DEBUT Phase 2B: Self- Stabilizing Cane for Parkinson's Disease

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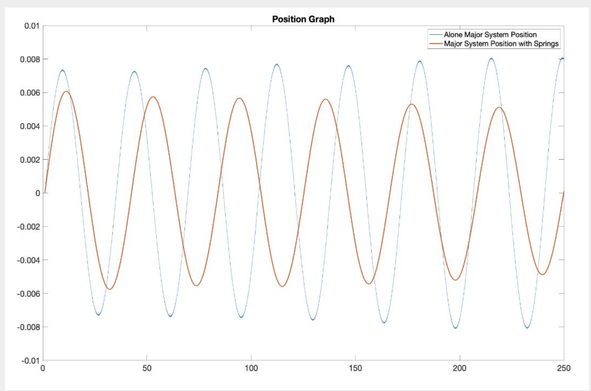
Background

Parkinson's Disease (PD) ranks among the leading causes of neurological disability in the United States, affecting an estimated 500,000 Americans. Of these 500,000 Americans about 80% of them suffer from PD Tremors. These uncontrollable hand oscillations are a common symptom of Parkinson's disease that leads to instability of a person using a cane, increasing the chances of a fall. It is estimated that 45%-68% of patients will fall yearly as a result of their instability, limiting their independence and mobility. Although there are current walking-assistive devices, they do not entirely support users both physically and emotionally.

Objective

Our team has designed a novel Self-Stabilizing Cane for Parkinson's Disease to mitigate the effect of hand tremors on standard canes. The design novelly adapts a standard structural mechanism typical for skyscraper stabilization towards improved gait stability for PD patients. The passive, assistive walking device primarily integrates a tuned mass-damper system into the frame of the device as a physical mechanism to lessen the effective displacement amplitude of hand tremors on a cane. Additionally, a dynamic TPU cane base stabilizer was designed as a new experimental design for standard cane bases to increase mobility for patients. Overall, our patent specifically maximizes both non-invasiveness and effectiveness for assistive walking technology and creates a more well-balanced device in comparison walkers and other cane designs.



Position-time Graph of a Close-to-Ideal Mass and Spring Constant Combination The system that contains the TMD (red) effectively dampens the amplitude of the standard system (blue) as there is roughly a 50% decrease in amplitude.

Device Design and Materials

This device implements two main mechanisms: a tuned mass damper (TMD) and a flexible, semi-spherical base stabilizer. The tuned mass damper is comprised of a spring-mass that is built into the top frame of a typical aluminum cane, acting to re-centralize the cane position as a result of any PD Tremor related cane displacement. Additionally, the TPU base stabilizer integrates at the base and flexes with applied pressure in order to adapt to various terrains and increase surface contact.

Tuned Mass Damping System

The Tuned Mass Damper is integrated into the design of a typical walking cane through the use of an ABS printed casing. A springed aluminum mass is press fitted into the interior of the casing, and the opposing oscillation of the system inhibits total angular displacement as a result of PD Tremor.

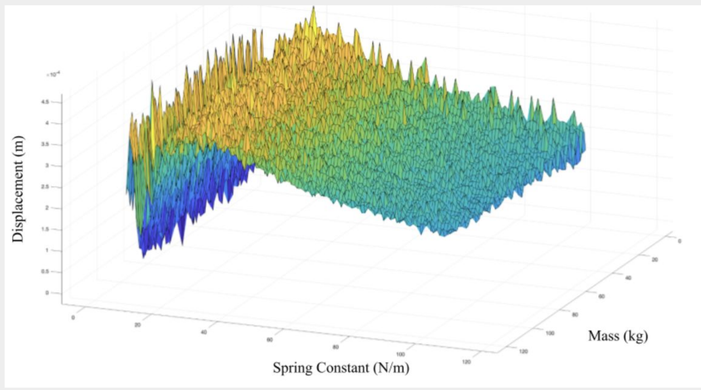
Dynamic TPU Base Stabilizer

The Dynamic Base Stabilizer is comprised of a flexible, 3D-printed thermoplastic known as TPU. Models were fabricated to determine ideal infill, and rubber coatings were added for additional friction.

Preliminary Results

Mathematical models of the cane were scripted to predict realistic and effective mass and spring constant values for the TMD given the various preset parameters of the cane. First, a 2D model was scripted to determine the amplitudinal cane displacement with various mass and spring values over time.

Second, after defining the dimensional constraints of our TMD casing, a 3D surface plot was constructed to plot the average max peak oscillation values for various potential mass and spring combinations. The trend of good combinations was found to be associated with higher mass and spring values, and further fine tuning was done to determine the ideal spring constant. Based on the chart, the optimal mass and spring constant for the model are 0.45 kg and 630 N/m, respectively.



3D Surface Plot Model This graph shows all of the possible combinations of spring constant and mass values plotted against displacement.

Future Experimental Methods

Mechanical testing of the cane will be conducted in two phases: Isolated trials and integrated trials. First, isolated trials will involve confirming the efficacy of the spring-mass values for the TMD by applying preset, oscillating forces to a modified TMD testing apparatus and measuring linear displacement. Second, an in-person clinical trial will be conducted at SUNY Cortland with participants with Parkinson's Disease to confirm the realistic efficacy. A total of ten participants will be recruited for the study and will all be screened through the eligibility process of the Cortland exercise intervention lab. Experimentation will specifically compare linear displacement and acceleration at the top of the cane between the conventional cane and the Self-Stabilizing Cane. These results will be compared across a variety of usage metrics, more specifically by tasking participated with various tasks such as standing up and walking up a ramp with the cane. The results will be used to evaluate the effectiveness of the Self-Stabilizing Cane in decreasing the acceleration and displacement of the cane due to PD Tremor.