A modular demand-driven complexity neuromechanical model of *Aplysia* feeding

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Introduction & Motivation

Fig 1. *Aplysia californica*.

Switching behaviors allows animals to adapt to a changing environment.

- Changes in mechanical or chemical stimuli induce the sea slug *Aplysia californica* to switch behaviors appropriately.
- Previously, a Boolean-like neuron circuit with 1st order muscles and 1D mechanics was developed for *Aplysia* feeding behaviors [1].
- Computational models must trade off accuracy and speed.

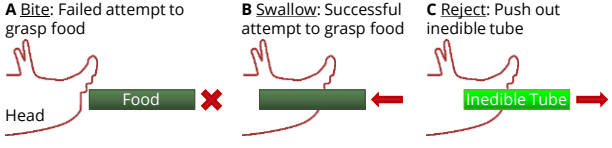
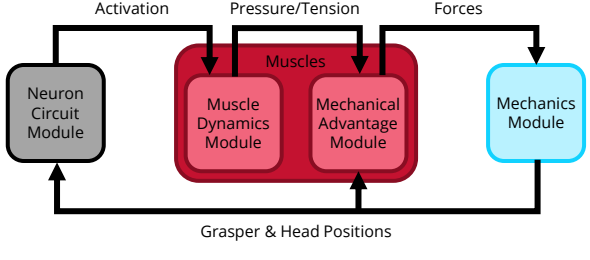


Fig 2. (A) During biting, there is only chemical and mechanical sensation at the lips. **(B)** The transition from biting to swallowing is triggered by the addition of mechanical sensation at the grasper. **(C)** If an object that was swallowed lacks the appropriate chemical sensation, it will be rejected.

Using a demand-driven complexity approach, we need models that can be easily adjusted based on the level of detail that is required.

Simulink Modeling Framework



Module Comparisons

Mechanics Modules
1-Dimensional [1]
2-Dimensional

Muscle Dynamics Modules
1st Order Muscles [1]
Hill-type Muscles [2]

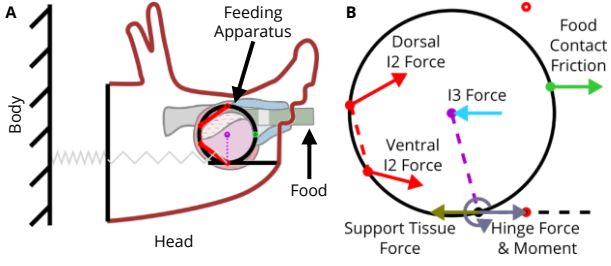


Fig 3. A 2D mechanics model of the *Aplysia* feeding. **(A)** Overall model of the head and feeding apparatus relative to the body. **(B)** Free body diagram of the feeding apparatus illustrates the loads applied by muscles (I2, I3, hinge), friction, and surrounding support tissue.

Table 1. As the complexity of the modules were altered, parameters were tuned to generate behavior that was qualitatively similar to the original model [1]. The highlighted values differ from the equivalent parameter in the original model [1].

Parameter		Original Model [1] (1D Biomechanics + 1st Order Muscles)	2D Biomechanics + 1st Order Muscles	2D Biomechanics + I2 Hill Type Muscle
Maximum Hinge Force		0.2	0.2	0.6
Maximum I3 Force		1	1	2
Minimum I2 Activation		0	0	0.0075
Sensory Thresholds	B64 Bite Protract	0.89	0.84	0.785
	B4/B5 Protract	0.7	0.7	0.615
	B31 Swallow Off	0.4	0.4	0.392
	B31 Bite On	0.9	0.9	0.785
	B31 Swallow On	0.75	0.81	0.71
	B31 Rejection On	0.89	0.89	0.7
	B7 Bite Protract	0.9	0.84	0.8

Model Behaviors

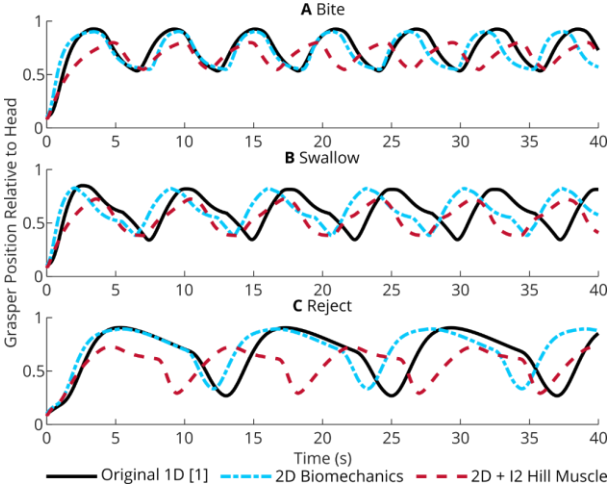


Fig 4. The position of the grasper relative to the head was used to compare each model. For all three behaviors (**(A)** bite, **(B)** swallow, **(C)** reject), the position calculated was qualitatively similar. However, additional tuning may be needed.

Conclusions

- Module complexity affects the transient response but is qualitatively similar
- Different modules are sensitive to parameter values

Future Work

- Investigate the effect of varying additional modules
- Parameter tuning to match animal behavior

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References

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2. Yu S-N, Crago PE, Chiel HJ. (1999). Biomechanical properties and a kinetic simulation model of the smooth muscle I2 in the buccal mass of *Aplysia*. *Biological Cybernetics*. 81: 505-513.