The biological brain is a complex, modular structure designed to handle a range of inputs with minimal neuronal hardware. To promote this modularity in simulation, we propose the use of critical random boolean networks (RBNs) to represent multiple gait patterns in a single data structure for a robot. We used a two-part genetic algorithm to evolve 8-node RBNs, each containing multiple cyclic attractors. This shows the significance of evolving RBNs to perform repetitive tasks on simulated robots.

In this project, 3 distinct types of RBNs were utilized. Two experiments were conducted with static regulators of length 2 and 4, while the third type of RBN used a set of randomly generated regulators between length 2 and 5. The first GA driver is designed to evolve toward variability, the type of RBN is somewhat arbitrary. From these preliminary results, there is no evidence that any one choice of these types of regulators is optimal. Results show that each choice will result in networks with diverse sets of attractors that can perform different tasks. Future work can continue running these simulations in order to determine if one choice of regulators will significantly outperform the others. Nevertheless, the final individuals from each experiment exhibit attractive patterns that translate to different types of robotic gaits.

Evolutionary Algorithm

The attractor sets of each RBN are the driving force for simulating robotic gaits. Sustained motion is a repetitive process in nature. Thus, the attractor sets of a network will translate to repetitive robotic motion that can result in a robotic gait. The goal of evolution is to evolve these attractor sets into different types of robotic gaits, and create a diverse network that can perform different tasks. We use a two-part genetic algorithm (GA) to evolve our RBNs. The first step is to evolve a diverse set of critical networks that will be candidates for the initial population of the second GA. The final population from this first GA is then sent into the Bullet Physics simulator to test each attractor set on the simulated robot. The best individuals from the first GA are then sent into the Bullet Physics simulator to test each attractor set on the simulated robot. The best individuals from the first GA are then sent into the Bullet Physics simulator to test each attractor set on the simulated robot.

Here, we track the average simulated fitness of the population per generation of the second GA for 2, 4, and a random number from 2 to 5 regulators per node. Individuals in the population had a rapid decrease in fitness for the first few generations, but then oscillated between fitness values for the rest of the simulation.

Results

The following shows the trajectory of the attractors of the best final network given 2 or 4 of the 5 regulators per node. All simulations begin at the (x, y, z) origin and move outwards. Trajectories are colored based on the acceptable fitness threshold of 0.075. Green trajectories meet this fitness threshold, while red trajectories do not. Here there is an apparent wide range of types of trajectories due to the different types of acceptable gaits.

Discussion

In this project, 3 distinct types of RBNs were utilized. Two experiments were conducted with static regulators of length 2 and 4, while the third type of RBN used a set of randomly generated regulators between length 2 and 5. The first GA driver is designed to evolve toward variability, the type of RBN is somewhat arbitrary. From these preliminary results, there is no evidence that any one choice of these types of regulators is optimal. Results show that each choice will result in networks with diverse sets of attractors that can perform different tasks. Future work can continue running these simulations in order to determine if one choice of regulators will significantly outperform the others. Nevertheless, the final individuals from each experiment exhibit attractive patterns that translate to different types of robotic gaits. These gait patterns are differentiated due to the clear changes in trajectory along with different types of stability. Each final individual contains a host of different attractors, each of which corresponds to different types of robotic gaits.