Senior Project – Computer Science – 2015

Evolving Behaviorally Diverse Soft Robots

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Abstract

Soft Robots are complex enough systems where it's unknown which specific motor frequencies produces specific behaviors. One could have trails of a soft robot until its full behavior is found. This can be inefficient and time consuming to do with every new design. Our research is to develop a more efficient method of evaluating behavioral diversity for soft robots with unknown behavior and incorporating it in an existing genetic algorithm used to evolve soft robots. We breed robots based on how differently they behave to various motor frequencies. The aim is figure out the frequencies to navigate a space with the minimum amount of trails.

Behavioral Fitness

To evaluate the behavioral fitness of an individual, we record the reached locations and their associated frequencies. We then derive other reachable locations from these initial prime locations. This behavioral envelope is then evaluated by a zoning technique where we divide the search area into zones and see if the locations fall into distinct zones. The number of distinct zones is the fitness.

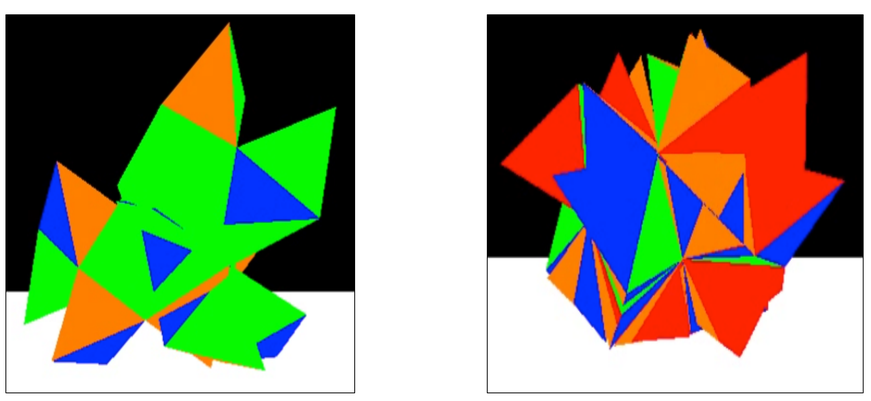


Figure 1 (above). These two images shows examples of soft robots in simulation.
Images from: Ben Berger '15 Senior Thesis Poster

Envelope	
Location	Behavior
(1,1)	A
(3,1)	B
(2,2)	AA
(3,3)	AAA
(6,2)	BB
(9,3)	BBB
(4,2)	BA
(7,3)	BAB

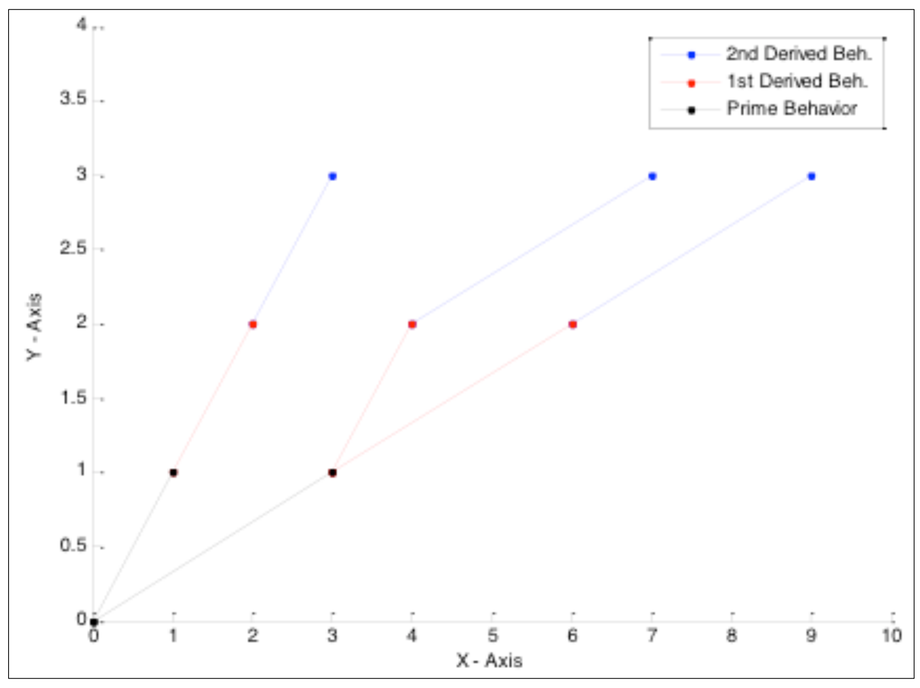


Figure 3. The image left shows an table representation of the behavioral envelope. The right image shows a graphical representation of the behavioral envelope.

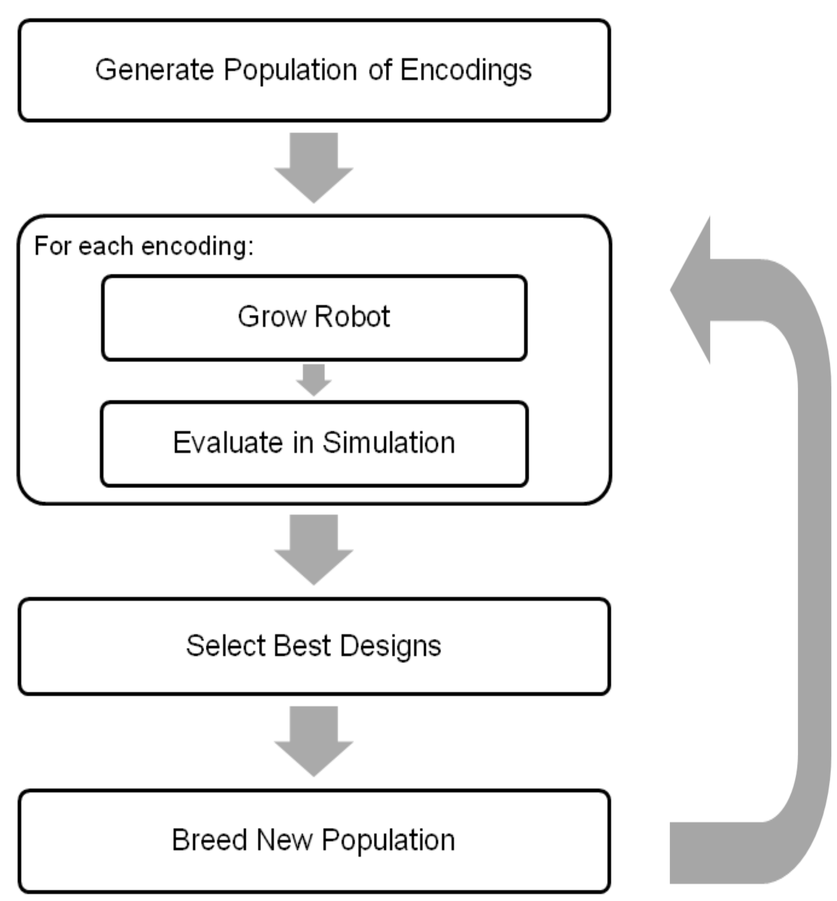
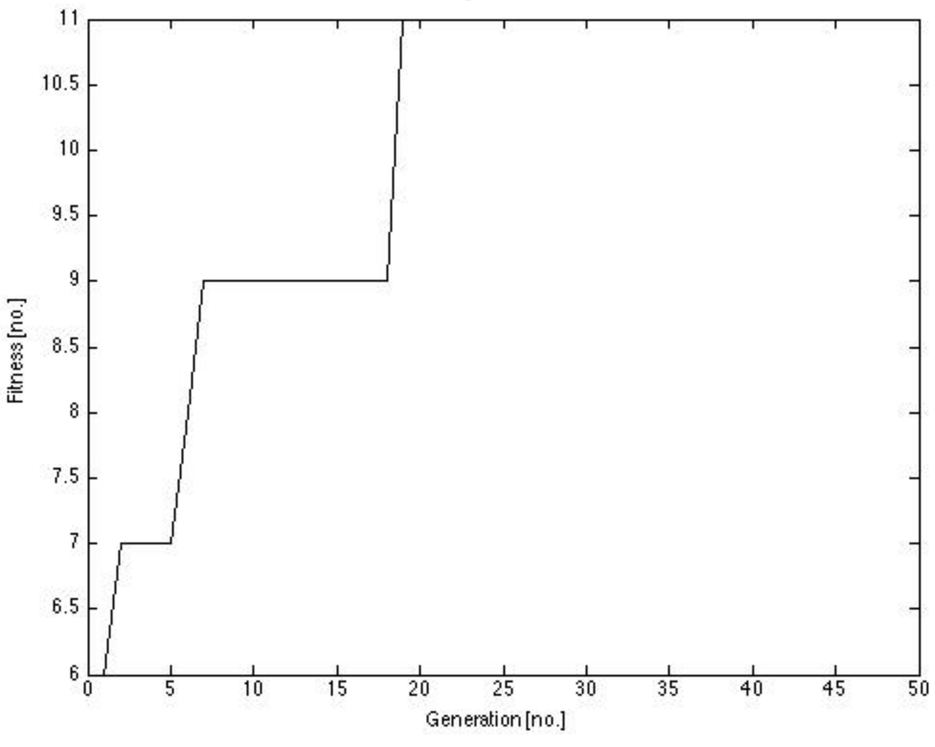


Figure 2 (above). This image illustrates the genetic algorithm process we use to evolve designs. A generation of individuals are randomly generated and are each tested in simulation. Individuals that don't perform well are replaced and individuals that perform well are used to breed the next generation. for the next round of testing. Over time, we get evolve better and better designs.
Image: Ben Berger '15 Senior Thesis Poster



Results and Future Work

The new genetic algorithm successfully breeds more behaviorally diverse individuals as shown in Figure 4. Further experiments needs to be done with various search space, search depth, zone size, and other variables in order to discover trends and patterns. If we are able to find the configuration necessary to be able find the set of frequencies to navigate a space we then can 3D print favorable candidates and have real-world testing.

Figure 4 (left). This graph shows the best fitness values per generation over the course of an experiment. At Generation 19 The best fitness value is found for the whole experiment.