Analyzing the Behavior of Aggregate Robotic Systems

Undergraduate students Austin Born, John Born, Chris Horn;
Graduate student Alexandra Nilles; **Professor** Steven M. LaValle

Motivation

This ongoing research project is motivated by the desire to generalize the resultant behavior of aggregate systems from minimally-controlled constituents. Large aggregate systems surface in a variety of fields, from insect colonies in nature to autonomous drones and vehicles in industry. In these systems, complex behavior at the aggregate level arises from simple laws at the constituent level. The challenge posed by the team is to characterize a specific aggregate system of connected "weaselballs", then generalize the characterization to other systems.

Methodology

The approach uses weasel balls, which are simple spherical spinning motors with quasi-random motion. We are designing hubs which contain the weaselballs and connect to form different aggregate shapes. We are then collecting data on the natural dynamics of different aggregate shapes, with the goal of creating minimal controllers to accomplish robotic tasks (navigation, object manipulation, etc).

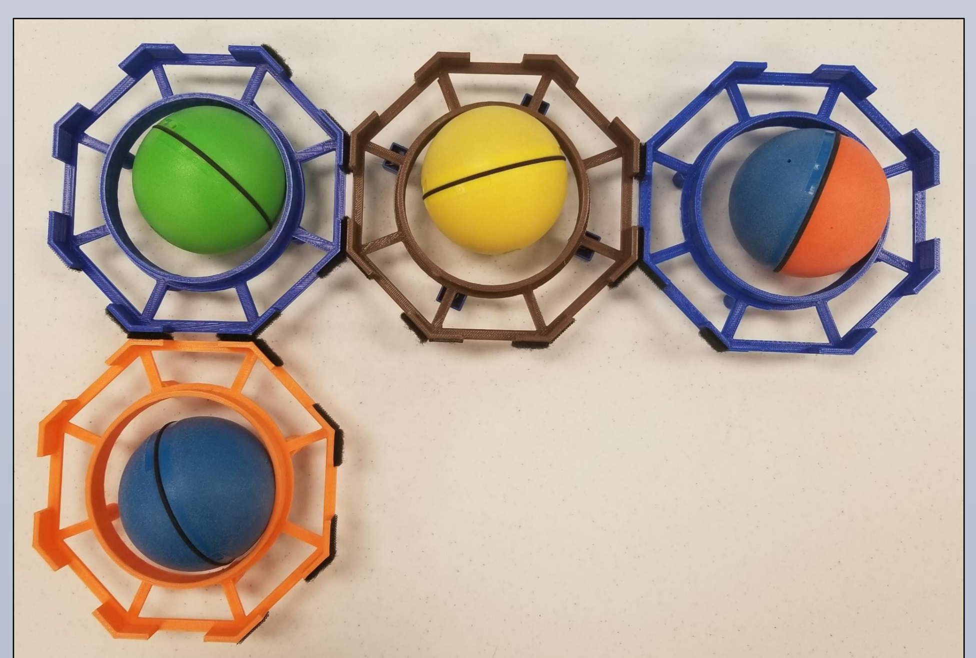

Figure 1. Example of the 4-ball "L" arrangement.

Design Goals and Constraints

- Remove excess material (weaselballs have limited power to push assemblies)
- Parameterize design over number of connection points (original design had 4, current design has 4-, 6-, and 8-sided versions)
- Create modular connectors to experiment with passive and active connections

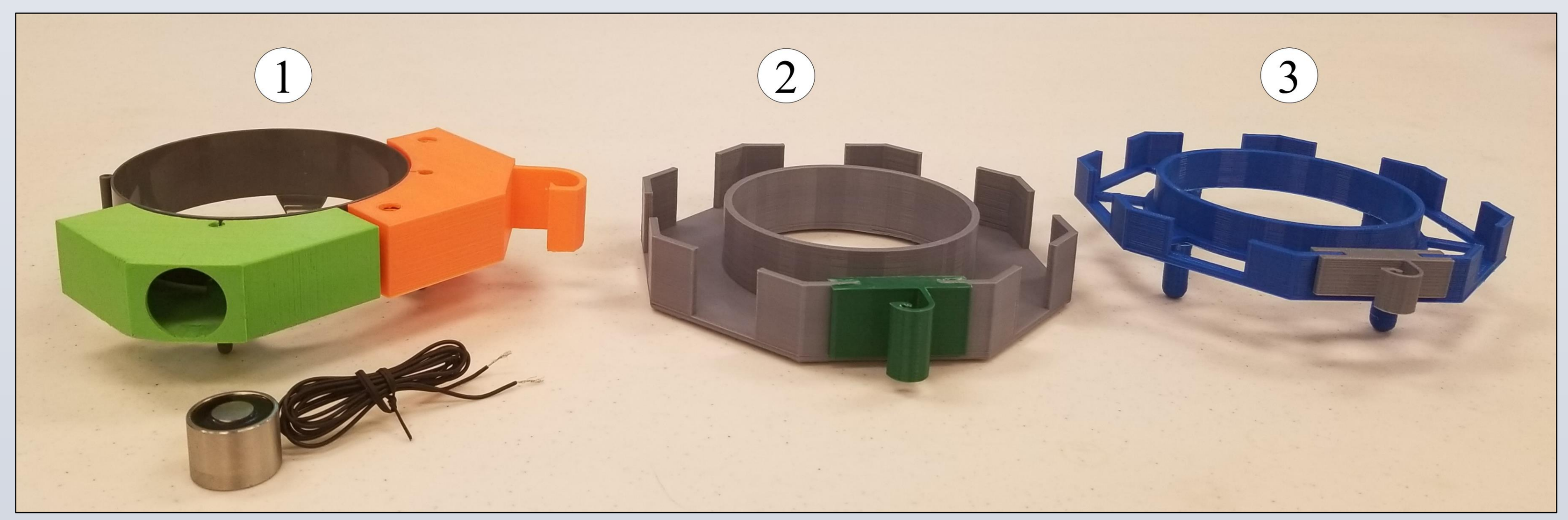

Figure 2. The 1st, 2nd, and 3rd iterations of the hub design. Along with the hook attachment, the first design also illustrates an electromagnet attachment.

In each iteration, unnecessary material has been removed to improve the weaselballs' speed and power in the test field.

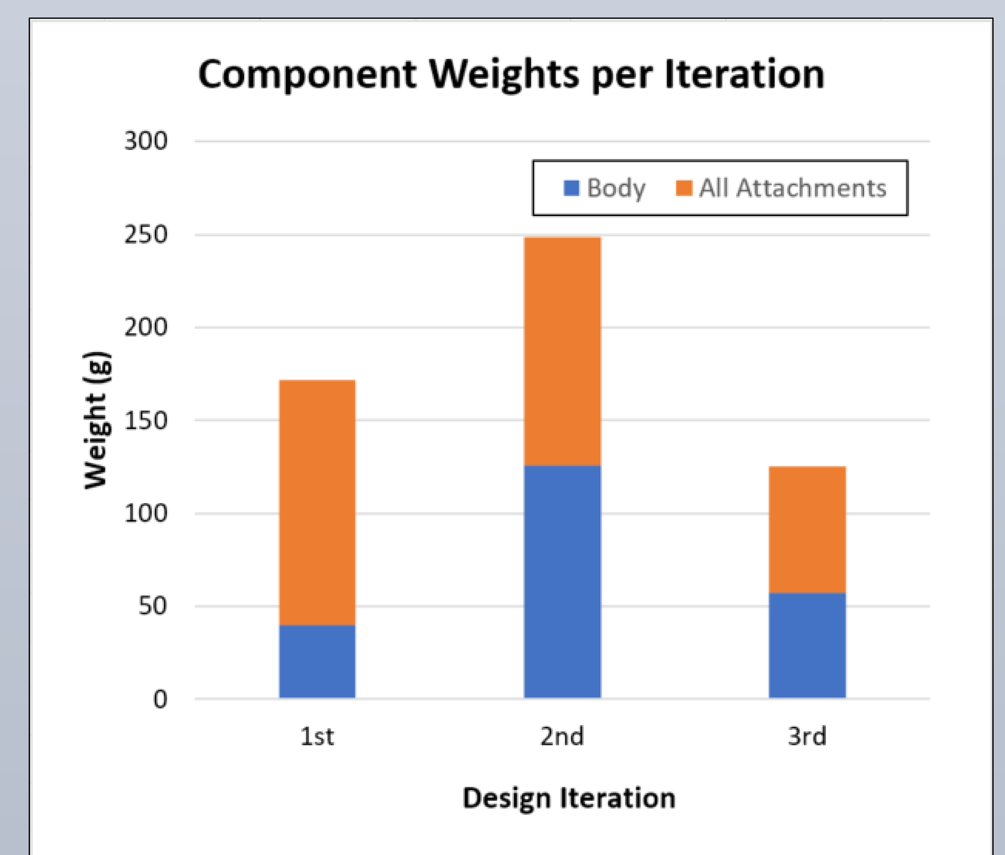

Figure 3. The net weight of each design iteration is compared, in the case where all potential hook attachment connection points are used.

Project Flow

The workflow consists of parallel goals to narrow our set of hypotheses, while also adjusting the experimental setup to suit our current and long-term needs.

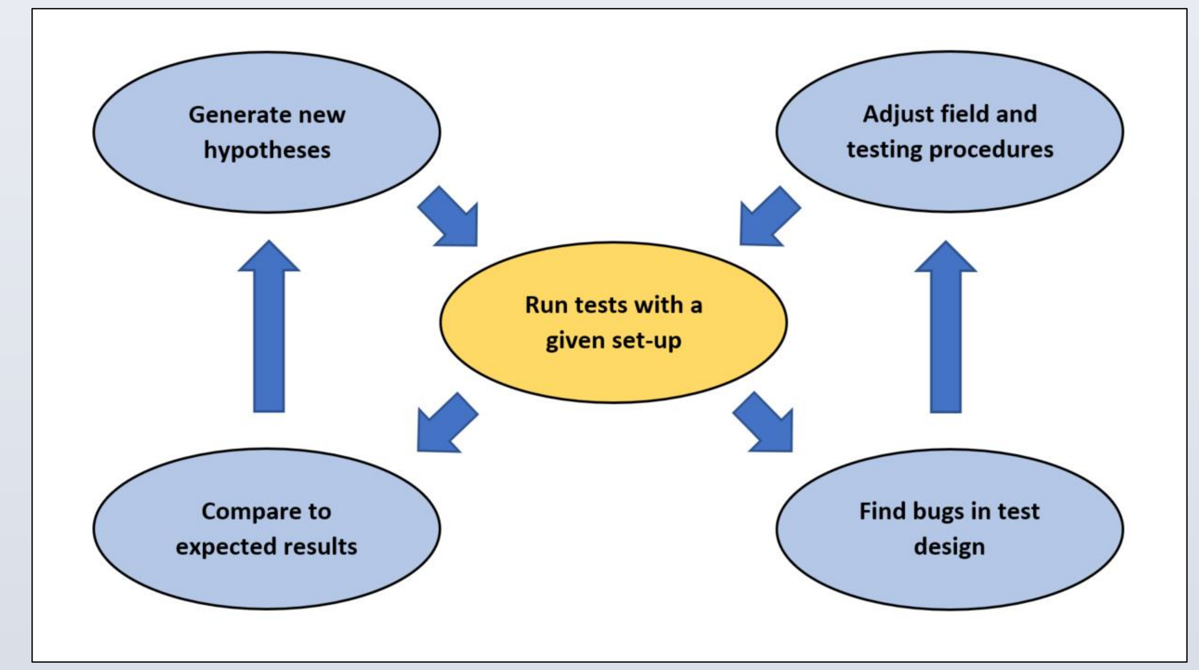

Figure 4. Flowchart diagram of recurring project steps.

Results

Using the OpenCV library, we process recorded videos of the aggregate shapes' movement over time to obtain information on net rotation, translation, position, etc. Our current hypotheses to be tested include the effects of asymmetry on rotational motion, other effects of aggregate shape on motion, and the consequences of different connector types (active vs. passive).

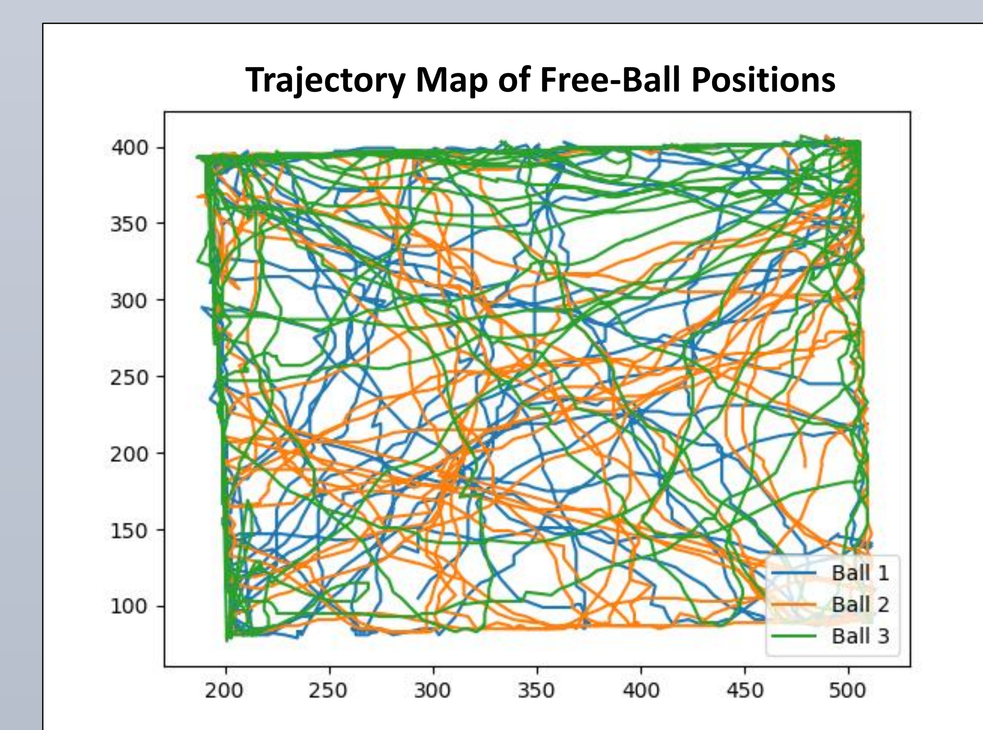

Figure 5. Map of position over time for three disconnected weaselballs over approx. 35 minutes.