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SYNCHRONIZATION OF MULTIPLE EMG BLUETOOTH LOW ENERGY SENSORS FOR PROSTHETIC CONTROL

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INTRODUCTION

Prosthetic sockets have long been one of the primary sources of complaints for both upper- and lower-limb amputees [1]. The increased utilization of osseo-integration procedures means that more individuals do not use traditional sockets. While prosthetic sockets create difficulties for many amputees, they do provide a place to locate various physiological sensors that interface with the residual limb. Additionally, there are scenarios (e.g., transhumeral or higher level amputations) with conventional sockets in which it can be advantageous to acquire signals from the user outside of the socket.

Therefore, we have developed a wireless sensor solution to allow for placement of sensors anywhere on the body. Our solution uses Bluetooth Low Energy (BLE) as the wireless protocol with multiple peripheral sensors.

One inherent problem with wireless communication is reliability [2], as packets can be delayed or ultimately lost. Unreliable and inconsistent prosthetic control can result if data from each sensor is not synchronized within 125ms [3] of each other. Additionally, variability in clock sources (e.g., temp coefficients) for each individual sensor can lead to timing drift and sample rate differences. Over long periods of time these differences will cause problems for signal processing and control algorithms. To address the synchronization problems, we have designed and implemented both data and time synchronization algorithms.

METHODS

Algorithms:

Data Size Synch: The number of samples the central device receives from each EMG sensor is "normalized" periodically by inserting or removing samples before processing the data. The decision to insert or remove is based on calculation results derived from the variables: central TS (TimeStamp), peripheral TS, sample rate, clock speed, and number of counter ticks in 1ms.

Time Synch: The central device serves as the master clock for synchronization. An affline model is used to produce the most accurate synchronization. Clock information is transferred from the central to peripheral node to get the initial clock pairs. An affine model is then built based on the initial clock information**.** The central node will transfer new clock information to peripheral node periodically (at a multiple of connection interval). The affine model is updated continuously based on the new clock value.

Procedures:

A system consisting of 1 central node and 2 EMG sensor nodes is used to evaluate performance and determine the optimum parameters for the algorithm. Each test iteration ran for approximately 12 minutes.

RESULTS

Data Size Synch: We evaluated different values for the transmit intervals and thresholds. For each 12 minute test the optimum settings results in ~1 correction per minute for each sensor.

TTI= Transmit Time Interval in ms
Thresh = Threshold for insert/remove x 1ms

TTI	Thresh	P1+1	P1-1	P2+1	P2-1	Total
150	x1	46	15	61	15	137
15000	x1	15	0	17	0	32
150	x2.5	19	0	27	0	46
1500	x2.5	13	0	13	0	26
1000	x1.5	16	0	13	0	29

Table 1. Comparison of TTI, threshold, and insertions (+1) or deletions (-1) for peripherals 1&2.

Time Synch: The time synch algorithm lowered the time difference between different peripherals to less than 0.5ms which leads to minimal offset between peripherals.

DISCUSSION/CONCLUSION

The data indicates that the algorithms meet the goals of data size and time synchronization using 2 EMG sensors. Future work will involve testing with more sensors and processing the data for control of a prosthetic device.

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DISCLOSURE

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