Fashionable Automated Stage Hardware (FASH)

TEXAS A&M UNIVERSITY Engineering

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TEXAS A&M UNIVERSITY ROBOTICS TEAM & LEADERSHIP EXPERIENCE

Project Statement

The purpose of this project is to explore the intersection of fashion, fine arts, and robotics. This project challenges the conventional boundaries of wearable designs by embedding automation directly into performance garments. The design consists of an automated wing linkage system for various ballet performances. The linkages convert movement into a smooth and controlled wing articulation that the user can operate in real-time for self-expression as well as be controlled externally within the user's environment.

Objectives and Requirements

- **The wings shall be developed for use in ballet performances**
- **The wings shall not cause harm to the user**
- **The wings shall have a human-interface system that does not inhibit the subject**
- **The wings shall be designed for use by a non-technical user**
- **The wings shall be designed for multiple ballet performances and users**
  - The aesthetic covering and movement programming will be interchangeable between performances and users, allowing for cleaning.
- **The wings shall have two methods of control**
  - The system can be worn and controlled by a single user or directed by the tech booth via Digital Multiplex (DMX).

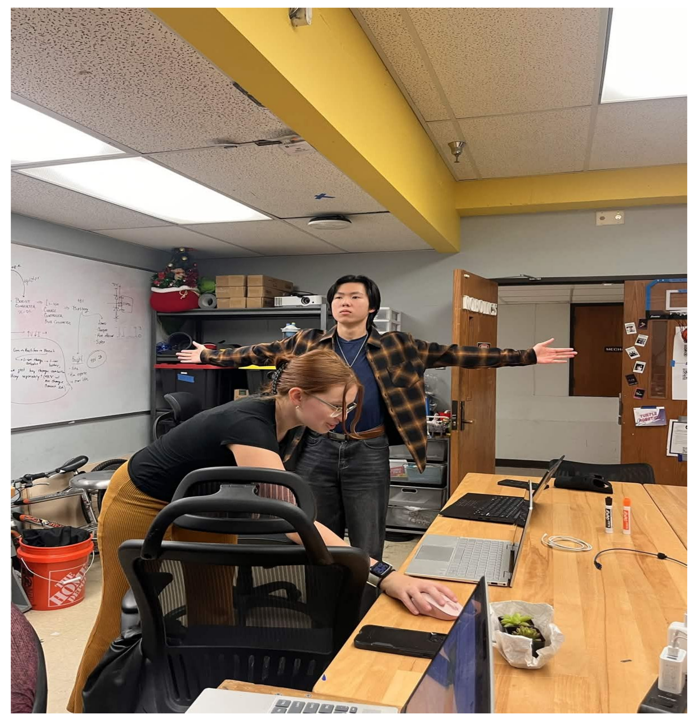


Figure 1. Determining Linkage Length (One Size Fits Most)

Linkages

To produce a functional linkage system, this semester was spent designing the initial prototype. Our design options were:

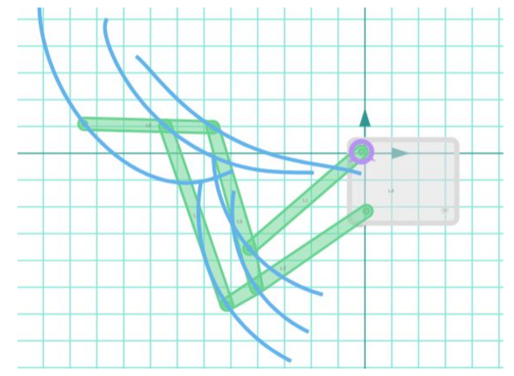


Figure 2. Bone Wing

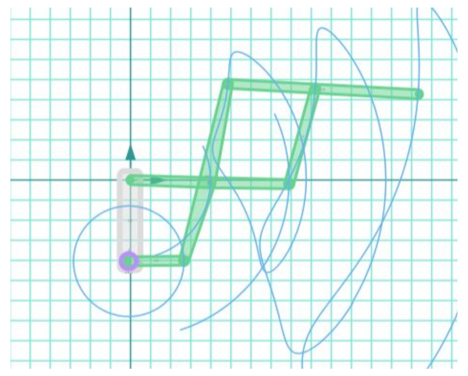


Figure 3. Scissor wing

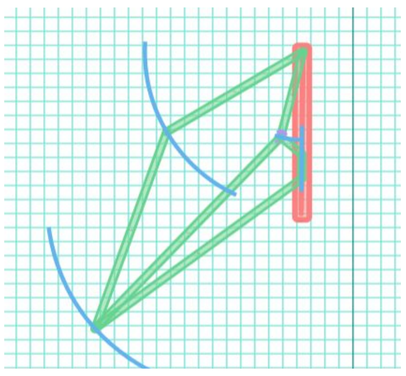


Figure 4. Rocket Wing

Based off of weight, strength of shape, range of motion, materials needed, complexity, foldability, and surface area, our team picked the bone wing (5 bar linkage with rotary actuators) for the wing linkage design.

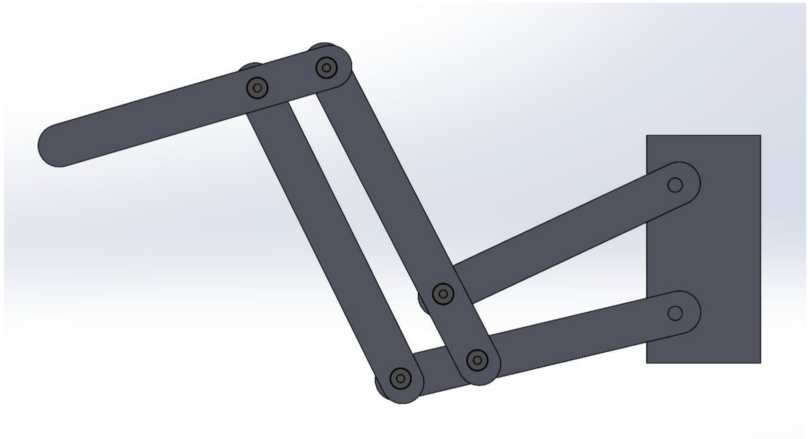


Figure 5. Linkage CAD on SolidWorks

Mount

Due to the intended use of this device, the physical connection to the user must be specially designed to not limit their ability to perform. Specifically the mount for the wings must not limit the subjects range of motion and must protect the user from the electronics.

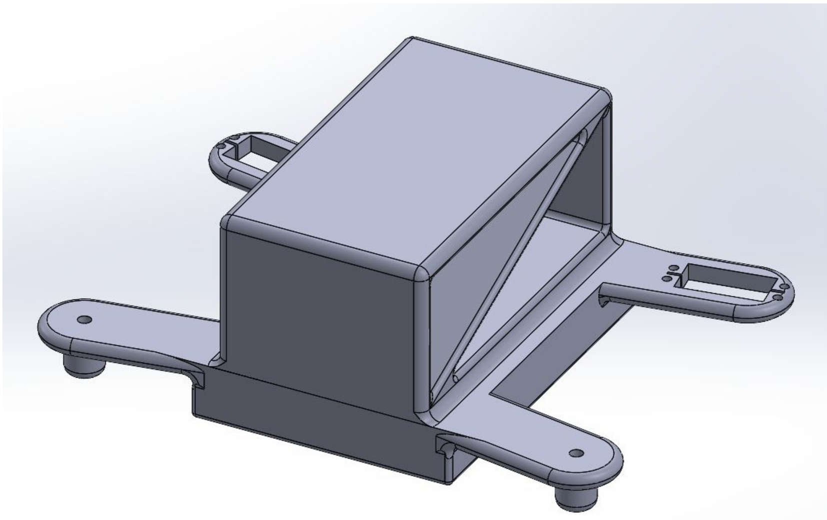
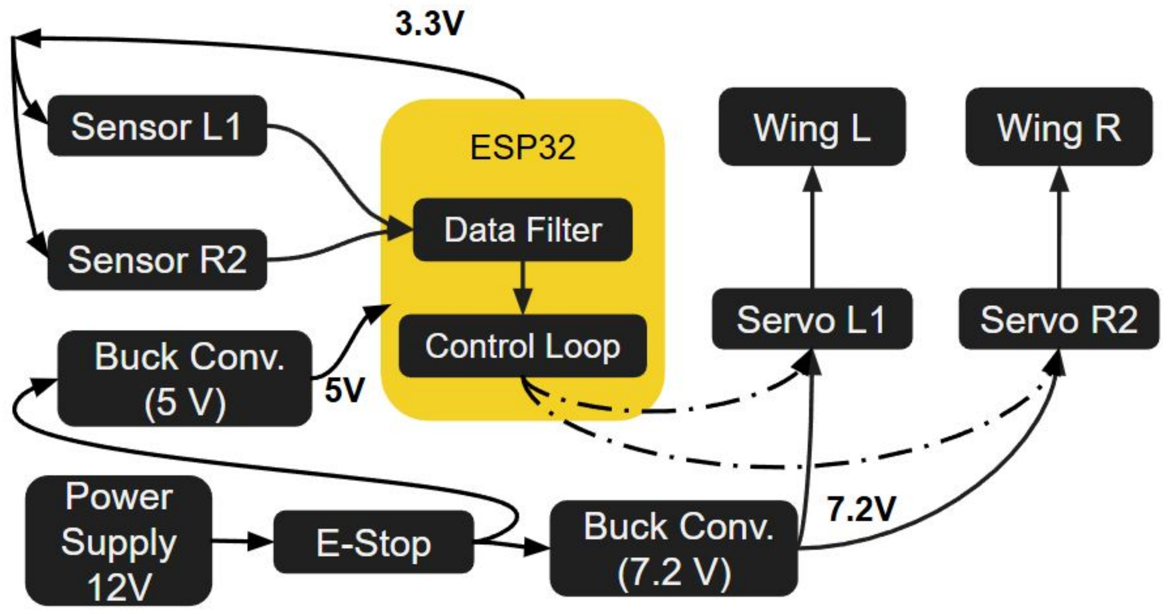


Figure 6. Mount CAD on SolidWorks

Electrical & Control



The movement of the wing is controlled by an input from a stretch sensor attached to the user's shoulder. An ESP-32 is used to control the input, and C++ code is used to process the input from the stretch sensor, normalize this input, and outputted to the servos attached to the wings. In addition, an E-Stop button will be attached to the vest of the dancer.

Component	Voltage (V)	Typical Current (A)	Stall Current (A)	Typical Power (W)	Max Power (W)
ZOSKAY 45kg Servo	7.4	2	5	14.8	37
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ESP32	5	0.25	0.7	1.25	3.5
Buck Converter Loss	5	0.1	0.2	0.5	1
TOTAL		4.35	10.9	31.35	78.5

Running Constantly at Typical Current		Running Constantly at Max Current		Selected Battery	
Battery Voltage (V)	7.2	Battery Voltage (V)	7.2	Selected Capacity (Ah)	10
Target Run Time (hours)	2	Target Run Time (hours)	2	Continous Run Time (hours)	2.297
Needed Capacity (Wh)	62.7	Needed Capacity (Wh)	157	Percent Activity Estimate	0.5
Capacity (Ah)	8.708	Capacity (Ah)	21.806	Predicted Battery Life	4.593

Figure 7. Power Calculations

Logic for Code:

The input to the ESP-32 is a measure of voltage. This voltage change will be based off the resistance of the stretch sensor, which differs based on how stretched the sensor is. Our objective is to use this voltage measure to determine what needs to be inputted to the wing, which will be in pwm. This can be achieved utilizing Ohm's Law and normalizing the pwm to account for extremes, as seen in the following equation.

$$pwm_{out} = \frac{C_1}{V_{out}} - C_2$$

where:

$$C_1 = \frac{V_+ R_2}{R_1 max - R_1 min}$$

$$C_2 = \frac{R_2 - R_1 min}{R_1 max - R_1 min} \cdot \frac{pwm_{max}}{\theta_{max}} \cdot \theta_{ACTUAL\ max}$$

Aesthetics

Three preliminary fabric options were selected from Mood Fabrics due to their ability to stretch and breathable material. These factors will ensure ease of cleaning, sweat resistance, and user comfortability. Further testing will be performed to select the highest performing fabric based on a variety of factors: including highest stretch, color options, and fiber composition.

Figure 8. Max-Dri Performance Spandex

Figure 9. Navy Nylon Spandex

Figure 10. Polyester Spandex Tricot Knit

Next Steps

In the coming semester, our team plans to continue improving our project by:

- Delving into different types of fabric and aesthetic choices for testing
- Adapting the mount to fit the electronic system
- Testing the mount design and adjusting based on user feedback
- Collaborating with performers and theatre technicians
- Implementing theatre tech equipment and software via DMX with the wing garment
- Adapting the linkage from half scale to full scale
- Advancing from a one-degree-of-freedom wing linkage system to a two-degree-of-freedom system
- Further exploring the creep of the stretch sensor over the lifestyle of the wings and how it would be calibrated for each user before performer
- Adding an E-stop and implementing this to be easily reachable to turn off and remove wings for user

Texas A&M University Robotics Team and Leadership Experience (TURTLE)