

Donato Lab - Block course

Day 2, 24.05.2022

Introduction

- 1-Photon imaging, the miniscope
- Animal recording and tracking in open arena
- Combining neuronal events with behavior
- Processing raw data with Matlab to find Place Cells



Donato Lab - Block course

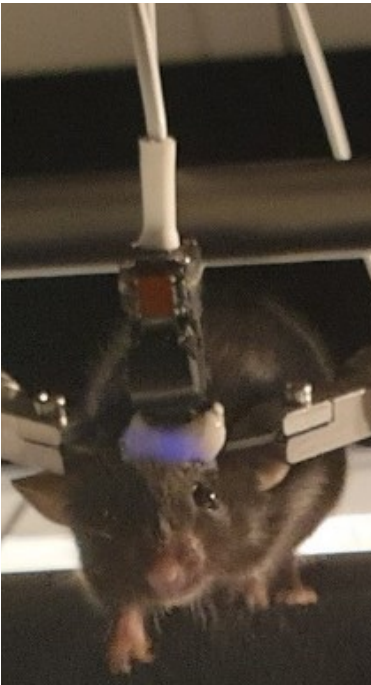
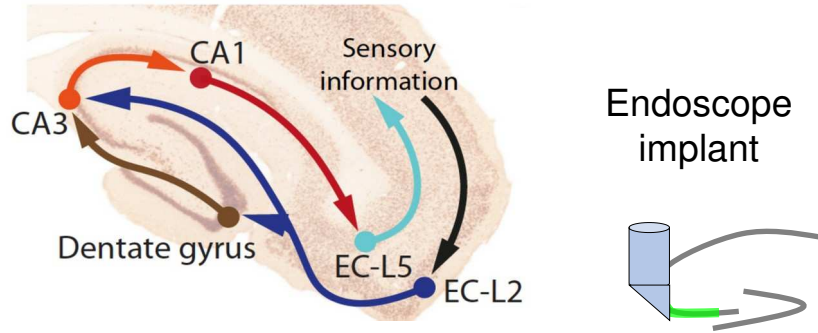
Day 2, 24.05.2022

Practical

- Matlab basics
- Breaking down raw data
- Tidying up the data
- Aligning behavior and neuronal data



1 Photon imaging, the miniscope



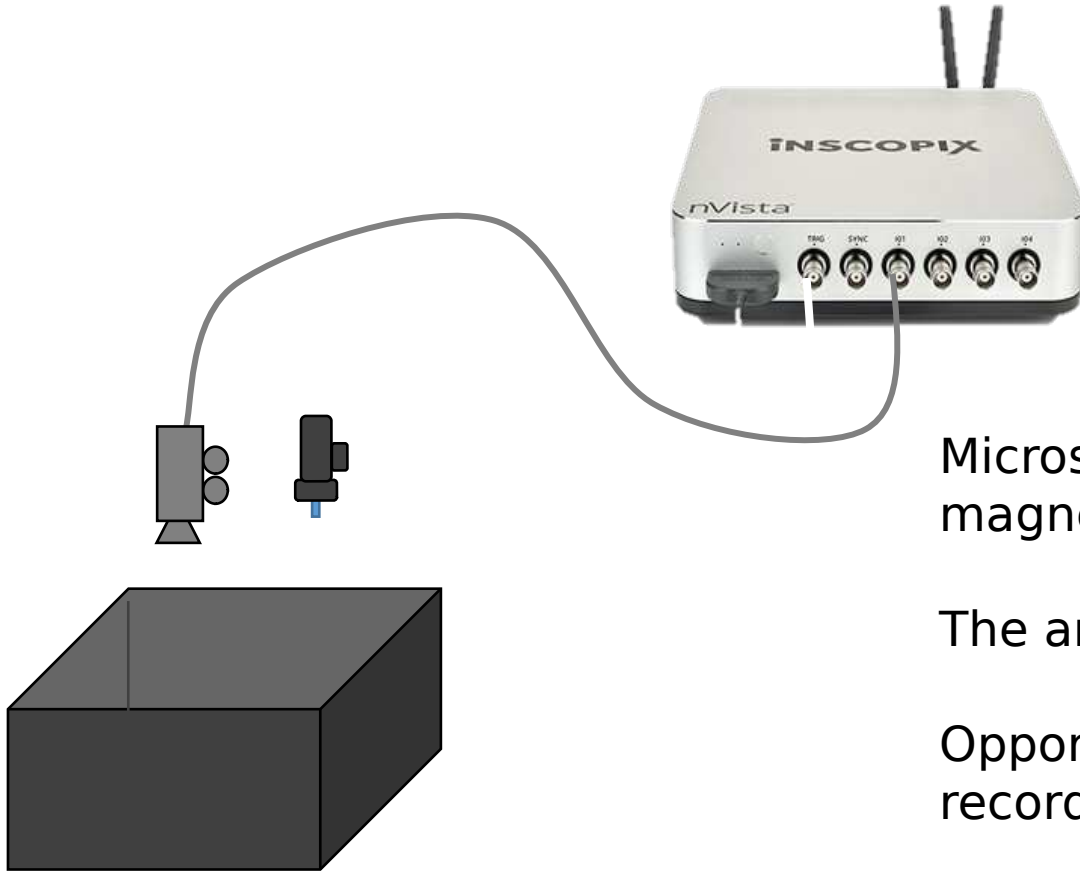
Microscope the size of a thumb attached onto an magnetic plate

The animal has the opportunity to freely move

Opportunity for 2 dimensional behavior during neuronal recording

Data acquisition box ensures synchronization of
behavioral video recording
miniscope neuronal recording
other experimental controller or readouts

1 Photon imaging, the miniscope



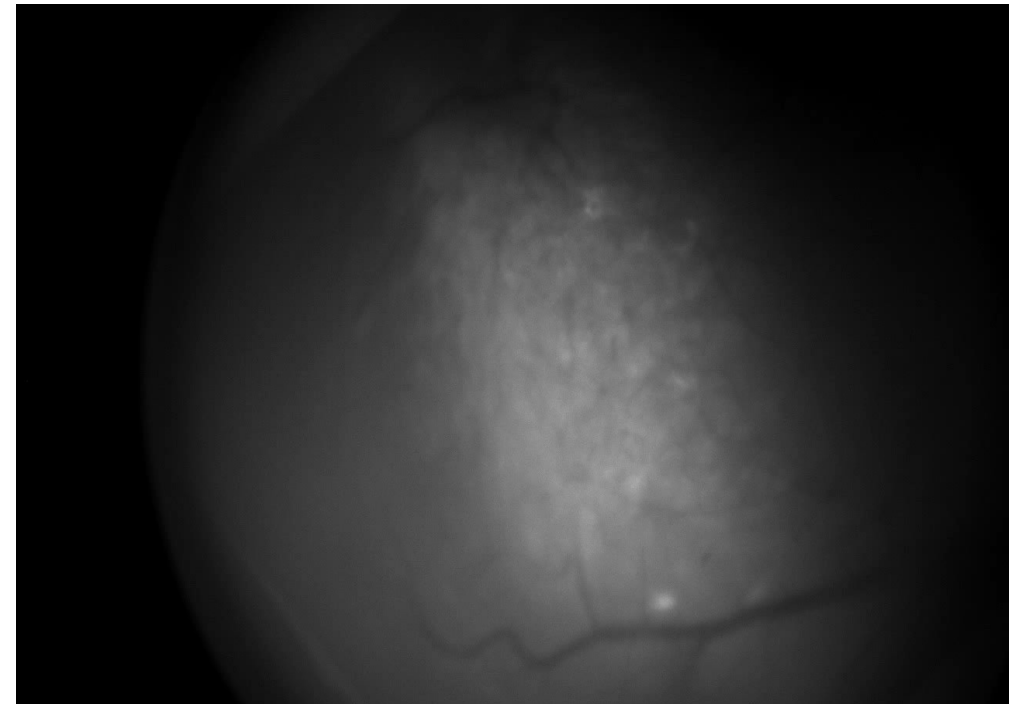
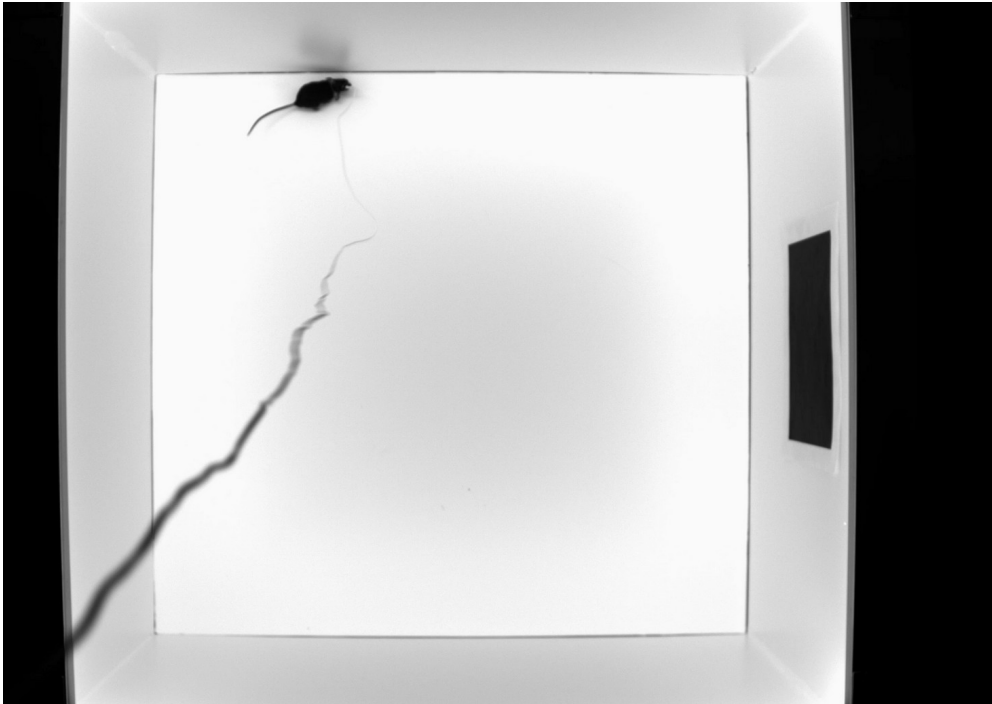
Microscope the size of a thumb attached onto an magnetic plate

The animal has the opportunity to freely move

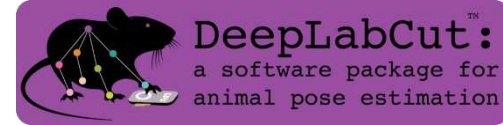
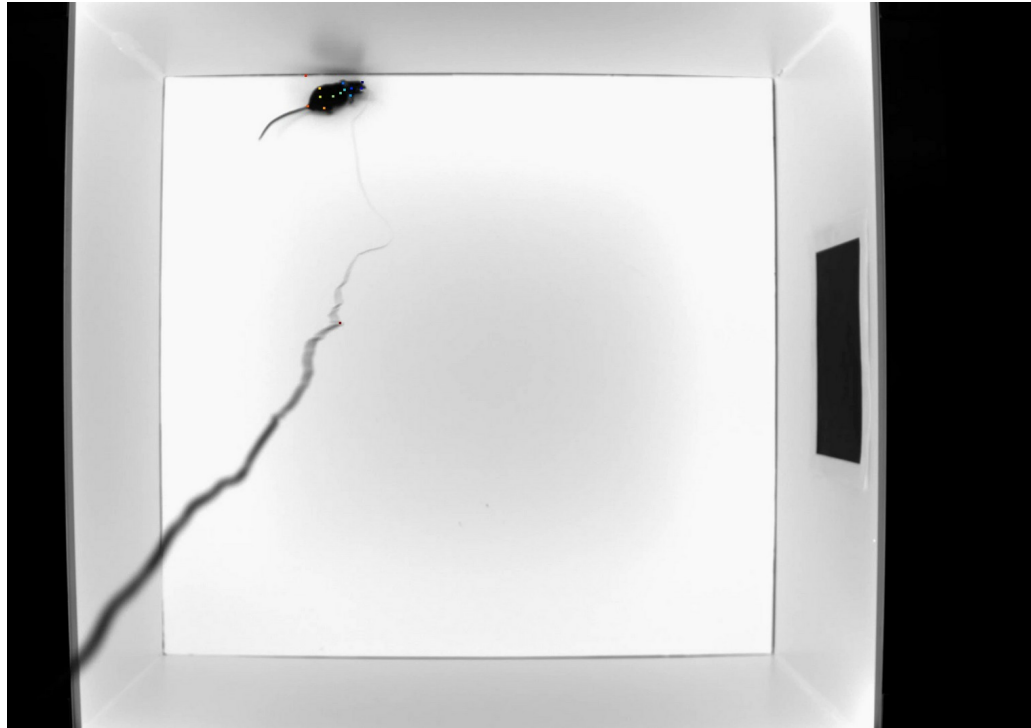
Opportunity for 2 dimensional behavior during neuronal recording

Data acquisition box ensures synchronization of
behavioral video recording
miniscope neuronal recording
other experimental controller or readouts

1 Photon imaging, the miniscope



Animal recording and tracking in open arena



Deep computational neuronal network for body part tracking

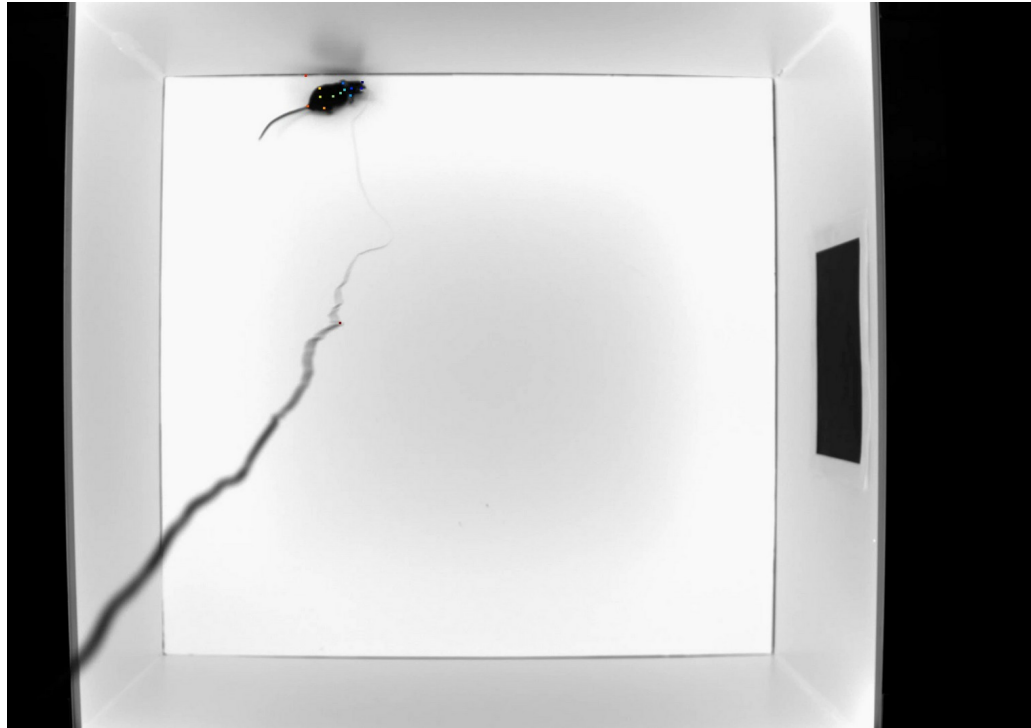
Train DLC neuronal network by marking body parts on ~200 frames manually

The trained neuronal network will then mark the body parts for each frame automatically

How many frames does get labeled ?
30 min per Video with 20 frames per second

$30 \text{ min} * 60 \text{ sec} * 20 = 36000 \text{ frames}$

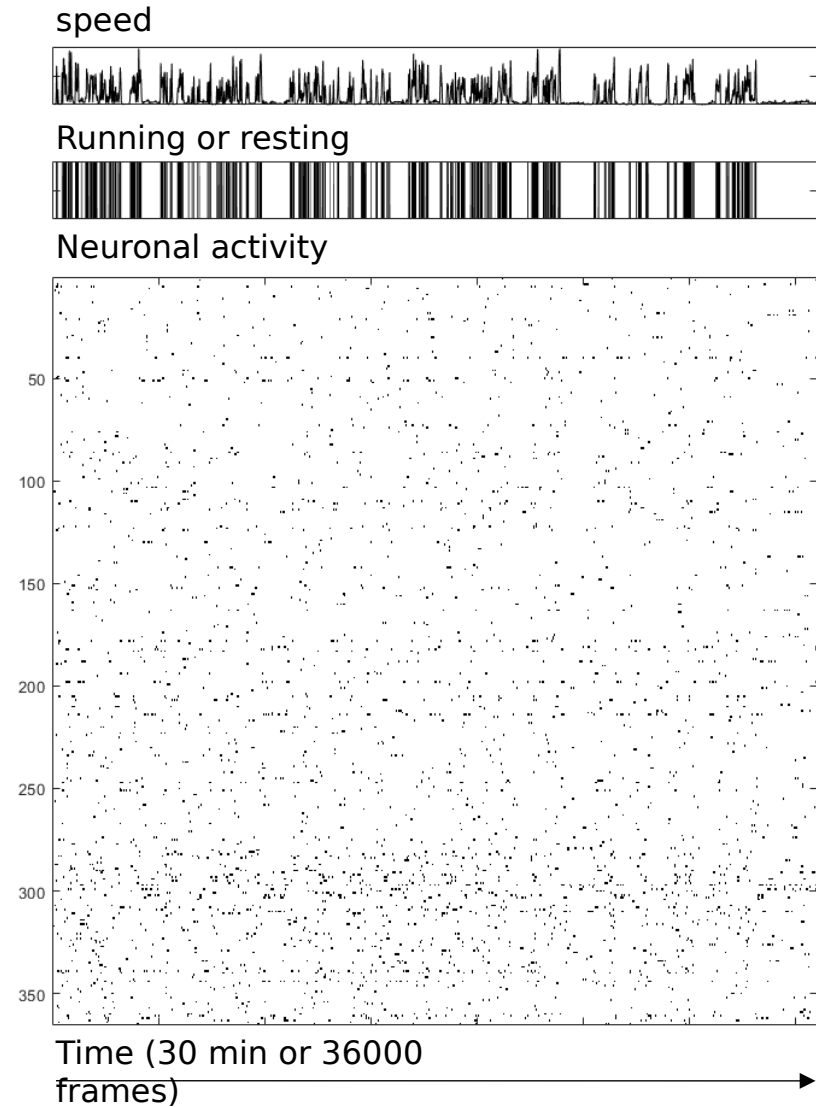
Animal recording and tracking in open arena



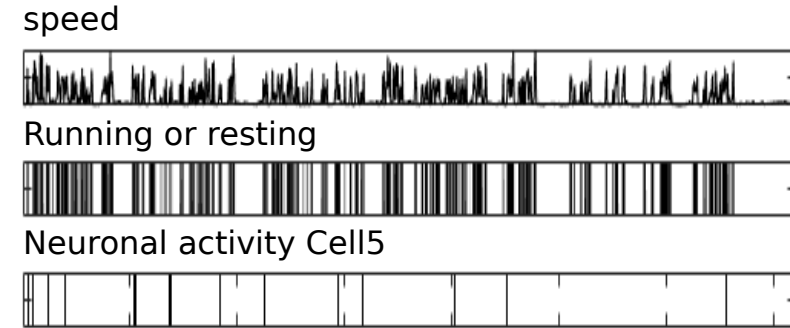
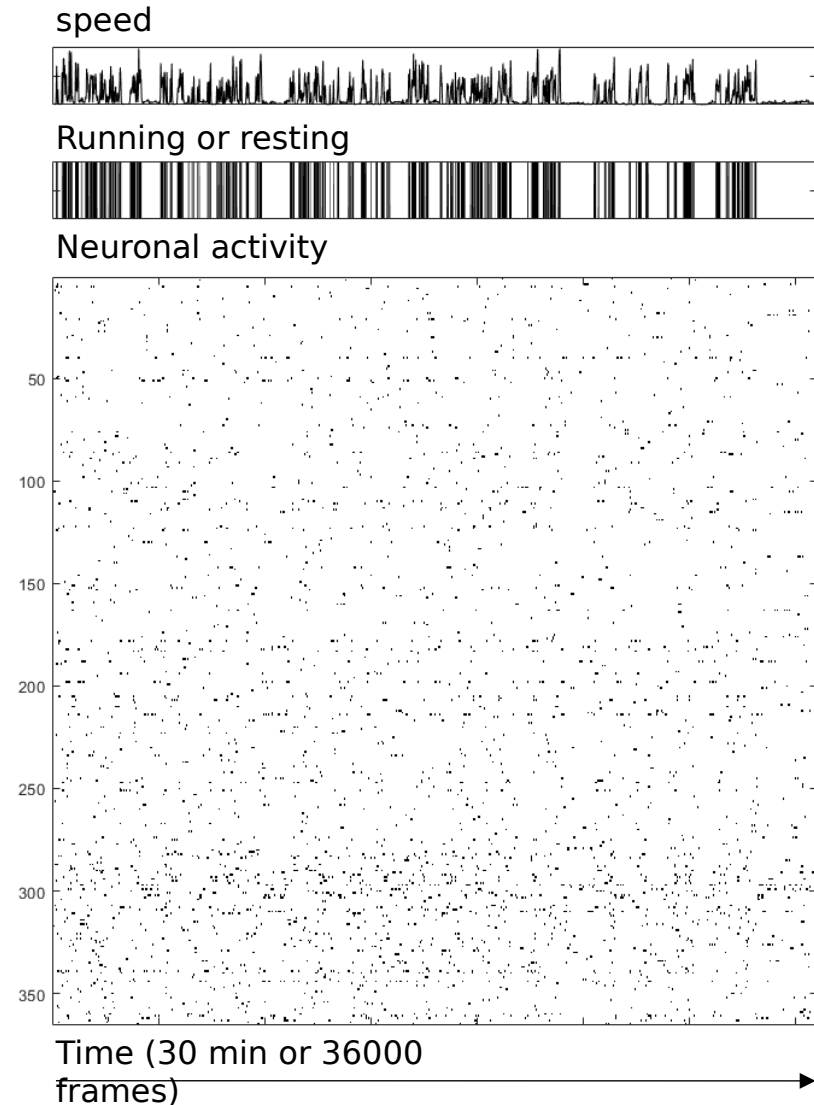
Snout
Miniscope top
Miniscope bottom
Left ear
Right ear
Head/Neck
Shoulders
Body Center
Hip center
Hip left
Hip right
Base tail
Center tail
Tip tail

Blow up the mouse

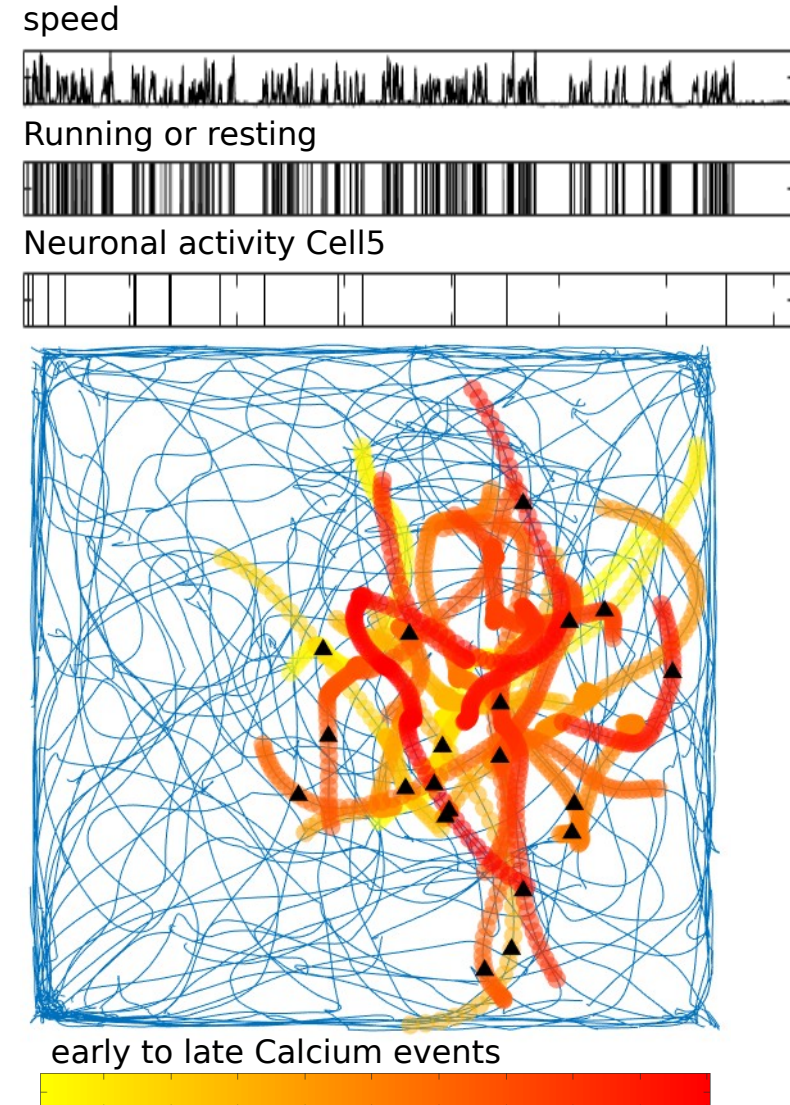
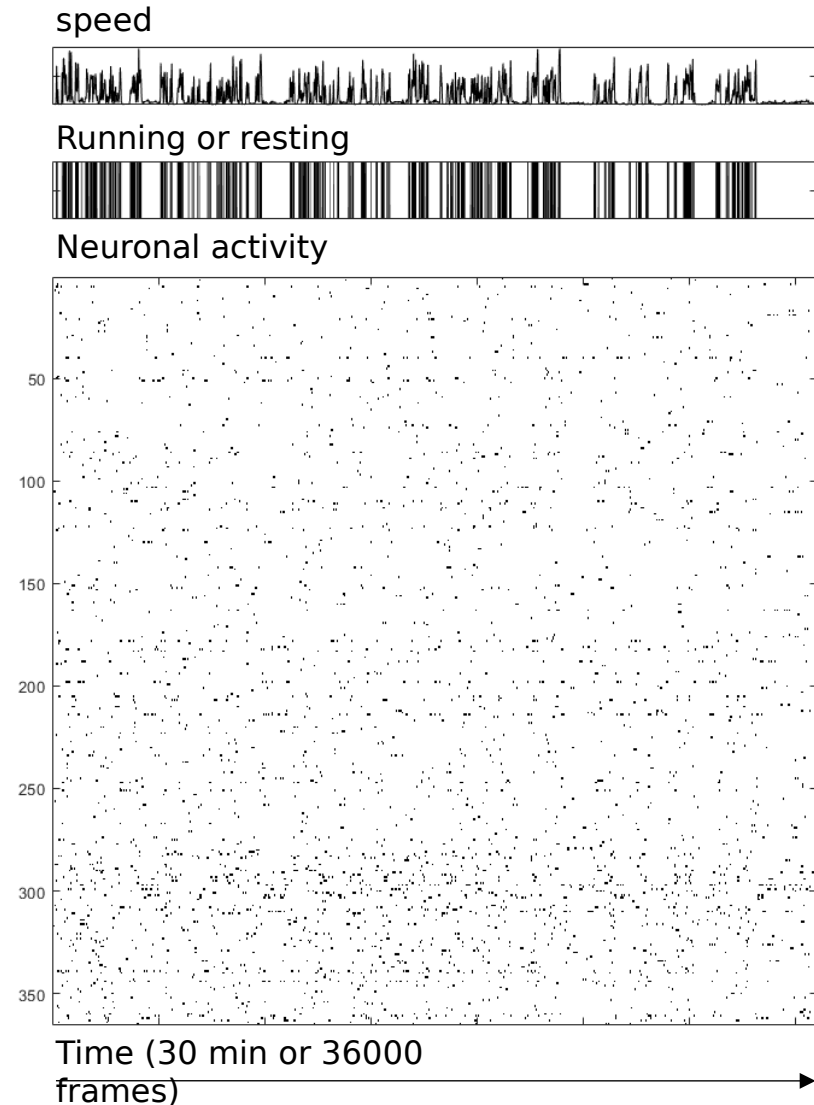
Combining neuronal events with behavior



Combining neuronal events with behavior



Combining neuronal events with behavior



Processing raw data with Matlab to find Place Cells

43 columns

36000 rows

36000x43 double

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0	1.4810e+03	1.3898e+03	0.2334	1.4752e+03	1.3855e+03	0.9794	1.4945e+03	1.3642e+03	0.9903	1.5093e+03	1.3697e+03	0.9947	1.4823e+03	1.3524e+03	0.9791	1.5012e+03	1.3543e+03	0.9872	1.5057e+03	1.3438e+03
2	1	1.4641e+03	1.3683e+03	0.3785	1.4645e+03	1.3638e+03	0.9248	1.4995e+03	1.3611e+03	0.9404	1.5096e+03	1.3749e+03	0.9271	1.4856e+03	1.3454e+03	0.9863	1.5049e+03	1.3537e+03	0.9866	1.5107e+03	1.3491e+03
3	2	1.4664e+03	1.3647e+03	0.3885	1.4658e+03	1.3603e+03	0.8853	1.5003e+03	1.3585e+03	0.9300	1.5111e+03	1.3710e+03	0.9413	1.4874e+03	1.3437e+03	0.9840	1.5064e+03	1.3522e+03	0.9903	1.5118e+03	1.3481e+03
4	3	1.4667e+03	1.3634e+03	0.4300	1.4668e+03	1.3590e+03	0.9143	1.5005e+03	1.3565e+03	0.9408	1.5107e+03	1.3700e+03	0.9449	1.4874e+03	1.3432e+03	0.9843	1.5066e+03	1.3515e+03	0.9893	1.5120e+03	1.3475e+03
5	4	1.4662e+03	1.3623e+03	0.4723	1.4666e+03	1.3582e+03	0.9092	1.5002e+03	1.3559e+03	0.9283	1.5111e+03	1.3695e+03	0.9504	1.4852e+03	1.3428e+03	0.9867	1.5065e+03	1.3512e+03	0.9847	1.5119e+03	1.3472e+03
6	5	1.4636e+03	1.3617e+03	0.4895	1.4634e+03	1.3576e+03	0.9119	1.4991e+03	1.3552e+03	0.9230	1.5093e+03	1.3695e+03	0.9504	1.4850e+03	1.3419e+03	0.9870	1.5051e+03	1.3510e+03	0.9845	1.5111e+03	1.3478e+03
7	6	1.4640e+03	1.3626e+03	0.4716	1.4635e+03	1.3587e+03	0.9112	1.4952e+03	1.3566e+03	0.9235	1.5090e+03	1.3696e+03	0.9292	1.4862e+03	1.3421e+03	0.9850	1.5047e+03	1.3516e+03	0.9843	1.5104e+03	1.3484e+03
8	7	1.4645e+03	1.3646e+03	0.4868	1.4659e+03	1.3600e+03	0.9310	1.4953e+03	1.3576e+03	0.9584	1.5091e+03	1.3717e+03	0.9229	1.4859e+03	1.3424e+03	0.9878	1.5055e+03	1.3522e+03	0.9899	1.5109e+03	1.3489e+03
9	8	1.4643e+03	1.3682e+03	0.3549	1.4635e+03	1.3633e+03	0.8660	1.5001e+03	1.3607e+03	0.9553	1.5102e+03	1.3738e+03	0.9260	1.4846e+03	1.3461e+03	0.9862	1.5059e+03	1.3533e+03	0.9891	1.5115e+03	1.3492e+03
10	9	1.4636e+03	1.3724e+03	0.3680	1.4631e+03	1.3660e+03	0.9143	1.4992e+03	1.3618e+03	0.9677	1.5083e+03	1.3746e+03	0.9267	1.4851e+03	1.3480e+03	0.9875	1.5053e+03	1.3533e+03	0.9888	1.5109e+03	1.3492e+03
11	10	1.4630e+03	1.3749e+03	0.3256	1.4618e+03	1.3710e+03	0.9046	1.4997e+03	1.3634e+03	0.9710	1.5108e+03	1.3758e+03	0.9275	1.4841e+03	1.3505e+03	0.9870	1.5053e+03	1.3555e+03	0.9855	1.5109e+03	1.3505e+03
12	11	1.4630e+03	1.3753e+03	0.3120	1.4624e+03	1.3708e+03	0.9172	1.4999e+03	1.3635e+03	0.9718	1.5089e+03	1.3756e+03	0.9406	1.4854e+03	1.3507e+03	0.9773	1.5052e+03	1.3553e+03	0.9860	1.5109e+03	1.3505e+03
13	12	1.4630e+03	1.3763e+03	0.2635	1.4626e+03	1.3724e+03	0.8879	1.4995e+03	1.3636e+03	0.9669	1.5092e+03	1.3754e+03	0.9420	1.4862e+03	1.3509e+03	0.9721	1.5051e+03	1.3557e+03	0.9820	1.5108e+03	1.3509e+03
14	13	1.4635e+03	1.3763e+03	0.2528	1.4630e+03	1.3721e+03	0.8722	1.4994e+03	1.3637e+03	0.9497	1.5087e+03	1.3759e+03	0.9191	1.4866e+03	1.3502e+03	0.9718	1.5054e+03	1.3579e+03	0.9744	1.5111e+03	1.3497e+03
15	14	1.4609e+03	1.3757e+03	0.3452	1.4615e+03	1.3713e+03	0.9295	1.4980e+03	1.3629e+03	0.9556	1.5076e+03	1.3756e+03	0.9298	1.4852e+03	1.3499e+03	0.9804	1.5039e+03	1.3550e+03	0.9811	1.5102e+03	1.3494e+03
16	15	1.4622e+03	1.3728e+03	0.3549	1.4634e+03	1.3662e+03	0.8860	1.4973e+03	1.3621e+03	0.9561	1.5067e+03	1.3752e+03	0.9260	1.4843e+03	1.3482e+03	0.9897	1.5032e+03	1.3541e+03	0.9826	1.5099e+03	1.3491e+03
17	16	1.4608e+03	1.3682e+03	0.3660	1.4619e+03	1.3630e+03	0.9037	1.4978e+03	1.3603e+03	0.9489	1.5063e+03	1.3746e+03	0.9422	1.4834e+03	1.3455e+03	0.9878	1.5036e+03	1.3535e+03	0.9857	1.5100e+03	1.3482e+03
18	17	1.4631e+03	1.3652e+03	0.3878	1.4641e+03	1.3598e+03	0.8424	1.4946e+03	1.3570e+03	0.9581	1.5034e+03	1.3715e+03	0.9319	1.4850e+03	1.3419e+03	0.9865	1.5038e+03	1.3522e+03	0.9856	1.5097e+03	1.3466e+03
19	18	1.4634e+03	1.3605e+03	0.4831	1.4631e+03	1.3560e+03	0.9236	1.4957e+03	1.3571e+03	0.9454	1.5084e+03	1.3707e+03	0.9525	1.4860e+03	1.3413e+03	0.9855	1.5052e+03	1.3520e+03	0.9871	1.5109e+03	1.3471e+03
20	19	1.4620e+03	1.3587e+03	0.5391	1.4627e+03	1.3546e+03	0.9374	1.4951e+03	1.3565e+03	0.9509	1.5074e+03	1.3691e+03	0.9587	1.4838e+03	1.3392e+03	0.9892	1.5045e+03	1.3518e+03	0.9837	1.5108e+03	1.3488e+03
21	20	1.4622e+03	1.3588e+03	0.4762	1.4622e+03	1.3548e+03	0.9376	1.4946e+03	1.3569e+03	0.9428	1.5074e+03	1.3695e+03	0.9461	1.4828e+03	1.3415e+03	0.9841	1.5044e+03	1.3521e+03	0.9810	1.5109e+03	1.3473e+03
22	21	1.4636e+03	1.3629e+03	0.4606	1.4632e+03	1.3581e+03	0.9050	1.4952e+03	1.3575e+03	0.9490	1.5091e+03	1.3707e+03	0.9376	1.4838e+03	1.3431e+03	0.9861	1.5055e+03	1.3526e+03	0.9872	1.5115e+03	1.3474e+03
23	22	1.4634e+03	1.3656e+03	0.4116	1.4659e+03	1.3615e+03	0.9039	1.4941e+03	1.3587e+03	0.9530	1.5082e+03	1.3728e+03	0.9006	1.4843e+03	1.3448e+03	0.9904	1.5051e+03	1.3535e+03	0.9844	1.5111e+03	1.3486e+03
24	23	1.4638e+03	1.3727e+03	0.3301	1.4644e+03	1.3658e+03	0.8831	1.4992e+03	1.3625e+03	0.9628	1.5085e+03	1.3748e+03	0.9361	1.4850e+03	1.3482e+03	0.9903	1.5057e+03	1.3542e+03	0.9881	1.5112e+03	1.3501e+03
25	24	1.4638e+03	1.3737e+03	0.3608	1.4641e+03	1.3697e+03	0.8747	1.4989e+03	1.3629e+03	0.9620	1.5069e+03	1.3754e+03	0.9251	1.4853e+03	1.3490e+03	0.9877	1.5052e+03	1.3545e+03	0.9844	1.5106e+03	1.3505e+03
26	25	1.4637e+03	1.3744e+03	0.3382	1.4641e+03	1.3704e+03	0.8980	1.4985e+03	1.3627e+03	0.9596	1.5066e+03	1.3757e+03	0.9207	1.4859e+03	1.3490e+03	0.9872	1.5049e+03	1.3545e+03	0.9835	1.5110e+03	1.3490e+03
27	26	1.4636e+03	1.3733e+03	0.3380	1.4639e+03	1.3695e+03	0.8658	1.4987e+03	1.3627e+03	0.9574	1.5067e+03	1.3759e+03	0.9107	1.4852e+03	1.3490e+03	0.9865	1.5047e+03	1.3552e+03	0.9828	1.5109e+03	1.3495e+03
28	27	1.4622e+03	1.3718e+03	0.3447	1.4634e+03	1.3656e+03	0.9080	1.4984e+03	1.3626e+03	0.9491	1.5071e+03	1.3761e+03	0.9075	1.4835e+03	1.3488e+03	0.9887	1.5043e+03	1.3551e+03	0.9845	1.5107e+03	1.3498e+03
29	28	1.4620e+03	1.3677e+03	0.3478	1.4633e+03	1.3630e+03	0.8716	1.4939e+03	1.3599e+03	0.9435	1.5066e+03	1.3748e+03	0.8900	1.4832e+03	1.3463e+03	0.9901	1.5041e+03	1.3543e+03	0.9826	1.5105e+03	1.3492e+03
30	29	1.4612e+03	1.3677e+03	0.3711	1.4623e+03	1.3626e+03	0.9305	1.4935e+03	1.3598e+03	0.9395	1.5069e+03	1.3748e+03	0.9053	1.4828e+03	1.3464e+03	0.9905	1.5041e+03	1.3538e+03	0.9839	1.5104e+03	1.3487e+03
31	30	1.4619e+03	1.3678e+03	0.3472	1.4627e+03	1.3631e+03	0.9092	1.4942e+03	1.3596e+03	0.9472	1.5063e+03	1.3744e+03	0.9160	1.4836e+03	1.3461e+03	0.9885	1.5039e+03	1.3539e+03	0.9863	1.5103e+03	1.3487e+03
32	31	1.4630e+03	1.3715e+03	0.3569	1.4635e+03	1.3650e+03	0.9155	1.4989e+03	1.3612e+03	0.9578	1.5070e+03	1.3746e+03	0.9375	1.4846e+03	1.3473e+03	0.9899	1.5047e+03	1.3538e+03	0.9889	1.5111e+03	1.3483e+03
33	32	1.4637e+03	1.3722e+03	0.3460	1.4643e+03	1.3658e+03	0.8945	1.4992e+03	1.3619e+03	0.9548	1.5064e+03	1.3752e+03	0.9276	1.4850e+03	1.3478e+03	0.9889	1.5047e+03	1.3543e+03	0.9859	1.5111e+03	1.3489e+03
34	33	1.4634e+03	1.3733e+03	0.3680	1.4634e+03	1.3693e+03	0.8925	1.4990e+03	1.3622e+03	0.9630	1.5063e+03	1.3753e+03	0.9347	1.4857e+03	1.3481e+03	0.9891	1.5049e+03	1.3541e+03	0.9875	1.5113e+03	1.3487e+03
35	34	1.4635e+03	1.3731e+03	0.3505	1.4636e+03	1.3693e+03	0.8819	1.4988e+03	1.3624e+03	0.9595	1.5066e+03	1.3756e+03	0.9227	1.4851e+03	1.3485e+03	0.9891	1.5045e+03	1.3542e+03	0.9861	1.5109e+03	1.3489e+03

Breaking down raw data

36000x43 double																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0	1.4810e+03	1.3898e+03	0.2334	1.4752e+03	1.3855e+03	0.9794	1.4945e+03	1.3642e+03	0.9903	1.5093e+03	1.3697e+03	0.9947	1.4823e+03	1.3524e+03	0.9791	1.5012e+03	1.3543e+03	0.9872	1.5057e+03	1.3438e+03
2	1	1.4614e+03	1.3683e+03	0.3785	1.4645e+03	1.3638e+03	0.9248	1.4995e+03	1.3611e+03	0.9404	1.5096e+03	1.3749e+03	0.9271	1.4856e+03	1.3454e+03	0.9863	1.5049e+03	1.3537e+03	0.9866	1.5107e+03	1.3491e+03
3	2	1.4664e+03	1.3647e+03	0.3885	1.4658e+03	1.3603e+03	0.8853	1.5003e+03	1.3585e+03	0.9300	1.5111e+03	1.3710e+03	0.9413	1.4874e+03	1.3437e+03	0.9840	1.5064e+03	1.3522e+03	0.9903	1.5118e+03	1.3481e+03
4	3	1.4667e+03	1.3634e+03	0.4300	1.4668e+03	1.3590e+03	0.9143	1.5005e+03	1.3565e+03	0.9408	1.5107e+03	1.3700e+03	0.9449	1.4874e+03	1.3432e+03	0.9843	1.5066e+03	1.3515e+03	0.9893	1.5120e+03	1.3475e+03
5	4	1.4662e+03	1.3623e+03	0.4723	1.4666e+03	1.3582e+03	0.9092	1.5002e+03	1.3559e+03	0.9283	1.5111e+03	1.3695e+03	0.9504	1.4852e+03	1.3428e+03	0.9867	1.5065e+03	1.3512e+03	0.9847	1.5119e+03	1.3472e+03
6	5	1.4636e+03	1.3617e+03	0.4895	1.4634e+03	1.3576e+03	0.9119	1.4991e+03	1.3552e+03	0.9230	1.5093e+03	1.3695e+03	0.9504	1.4850e+03	1.3419e+03	0.9870	1.5051e+03	1.3510e+03	0.9845	1.5111e+03	1.3478e+03
7	6	1.4640e+03	1.3626e+03	0.4716	1.4635e+03	1.3578e+03	0.9112	1.4952e+03	1.3566e+03	0.9235	1.5090e+03	1.3696e+03	0.9292	1.4862e+03	1.3421e+03	0.9850	1.5047e+03	1.3516e+03	0.9843	1.5104e+03	1.3484e+03
8	7	1.4645e+03	1.3646e+03	0.4868	1.4659e+03	1.3600e+03	0.9310	1.4953e+03	1.3576e+03	0.9584	1.5091e+03	1.3717e+03	0.9229	1.4859e+03	1.3424e+03	0.9878	1.5055e+03	1.3522e+03	0.9899	1.5109e+03	1.3489e+03
9	8	1.4643e+03	1.3682e+03	0.3549	1.4635e+03	1.3633e+03	0.8660	1.5001e+03	1.3607e+03	0.9553	1.5102e+03	1.3738e+03	0.9260	1.4846e+03	1.3461e+03	0.9862	1.5059e+03	1.3533e+03	0.9891	1.5115e+03	1.3492e+03
10	9	1.4636e+03	1.3724e+03	0.3680	1.4631e+03	1.3660e+03	0.9143	1.4992e+03	1.3618e+03	0.9677	1.5083e+03	1.3746e+03	0.9267	1.4851e+03	1.3480e+03	0.9875	1.5053e+03	1.3533e+03	0.9888	1.5109e+03	1.3492e+03
11	10	1.4630e+03	1.3749e+03	0.3256	1.4618e+03	1.3710e+03	0.9046	1.4997e+03	1.3634e+03	0.9710	1.5108e+03	1.3758e+03	0.9275	1.4841e+03	1.3505e+03	0.9870	1.5053e+03	1.3555e+03	0.9855	1.5109e+03	1.3505e+03
12	11	1.4630e+03	1.3753e+03	0.3120	1.4624e+03	1.3708e+03	0.9172	1.4999e+03	1.3635e+03	0.9718	1.5089e+03	1.3756e+03	0.9406	1.4854e+03	1.3507e+03	0.9773	1.5052e+03	1.3553e+03	0.9860	1.5109e+03	1.3505e+03
13	12	1.4630e+03	1.3763e+03	0.2635	1.4626e+03	1.3724e+03	0.8879	1.4995e+03	1.3636e+03	0.9669	1.5092e+03	1.3754e+03	0.9420	1.4862e+03	1.3509e+03	0.9721	1.5051e+03	1.3557e+03	0.9820	1.5108e+03	1.3509e+03
14	13	1.4635e+03	1.3763e+03	0.2528	1.4630e+03	1.3721e+03	0.8722	1.4994e+03	1.3637e+												

Snout
Miniscope top
Miniscope bottom
Left ear
Right ear
Head/Neck
Shoulders
Body Center
Hip center
Hip left
Hip right
Base tail
Center tail
Tip tail

Processing raw data with Matlab to find Place Cells

Breaking down raw data

43 columns = coordinates each body part

36000 rows
= frames

36000x43 double

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0	1.4810e+03	1.3898e+03	0.2334	1.4752e+03	1.3855e+03	0.9794	1.4945e+03	1.3642e+03	0.9903	1.5093e+03	1.3697e+03	0.9947	1.4823e+03	1.3524e+03	0.9797	1.5012e+03	1.3543e+03	0.9872	1.5057e+03	1.3438e+03
2	1	1.4641e+03	1.3683e+03	0.3785	1.4645e+03	1.3638e+03	0.9248	1.4995e+03	1.3611e+03	0.9404	1.5096e+03	1.3749e+03	0.9271	1.4856e+03	1.3454e+03	0.9863	1.5049e+03	1.3537e+03	0.9866	1.5107e+03	1.3491e+03
3	2	1.4664e+03	1.3647e+03	0.3885	1.4658e+03	1.3603e+03	0.8853	1.5003e+03	1.3585e+03	0.9300	1.5111e+03	1.3710e+03	0.9413	1.4874e+03	1.3437e+03	0.9840	1.5064e+03	1.3522e+03	0.9903	1.5118e+03	1.3481e+03
4	3	1.4667e+03	1.3634e+03	0.4300	1.4668e+03	1.3590e+03	0.9143	1.5005e+03	1.3565e+03	0.9408	1.5107e+03	1.3700e+03	0.9449	1.4874e+03	1.3432e+03	0.9843	1.5066e+03	1.3515e+03	0.9893	1.5120e+03	1.3475e+03
5	4	1.4662e+03	1.3623e+03	0.4723	1.4666e+03	1.3582e+03	0.9092	1.5002e+03	1.3559e+03	0.9283	1.5111e+03	1.3695e+03	0.9504	1.4852e+03	1.3428e+03	0.9867	1.5065e+03	1.3512e+03	0.9847	1.5119e+03	1.3472e+03
6	5	1.4636e+03	1.3617e+03	0.4895	1.4634e+03	1.3576e+03	0.9119	1.4991e+03	1.3552e+03	0.9230	1.5093e+03	1.3695e+03	0.9504	1.4850e+03	1.3419e+03	0.9870	1.5051e+03	1.3510e+03	0.9845	1.5111e+03	1.3478e+03
7	6	1.4640e+03	1.3626e+03	0.4716	1.4635e+03	1.3587e+03	0.9112	1.4952e+03	1.3566e+03	0.9235	1.5090e+03	1.3696e+03	0.9292	1.4862e+03	1.3421e+03	0.9850	1.5047e+03	1.3516e+03	0.9843	1.5104e+03	1.3484e+03
8	7	1.4645e+03	1.3646e+03	0.4868	1.4659e+03	1.3600e+03	0.9310	1.4953e+03	1.3576e+03	0.9584	1.5091e+03	1.3717e+03	0.9229	1.4859e+03	1.3424e+03	0.9878	1.5055e+03	1.3522e+03	0.9899	1.5109e+03	1.3489e+03
9	8	1.4643e+03	1.3682e+03	0.3549	1.4635e+03	1.3633e+03	0.8660	1.5001e+03	1.3607e+03	0.9553	1.5102e+03	1.3738e+03	0.9260	1.4846e+03	1.3461e+03	0.9863	1.5059e+03	1.3533e+03	0.9891	1.5115e+03	1.3492e+03
10	9	1.4636e+03	1.3724e+03	0.3680	1.4631e+03	1.3660e+03	0.9143	1.4992e+03	1.3618e+03	0.9677	1.5083e+03	1.3746e+03	0.9267	1.4851e+03	1.3480e+03	0.9875	1.5053e+03	1.3533e+03	0.9888	1.5109e+03	1.3492e+03
11	10	1.4630e+03	1.3749e+03	0.3256	1.4618e+03	1.3710e+03	0.9046	1.4997e+03	1.3634e+03	0.9710	1.5108e+03	1.3758e+03	0.9275	1.4841e+03	1.3505e+03	0.9870	1.5053e+03	1.3555e+03	0.9855	1.5109e+03	1.3505e+03
12	11	1.4630e+03	1.3753e+03	0.3120	1.4624e+03	1.3708e+03	0.9172	1.4999e+03	1.3635e+03	0.9718	1.5089e+03	1.3756e+03	0.9406	1.4854e+03	1.3507e+03	0.9773	1.5052e+03	1.3553e+03	0.9860	1.5109e+03	1.3505e+03
13	12	1.4630e+03	1.3763e+03	0.2635	1.4626e+03	1.3724e+03	0.8879	1.4995e+03	1.3636e+03	0.9669	1.5092e+03	1.3754e+03	0.9420	1.4862e+03	1.3509e+03	0.9721	1.5051e+03	1.3557e+03	0.9820	1.5108e+03	1.3509e+03
14	13	1.4635e+03	1.3763e+03	0.2528	1.4630e+03	1.3721e+03	0.8722	1.4994e+03	1.3637e+03	0.9497	1.5087e+03	1.3759e+03	0.9191	1.4866e+03	1.3502e+03	0.9718	1.5054e+03	1.3579e+03	0.9744	1.5111e+03	1.3497e+03
15	14	1.4609e+03	1.3757e+03	0.3452	1.4615e+03	1.3713e+03	0.9295	1.4980e+03	1.3629e+03	0.9556	1.5076e+03	1.3756e+03	0.9298	1.4852e+03	1.3499e+03	0.9804	1.5039e+03	1.3550e+03	0.9811	1.5102e+03	1.3494e+03
16	15	1.4622e+03	1.3728e+03	0.3549	1.4634e+03	1.3662e+03	0.8860	1.4973e+03	1.3621e+03	0.9561	1.5067e+03	1.3752e+03	0.9260	1.4843e+03	1.3482e+03	0.9897	1.5032e+03	1.3541e+03	0.9826	1.5099e+03	1.3491e+03
17	16	1.4608e+03	1.3682e+03	0.3660	1.4619e+03	1.3630e+03	0.9037	1.4978e+03	1.3603e+03	0.9489	1.5063e+03	1.3746e+03	0.9422	1.4834e+03	1.3455e+03	0.9878	1.5036e+03	1.3535e+03	0.9857	1.5100e+03	1.3482e+03
18	17	1.4631e+03	1.3652e+03	0.3878	1.4641e+03	1.3598e+03	0.8424	1.4946e+03	1.3570e+03	0.9581	1.5034e+03	1.3715e+03	0.9319	1.4850e+03	1.3419e+03	0.9863	1.5038e+03	1.3522e+03	0.9856	1.5097e+03	1.3466e+03
19	18	1.4634e+03	1.3605e+03	0.4831	1.4631e+03	1.3560e+03	0.9236	1.4957e+03	1.3571e+03	0.9454	1.5084e+03	1.3707e+03	0.9525	1.4860e+03	1.3413e+03	0.9855	1.5052e+03	1.3520e+03	0.9871	1.5109e+03	1.3471e+03
20	19	1.4620e+03	1.3587e+03	0.5391	1.4627e+03	1.3546e+03	0.9374	1.4951e+03	1.3565e+03	0.9509	1.5074e+03	1.3691e+03	0.9587	1.4838e+03	1.3392e+03	0.9892	1.5045e+03	1.3518e+03	0.9837	1.5108e+03	1.3488e+03
21	20	1.4622e+03	1.3588e+03	0.4762	1.4622e+03	1.3548e+03	0.9376	1.4946e+03	1.3569e+03	0.9428	1.5074e+03	1.3695e+03	0.9461	1.4828e+03	1.3415e+03	0.9841	1.5044e+03	1.3521e+03	0.9810	1.5109e+03	1.3473e+03
22	21	1.4636e+03	1.3629e+03	0.4606	1.4632e+03	1.3581e+03	0.9050	1.4952e+03	1.3575e+03	0.9490	1.5091e+03	1.3707e+03	0.9376	1.4838e+03	1.3431e+03	0.9861	1.5055e+03	1.3526e+03	0.9872	1.5115e+03	1.3474e+03
23	22	1.4634e+03	1.3656e+03	0.4116	1.4659e+03	1.3615e+03	0.9039	1.4941e+03	1.3587e+03	0.9530	1.5082e+03	1.3728e+03	0.9006	1.4843e+03	1.3448e+03	0.9904	1.5051e+03	1.3535e+03	0.9844	1.5111e+03	1.3486e+03
24	23	1.4638e+03	1.3727e+03	0.3301	1.4644e+03	1.3658e+03	0.8831	1.4992e+03	1.3625e+03	0.9628	1.5085e+03	1.3748e+03	0.9361	1.4850e+03	1.3482e+03	0.9903	1.5057e+03	1.3542e+03	0.9881	1.5112e+03	1.3501e+03
25	24	1.4638e+03	1.3737e+03	0.3608	1.4641e+03	1.3697e+03	0.8747	1.4989e+03	1.3629e+03	0.9620	1.5069e+03	1.3754e+03	0.9251	1.4853e+03	1.3490e+03	0.9877	1.5052e+03	1.3545e+03	0.9844	1.5106e+03	1.3505e+03
26	25	1.4637e+03	1.3744e+03	0.3382	1.4641e+03	1.3704e+03	0.8980	1.4985e+03	1.3627e+03	0.9596	1.5066e+03	1.3757e+03	0.9207	1.4859e+03	1.3490e+03	0.9872	1.5049e+03	1.3545e+03	0.9835	1.5110e+03	1.3490e+03
27	26	1.4636e+03	1.3733e+03	0.3380	1.4639e+03	1.3695e+03	0.8658	1.4987e+03	1.3627e+03	0.9574	1.5067e+03	1.3759e+03	0.9107	1.4852e+03	1.3490e+03	0.9863	1.5047e+03	1.3552e+03	0.9828	1.5109e+03	1.3495e+03
28	27	1.4622e+03	1.3718e+03	0.3447	1.4634e+03	1.3656e+03	0.9080	1.4984e+03	1.3626e+03	0.9491	1.5071e+03	1.3761e+03	0.9075	1.4835e+03	1.3488e+03	0.9887	1.5043e+03	1.3551e+03	0.9845	1.5107e+03	1.3498e+03
29	28	1.4620e+03	1.3677e+03	0.3478	1.4633e+03	1.3630e+03	0.8716	1.4939e+03	1.3599e+03	0.9435	1.5066e+03	1.3748e+03	0.8900	1.4832e+03	1.3463e+03	0.9901	1.5041e+03	1.3543e+03	0.9826	1.5105e+03	1.3492e+03
30	29	1.4612e+03	1.3677e+03	0.3711	1.4623e+03	1.3626e+03	0.9305	1.4935e+03	1.3598e+03	0.9395	1.5069e+03	1.3748e+03	0.9053	1.4828e+03	1.3464e+03	0.9905	1.5041e+03	1.3538e+03	0.9839	1.5104e+03	1.3487e+03
31	30	1.4619e+03	1.3678e+03	0.3472	1.4627e+03	1.3631e+03	0.9092	1.4942e+03	1.3596e+03	0.9472	1.5063e+03	1.3744e+03	0.9160	1.4836e+03	1.3461e+03	0.9885	1.5039e+03	1.3539e+03	0.9863	1.5103e+03	1.3487e+03
32	31	1.4630e+03	1.3715e+03	0.3569	1.4635e+03	1.3650e+03	0.9155	1.4989e+03	1.3612e+03	0.9578	1.5070e+03	1.3746e+03	0.9375	1.4846e+03	1.3473e+03	0.9899	1.5047e+03	1.3538e+03	0.9889	1.5111e+03	1.3483e+03
33	32	1.4637e+03	1.3722e+03	0.3460	1.4643e+03	1.3658e+03	0.8945	1.4992e+03	1.3619e+03	0.9548	1.5064e+03	1.3752e+03	0.9276	1.4850e+03	1.3478e+03	0.9889	1.5047e+03	1.3543e+03	0.9859	1.5111e+03	1.3489e+03
34	33	1.4634e+03	1.3733e+03	0.3680	1.4634e+03	1.3693e+03	0.8925	1.4990e+03	1.3622e+03	0.9630	1.5063e+03	1.3753e+03	0.9347	1.4857e+03	1.3481e+03	0.9897	1.5049e+03	1.3541e+03	0.9875	1.5113e+03	1.3487e+03
35	34	1.4635e+03	1.3731e+03	0.3505	1.4636e+03	1.3693e+03	0.8819	1.4988e+03	1.3624e+03	0.9595	1.5066e+03	1.3756e+03	0.9227	1.4851e+03	1.3485e+03	0.9897	1.5045e+03	1.3542e+03	0.9861	1.5109e+03	1.3489e+03

head/neck coordinates

17 - X-direction

18 - Y-direction

19 - reliability estimator (was the tracking any good)

Snout

Miniscope top

Miniscope bottom

Left ear

Right ear

Head/Neck

Shoulders

Body Center

Hip center

Hip left

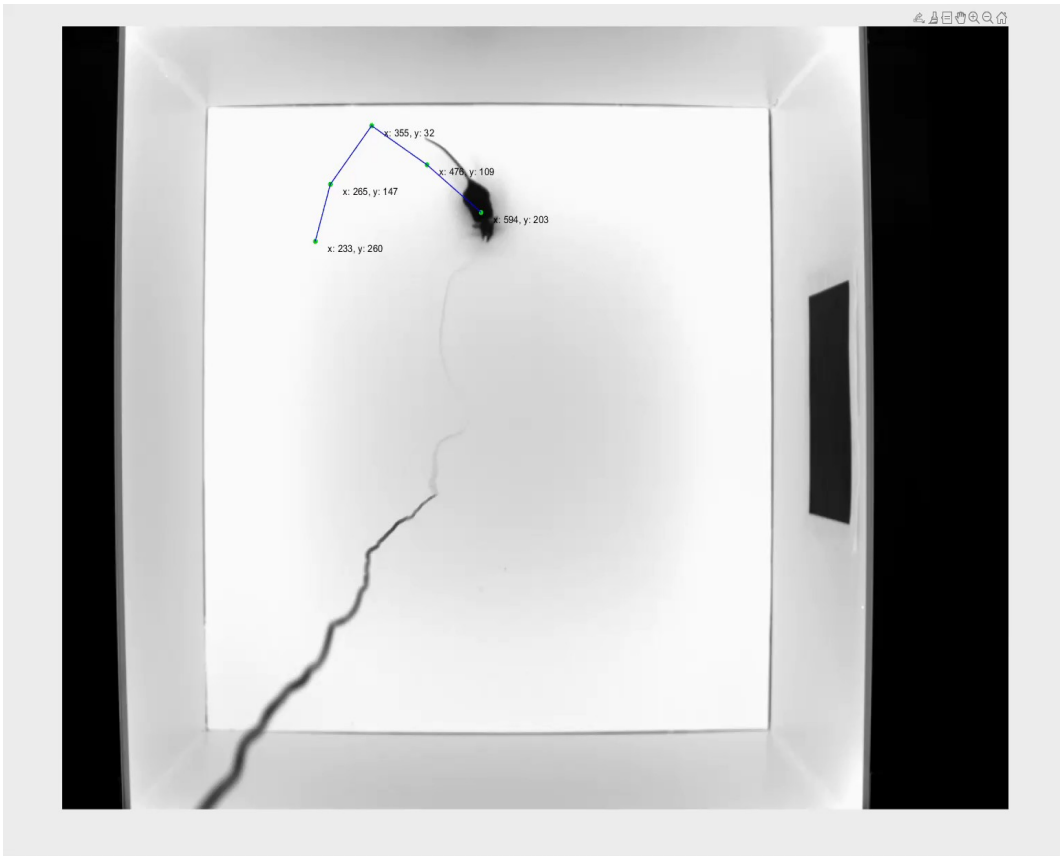
Hip right

Base tail

Center tail

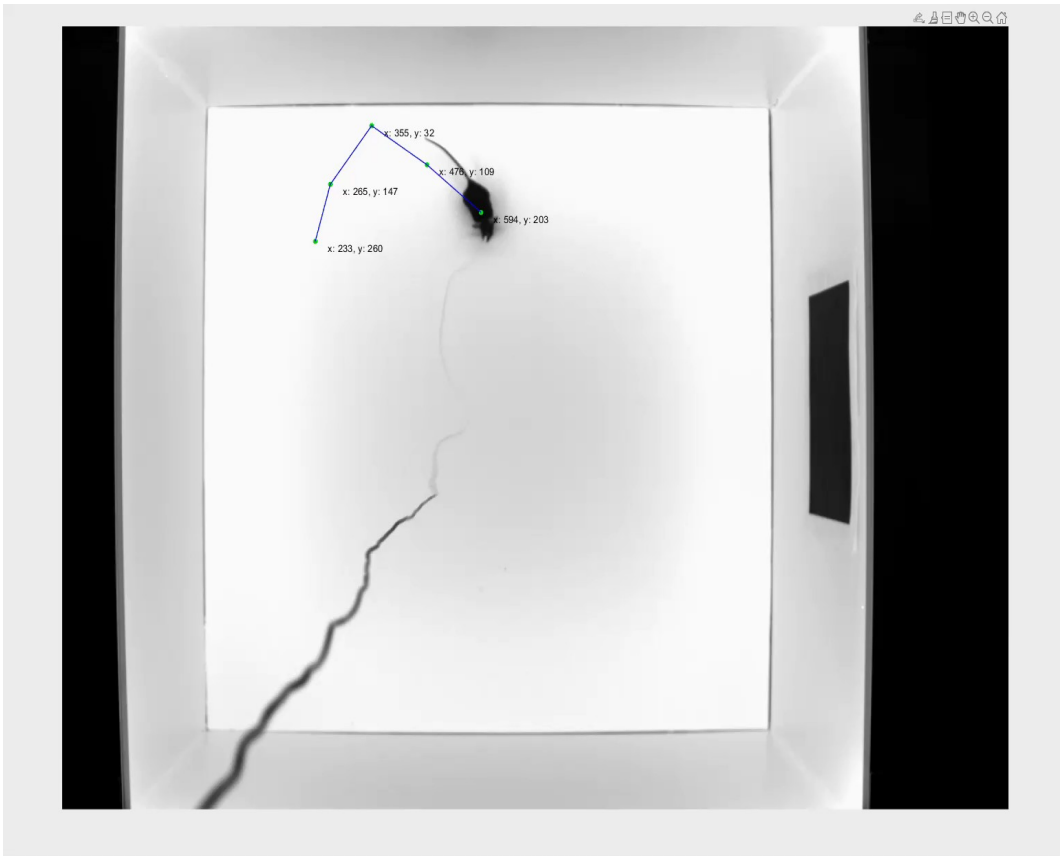
Tip tail

Processing raw data with Matlab to find Place Cells



sec: 1, x: 233, y: 260, estimator: 0.976
sec: 2, x: 265, y: 147, estimator: 0.971
sec: 3, x: 355, y: 32, estimator: 0.949
sec: 4, x: 476, y: 109, estimator: 0.976
sec: 5, x: 594, y: 203, estimator: 0.986
sec: 6, x: 661, y: 434, estimator: 0.989
sec: 7, x: 545, y: 564, estimator: 0.974
sec: 8, x: 400, y: 640, estimator: 0.815
sec: 9, x: 237, y: 646, estimator: 0.939
sec: 10, x: 92, y: 441, estimator: 0.987
sec: 11, x: 51, y: 265, estimator: 0.991

Processing raw data with Matlab to find Place Cells

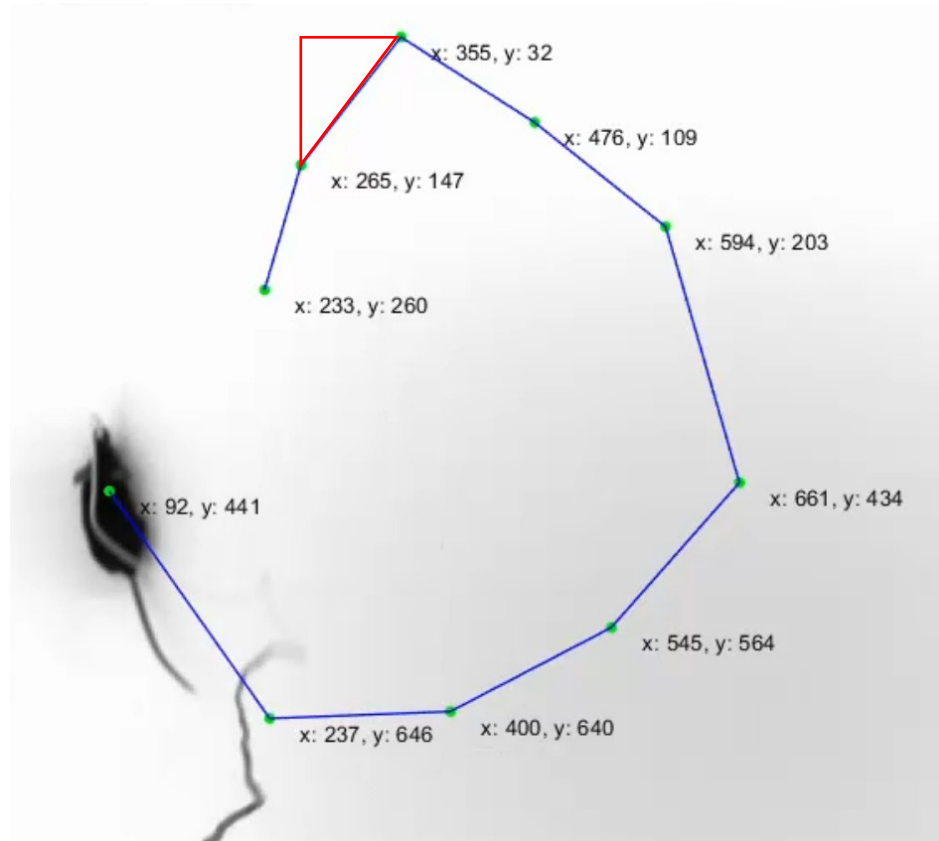


sec: 1, x: 233, y: 260, estimator: 0.976
sec: 2, x: 265, y: 147, estimator: 0.971
sec: 3, x: 355, y: 32, estimator: 0.949
sec: 4, x: 476, y: 109, estimator: 0.976
sec: 5, x: 594, y: 203, estimator: 0.986
sec: 6, x: 661, y: 434, estimator: 0.989
sec: 7, x: 545, y: 564, estimator: 0.974
sec: 8, x: 400, y: 640, estimator: 0.815
sec: 9, x: 237, y: 646, estimator: 0.939
sec: 10, x: 92, y: 441, estimator: 0.987
sec: 11, x: 51, y: 265, estimator: 0.991

1 Task:
using the estimator to find the most promising body part to plot the trajectory

- Index raw matrix to create a matrix that contains the estimator values only
- Find a math/statistical operator to find the best body part to track
- Draw correct X- and Y-coordinates from raw matrix
- Plot the running trajectory

Processing raw data with Matlab to find Place Cells



sec: 1, x: 233, y: 260, estimator: 0.976
sec: 2, x: 265, y: 147, estimator: 0.971
sec: 3, x: 355, y: 32, estimator: 0.949
sec: 4, x: 476, y: 109, estimator: 0.976
sec: 5, x: 594, y: 203, estimator: 0.986
sec: 6, x: 661, y: 434, estimator: 0.989
sec: 7, x: 545, y: 564, estimator: 0.974
sec: 8, x: 400, y: 640, estimator: 0.815
sec: 9, x: 237, y: 646, estimator: 0.939
sec: 10, x: 92, y: 441, estimator: 0.987
sec: 11, x: 51, y: 265, estimator: 0.991

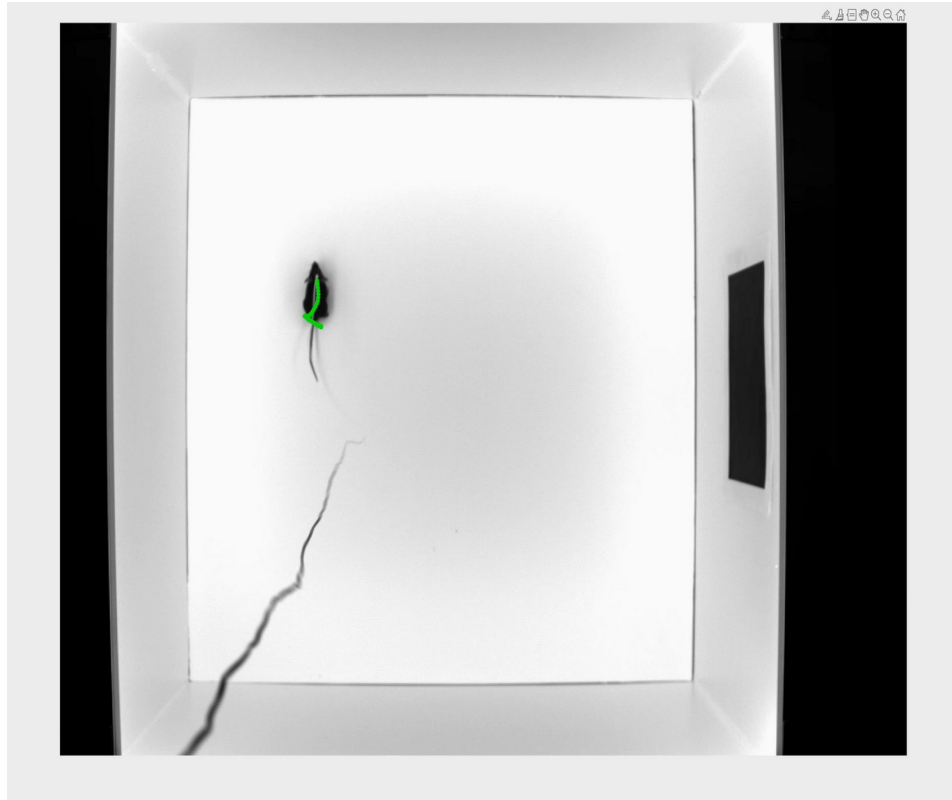
$$\text{Distance} c = \sqrt{a^2 + b^2}$$

Distance/time = speed

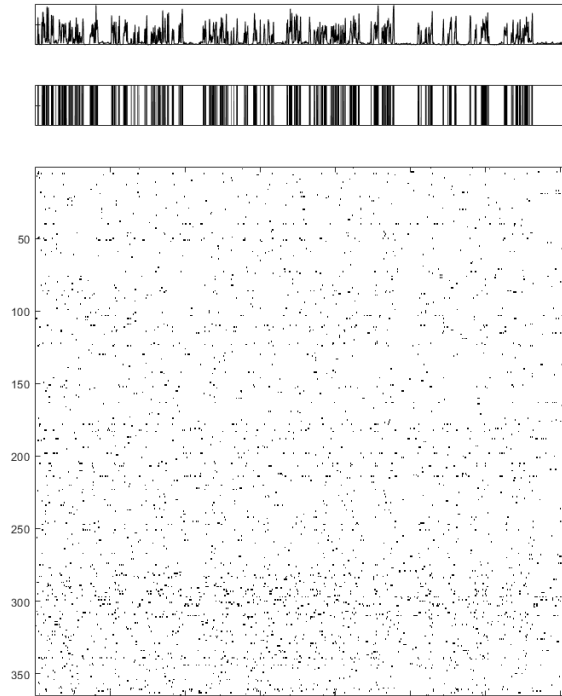
2 Task:
using the correct body part to calculate the speed of the animal and the total distance travels

- Adjust coordinates for better plotting (find point (0|0) and use moving mean)
- Find the size of the arena in pixel and convert it in cm
- Find the distance traveled in per frame
- Calculate the animals speed

Processing raw data with Matlab to find Place Cells



2 x
speed



3 Task:
Track the animals
behavior, read out
neuronal data to the
animals behavior and
plot single neuron
activity to running
trajectory

- Find resting and running epochs
- Read out neuronal activity correlated to behavior

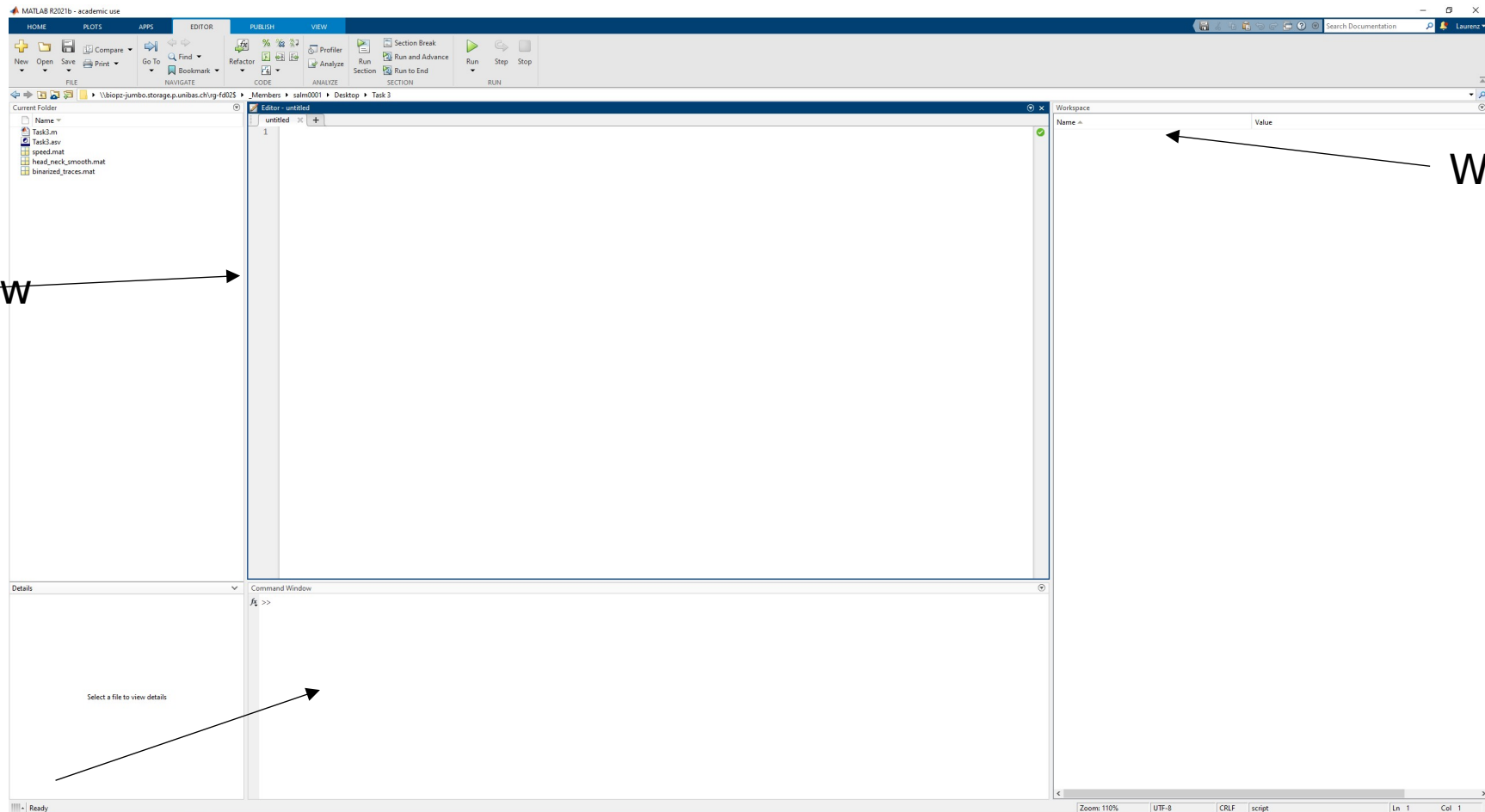
Processing raw data with Matlab to find Place Cells

Current folder

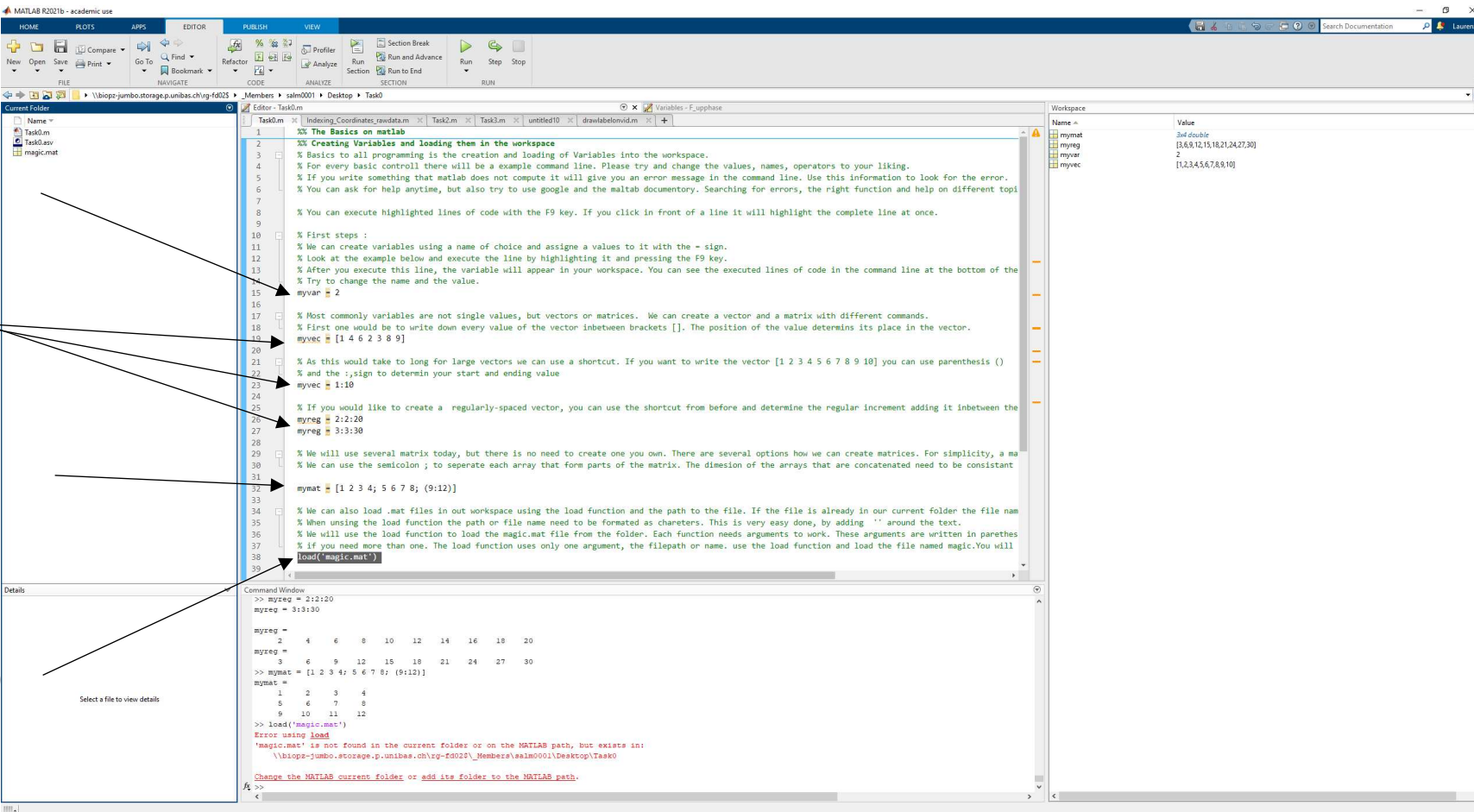
Editor window

Command window

Workspace



Processing raw data with Matlab to find Place Cells



The screenshot displays the MATLAB R2021b environment. The Editor window shows a script titled 'Task0.m' with the following content:

```
1 %% The Basics on matlab
2 %% Creating Variables and loading them in the workspace
3 % Basics to all programming is the creation and loading of Variables into the workspace.
4 % For every basic controll there will be a example command line. Please try and change the values, names, operators to your liking.
5 % If you write something that matlab does not compute it will give you an error message in the command line. Use this information to look for the error.
6 % You can ask for help anytime, but also try to use google and the matlab documentary. Searching for errors, the right function and help on different topics
7 % You can execute highlighted lines of code with the F9 key. If you click in front of a line it will highlight the complete line at once.
8
9 % First steps :
10 % We can create variables using a name of choice and assign a values to it with the = sign.
11 % Look at the example below and execute the line by highlighting it and pressing the F9 key.
12 % After you execute this line, the variable will appear in your workspace. You can see the executed lines of code in the command line at the bottom of the
13 % Try to change the name and the value.
14 myvar = 2
15
16 % Most commonly variables are not single values, but vectors or matrices. We can create a vector and a matrix with different commands.
17 % First one would be to write down every value of the vector inbetween brackets []. The position of the value determines its place in the vector.
18 myvec = [1 4 6 2 3 8 9]
19
20 % As this would take too long for large vectors we can use a shortcut. If you want to write the vector [1 2 3 4 5 6 7 8 9 10] you can use parenthesis ()
21 % and the :, sign to determine your start and ending value
22 myvec = 1:10
23
24 % If you would like to create a regularly-spaced vector, you can use the shortcut from before and determine the regular increment adding it inbetween the
25 myreg = 2:2:20
26 myreg = 3:3:30
27
28 % We will use several matrix today, but there is no need to create one you own. There are several options how we can create matrices. For simplicity, a matrix
29 % We can use the semicolon ; to separate each array that form parts of the matrix. The dimension of the arrays that are concatenated need to be consistent
30 mymat = [1 2 3 4; 5 6 7 8; (9:12)]
31
32 % We can also load .mat files in our workspace using the load function and the path to the file. If the file is already in our current folder the file name
33 % When using the load function the path or file name need to be formatted as characters. This is very easy done, by adding '' around the text.
34 % We will use the load function to load the magic.mat file from the folder. Each function needs arguments to work. These arguments are written in parentheses
35 % if you need more than one. The load function uses only one argument, the filepath or name. use the load function and load the file named magic. You will
36 load('magic.mat')
```

The Workspace window on the right shows the following variables:

Name	Value
myvar	2
myvec	[1, 4, 6, 2, 3, 8, 9]
myreg	[2, 4, 6, 8, 10, 12, 14, 16, 18, 20]
mymat	[1, 2, 3, 4; 5, 6, 7, 8; 9, 10, 11, 12]

The Command Window at the bottom shows the execution of the script:

```
>> myvec = 2:2:20
myvec =
     2     4     6     8    10    12    14    16    18    20

>> mymat = [1 2 3 4; 5 6 7 8; (9:12)]
mymat =
     1     2     3     4
     5     6     7     8
     9    10    11    12

>> load('magic.mat')
Error using load
'magic.mat' is not found in the current folder or on the MATLAB path, but exists in:
\\biops-jumbo.storage.p.uniba.ch\rg-fs025\Members\salm001\Desktop\Task0
Change the MATLAB current folder or add its folder to the MATLAB path.
```

Arrows from the left point to specific lines in the script:

- Scalars** points to line 14: `myvar = 2`
- Vectors** points to line 18: `myvec = [1 4 6 2 3 8 9]`
- Matrix** points to line 30: `mymat = [1 2 3 4; 5 6 7 8; (9:12)]`
- Functions** points to line 36: `load('magic.mat')`

- Find github link here