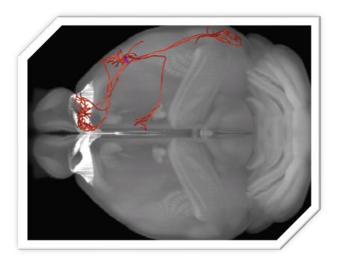
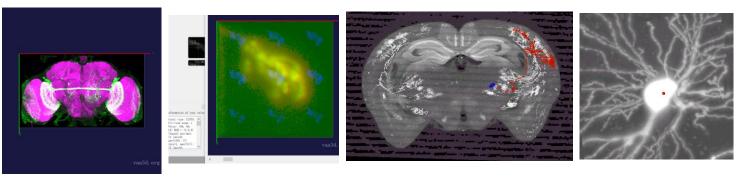
Reconstruction and quality control of neuron morphology in Vaa3D

Lulu Yin 20211207

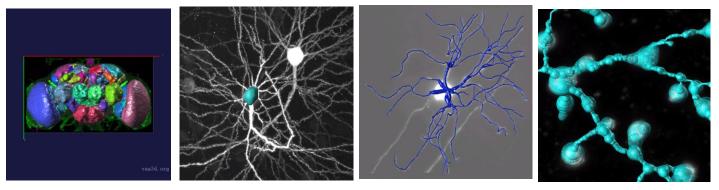


Vaa3D : The "3D Visualization-Assisted Analysis" software

• For the visualization and analysis of large-scale multidimensional images.



• Visualization of heterogeneous images and respective surface objects .

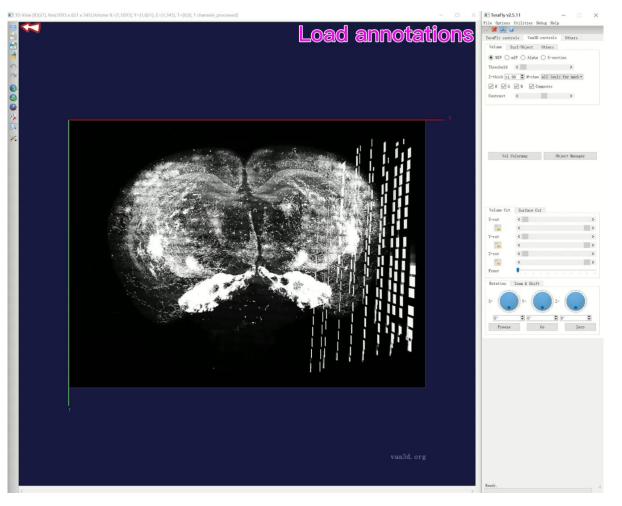


- Extension of Vaa3D functions using its plug-in interface.
- 3D image object generation and quantitative measurement.
- Neuron morphology reconstruction, quantification and comparison.

Vaa3D-TeraFly: Neuron morphology reconstruction

Video show: TeraFly

- Load annotations
- Annotate data
- Add marker
- Change resolution: Double click or Zoomin/out with mouse-scroll
- Volume cut
- Save annotations

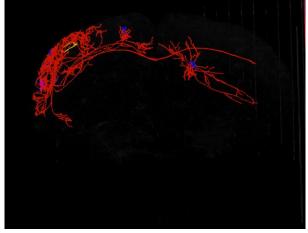


Expansion 1, Linker-file Plug-in

• Plug-in path

linker_file	•	Linker_File_Generator	•	for all SWC/ESWC (e.g. neuron) files under a directory
marker_utilities	•	linker_terafly	•	for all APO (point cloud) files under a directory
misc	•	Save_3Dviewer_Content_to_Linker_File	e 🕨	for all TIF images under a directory
movies_and_snapshots	· · · T			for all LSM images under a directory
neuron_toolbox	· · ·			for all V3D Raw images under a directory
neuron_tracing				for all images (*.tif, *.tiff, *.raw) under a directory
neuron_utilities				for all V3D-recognizable files under a directory
0.00 5				

• Linker_file_Generator: Link multiple SWC/ESWC, APO, TIF, LSM, etc. to the same directory, which can be opened in one brain at the same time.





• Linker_terafly: Generate the corresponding ano and apo files from a single swc, so that the swc file can be opened in terafly.

2021/1/27 22:51 2021/8/9 10:19 2021/8/9 10:19

Expansion 2、Multiple swc files generate corresponding ano files in batches, and extract swc file information

• Use this script and enter the command line to generate ano files in batches

wJX@DESKTOP-IDNU9AG MINGW64 /d/SEUAllenJointDataCenter/MorphoHub/Database/Funct
ons/Init (master)
\$ sh ./GenerateAnoInfolder.sh [z/L2/YLL/swc] 👞 swc file
/z/L2/YLL/swc/1//86_0001/_YLL_stamp_2020_11_10_10_35.ano.eswc
/z/L2/YLL/swc/17786_00023_YLL_stamp_2020_11_10_10_34.ano.eswc
/z/L2/YLL/swc/17786_00024_YLL_stamp_2020_11_10_10_33.ano.eswc

Picture1

• Use the following script to extract swc information: brain and neuron numbers, neuron coordinates, neuron tracking author, neuron completion status and update time, etc.

wJX@DESKTOP-IDNU9AG MINGW64 /z/L2/YLL_WYP_trackinglist Swc file \$ sh ./get_statistics_table.sh /z/L2/YLL_WYP_trackinglist/Get_data_Excel /z/L2/Y LL_WYP_trackinglist/pre_reconstruction_somalist pre_18864_00005 18864, 5332_X2880_Y20576,18864_00005,SEU,stamp,Finished,2021,2021_07_30_15_45 pre_18864_00007 18864, 5366_X3112_Y12350,18864_00007,SEU,wyp,Finished,stamp,2021_07_21_16_15

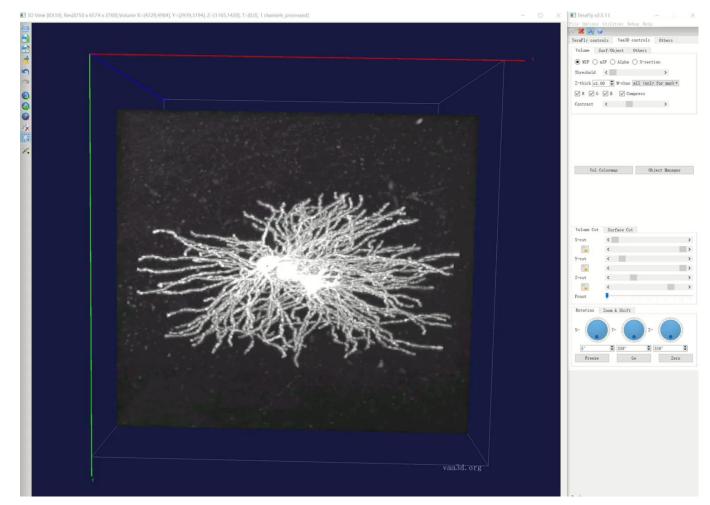
Picture2

Result:

Hust_Brain	Cellname	SEU_Neuro	Reconstruc	Reconstruc	Reconstruc	Reconstruc	Reconstruction_Updat	eDate
18864	4610_X6120_Y30222	18864_001	ISEU	YLL	Finished	stamp	2021_08_02_10_44	
18864	5776_X7238_Y31018	18864_001	ISEU	YLL	Finished	stamp	2021_08_02_10_45	
18864	5208_X9666_Y1706	18864_002	SEU	YLL	Finished	stamp	2021_08_02_10_45	

These two methods come from Shengdian ⁵

Expansion 3、Method to improve reconstruction speed: manual and controllable automatic reconstruction

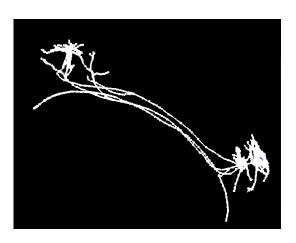


The retrace plug-in comes from Xuan Zhao ₆

Vaa3D-TeraFly and TeraVR: Quality control of neuron reconstruction

Manual inspection:

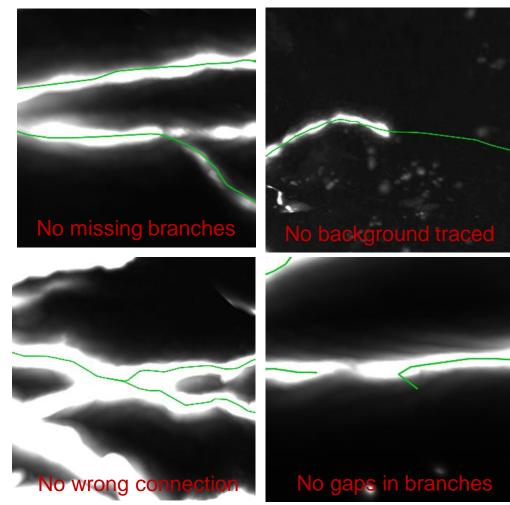
• Use Alt+N: A signal tree



• Use VR and VR-Farm

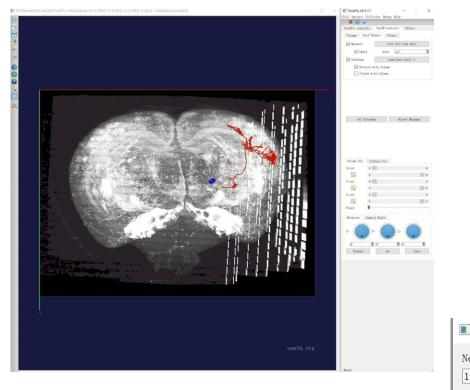
TeraFly v2.5.11	- 🗆 🗙
File Options Utilities Debu	ig Help
🔍 🎇 🙀 🕡	
TeraFly controls Vaa3D co	ontrols Others
Viewer	
Resolut: 1706×2187×649 (v	oxel: 16.0×16.0×16.0 μ -
Max dim 256(x) 🖨 256(y)	 256 (z) 2(t)
See in VR	Collaborate in VR

• Need to meet the following requirements:



Vaa3D-TeraFly: Post-processing by running the plugin

1. Soma node is defined and labeled as type '1'



2. Sort swc file:sort_swc: Process a single file;Sort_swc_batch: Batch processing of files

		▲	-	
neuron_tracing	•			
neuron_utilities	•	calculate_reliability_score	•	
neuronQC0.5	•	color_render_ESWC_features	•	
neuronQC0.6	۲.	consensus_skeleton_via_clustering	•	
neuronQC0.7	•	Enhanced_SWC_Format_Converter	•	
neuronQC0.9	•	global_neuron_feature	•	
neuronQC1.1	•	hierarchical_labeling_of_neuron	•	
pixel intensity	•	inter_node_pruning	•	
quality control	•	N3DFix	•	
Retrace0.22	•	neuron_color_display	•	
Retrace0.23	•	neuron_color_seperator	•	
shape analysis	•	neuron_connector	•	
synapse detector	•	neuron_distance	•	
Sync Views	•	neuron_fragment_extractor	•	
TypeLength	•	neuron_image_profiling	•	
Vaa3D PluginInterface Demos	•	neuron_radius	•	
wpkenanPlugin	•	node_connect	•	
		pruning_swc_simple	•	
		resample_swc	•	
		sort_neuron_swc	sort swc	
		standardize_swc	sort swc batch	
		subtree labelling	about	
		swc qui resample	•	1

III Would you like to specify new root number?

New root number: (If you select 'cancel', the first root in file is set as default)

OK Cancel

Would you like to set a threshold for the newly generated link?

 \times

Cancel

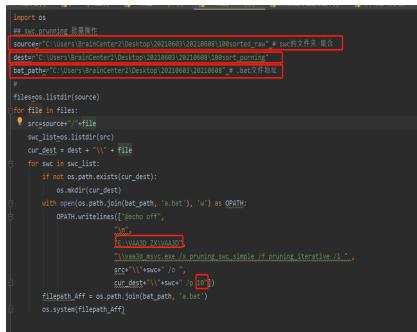
threshold:(If you select 'cancel', all the points will be connected automated; If you set '0', no new link will be generated)
0.0

3. Pruning swc file: Cut off short branches of a specific length

		\sim	1		<u> </u>
	neuron_tracing		blastneuron		
	neuron_utilities	•		÷	
	neuronQC0.5	•	calculate_reliability_score		
	neuronQC0.6	•	color_render_ESWC_features	•	
	neuronQC0.7	•	consensus_skeleton_via_clustering		
	neuronQC0.9	•	Enhanced_SWC_Format_Converter	•	
	pixel intensity	•	global_neuron_feature	•	
	quality control	•	hierarchical_labeling_of_neuron	•	
	Retrace0.22	•	inter_node_pruning	•	
	Retrace0.23	•	N3DFix	٠	
	shape analysis	•	neuron_color_display	٠	
	synapse detector	•	neuron_color_seperator	•	
	Sync Views		neuron_connector	•	
	TypeLength	(neuron_distance	•	
		(neuron fragment extractor	•	
	Vaa3D_PluginInterface_Demos		neuron image profiling		
1	wpkenanPlugin		neuron radius	•	
			node connect		
			pruning swc simple	•	pruning
			resample swc	•	pruning iterative
			sort neuron swc		pruning based on markers
			standardize swc	•	about
			· · · · · · · · · · · · · · · · · · ·		

• Process a single file: Use pruning_swc_simple plugin

• Batch processing of files : Use python



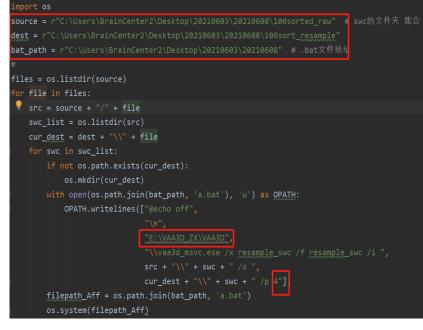
First box : path of swc files; Second box: path of swc after pruning; Third box: bat path; Fourth box: path of Vaa3D; The last one: Short branch length.

4. Resample swc file: Rearrange the node distance

• Process a single file: Use resample_swc plugin

neuron_utilities	•	blastneuron	۲	
neuronQC0.5	•	calculate_reliability_score	۲	
neuronQC0.6	•	color_render_ESWC_features	۲	
neuronQC0.7	•	consensus_skeleton_via_clustering	۲	
neuronQC0.9	•	Enhanced_SWC_Format_Converter	۲	
pixel intensity	•	global_neuron_feature	۲	
quality control	•	hierarchical_labeling_of_neuron	۲	
Retrace0.22	•	inter_node_pruning	۲	
Retrace0.23	•	N3DFix	۲	
shape analysis	•	neuron_color_display	۲	
synapse detector	•	neuron_color_seperator	۲	
Sync_Views	,	neuron_connector	۲	
TypeLength	•	neuron_distance	۲	
Vaa3D PluginInterface Demos	•	neuron_fragment_extractor	۲	
wpkenanPlugin	,	neuron_image_profiling	۲	
npicenami ragini		neuron_radius	۲	
		node_connect	۲	
		pruning_swc_simple	۲	
		resample_swc	•	resampl
		sort_neuron_swc	۲	about
		standard the second		

• Batch processing of files : Use python



First box : path of swc files; Second box: path of swc after pruning; Third box: bat path; Fourth box: path of Vaa3D; The last one: node distance.

Vaa3D-TeraFly : Quality control of neuron reconstruction

Automatic check: NeuronQC plugin

		> smbexport (\\172.16.1.253) (Z:) > L2 > 1741 > Cer	abral cartay nauron 17	D 100 + 100corted	
neuronQC0.9	•	· · · · · · · · · · · · · · · · · · ·		-	- tot
neuronQC1.1	•	▲ 名称 → 17781 00001.swc sorted.swc	修改目期 2021/6/4 11:04	类型 SWC 文件	大小 2.596 KB
pixel_intensity	•	17781_00003.swc_sorted.swc	2021/6/4 11:04	SWC 文件	284 KB
quality_control	•	17781_00004.swc_sorted.swc 17786_00001_LJ_SYY_stamp_2021_01_27_1	2021/6/4 11:04 2021/6/4 11:04	SWC 文件 SWC 文件	736 KB 449 KB
		18047_00047.swc_sorted.swc	2021/6/4 11:04	SWC 文件	1,106 KB

Input the command: path_of_Vaa3D /x path_of_neuronQC /F neuronQC_batch /i path_of_swc /o path_of_csv /p 10 4.2 1(Short branch length/node distance/1 refers to the loop check)

🔜 命令提示符

Microsoft Windows [版本 10.0.19042.1110] (c) Microsoft Corporation。保留所有权利。

C:\Users\15951>D:\y11\y11\Vaa3D_YLL\Vaa3D_YLL\vaa3d_msvc.exe /x D:\y11\y11\Vaa3D_YLL\Vaa3D_YLL\plugins\neuronQC1.1 /f ne uronQC_batch /i C:\Users\15951\Desktop\100sorted /o C:\Users\15951\Desktop\100sorted\100.csv /p 10 4.2 1

Result: 0 means unqualified; 1 means qualified.

AB	C	D	E	F	G	H I	J K		М		0	P Q	_ P
neuronId floop	oop Info	threeBifurc th	nreeBifur	isSort	isSort Info	somaType tomaType	gap 🛛 🔤 gap Info	allTypes	allTypes In	shortBranc	hortBranc	nodeLengt	sQualified
17781_00	1 number o	1	C	1	continuou	1	. 1 C	1	1234	0	13	0 minLength	0
17781_00	1 humber of	0	1	1	continuou	0 The first n	c 1 The soma	1	The soma	1	The somaT	1 The somaT	0
17781_00	1 number of	0	3	1	continuou.	1	. 1 C	1	1234	1	0	0 minLength	0
17786_00	1 number o	1	Q	1	continuou	1	1 0	1	123	0	75	0 minLength	0
18047_000	1 humber of	1	0	1	continuou	1 1	1 0	0	2 3 4 typ	1	0	0 minLength	0

Fully qualified as shown below:

17	<u> </u>																	
neuronId	loop	loop Info	threeBifurc	threeBifurc isSort		isSort Info	somaType	somaTyp	e gap	ga	p Info	allTypes	allTypes	In shortBrand	shortBranc ı	nodeLeng	t nodeLengt is	Qualified
18470_322		1 number of	f 1	0	1	continuou	1		1	1	0	1	1234	1	0	1	the node le	1
18864_252		1 number of	f 1	0	1	continuou	1		1	1	0	-	1234	1	0	1	the node le	1
18864_333		1 number of	f 1	0	1	continuou	1		1	1	0	-	1234	1	0	1	the node le	1
18864_377		1 number of	- 1	0	1	continuou	1		1	1	0	-	123	1	0	1	the node le	1
18864_412		1 number of	1	0	1	continuou	1		1	1	0	-	1234	1	0	1	the node le	1
18864_438		1 number of	f 1	0	1	continuou	1		1	1	0	1	123	1	0	1	the node le	1
18864 442		1 number of	1	0	1	continuou	1		1	1	0	-	1234	1	0	1	the node le	1

The NeuronQC plug-in comes from Xuan Zhao ¹¹

Vaa3D : Analyze neuron gold standard data

- Calculate the global feature of the gold standard data of each cell type, analyze and build a model
- Quantification and analysis of neuron dendritic radius
- Quantification of soma surface
- Projection area of each cell type

Expansion 1: Global_neuron_feature plugin

• Process a single file: Use Global_neuron_feature plugin

neuron_tootbox	, 2
neuron_tracing	assemble_neuron_live
neuron_utilities	, blastneuron ,
neuronQC0.5 neuronQC0.6 neuronQC0.7	calculate reliability_score color_render_ESWC_features consensus_skeleton_via_clustering
neuronQC0.9 pixel intensity	Enhanced_SWC_Format_Converter global_neuron_feature compute global features
quality_control	hierarchical_labeling_of_neuron compute global features (only the first connected tree inter node pruning Help
Retrace0.22	NRDFiv

• Batch processing of files: input the

v3d software plugin name function name path of swc files where to save ↓ ↓ ↓ ↓ ↓ W v3d /x global_neuron_feature /f compute_feature_in_folder /i path_of_swc_folder /o csv_to_save L/M v3d -x global_neuron_feature -f compute_feature_in_folder -i path_of_swc_folder -o csv_to_save

• Result:

А	В	С	D	E	F	G	Н	I	J	К	L	М	Ν	0	Р	Q	R	S	Т
ID	CellType	Number of	Soma Surfa	Number	o Number o	Number o	Number of	Overall Wie	Overall He	Overall De	Average D	Total Leng	Total Surfa	Total Volu	Max Euclid	Max Path [Max Branc	Average Co	Average Fr
r10_21025	ACAd	600	12.5664		8 207	420	215	442.072	259.207	266.175	1.99333	2975.27	18694.2	9347.1	320.955	480.154	27	0.989722	0.42381
r10_21025	ACAd	372	12.5664		6 141	286	147	291.166	196.877	224.56	1.98925	1506.77	9467.33	4733.66	125.546	304.191	18	0.987063	0.293706
r10_18047	ACAv	1084	12.5664		7 425	855	432	399.21	237.492	263.53	1.99631	4207.39	26435.8	13217.9	203.308	491.991	35	0.992452	0.265497
r10_18047	ACAv	1068	12.5664	1	1 414	837	425	397.839	237.676	261.272	1.99625	4210.36	26454.5	13227.2	203.48	486.969	35	0.992428	0.273596
r10_18453	ACAv	601	12.5664		8 212	431	221	374.258	154.389	282.361	1.99334	2721.07	17097	8548.49	172.329	239.192	32	0.982526	0.389791
r10_18457	ACB	212	12.5664		5 100	204	106	200.95	254.524	208.275	1.98113	385.636	2423.02	1211.51	67.6218	94.243	23	0.999418	0.029412
r10_18457	ACB	283	12.5664		6 133	270	139	221.53	249.226	192.809	1.98587	491.542	3088.45	1544.23	88.4742	145.829	33	0.999049	0.040741
r10_18457	ACB	227	12.5664		4 106	216	112	217.886	244.713	193.286	1.98238	376.359	2364.73	1182.37	78.1844	138.583	27	0.999223	0.041667
r10_18458	ACB	458	12.5664		4 213	430	219	390.784	254.249	205.995	1.99127	962.73	6049.01	3024.5	223.554	304.89	67	0.998981	0.060465
r10_18465	ACB	282	12.5664		5 136	275	141	230.741	260.133	185.252	1.98582	471.975	2965.5	1482.75	71.3951	101.803	32	0.999672	0.018182
r10_18465	ACB	253	12.5664		6 122	248	128	215.391	258.059	212.874	1.98419	415.043	2607.79	1303.9	78.6104	96.131	25	0.999868	0.012097
r10_18465	ACB	209	12.5664		7 98	201	105	213.117	258.943	199.816	1.98086	348.684	2190.85	1095.42	77.2898	108.513	27	0.999188	0.029851

Global features of the neuron:

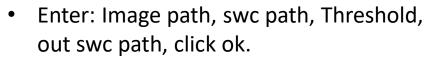
number of nodes	:	449
soma surface	:	12.5664
number of stems	:	8
number of bifurcations	:	117
number of branches	:	240
number of tips	:	124
overall width	:	91.8282
overall height	:	133.041
overall depth	:	249.429
average diameter	:	1.99555
total length	:	2676.5
total surface	:	16816.9
total volume	:	8408.47
max euclidean distance	:	188.366
max path distance	:	372.526
max branch order	:	26
average contraction	:	0.95394
average fragmentation	:	0.866667
average parent-daughter ratio	:	1
average bifurcation angle local	:	64.4414
average bifurcation angle remote	:	66.1306
Hausdorff dimension	:	1.34882

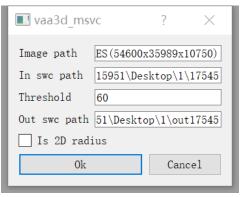
Expansion 2: Neuron_radius plugin

• Path:

neuron utilities	•	giobal_neuron_leature	,	
neuronQC1.1	•	hierarchical_labeling_of_neuron	•	
pixel intensity	•	inter_node_pruning	•	
quality control	•	N3DFix	•	
Retrace0.22	+	neuron_color_display	+	
Retrace0.23	•	neuron_color_seperator	•	
shape analysis	•	neuron_connector	•	
synapse detector	•	neuron distance	•	
Sync Views	•	neuron fragment extractor	•	
TypeLength		neuron image profiling	•	
Vaa3D PluginInterface Demos	•	neuron radius	•	neuron radius
wpkenanPlugin		node connect	•	neuron radius current window
wpkenanriugin		- pruning swe simple	•	neuron_radius_taraflu

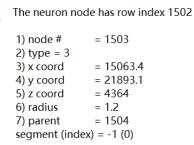
• Radius of dendrites







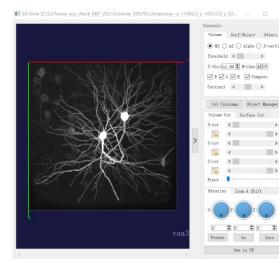
##n type x y z radius parent
2 3 15372.3 21628.5 4359.01 1.0 3
3 3 15367.2 21631.8 4359.01 1.1 <mark>1111 4</mark>
4 3 15361.5 21634.0 4358.8 1 <mark>.</mark> 14 <mark>3</mark> 15 5
5 3 15358.7 21633.4 4358.64 <mark>1.2</mark> 3395 6
6 3 15352.8 21634.7 4358.43 <mark>1.4</mark> 4444 7
7 3 15346.7 21636.7 4358.43 1.6 <mark>2</mark> 414 8
8 3 15341.8 21640.8 4358.43 1.4 7965 9



• Check: Drag in the original image, Determine whether the generated radius is consistent with the image.

Expansion 3: Soma surface

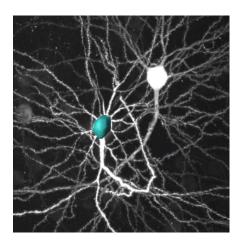
• Drag the V3Draw file into Vaa3D, see in 3D. •



Drag the TIF file into 3D image, creating mesh

- Creating Mesh method: Marching Cubes
- Creating Mesh density: 100
- No, Yes.

• Result: Create the surface, and you can quantify the surface area.







The surface area is: 2102.02

OK

