GaitMate:
A Gait Monitoring Solution for Pediatric Cerebral Palsy

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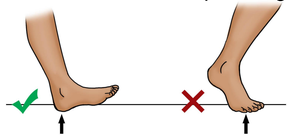
Background & Objective

- Cerebral palsy is neurological disorder of movement and posture that results from brain damage near time of birth that affects **1 in 323 children.**[1]
- **1 in 323 children** are diagnosed with cerebral palsy.[1]
- Out of all patients, **1 in 3** walk with the majority of their weight on the balls of their feet, as opposed to even weight distribution, eventually causing stiffness of leg muscles.[2]
- Current treatment for spastic cerebral palsy is through physical therapy and gait monitoring using external sensors and cameras.[3]
- Time between sessions can result in relapse as gait is not monitored constantly.



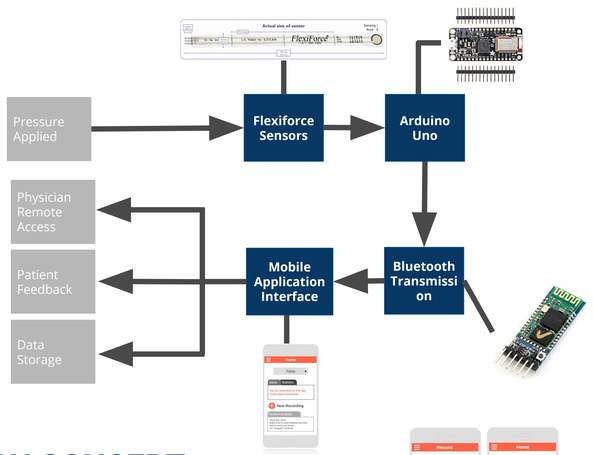
Heel-to-Toe Strike Toe-to-Heel Strike

GOAL:

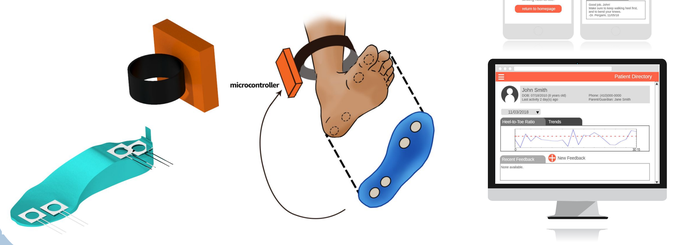
Improve patient physical therapy with increased data collection through a portable and wearable gait monitoring system.

Methods

DATA ACQUISITION:



DESIGN CONCEPT:



Results

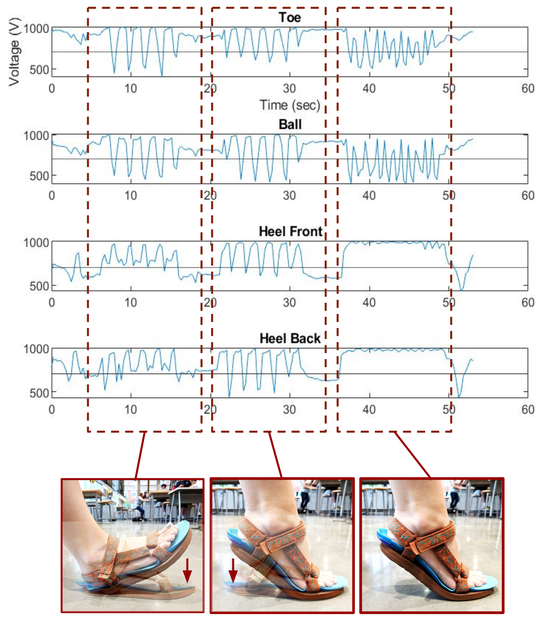


Figure 1. Characterization of the device shows it can accurately sense and output the force generated by different gait patterns. Note here, the differences between standing still (t:0-9 s), heel-toe walking (t: 9-15 s), toe-heel walking (t:22-32 s) and more severe cases of just toe-toe walking (t:38-48 s)

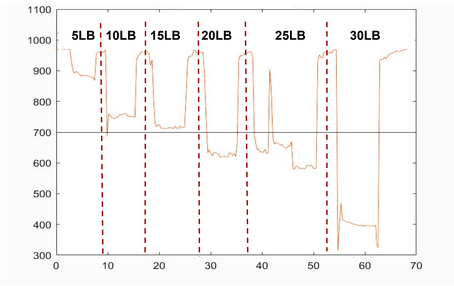


Figure 2. Sensor performance under known weights (5, 10, 15, 20, 25, 30) lbs represented in voltage vs.time in second. Results suggest that sensors respond similarly to different weight ranges, suggesting they can easily be adapted towards different aged children.

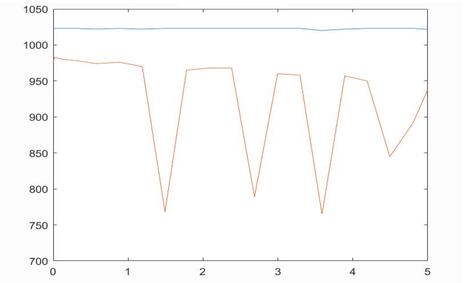


Figure 3. Sensor performance for short period of 5 seconds and small weight of 10 pounds shows relative speed in response time. Results suggest that the data acquisition system is fast enough to respond to a child walking in real time.

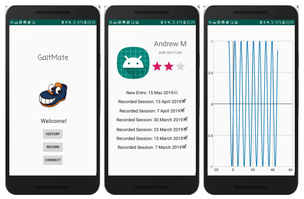


Figure 4. Screenshots of prototype mobile application featuring the main components of the patient interface. From left to right: navigation homepage, patient history, and sample recording screen.

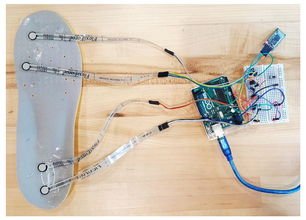
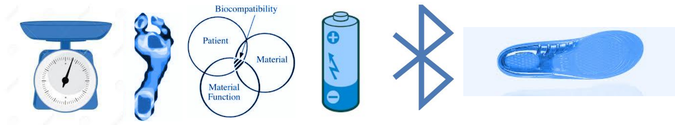


Figure 5. Picture of the pressure sole device prototype, connected to Matlab via Arduino for data collection and graphing.

Discussion and Conclusion



◇ Lightweight ◇ High Pressure Range ◇ Bluetooth Compatible
◇ Portable ◇ Rechargeable ◇ Comfortable ◇ Biocompatible

DISCUSSION:

In addition to our main goal, we were able to successfully meet all our initial design specifications:

- **Lightweight**: Prototype weights only **7.58 oz**, making it light enough for children to wear.
- **Portable and Rechargeable**: Inclusion of a 9V battery and bluetooth module makes the device portable and allows it to be **used for hours at a time** before replacing the battery
- **Biocompatible & Comfortable:** Using biocompatible materials for the soles makes the device **safe, comfortable** and easier to be approved by the FDA
- **High Pressure Range**: As seen in Figure 2, the device is able to detect a wide range of pressures, allowing it to be **easily adapted for children of all ages**
- **Cost effective**: The device only costs around 180 dollars. Given the device's **ease of adaptability** to different shoe sizes and weights, it can easily last throughout a child's progression through therapy.This makes it a **cost effective alternative** to the multiple trips to the physical therapy office which would otherwise be otherwise needed.
- **Fast response time**: As seen in Figure 1, device can **quickly adapt** to different changes in gait

CONCLUSION AND IMPACT:

Overall, we have developed a successful prototype of the pressure sole gait monitoring system that will:

- Increase data collection and monitoring for accurate gait analysis and monitoring
- Reduce patient relapse between therapy sessions
- Improve accessibility due to low cost and simple user interface
- Children of all ages will be positively affected, benefiting from more accessible physical therapy. Physicians will also benefit from wireless data acquirement.

Future Work

While we have demonstrated that our prototype can accurately measure and present results for an adult walking, there are a few areas we would like to further develop for the finalization of our product.

1. Characterize and personalize device with children at varying stages of adolescence to validate product adaptability and ensure personalized care.
2. Test device with both children who wear leg braces and those with regular shoes to optimize design for maximum comfort and decrease overall product size.
3. Adapt sensors so they are more sensitive to faster motion such as running or fast walking.
4. Further develop mobile app to be more kid friendly, interactive with live feedback, and with a secure data storage system for patient privacy.

References

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2. "Cerebral Palsy (CP)." Centers for Disease Control and Prevention. April 18, 2018. Accessed September 26, 2018. https://www.cdc.gov/ncbddd/cp/facts.html.
3. Armand, Stéphane, Geraldo Decoulon, and Alice Bonnefoy-Mazure. Current Neurology and Neuroscience Reports. December 2016. Accessed September 26, 2018.https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5489760/.