Wearable Device for Human Gait Assessment

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STRIDE INSIGHT

Executive Summary

The goal of this project was to develop a wearable gait analysis device to replace traditional lab equipment. The device we created is capable of

- one hour of use on a single charge,
- measuring Ground Reaction Force, Ankle Flexion Angle, and Muscle Activation (EMG), and
- providing downloadable data for analysis by a physician.

Our team accomplished this task by designing and iterating upon a Raspberry Pi-based device using the sensors shown below.

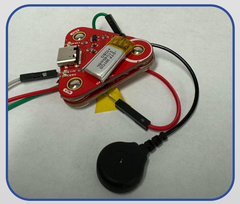

Figure 1. Myoware EMG Sensor.

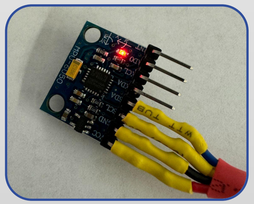

Figure 2. MPU 6050 (ankle angle).

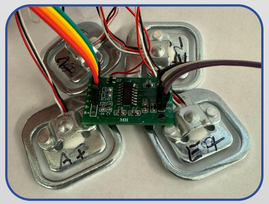

Figure 3. Load Cells + HX711 Amp (GRF).

Key Features/Objectives

1. The system must collect data on:
   - Electromyography of at least two muscles: the tibialis anterior and either the soleus or gastrocnemius muscles. (mV)
   - Ankle joint angles. (deg)
   - Ground reaction forces. (N)
2. The wearable system must be stand-alone, without tethers that limit user movement.
3. The system must include a soft, wearable interface around the ankle and calf that does not inhibit the user's natural mobility.
4. The system must be securely attached for at least 1 hour to ensure accurate data collection.
5. Processed data that can be analyzed by the wearer's physician must be available for download after use.

Figure 5. Prototype C.

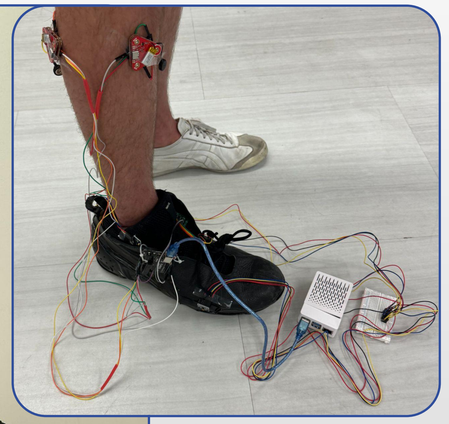

Figure 4. Prototype B.

Future Considerations

- Refine sensor selection by assessing 2-3 leading candidates for each critical parameter
- Improve sensor integration to increase accuracy
- Build a more robust and user-friendly GUI
- Develop a more user-friendly calf sleeve with integrated electrodes for automatic muscle detection
- Integrate MPU6050 ability to measure pitch and roll to improve ankle angle detection

Acknowledgements/References

1. UCI Rehabilitation & Augmentation Lab
2. Thomas, S. J., Zeni, J. A., & Winter, D. A. (2022). Winter's biomechanics and motor control of human movement (4th ed.). Wiley.

Reference Images

1. GRF - Winter DA (1991) The biomechanics and motor control of human gait: normal, elderly and pathological. University of Waterloo press, Ontario.
2. Ankle Angle - Blaya, Joaquin. (2005). Force-controllable ankle foot orthosis (AFO) to assist drop foot gait.
3. EMG - C.A. Byrne, D.T. O'Keeffe, A.E. Donnelly, G.M. Lyons, Effect of walking speed changes on tibialis anterior EMG during healthy gait for FES envelope design in drop foot correction, Journal of Electromyography and Kinesiology, Volume 17, Issue 5, 2007, Pages 605-616, ISSN 1050-6411, https://doi.org/10.1016/j.jelekin.2006.07.008.

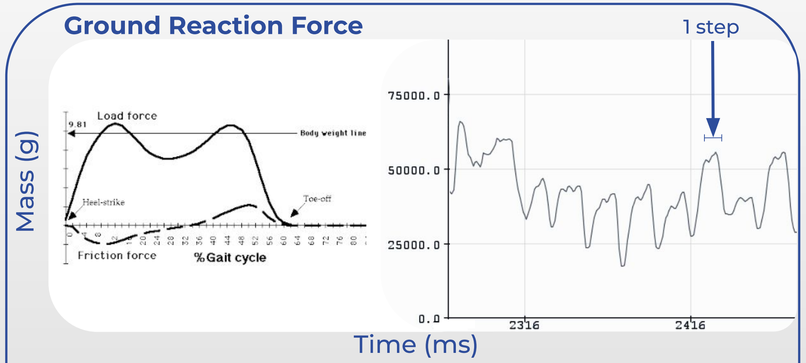

Figure 6. Measured GRF for 1 step from lab-grade equipment (left) and 5 steps from load cells (right).

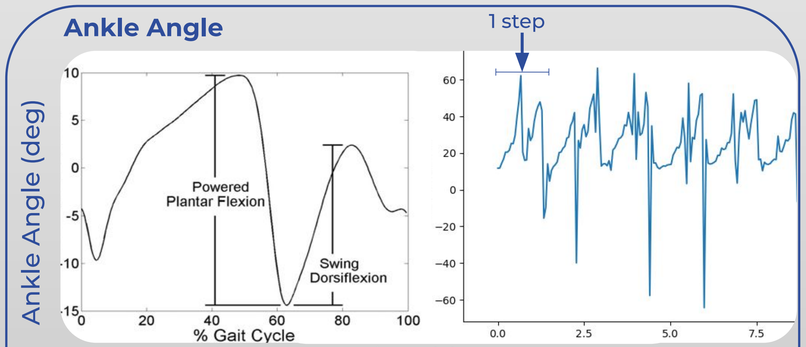

Figure 7. Measured ankle angle for 1 step from lab-grade equipment (left) and 5 steps from IMUs (right).

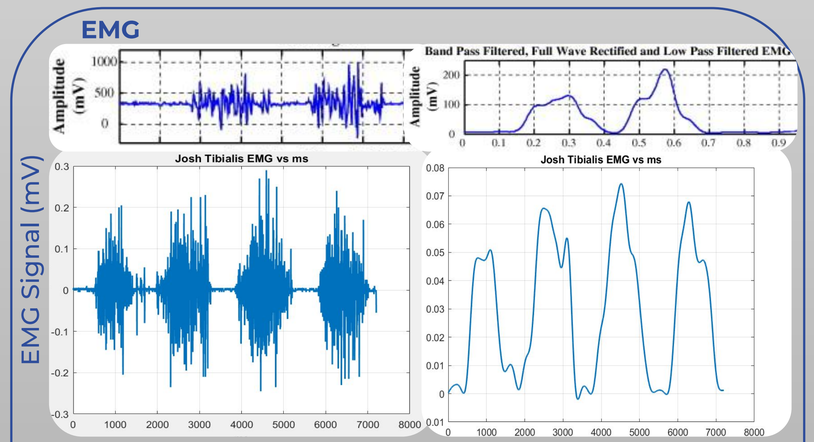

Figure 8. Measured EMG for 1 step from lab-grade equipment (top) and 2 steps from myoware sensors (bottom). Unfiltered (left) and Filtered (right).