectomics

Carlotta Hölzle
Master Seminar
Machine Learning for Connectomics




TAKE AWAYS:
> proofreading is time consuming
> proofreading is very important
> proofreading is very complex &
hard to automate

Image Sources:

Background Main View: https://flyconnecto.me/wp-content/uploads/2017/12/cropped-2ndreducedwholefly.png
Background Interactive Tools: https://bernstein-network.de/wp-content/uploads/2024/03/20240227_900x600.png
Icons Requirements: Power Point Icon Gallary
Background Automated Processes: https://static01.nyt.com/images/2021/10/22/autossell/00SCI-FLYBRAIN-vid3/00SCI-FLYBRAIN-vid3-videoSixteenByNine3000.jpg

Literature Sources:

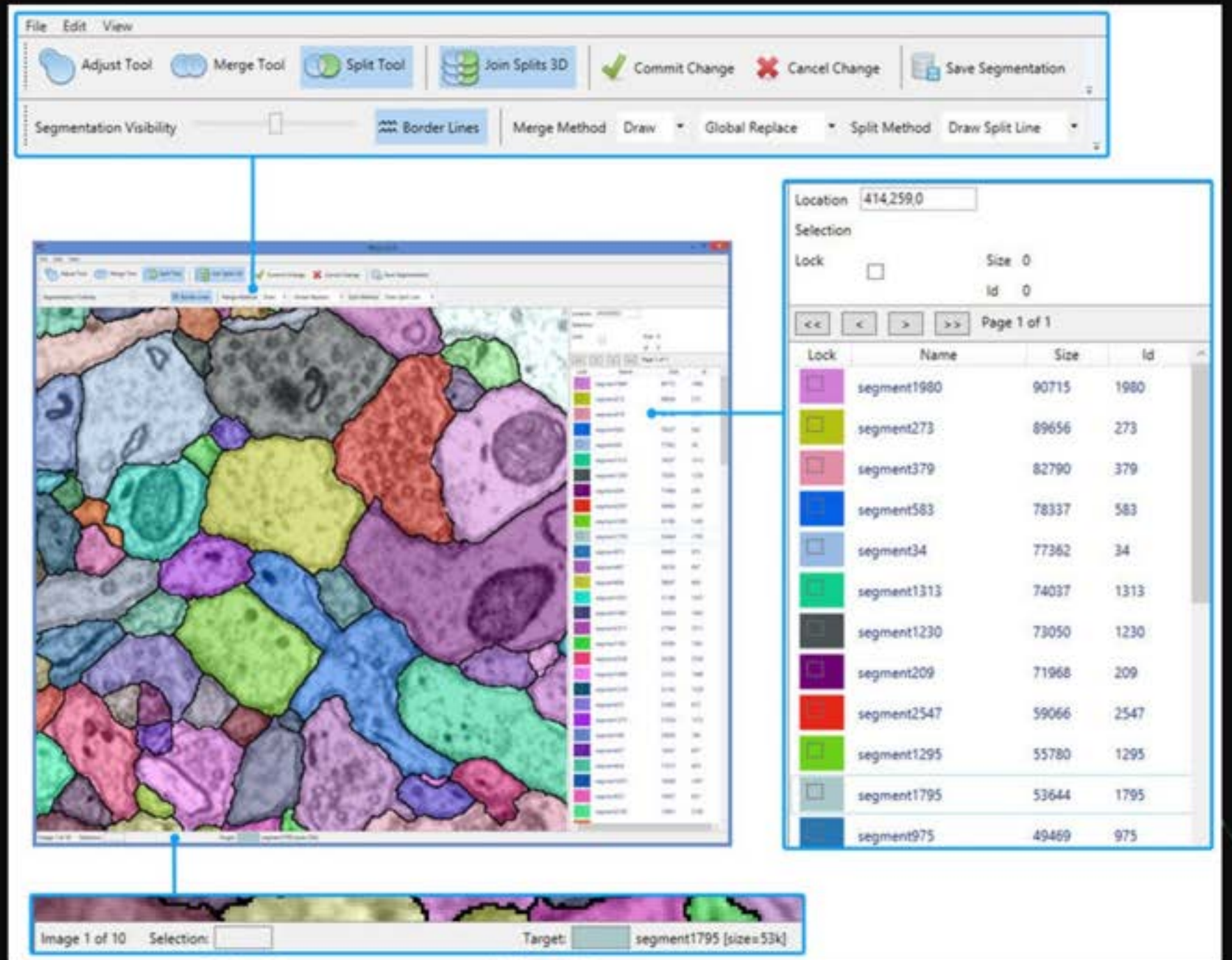
Sheridan, A., Nguyen, T. M., Deb, D., Lee, W.-C. A., Saalfeld, S., Turaga, S. C., Manor, U., and Funke, J. Local shape descriptors for neuron segmentation. Nature methods, 20(2):295–303, 2023

Tinati, R., Luczak-Roesch, M., Simperl, E., and Hall, W. An investigation of player motivations in eyewire, a gamified citizen science project. Computers in Human Behavior, 73:527–540, 2017

Hölzle, C. (2023). Proofreading and automated error correction of neuron instance segmentation. Manuscript submitted as Seminar Paper.

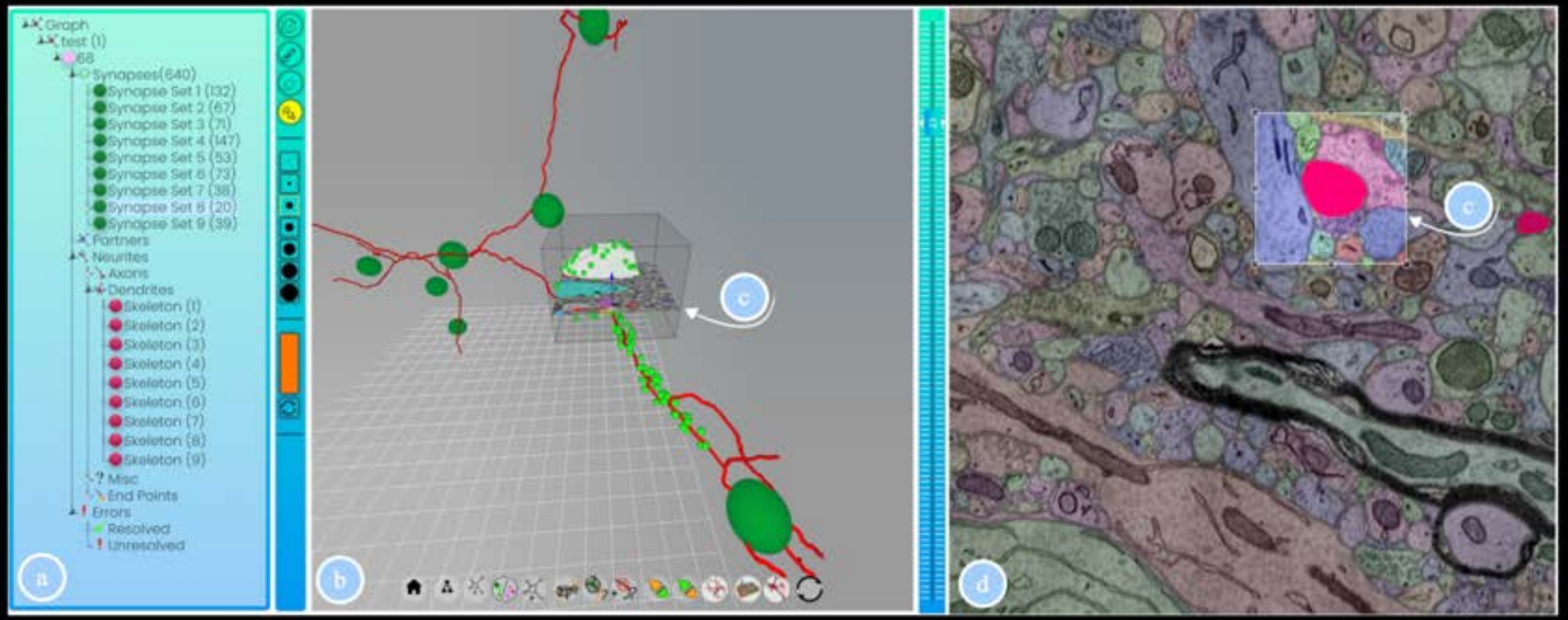
Mojo

Collaboration/ Accessibility	0
Visualisation	0
Error Automation	0
Interface/Tools	1
Progress/History Tracking	0
Computation	2
Scalability	3
	2



VICE

1 3 3 2 0 3 3 2



Proofreading Connectomics

Carlotta Hölzle
Master Seminar
Machine Learning for Connectomics