Agent-Based Model of Black Soldier Fly Larva

Ethan Brady[1,2]*, **Eagle Yuan**[1,2]*, Olga Shishkov[3], Jan-Michael Carrillo[1], David L. Hu[3,4], Miguel Fuentes-Cabrera[1]

Center for Nanophase Materials Sciences, Oak Ridge National Laboratory[1]

Oak Ridge High School[2]

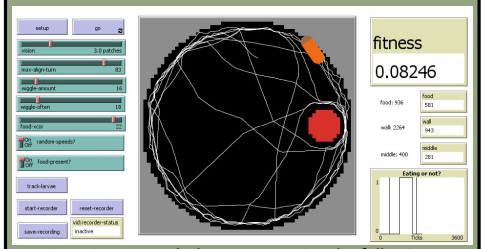
Georgia Institute of Technology, Schools of Mechanical Engineering[3] and Biology[4]

*Both Ethan and Eagle contributed equally to this work

Introduction

- Black Soldier Fly larvae are investigated for their recycling capabilities of urban solid waste.
- Understanding their collective motion while eating could optimize their eating rate.
- We present an agent-based model (ABM) that mimics an experimental setup with one larva only.

The Agent-Based Model (ABM)



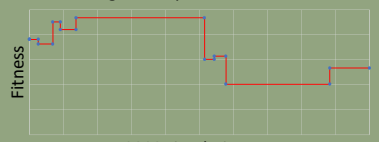
Written in NetLogo[1], the ABM contains the following procedures for larva behavior:

- Random direction adjustment
- Alignment to boundaries
- Move
- Eat

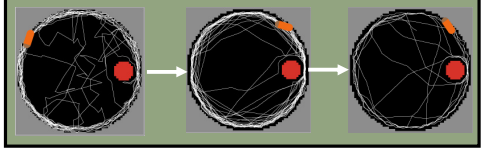
A Genetic Algorithm[2] optimized parameters to minimize a fitting-function[3] based on experimental comparison with time eating (f) and time on boundaries (w).

$$\text{fitness} = \frac{\left(\frac{f-.26}{.26}\right)^2 + \left(\frac{w-.629}{.629}\right)^2 + \left(\frac{m-.111}{.111}\right)^2}{3}$$

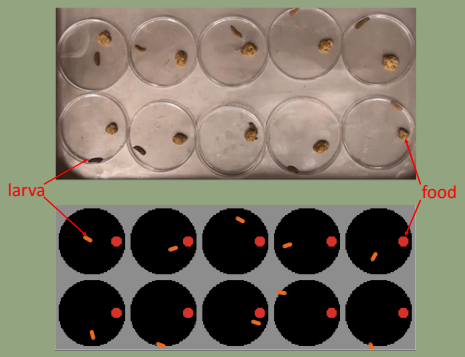
Progressively Better Fitness



10000 simulation runs



Comparison of Experiment to ABM

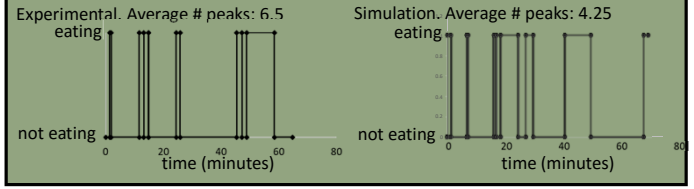


Results

Quantitative Comparison of Behavior Features

	Experiment	Simulation
Time eating	26%	24.8%
Time on boundary	62.9%	62%

Additional Comparison of Eating



Discussion

- **Sensing:** Simulated larvae sense by sight up to 6 mm away, despite experiments suggesting blindness
- **Wall following assumption:** Since the model accurately reproduces the experiment, the supposition that larvae prefer to follow boundaries is justifiable
- **Low randomness:** The genetically optimized parameters of randomness are relatively low
- **Eating times limitation:** The time of each instance of eating is imposed to values based on a specific food arrangement. We do not know how or if a larva is cognizant of hunger

Conclusion

Our ABM, with genetically optimized parameter values, accurately replicates the experimental behavior. A quantitative comparison of a larva's time eating and time on the wall shows close similarity. An additional aspect of eating (the frequency of eating in addition to the total time eating) also shows similarity.

Future Work

- **Simulating a collection of larvae:** They form vortices around food; these vortices resemble Kosterlizt-Thouless vortices in superconductivity
- **Eating rates:** After accounting for aggregations, low cost experiments could optimize eating rate
- **Artificial larvae:** Artificial larvae programmed using neural networks could clean toxic waste

References

1) Wilensky, U. (1999). NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.

2) Stonedahl, F., & Wilensky, U. (2010). BehaviorSearch [computer software]. Center for Connected Learning and Computer Based Modeling, Northwestern University, Evanston, IL. Available online: http://www.Behaviorsearch.org

3) Thiele, Jan C., Kurth, Winfried and Grimm, Volker (2014) "Facilitating Parameter Estimation and Sensitivity Analysis of Agent-Based Models: A Cookbook Using NetLogo and 'R'" Journal of Artificial Societies and Social Simulation 17 (3) 11 . doi: 10.18564/jasss.2503

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