# Wearable sensor technology: The accuracy of derived data and implications

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**Background:** Wearable sensor technology, such as inertial measurement units (IMUs), has introduced new ways of assessing performance, monitoring change, and promoting learning and skill acquisition. These sensors are particularly attractive to professionals because they are easy to use, can be used to measure complex tasks, and be used in a variety of settings. A limitation associated with sensors that is often overlooked is that they are prone to errors and drifts, particularly when used over a long period of time. They work on the principle of fusing measured angular velocity, acceleration, and angle derived from several sensor types. Some of the sensors are sensitive to magnetic field distortions caused by nearby metal structures and electrical cables that if unknown, may affect the accuracy of information gathered and clinical decisions.

**Purpose:** The purpose of this report is to raise awareness about the potential pitfalls associated with the use of wearable sensor technology and their remedies. For this presentation, we will demonstrate how data collected from IMUs in real time become distorted during use, and a new approach that can be used to address the resulting errors.

**Method:** We developed an anatomical constraint method that uses an algorithm to find a three degree-of-freedom correction of each sensor using joint angle constraints. Because the method does not require that there be a limited range of motion in one or more joints, it can be used on any joint and corrections can be large. We tested the algorithm on 56 infants with and without Cerebral Palsy who were learning prone locomotion on a robotic device over a period of up to 20 weeks.

**Results:** Our findings, which will be presented in vignettes, show that the anatomical constraint method is able to correct for IMU alignment and calibration errors by reducing the extent to which mean joint angles exceed normal anatomical joint limits. The algorithm was able to find a three degree-of-freedom correction of each sensor, reduce the effect of IMU errors by computing a correction for overlapping time intervals, compensate for IMU drift by adjusting calibration as a *function of time.* The assumption is that movement is constrained to within normal anatomical joint limits.

**Discussion:** Several approaches for reducing wearable sensor errors/drift are proposed in the literature, including calibration. Because many of the wearable sensors are intended to use during movement involving multiple joints and in varying limb positions and environments, calibration offers a partial solution. Our results show that the anatomical constraint method is a promising new approach for correcting IMU based measurements of human body joint angles. The algorithm was able to compensate for IMU error and drift by making the correction a time-dependent function. Although this method was applied to wearable sensors used by children, the general approach of using anatomical joint limits may be applied to other IMU based measurements of any biomechanical systems. The innovation of our approach is that it was informed by and verified with actual videos and behavioral movement data of children in a longitudinal and repeated measures study.

**Relevance to Allied Health:** An increasing number of professionals who work with patients with movement disorders, impairments in cognition and communication, are using wearable sensors in practice and research. Data derived from these sensors inform decisions that are consequential. This presentation is designed to expose allied health professionals to potential pitfalls associated with sensors, particularly off-the shelf or inexpensive wearable sensors, measurement degradation, and the significance of calibration.

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