Team 35 – Inchworm Robot

University of Illinois at Chicago – Engineering Expo 2021

Design Challenge

This goal of this project was to create an inchworm style robot capable of moving in a straight line as well as turn with a locomotion mimicking that of an inchworm. The motivation of the project was purely research based and as such the primary goal was the creation of a novel mechanism that would produce the desired motion. Inchworms move using a form of locomotion, shown in Figure 1, known as the two-anchor crawl gait which involves the inchworm beginning with its front and back legs close together such that its body is above them forming a "loop", then lifting its front legs and fully extending its body before lowering them back to the ground. A full cycle of the motion is completed when the rear legs of the inchworm are brought close to the front legs once again forming a "loop" with its body. Other typical design considerations outside of the mimicry of the motion, such as scale or speed, were considered significantly less important that the primary goal, and thus did not have any notable impact on the design process.

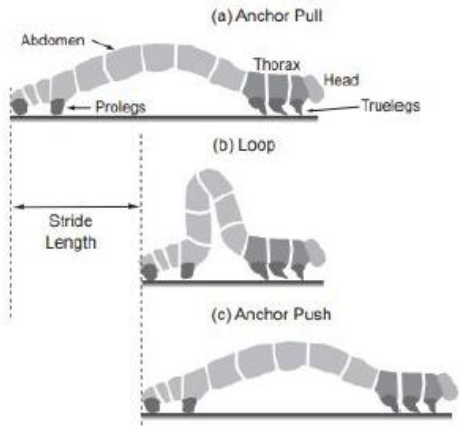

Figure 1 - Diagram Depicting the Two-Anchor Crawl Gait of an Inchworm

Design Process

In order to accurately recreate the two-anchor crawl gait, the team identified the lifting of the front legs, the formation of the "loop" with the body, and the dragging of the back legs as the most important aspects of the motion cycle. To do this, the team split the design process into three sections, one for each component of the motion. The front foot section would need to be able to anchor itself to pull the rear forward while also being lightweight enough to be lifted, the rear foot section would need to be able to lift the front section of the robot without slipping backwards and be able to be dragged forward via the arching of the body, and the body section would need to be able to create a "loop" or arch that would drag the rear foot and be able to straighten out when the front section is lifted. Each section was treated as its own design challenge in which several design alternatives were generated, and once a design concept had been selected for each section, the overall robot design was created.

Final Design

The final design of the robot, shown in Figure 2, utilizes two different methods of anchoring, one for the front foot and one for the rear foot, and the motion is generated via two stepper motors pulling on tendons through a multi-linkage body section. The body segment consists of 3D printed PLA plastic disks through which four tendons run from the front foot to the rear foot where the controlling stepper motors are housed. A rubber tubing through the center of the body acts as a spring, allowing the body to bend as the tendons are pulled and released by the motors while also forcing the body to straighten when there is no tension on the tendons. The rear foot houses the motors as well as the motor drivers and Arduino Uno microcontroller used to control the motors via analog joystick. Its anchoring system is two rubber wheels mounted on one-way clutch bearings that only allow the wheels to turn in one direction. The front foot consists of a body segment disk with a hinged plate mounted below it. The underside of the plate has a special type of friction pad called Gecko Tape that resists lateral forces but can be lifted up with hardly any force. This allows the front foot to anchor itself and pull the rear foot when the body arches without slipping.

Figure 2 - Final Inchworm Robot Prototype

Results

The inchworm robot created by the team successfully re-created the two-anchor crawl gait of an inchworm caterpillar by designing a robot capable of mimicking three of the main characteristics of the motion. With both the front and rear feet of the robot capable of anchoring themselves to the ground surface they are both able to move the other foot in a controlled direction through use of the body segment and its flexibility. Improvements to the robot, such as a smaller rear foot design, a motor change for more torque, or a more refined front foot mechanism to allow for smoother motion, would all allow the robot to mimic the two-anchor crawl gait more accurately and effectively.