Abstract

Consistency and Discrepancy Analysis of Human Walking

by

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As the trend for wearable bioinformatic sensors continues to increase, researchers pursue integrating knowledge of the human body into the design of a simpler sensory system. By observing the consistency and discrepancy of human behavior, insight can be gained on how to design a monitoring architecture and what content to monitor. Because no two human individuals are identical, it is important to capture consistency among people based on an all-inclusive understanding. The first step of monitoring is to quantify the behavior. Because there is a limitation to a commercial motion capturing system, a durable sensory system, the Smartshoe, is designed to remotely record and measure ground contact force (GCF). The recorded data is locally processed by the hardwares computing unit and a non-blocking software architecture regulates the data rate of the recording. The accuracy and repeatability of GCF measurements with the piezoelectric sensor are demonstrated. The detailed schematic design is also explained in the text. A graphical user interface (GUI) is designed to show the real-time applicability of the software.

An optimal sensor location consistently differentiates distinct human movements and requires a minimal usage of the computational resource. Drawing inspiration from L1 regularization in classification problems, the use of feature selection results is an optimal sensor layout for gait phase estimation. The method reveals the significant sensor location involving in the classification and filters out the redundant locations. As a consequence of this optimization, the input complexity is greatly reduced. The results resemble some of the previous choices but also eliminate some redundancy. The estimators' performance of the optimized layout and the anatomic layout are compared and there is no significant disagreement.

Finally, a two-level hierarchical decision framework is proposed for a comprehensive representation of human bipedal behavior. The method decouples behavior identification to two levels, discrete modes and mode-dependent special tasks. The double-peaked GCF pattern is used as a metric to distinguish walking mode from running mode. Support vector machine (SVM) with a moving window is implemented to identify the discrete modes in the first level. In the second level, the mode-dependent tasks are defined under single or multiple modes. In walking mode, a set of two-sided fuzzy logic rules is utilized for robustly recognizing the gait

phases. The speed of walking is also estimable by observing the peak-to-valley ratio in the GCF pattern. The diagnosis of touch-based symptoms, on the other hand, are dual-mode specific tasks. Plantar Fasciitis causes a smaller Mid-Stance to Terminal Stance ratio in combination with asymmetric running GCF pattern in the affected side. And finally, the combined performance using the framework shows a robust and accurate analysis of human walking behavior.