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Supplementary information

NeuroMechFly, a neuromechanical model of adult *Drosophila melanogaster*

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Supplementary information

Supplementary Tables

Supplementary Table 1: Model body parts and degrees-of-freedom between each segment and its parent.

Body part	**Segment**	**Parent**	**Degrees of freedom**
Abdomen	A1A2	Thorax	1
	A3	A1A2	1
	A4	A3	1
	A5	A4	1
	A6	A5	1
Head	Head capsule	Thorax	3
	Eyes (x2)	Head	0
	Antennae (x2)		1
	Rostrum		1
	Haustellum	Rostrum	1
Legs	Coxa (x6)	Thorax	3
	Trochanter-Femur (x6)	Coxa	2
	Tibia (x6)	Femur	1
	Tarsus1 (x6)	Tibia	1
	Tarsus2 (x6)	Tarsus1	1
	Tarsus3 (x6)	Tarsus2	1
	Tarsus4 (x6)	Tarsus3	1
	Tarsus5-Claw (x6)	Tarsus4	1
Thorax	Halteres (x2)	Thorax	3
	Wings (x2)		3
	Thorax	-	0

Supplementary Table 2: Matrix of p-values from a posthoc Conover's test for pairwise comparisons of position errors after calculating forward kinematics for walking. The Holm method was used to correct for multiple comparisons. Numbers in bold (except in the case of identity) indicate that the p-value > 0.001 (i.e., no statistical difference).

	Base	**IK**	**Base & CTr roll**	**Base & CTr yaw**	**Base & FTi roll**	**Base & FTi yaw**	**Base & TiTa roll**	**Base & TiTa yaw**
Base	1.00	5.42e-13	0.00	7.08e-184	2.28e-133	4.53e-50	**9.95e-01**	1.53e-197
IK	5.42e-13	1.00	0.00	4.48e-285	4.37e-222	6.82e-110	5.42e-13	8.62e-302
Base & CTr roll	0.00	0.00	1.00	5.49e-138	2.96e-189	0.00	0.00	1.57e-126
Base & CTr yaw	7.08e-184	4.48e-285	5.49e-138	1.00	2.52e-05	5.13e-45	7.83e-184	**5.38e-01**
Base & FTi roll	2.28e-133	4.37e-222	2.96e-189	2.52e-05	1.00	8.33e-22	2.44e-133	1.08e-07
Base & FTi yaw	4.53e-50	6.82e-110	0.00	5.13e-45	8.33e-22	1.00	4.53e-50	6.05e-52
Base & TiTa roll	**9.95e-01**	5.42e-13	0.0	7.83e-184	2.44e-133	4.53e-50	1.00	1.71e-197
Base & TiTa yaw	1.53e-197	8.63e-302	1.57e-126	**5.38e-01**	1.08e-07	6.05e-52	1.71e-197	1.00

Supplementary Table 3: Matrix of p-values matrix from a posthoc Conover's test for pairwise comparisons of position errors after calculating forward kinematics for grooming. The Holm method was used to correct for multiple comparisons. Numbers in bold (except in the case of identity) indicate that the p-value > 0.001 (i.e., no statistical difference).

	Base	**IK**	**Base & CTr roll**	**Base & CTr yaw**	**Base & FTi roll**	**Base & FTi yaw**	**Base & TiTa roll**	**Base & TiTa yaw**
Base	1.00	4.34e-128	0.00	7.57e-149	2.59e-131	4.72e-32	**1.00**	2.47e-192
IK	4.34e-128	1.00	0.00	**2.02e-01**	**1.00**	4.30e-34	3.27e-126	1.11e-07
Base & CTr roll	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Base & CTr yaw	7.57e-149	**2.02e-01**	0.00	1.00	**3.04e-01**	2.56e-45	8.05e-147	**1.08e-03**
Base & FTi roll	2.59e-131	**1.00**	0.00	**3.04e-01**	1.00	8.96e-36	2.08e-129	5.70e-07
Base & FTi yaw	4.72e-32	4.30e-34	0.00	2.56e-45	8.96e-36	1.00	3.84e-31	4.86e-71
Base & TiTa roll	**1.00**	3.27e-126	0.00	8.05e-147	2.08e-129	3.84e-31	1.00	4.85e-190
Base & TiTa yaw	2.47e-192	1.11e-07	0.00	**1.08e-03**	5.70e-07	4.86e-71	4.85e-190	1.00

Supplementary Table 4: Fixed angles for body joints during kinematic replay and optimization.

Body part	**Joint**	**Fixed angle (deg)**
Abdomen	A1A2	0
	A3	-15
	A4	-15
	A5	-15
	A6	-15
Head	Head capsule roll	0
	Head capsule pitch	10
	Head capsule yaw	0
	Left antenna	35
	Right antenna	-35
	Rostrum	90
	Haustellum	-60

Body part	**Joint**	**Fixed angle (deg)**
Thorax	Left haltere roll	0
	Left haltere pitch	0
	Left haltere yaw	0
	Right haltere roll	0
	Right haltere pitch	0
	Right haltere yaw	0
	Left wing roll	90
	Left wing pitch	0
	Left wing yaw	-17
	Right wing roll	-90
	Right wing pitch	0
	Right wing yaw	17

Supplementary Table 5: Fixed angles for leg joints during optimization (deg).

Body Part	**Side**	**ThC yaw**	**ThC pitch**	**ThC roll**	**CTr pitch**	**CTr roll**	**FTi**	**TiTa**
Front	Left	0	actuated	10	actuated	0	actuated	-39
	Right	0	actuated	-10	actuated	0	actuated	-39
Middle	Left	7.45	-5	actuated	actuated	0	actuated	-54
	Right	-7.45	-5	actuated	actuated	0	actuated	-54
Hind	Left	3.45	6.2	actuated	actuated	0	actuated	-45
	Right	-3.45	6.2	actuated	actuated	0	actuated	-45

Supplementary Table 6: Lower and upper limits for the muscle parameters during optimization.

Body part	**Joint**	$\Delta\varphi$ **[Lower limit, Upper limit]**	α **[Lower limit, Upper limit]**	β **[Lower limit, Upper limit]**	γ **[Lower limit, Upper limit]**	δ **[Lower limit, Upper limit]**
Front leg	ThC pitch	$[0.0, 0.47]$	$[1 \times 10^{-10}, 5 \times 10^{-9}]$	$[1 \times 10^{-10}, 1 \times 10^{-9}]$	$[1.0, 10.0]$	$[5 \times 10^{-13}, 1 \times 10^{-11}]$
	CTr pitch	$[-2.0, -1.68]$	$[1 \times 10^{-10}, 1 \times 10^{-9}]$			
	FTi	$[1.31, 2.05]$	$[1 \times 10^{-10}, 1 \times 10^{-9}]$			
Middle leg	ThC pitch	$[2.18, 2.01]$	$[1 \times 10^{-10}, 5 \times 10^{-9}]$			
	CTr pitch	$[-2.14, -2.01]$	$[1 \times 10^{-10}, 1 \times 10^{-9}]$			
	FTi	$[1.96, 2.22]$	$[1 \times 10^{-10}, 1 \times 10^{-9}]$			
Hind leg	ThC pitch	$[2.69, 2.53]$	$[1 \times 10^{-10}, 5 \times 10^{-9}]$			
	CTr pitch	$[-2.14, -1.55]$	$[1 \times 10^{-10}, 1 \times 10^{-9}]$			
	FTi	$[1.43, 2.26]$	$[1 \times 10^{-10}, 1 \times 10^{-9}]$			