A Device For Assessment of Different Prosthetic Feet By Able-Bodied People

Team 71

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Abstract— **The purpose of this project is to evaluate the ground reaction forces from a prosthetic foot. These forces and moments will be noticed when the examiner loads it during the gait cycle. This includes walking, running, jumping, and stationary stance. The user is to be an able-bodied individual with no lower-limb amputations. The user will be secured to the device by stepping onto the base and strapping their foot and leg to the device. This device is built using parts from a construction stilt which will be used as the examiner's attachment to the device. Load cells will be mounted between a prosthetic pylon and the foot plate for force measurements. Various kinds of prosthetic feet will be able to be tested by attaching to the pylon at the base of the device. The design of this device is meant to be versatile and modular to allow for different configurations.**

I. Introduction

In the ever changing field of prosthetics and orthotics, technology advancements have been achieved through recent changes in prosthetic devices. The prosthetic foot is the most important component of a lower-limb prosthetic as it forms the basis of an effective amputee gait. Lower-limb amputees have identified many issues with current prosthetic technology including mobility and comfort of long-term use. Improving these devices can be difficult without data analysis to base design improvements on. The goal of this project is to build a device that can measure different ground reaction forces throughout the prosthetic and use this data to improve future technology within this industry.

Measurements of forces and moments in lower-limb prosthetics began in the 1980s with strain gauges glued to the pylon and then progressed to one-of-a-kind dedicated systems designed specifically for O&P studies in the 1990s [2]. Load cells were eventually adopted and incorporated into studies of prosthetics in the 2000's. These studies were done on individuals with lower-limb amputations. The load cells would measure the forces at the base of the user's socket.

Force sensors for lower-limb prosthetics have been used in many applications for studying the reactions of these devices. There are many similar devices such as the device built for this project. However, this device uses testing methods that differ from others by using non-amputee individuals to examine different prosthetic feet.

One difficulty that was present for the initial research and design ideas was finding the right force sensor. Measuring the forces from the device is the single most important concept of this device. There were many different ideas thought of including strain gauges, load cells, and accelerometers. The sensor which best fit this design was a single-axis load cell. Each device would need at least four in order to measure the forces in three dimensions. This option was also cheaper than a single three-dimensional load cell of a price almost ten times higher.

II. Methods

A model of the device can be seen in figure 1. The overall design of this device is meant to accomplish certain requirements made by the client. The core requirements for this device are the ability to attach the device to an individual for examination, force measurement, and a user interface to visualize and interpret data.

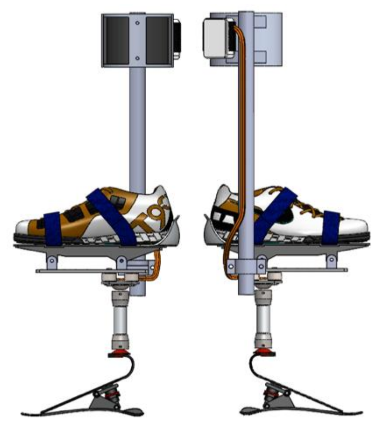


Fig. 1. Device model showing entire assembly

The core structure of the device is built around a construction stilt. The stilt is how the device's examiner will mount to the device and be able to walk and move around. The parts of the construction stilt that are used include: foot plate, upper strut tube, tube clamp, upper leg support, straps, and hardware. This part of the design can also be seen in figure 1; the stilt is shown as the top half of the device. The base of the construction stilt (foot plate) will be secured to a 304 stainless steel plate which will have mounting holes for attachment. Under the steel base plate there will be four load cells for data acquisition. The load cell will have a steel adapter plate underneath to attach a prosthetic adapter to. The rest of the device include the pylon tube and prosthetic foot which can be seen in many different prosthetic applications. A list of parts for the device can be seen in table 1.

The main purpose of this device is to measure ground reaction forces, and moments experienced by the user. Each pair of these devices will include four tension/compression load cells. The load cells will be used to measure the forces and the moments on the leg socket in three dimensions. The best way to measure these forces is to use a single, three dimensional load cell. However, for this application, 3-axis load cells are too costly. It is possible to achieve three dimensional reaction forces by using four single-axis load cells in a square configuration which can be seen in figure 2.

	Vendor	Part Description	Model
1	Amazon	Load Cell	DYMH-103
2	Amazon	Drywall Stilt	T&HI-B01GP04S5Q
3	midweststeelsupply	Base Plate	304 stainless steel
4	midweststeelsupply	Adapter Plate	A36 steel
5	Otto Bock	Tube Clamp Adapter	4R91
6	Otto Bock	Male Socket Adapter	4R23
7	Otto Bock	Female Socket Adapter	4R37
8	National Instruments	Multifunction I/O Device	USB-6009

Table 1. Device Components

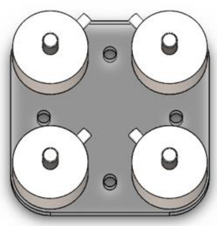


Fig. 2. Load cell configuration from one device

III. Results

Using four load cells allows for a wider base to be able to pinpoint the force locations during testing. Each load cell measures forces of tension or compression on a single axis. While the device is loaded, each load cell will measure forces of different magnitudes depending on the user's movements. The average of the four force readings can be found and the force location on a plane can be located.

The measured data from the load cells will be sent to a National Instruments I/O device. This device transmits the data to a LabVIEW interface where everything can be visualized by the user. This interface will show the information from both devices. Some of this information will be force location, force magnitudes, moments, etc. An example of the force location can be seen in figure 4(a) and 4(b).

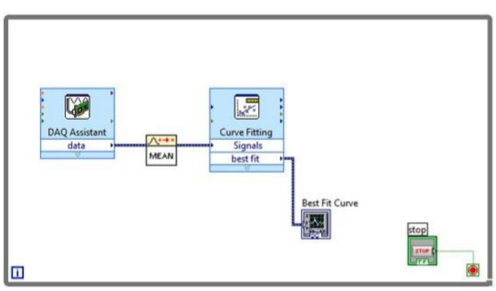
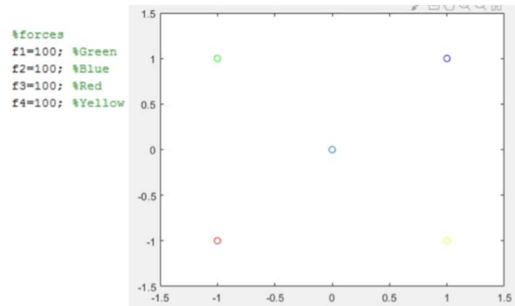
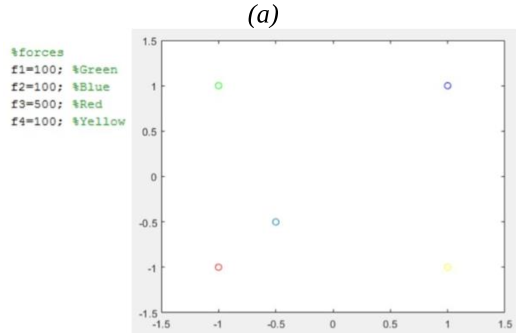


Fig. 3. LabVIEW program block diagram



(a)



(b)

Fig. 4. (a) Force location when all four forces are equal. (b) Force location as forces start to differ.

IV. Conclusion

This device will be used for the assessment of different prosthetic feet by various examiners. The data recorded will be used for educational purposes and studies to help improve prosthetic and orthotic parts in the future. This design is simple and easy to use while being relatively inexpensive. The ability for able-bodied people to study the effects of different prosthetic feet when in motion give a different yet positive perspective of what it is like to walk with prosthetic feet.

Acknowledgment

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References

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[2] Neumann, E. S., Brink, J., & Yalamanchili, K. (2012, August). Load cells enhance study of prosthetic foot rollover. Retrieved from https://lermagazine.com/article/load-cells-enhance-study-of-prosthetic-foot-rollover