Supplemental information:
A Network of Intrinsic Oscillators Can Drive Forward Locomotion in *C. elegans*

S1: Method to calculate wavelength, antero-posterior curvature profile and trajectory curvature

Calculation of body wavelength (Fig 1 B): The points in which the body transition from ventral to dorsal bending was utilized to perform a linear regression (dashed black lines). This line estimate the body curvature wave in the time v/s body axis plane. The horizontal separation between two consecutive regressions corresponds to the oscillation period, while the vertical distance corresponds to the body wavelength.

Calculation of trajectory curvature (Fig 1 C): After a period of adaptation, the body center of mass of simulated worms described circular trajectories in the 2D plane. We filtered simulated works that display trajectory curvature radii less than 1 mm.

Calculation of anterior-posterior curvature profile (Fig 1 D, E): Mean curvature along the body axis was plotted and a linear regression was fitted. A negative slope of the regression line indicates a tendency to bend more in the head than in the tail, as observed in the worms' forward locomotion.

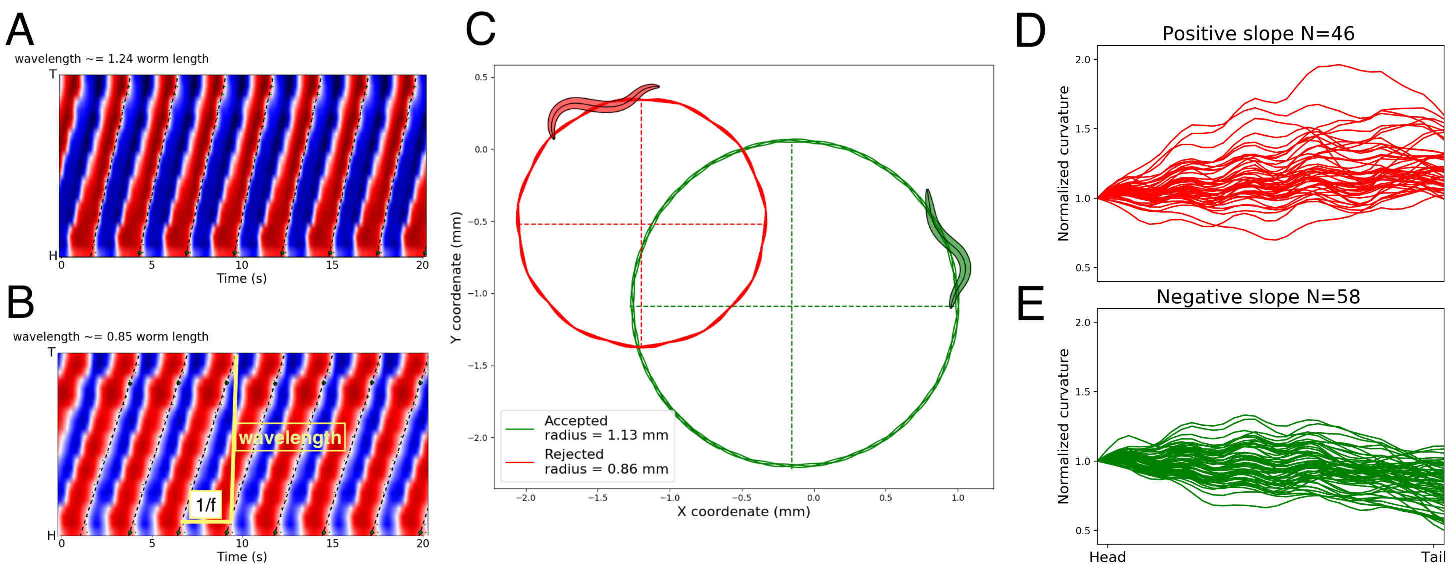

Fig 1. Examples of accepted and rejected models after the filtering process. [A]Rejected model due to a high bending wavelength, dotted lines depicted the linear regression for the bending against time. [B] Accepted model showing a wavelength of 0.85 body length. [C] accepted (green) and rejected (red) models due to trajectory curvature bias. Threshold of rejection was set to 1 mm. Mean body curvature along the body axis [D] 46 solutions were rejected for their trend to bend more in the tail than in the head. [E] 58 solutions presents stronger bending in the head than the tail, as observed in crawling worms.

S2: Movies of forward locomotion

Movies for the 15 filtered solutions can be found on https://drive.google.com/open?id=14FDIk02Mbfvjapd7eSoy-yYYtuf4bckv.

S3: Parameters combinations in the filtered solutions

individual index	4	5	9	21	23	30	37	42
Bias AS	2.28	-7.02	1.76	2.24	5.44	1.77	1.94	-9.02
Bias DA	14.98	4.80	7.07	-9.51	12.08	7.20	0.92	-8.78
Bias DB	3.36	-4.29	9.13	-7.64	8.19	2.52	-0.67	4.78
Bias DD	-4.73	-9.45	-13.66	3.62	-6.38	5.01	5.45	-6.40
Bias VD	-6.02	8.66	-5.64	5.80	-7.34	-0.55	6.66	1.79
Bias VB	-0.40	0.85	9.04	-13.13	11.72	4.35	-2.86	-0.57
Bias VA	-14.80	-11.82	2.32	12.03	6.04	3.66	-1.34	-2.48
Tau AS	0.63	0.26	0.69	1.30	1.11	0.25	0.16	0.18
Tau DA	1.77	0.55	1.04	0.11	1.58	0.63	1.24	0.55
Tau DB	0.10	0.58	0.10	0.66	0.15	0.22	0.15	0.28
Tau DD	0.78	0.20	1.54	0.56	1.27	0.63	1.41	2.30
Tau VD	0.65	0.91	1.30	0.32	0.11	1.26	0.14	1.05
Tau VB	0.39	1.41	1.31	0.16	0.19	0.12	0.64	0.79
Tau VA	0.98	0.31	0.18	0.88	0.38	0.46	1.15	2.30
Self conn AS	7.09	6.73	9.68	0.14	4.36	12.28	-1.67	-5.37
Self conn DA	-14.44	3.74	-0.14	7.82	-10.79	-14.69	9.39	14.37
Self conn DB	9.38	0.89	3.76	0.05	5.25	4.20	8.99	6.57
Self conn DD	-11.75	-0.92	-1.82	1.52	0.78	-6.01	1.60	6.04
Self conn VD	-0.44	-4.37	-7.51	14.80	-3.70	-13.16	-3.37	-14.45
Self conn VB	4.19	0.99	-9.48	9.15	-10.00	0.34	4.90	4.98
Self conn VA	2.38	10.81	-0.60	1.05	1.63	6.98	9.54	-4.75
AS $\rightarrow$ DA	-13.16	-14.75	-13.37	14.63	-13.57	-13.86	-13.37	14.96
AS $\rightarrow$ VD	12.54	-14.06	14.96	0.05	14.66	15.00	-14.87	7.94
DA $\rightarrow$ DB	-15.00	15.00	-14.88	9.91	-15.00	-14.42	-14.55	-14.90
DB $\rightarrow$ AS	-14.89	15.00	-13.29	-14.08	-14.84	-12.20	-14.07	14.66
VD $\rightarrow$ VA	-5.19	13.93	-6.72	7.39	-13.95	-15.00	10.53	14.81
VD $\rightarrow$ VB	6.86	-10.21	-8.13	11.57	-12.58	-8.24	8.98	3.46
DA $\rightarrow$ DD	11.80	6.70	-1.95	-8.99	3.68	-0.35	14.72	-8.36
VB $\rightarrow$ DD	1.90	-5.48	9.83	-7.73	2.19	-4.62	-2.73	4.81
VA $\rightarrow$ DD	-13.91	-10.73	4.77	-6.72	0.90	15.00	5.52	-10.89
VD $\vdash\dashv$ DD	0.22	0.50	0.44	1.71	0.27	0.46	1.60	0.40
NMJ weigth AS	0.83	0.45	0.00	0.76	0.13	1.20	0.58	0.67
NMJ weigth DA	0.23	0.63	0.20	0.51	0.27	1.13	0.29	0.00
NMJ weigth DB	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
NMJ weigth DD	-1.10	-0.26	-0.90	-0.79	-0.10	-0.81	-1.20	-0.50
NMJ weigth VD	-0.92	-0.37	-0.86	-0.46	-0.79	-0.27	-1.19	-0.83
NMJ weigth VB	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
NMJ weigth VA	0.96	0.14	0.81	0.43	0.30	0.29	0.57	0.39
A/P gain	0.67	0.62	0.61	0.35	0.36	0.92	0.72	0.79
DB $\rightarrow$ DDnext	-7.90	-14.18	-14.94	-8.14	9.19	3.43	-5.60	-0.26
VAnext $\rightarrow$ DD	-7.17	-7.90	12.03	4.34	-0.30	9.93	-13.99	4.71
AS $\vdash\dashv$ VAnext	0.77	1.76	0.81	0.96	0.08	1.41	0.48	0.02
DA $\vdash\dashv$ ASnext	0.05	0.00	0.02	0.20	0.47	0.08	0.17	1.26
VB $\vdash\dashv$ DBnext	0.53	1.44	0.84	0.66	1.18	0.62	1.03	0.60

individual index	45	53	63	66	68	101	103
Bias AS	-0.43	-7.74	-2.31	1.88	4.82	1.44	-9.27
Bias DA	-4.91	-6.31	-8.70	3.37	4.99	1.86	-9.47
Bias DB	-3.43	9.32	-0.09	-12.45	-0.71	-10.70	6.71
Bias DD	14.99	3.79	13.36	0.35	7.84	-11.37	6.33
Bias VD	-2.80	0.69	-1.92	-5.99	12.46	-1.45	4.52
Bias VB	-0.55	-5.89	-7.43	-10.16	-4.74	-7.51	4.63
Bias VA	-9.15	-5.65	-9.03	-14.03	1.84	-8.17	-6.61
Tau AS	0.30	0.30	1.68	0.29	1.63	0.49	0.45
Tau DA	0.97	0.97	1.11	0.88	1.01	0.95	0.17
Tau DB	0.21	0.84	0.12	0.10	0.11	0.13	1.11
Tau DD	2.45	1.60	0.59	2.21	1.31	0.15	0.84
Tau VD	0.46	2.46	0.12	0.10	0.91	1.28	0.24
Tau VB	0.85	0.13	0.87	1.78	0.12	1.38	0.52
Tau VA	0.54	0.10	1.02	0.99	0.35	1.42	0.10
Self conn AS	9.62	6.03	-5.47	-11.61	-0.02	-13.39	2.29
Self conn DA	0.10	-1.35	0.72	7.15	-0.70	8.14	10.43
Self conn DB	-0.82	-2.19	4.33	13.80	5.04	9.90	1.47
Self conn DD	-15.00	-8.26	4.87	12.17	-1.53	7.41	-6.94
Self conn VD	-3.67	-14.94	5.59	0.20	-12.82	-14.96	-4.65
Self conn VB	5.79	5.48	5.57	3.77	2.94	2.40	-8.41
Self conn VA	-6.52	-11.90	-11.89	2.69	-4.78	-3.94	0.83
AS $\rightarrow$ DA	13.45	14.69	14.08	-14.24	-11.83	-11.69	14.38
AS $\rightarrow$ VD	12.18	13.81	5.08	13.89	-14.58	14.99	-14.54
DA $\rightarrow$ DB	13.41	-15.00	-10.02	13.31	-14.51	14.64	-12.49
DB $\rightarrow$ AS	-14.91	12.84	13.26	12.32	-15.00	14.63	12.47
VD $\rightarrow$ VA	-9.57	-9.67	-2.60	-10.20	10.29	-10.94	9.94
VD $\rightarrow$ VB	-10.64	11.84	10.31	14.77	15.00	14.85	13.54
DA $\rightarrow$ DD	9.90	4.29	-3.14	-9.67	-5.78	14.13	-5.96
VB $\rightarrow$ DD	-10.79	-1.96	-13.57	-4.52	-6.10	-12.94	0.29
VA $\rightarrow$ DD	-0.38	7.45	-13.98	-10.43	-14.37	-12.78	-10.81
VD $\vdash\dashv$ DD	0.13	1.81	1.18	1.64	1.47	1.82	1.41
NMJ weigth AS	1.18	0.53	1.19	1.19	0.80	0.55	0.93
NMJ weigth DA	0.60	1.20	0.54	0.29	0.03	0.00	0.67
NMJ weigth DB	1.20	1.20	1.20	1.20	1.20	1.20	1.20
NMJ weigth DD	-0.35	-0.99	-0.96	-0.70	-0.93	-0.86	-1.16
NMJ weigth VD	-0.86	-0.52	-0.12	-0.27	0.00	-0.30	-0.28
NMJ weigth VB	1.20	1.20	1.20	1.20	1.20	1.20	1.20
NMJ weigth VA	1.10	0.51	0.41	0.08	0.65	1.08	1.14
A/P gain	0.56	0.91	0.39	0.77	0.79	0.56	0.76
DB $\rightarrow$ DDnext	-14.94	-14.86	2.10	1.95	2.06	9.15	4.54
VAnext $\rightarrow$ DD	3.26	-8.15	0.22	-0.66	1.74	-2.14	14.71
AS $\vdash\dashv$ VAnext	1.13	0.30	0.51	1.86	0.93	1.03	0.33
DA $\vdash\dashv$ ASnext	1.35	0.44	0.17	0.07	0.19	0.03	0.70
VB $\vdash\dashv$ DBnext	0.99	0.02	0.34	1.52	0.62	1.42	1.19

S4: Inter-unit phase shift and method to calculate neuron phase delay.

Calculation of phase delay (Fig 1 D, E): Neurons output oscillations were fitted by a sinusoidal function. To do so, phase = 0 was placed in the midpoint between the position of the minimum and maximum derivative of the neuron output. phase delay was calculated as usual for sinusoidal functions. This ad-hoc method performs better than Fourier transforms based methods mainly for composed neural traces.

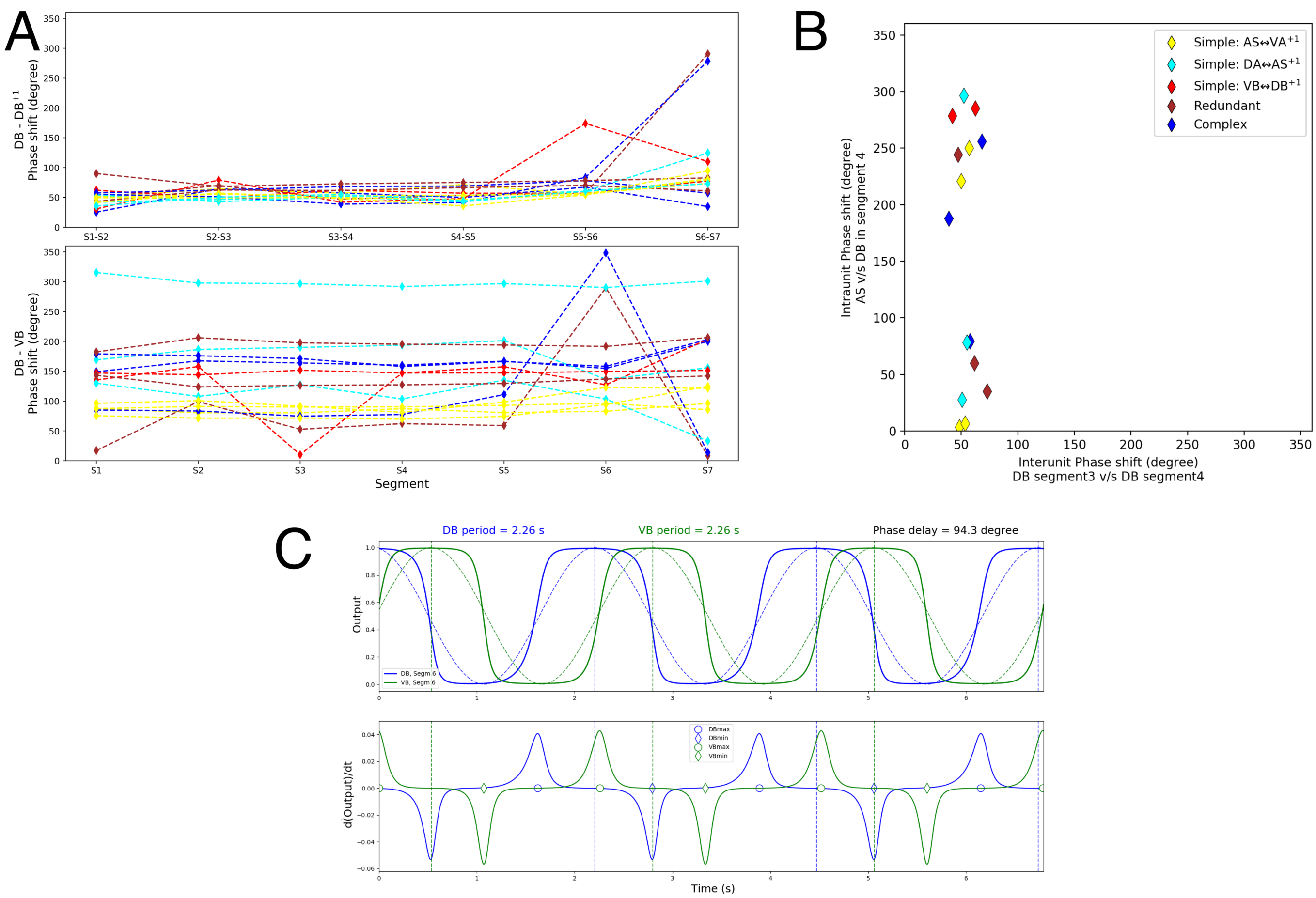

Fig 2. Phase shift in the ensemble show low intrerunit and large intraunit variability. [A] Top, phase shift measured between DB neurons of adjacent unit. Bottom, intraunit phase shift measured between neurons DB and VB. [B] There is no correlation between model classification and phase shift, colors indicate the classification due to the interunit connection necessary and sufficient to drive locomotion. [C] One example for the algorithm used to calculate phase shift. Top, solid lines correspond to neural activity, dashed lines show algorithm sinusoidal reconstruction, vertical lines show phase calculation. Bottom, derivative for neural traces shown on top. Circles and diamonds show algorithm detection of maximal and minimal derivative in the neural trace.