Strandbeest (BEEST)

Project Lead: Jonas Pearson

Karen Cabrera, Bennett Moorman, Javid Mustafa, Chris Shaji

TEXAS A&M UNIVERSITY Engineering

TEXAS A&M UNIVERSITY
ROBOTICS TEAM & LEADERSHIP EXPERIENCE

Problem Definition

BEEST is modeled after Theo Jansen's Strandbeests. He is a Dutch artist who uses links to create a motion using mechanical and biological properties with an artistic approach towards engineering. Our goal was to design a motorized Strandbeest to act as a showcase robot for TURTLE.

Methodology

First, a revised CAD model of BEEST was created, and materials and manufacturing processes were selected.

To create motion, a Raspberry Pi, O-Drive, and 2 brushless motors are implemented. Utilizing the dimensions of a Jansen linkage [1], BEEST's acrylic linkages transform the motors' rotational motion into a linear walking gait. In addition to the linkages, BEEST employs a simple gear system and 3D printed feet to allow for walking.

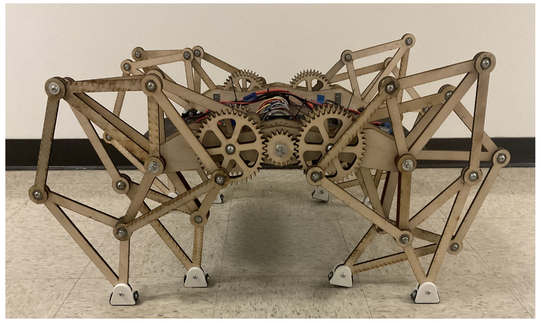

Figure 1. Side View of BEEST

Engineering Analysis

Leg Linkages

BEEST's legs each consist of a Jansen linkage. The unique aspect of the linkage is the ability to convert rotary motion into linear motion. The linkage typically consists of several connected segments arranged in a specific pattern as seen in *Figure 2*. Our linkage dimensioning was derived from those provided in a report giving an analysis of the Jansen linkage [1]. One of the major innovations we've attempted this year is to change the material of all linkages to acrylic in an attempt to increase rigidity in order to make movement more stable.

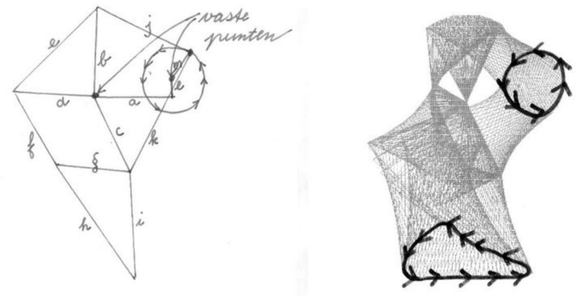

Figure 2. Theo Jansen's Linkage Strandbeest [2]

Mechanical Power and Motion Transmission

Jansen's Strandbeests used variations of his linkage design to achieve lifelike motion, driven by wind. However, in our design we used a brushless DC motor.

BEEST's mechanical motion begins with the rotary input provided by the motors. The motor shafts are coupled to D-shafts, which drive two gears each, one for each set of legs. As seen in *Figure 1,* the small gears drive two larger gears. This gear pattern ensures that the front and back legs remain in sync.

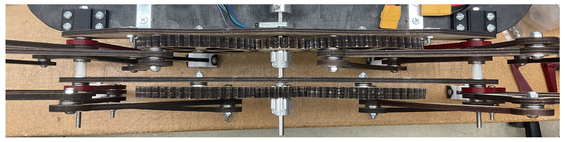

Figure 3. Top-Down View of Shaft and Gear System

As the first linkages move, the motion is transmitted to the other linkages throughout the pattern. The specific design of the linkage allows for the segments to move in a crawling motion. By continuously rotating the input, the linkage repeats its motion cycle, creating a continuous walking/crawling motion.

Feet

BEEST's feet have a flat bottom and are mounted with a single bolt, allowing for free rotation and constant ground contact. Weights are embedded within the PLA feet to ensure they remain parallel to the ground for good contact at the beginning of each step. Additionally, a layer of new grip tape material is fastened to the bottom for better traction on a wide range of surfaces.

Joint Design

At each linkage node, a combination of deep groove ball and needle roller thrust bearings are incorporated to allow for horizontal compression, while enabling rotational motion. This reduces sway while walking due to higher clamping forces. Reducing friction ensures that the legs can move freely.

Electronics

The Raspberry Pi utilizes Python scripts to control BEEST. The Python scripts communicate with a wireless controller and with the O-Drive, linking user input to the motors. Additionally, the O-Drive uses encoders to verify motor speed.

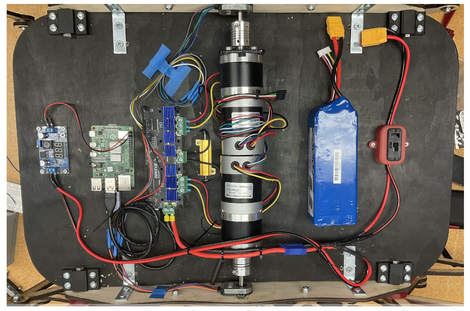

Figure 4. View of BEEST's Electronics System

Manufacturing

BEEST's main baseplate was cut from 3/8" plywood. Custom linkages, gears, and side plates were laser cut from 0.25" OPTIX Acrylic. Each gear consists of two acrylic layers adhered together to allow for increased contact area and wear resistance. Feet and extra support linkages were 3D printed with PLA.

Outcomes

This project created a robot with the following features:

- An easy to control robot, directly connected to its controller without need for any external startup.
- More stable forwards, backwards and turning motion across flat surfaces.
- A unique take on the generic quadruped design that weaves Theo Jansen's wind walking sculptures with electric motors and controls.

Impact

BEEST enabled current members in TURTLE to gain experience using CAD, perform motion analysis, utilize specialized manufacturing techniques such as laser cutting and 3D printing, as well as practice Python coding and electronics management.

BEEST will be utilized by TURTLE in the future to promote our organization at recruitment events. BEEST will also act as a showcase robot for outreach events with local educational STEM groups.

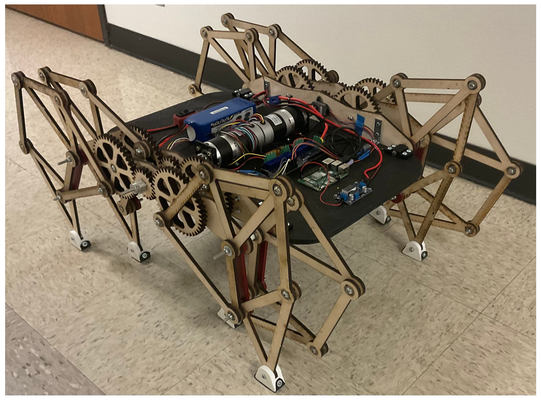

Figure 5. Isometric View of BEEST

Thanks to past team members:

Angie Alvarado, Abel Ayala, Abdulai Bah, Zachary Bucknor-Smartt, Sebastian Chu, Adrien Donley, Christian Flewelling, Rohan Singh, Tharshini Subash, Aaron Velez, Reagan Hoffman, Aryan Anand, Ben Harms, Marco Sanchez

References:

[1] Aan, A. & Heinloo, M.. (2014). Analysis and synthesis of the walking linkage of Theo Jansen with a flywheel. 12. 657-662.

[2] Theo Jansen's Linkage Mechanism on Kinetic Architecture, papers.cumincad.org/data/works/att/caadria2018_140.pdf . Accessed 24 Apr. 2024.