ROBOTIC FOOT PROSTHESIS WITH ACTIVE ANKLE JOINT

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Abstract

An active ankle joint foot prosthesis is an advanced form of prosthetic foot that aims to replicate the natural movement and function of the human ankle. It is designed for individuals who have lost their foot or ankle due to injury or amputation. The active ankle joint is a mechanical joint that allows for plantar flexion and dorsiflexion, which enables the user to walk, stand and perform other activities more naturally. The use of an active ankle joint foot prosthesis can significantly improve the mobility and quality of life for individuals with amputation and provide a more natural gait pattern. This type of prosthesis is considered as a complex and advanced technology, and it requires a high level of expertise in design, fitting and maintenance.

1. Introduction

A prosthesis is an assistive device that helps the person to further daily activities and prevent complications that may happen due to the sectomy of related limb/limbs with a prosthesis. With the help of prosthesis, one can continue to make function out of the lost limb and thus preventing the dependence on others in their daily life which could result in an increase in quality of life.

In the cases of transtibial amputation, passive prostheses are widely utilized by patients. It can be helpful in so many ways but is it a permanent solution? Recent researches show that a person using a lower limb prosthesis needs twice the metabolic energy compared to a healthy limb while walking. And, with the usage of the long-term passive prosthesis, it is observed that chronic conditions may emerge. It is aimed to determine the need of a person who had gone through transtibial amputation, prosthesis-wise.

It mimics the active joint ankle movement that will provide the walking motion of the below-knee prosthesis. This prosthesis is designed for masses who have experienced below-knee amputation. Based on the target audience, some restrictions have been determined in the structural design. In the first of these, the distance from the bottom of the knee to the sole was determined as 47 cm. Another limitation was that the prosthesis had the strength to carry a 50 kg individual.

2. Conceptual Design

Since the kinematic synthesis approach was planned to utilize, the joint type of the ankle needed to be determined. An experimental study has been done to observe the movement of the ankle and the foot.. The data acquired from Tracker showed that there is a negligible change of length between the ankle and the metatarsal part of the foot. Thus, the ankle was accepted as revolute joint throughout the study.

The gait cycle is the time interval between two successive occurrences of one of the repetitive events of locomotion. The human gait cycle is split into two separate regions representing the period of time when the foot is in contact with the ground, the stance phase

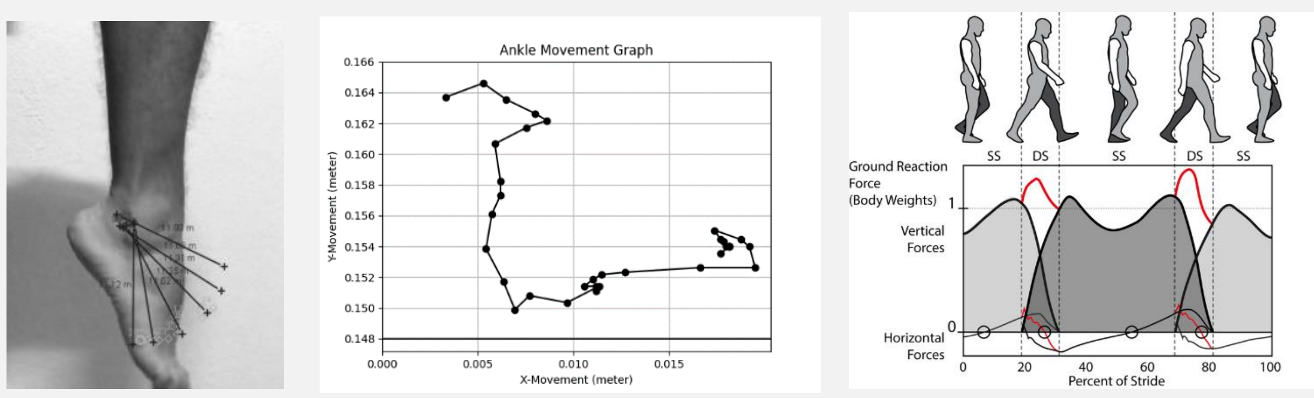

Figure 1: *(a)Human Ankle Analysis (b)Ankle Movement Graph (c)Gait Cycle*

Kinematic synthesis process is to yield the design of a mechanism to a desired set of motion characteristics

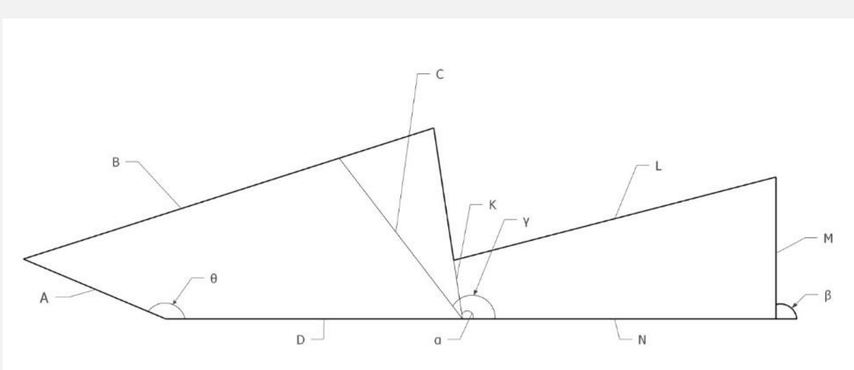

Figure 2: *Double FourBar Mechanism*

3. Prototype Design and Manufacturing

3D model of the prosthesis design was designed in CAD software prior to the prototype manufacturing.

In order to carry out motion verification to simulate the behavior of the prosthesis in gravity and force, a prototype was designed.

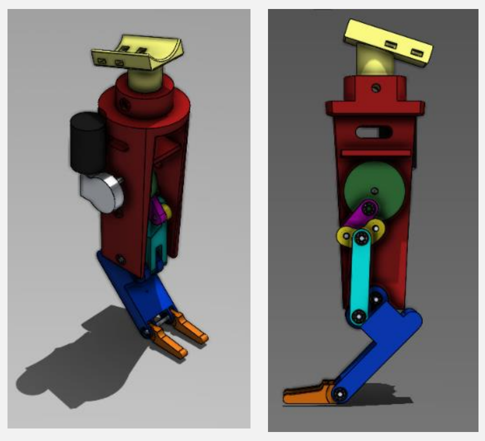

Figure 3: *CAD Software Views*

4. System Identification

However, since the motor be used for the prosthesis is a gray box system. In order to find these parameters, the torque constant was found with the load cell and the transfer function was obtained by collecting data with the DAQ card.

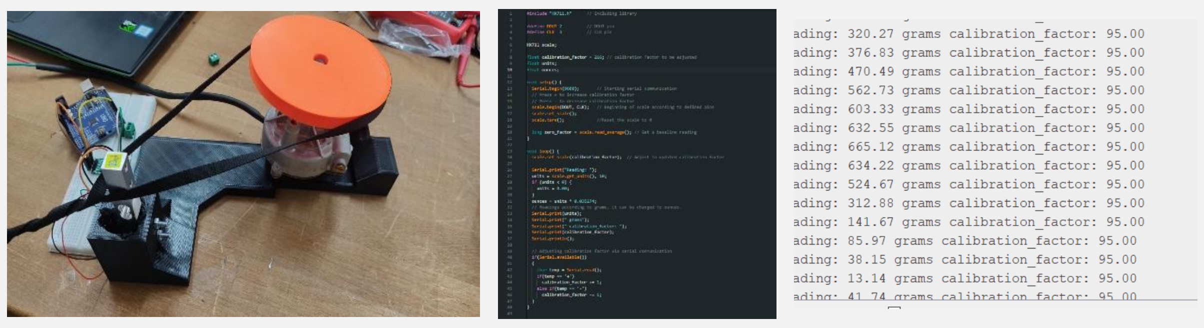

Figure 4: *(a) Experimental Setup (b)Calibration Code (c) Serial Torque Datas*

A load cells was placed to system and connected to the motor with a rope. After the calibration of the load cell, found the torque constant of the behavior of the motor. After this experiment, another experiment was done with the NI DAQ Device and encoder. Data was taken from the engine used. The values in the transfer function

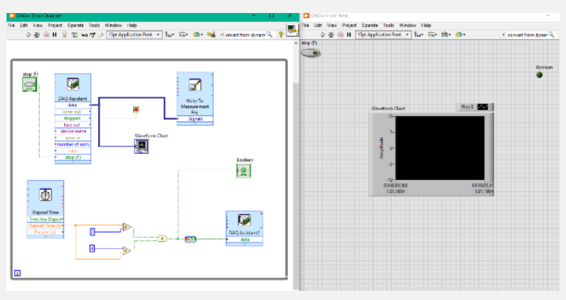

Figure 5: *(a) NI DAQ LabVIEW 2-6 seconds data acquisition circuit*

5. Results and Conclusions

Sizing process of the system has been completed and appropriate dimensions and specifications for the project has been determined. We have opted for 3D printing as the production method for the system. This approach offers flexibility, precision, and the ability to create complex geometries,necessary strength, durability, functional criteria and it ensures cost efficiency. Bearing, motor, and shaft selection have been meticulously carried out by considering factors such as load capacity, durability, and compatibility with the system's overall design to ensure reliable and efficient operation. By progressing through these steps and making informed decisions, we have successfully completed material selection, production method, component choice, and gearbox design.These measures guarantee that the system meets the required specifications while considering factors such as performance, feasibility, and cost-effectiveness.The transfer function was reached by performing the system identification of the motor. In order to collect more reliable data, data with a resolution of 1k Hz were collected and the least erroneous data was used as input. After all these steps, all parts were assembled and the motor connection was made.

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