INTRODUCTION/MOTIVATION

- Current mobility aids are highly institutional, disregarding the varying level of support required for each user.
- The Adaptable House Project aims to increase independence and confidence in the mobility of individuals by providing full or partial body weight support in a user’s home.
- This project is one of four subsystems within the Adaptable House Project, and only concerns vertical movement.

Problem Statement:
The project aims to provide adjustable mobility aid to users in order to assist people facing mobility and strength challenges through overhead suspension.

CORE FUNCTIONS

3 USER MODES:

1. **Body Weight Support (BWS):**
   - Constantly supports a specified percentage of user’s weight.

2. **Fall Protection:**
   - Detects the falling user and safely catches them.

3. **Float:**
   - Suspends the user for effortless vertical movement.
   - The user is able to transition between modes actively or passively.

FUNCTIONAL SPECIFICATIONS:

**FLOAT:**
- Sat. Velocity: -1.5 m/s
- Settling Time: 0.5 s
- Max Draw Speed: 0.75 m/s
- Max Velocity: 0.3 m/s

**BWS:**
- Max Draw Speed: 0.75 m/s
- Settling Time: 0.1 s

**FALL PROTECTION:**
- Vel. Threshold: -0.5 m/s
- Max Acceleration: 3 m/s^2

DESIGN AND DEVELOPMENT

**CONTROLLER:**
- Float: External force is proportionally turned into velocity of mass using PD controller.
- Fall Protection: LQR and path planning raises falling users safely.
- BWS: Provides constant tension force using a PIDF controller.

**MECHANICAL:**
- Traversing pulley connects the spring, carriage, and potentiometer.
- Springs acts a series elastic actuator to protect against sudden shocks.

**ELECTRICAL:**
- The potentiometer measures spring force.
- Printed circuit board with a low pass filter connects to sensors.

**EMBEDDED:**
- Code constantly calculates the essential state values from the sensors.

**FINAL DESIGN**

- Two springs are used to maintain tension and minimize hysteresis.
- Slotted holes allow for component placement adjustability.
- Addition of a kill switch stops unsafe operations.
- 3D printed spool allows for custom torque and speed tradeoff.
- The base plate, carriage attachment, and spacer are machined on a mill.

RESULTS/VALIDATION

- The system responds appropriately to the external disturbances experienced.
- Fall protection controller exhibits reference tracking performance as simulated.
- Float mode has a force to velocity scaling factor of 0.02

CONCLUSION/FUTURE WORK

- Series elastic actuator is suitable for lifting purpose, but requires high performance motor.
- A force deadzone is added to float mode to prevent unintended movement.
- A low friction angle sensing method for the wire must be identified for integration with the Anti Sway subsystem.
- The design changes associated with scaling up the project must be investigated for safe full scale use.

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