SJSU SAN JOSÉ STATE UNIVERSITY

SJSU Undergraduate Research Grants

Knee Flexion Angle and Biofeedback Unit

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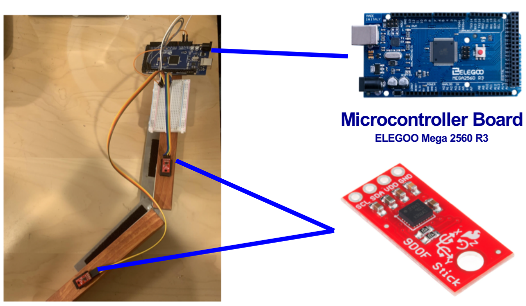
Abstract

Stiff-legged gait is a common gait abnormality associated with affected upper motor neurons in the brain or spinal cord. Individuals afflicted with the condition experience reduced knee flexion during the midstance to heel strike phase of gait. This results in increased energy expenditure during ambulation and lower extremity joint degradation [1]. Implementing biofeedback into gait retraining systems can help rehabilitate gait abnormalities by informing the user when they have not achieved a sufficient threshold for a designated action [2-5]. Traditionally, implementing biofeedback techniques into gait retraining involves in-lab setups that require motion capture equipment, walkways, and a biofeedback setup [6]. While wearable systems employing inertial measurement units (IMUs) and bending sensors have been explored for tracking motion, they generally do not include a built-in biofeedback system meant for out-of-lab usage [7, 8]. Here we describe a novel wearable biofeedback system for providing feedback to help increase knee flexion for individuals afflicted with stiff-legged gait. The system will collect knee flexion data and provide biofeedback cues through the usage of a smartphone and a mobile application.

Research Questions

- *How do we figure out how to use a smartphone's internal IMU sensors to help us create a knee angle measurement system?*
- *How do we approach measuring the real-time knee flexion angle with sensor data?*
- *How accurate is our device's knee angle measurements when compared to other wearable IMU systems on the market such as the Xsen MTi series?*
- *How useful is the biofeedback component in our system for users with stiff-legged gait?*

Project Activity 1: Initial Testing Setup

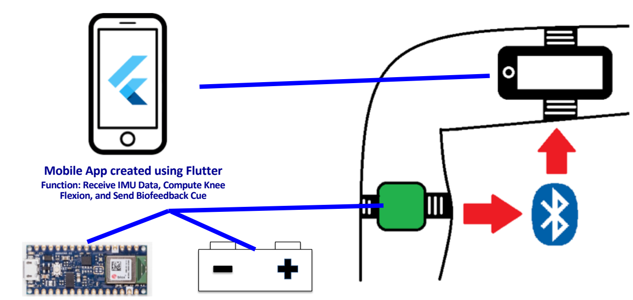


Microcontroller Board
ELEGOO Mega 2560 R3

2-Linkage Testing Setup with a Hinged Joint

9 Axis Inertial Sensor
SparkFun 9DoF Sensor Stick
Contains: Accelerometer, Gyroscope, Magnetometer

Project Activity 2: Mobile App & Sensor



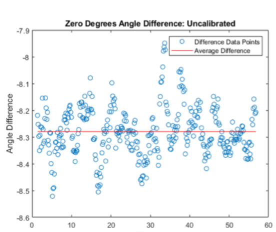
Mobile App created using Flutter
Function: Receive IMU Data, Compute Knee Flexion, and Send Biofeedback Cue

Microcontroller Board
Arduino Nano 33 BLE w/ Built in Bluetooth Module
9 Axis Inertial Sensor

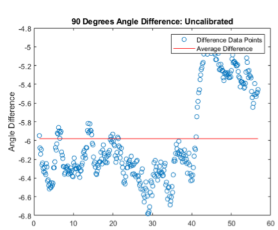
Battery

Knee Flexion Measurement Setup with Smartphone and External IMU Sensor

Preliminary Findings



Uncalibrated Angle Deviation at Zero Angle Position using Accelerometer Data



Uncalibrated Angle Deviation at 90 Degree Angle Position using Accelerometer Data

Citations

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3. *Chan, Z. Y. S., Zhang, J. H., et al (2018). Gait Retraining for the Reduction of Injury Occurrence in Novice Distance Runners: 1-Year Follow-up of a Randomized Controlled Trial. The American Journal of Sports Medicine, 46(2), 388–395. doi:10.1177/0363546517736277*
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6. *Chan, Z. Y. S., Zhang, J. H., Au, I. P. H., An, W. W., Shum, G. L. K., Ng, G. Y. F., & Cheung, R. T. H. (2018). Gait Retraining for the Reduction of Injury Occurrence in Novice Distance Runners: 1-Year Follow-up of a Randomized Controlled Trial. The American Journal of Sports Medicine, 46(2), 388–395. doi.org/10.1177/0363546517736277*
7. *Karatsidis, Angelos & Richards, Rosie & Konrath, Jason & Noort, Josien & Schepers, Martin & Bellusci, G. & Harlaar, Jaap & Veltink, Peter. (2018). Validation of wearable visual feedback for retraining foot progression angle using inertial sensors and an augmented reality headset. Journal of NeuroEngineering and Rehabilitation. 15. 10.1186/s12984-018-0419-2.*
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