Math Modeling of Fish Schools

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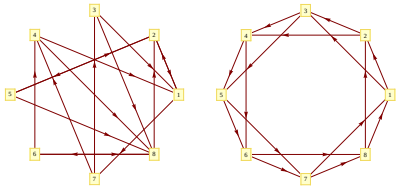
Research Focus: Dynamical systems theory with applications to marine systems, aquatic animals, underwater vehicles, and schooling behavior of social fish and their interaction with robots

Schooling fish in the Dynamical Systems Laboratory

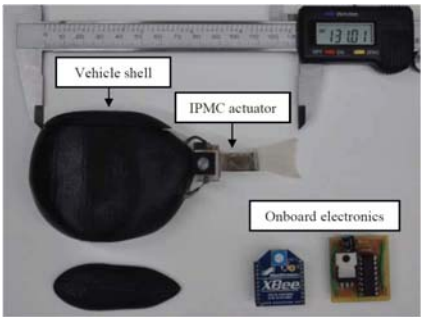


A numerosity-constrained directed graph and regular directed lattice on 8 vertices with numerosity constant 2

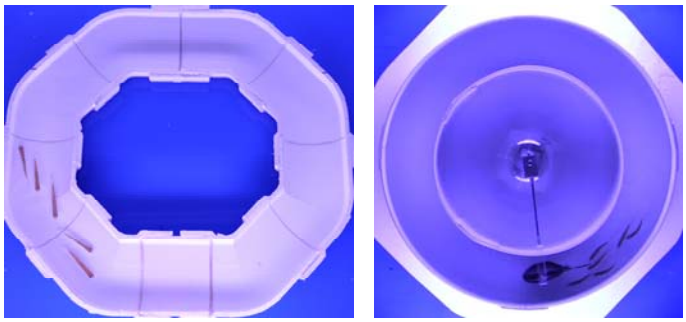
Theoretical analysis:

- Schools modeled as graphs with fish as vertices and interactions among fish as directed edges
- Incorporation of numerosity, a relevant biological phenomenon, into graph structure
- Interaction networks constructed with numerosity facilitate consensus to mimic coordination of movement seen in schooling

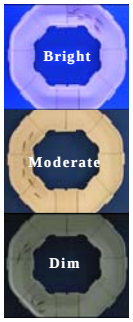
Live fish schooling studied in one-dimensional domain under stimuli, such as light and flapping by a miniature robot



Robotic fish with smart tail



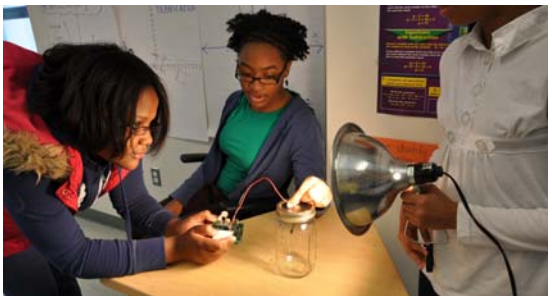
One-dimensional schooling environments for giant danios with and without robotic fish administering tail flapping stimulus



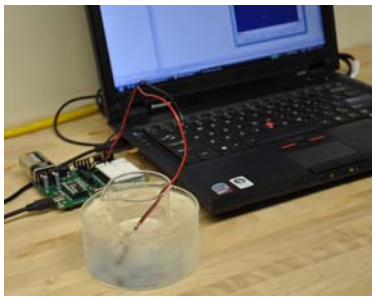
Ring domain under three light conditions

Physical proximity and adherence to a common heading are used to assess the effect of different stimuli on live school. Leadership mechanisms are being studied to determine the characteristics of school leader and to implement these in the robotic fish.

Research in Classroom: Facilitate a robotics elective with middle school students at the Urban Assembly Institute of Math and Science for Young Women, an all-girls public school. Direct hands-on projects that illustrate basic physical concepts using student-friendly mechatronics platforms like the Basic Stamp 2 and the LEGO NXT robot. Lab exercises introduce students to sensors, computing, and empirical methods used in graduate research.



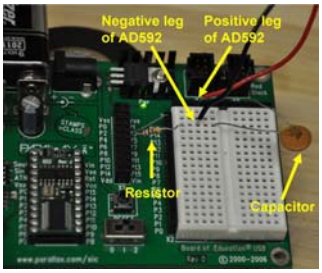
Students measure temperature in jar under heat lamp with Basic Stamp 2 microcontroller to simulate the greenhouse effect



Basic Stamp 2 microcontroller used to characterize Newton's law of cooling

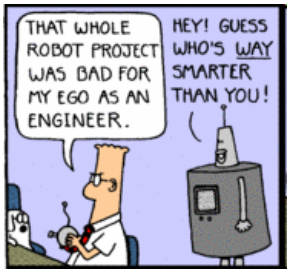
Fellow and students use spring scale and weight to demonstrate Newton's first law of motion

Students calculate gravitational constant using LEGO NXT robot



Basic Stamp 2 microcontroller with temperature probe circuit

LEGO NXT robot with pen attached to draw Fibonacci spiral



Planning a fun-science activity in collaboration with the New York Aquarium to introduce students to the basics of underwater locomotion. Using the swimming basics observed in live animals, students will have the opportunity to control robotic fish with a student-designed tail.

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