Title: A Phase Variable Approach for IMU-Based Locomotion Activity Recognition

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Abstract:

This paper presents a gait classification method that utilizes data from an inertial measurement unit (IMU) to recognize locomotion activities. The method employs a phase-variable description of gait, identifying activities based on the expected curvature characteristics over a gait cycle. The approach was tested with seven healthy subjects performing walking, stair descent, and stair ascent. The classification accuracy of the phase variable method was compared to a linear discriminant analysis (LDA) classifier. Results showed that the phase variable method outperformed LDA with nonsubject-specific training data, while LDA performed better with subject-specific training. The proposed method offers improved classification accuracy for gait classification applications trained with nonsubject-specific data.

Keywords: Classification algorithms, gait recognition, legged locomotion, patient monitoring.

Introduction:

This paper focuses on monitoring human locomotion activities, such as walking, running, stair ascent, and stair descent, using portable and wearable devices. The authors propose a methodology for activity monitoring that incorporates measurements from a single leg-worn IMU. They discuss the importance of employing a minimum set of sensors and highlight the suitability of low-cost multi-axis MEMS-based IMUs for activity monitoring applications.

Related research and methodologies for activity monitoring using body-mounted sensors are reviewed, particularly for gait activity classification. Pattern recognition approaches, such as support vector machines, hidden Markov models, Gaussian mixture models, linear discriminant analysis, neural networks, decision trees, and logistic regression, are commonly used for classifying activities based on sensor data. The authors note the use of various feature extraction techniques and dimension reduction methods in conjunction with classification algorithms.

Algorithm Description:

The proposed approach introduces a novel feature set based on a phase-variable-based coordinate system for gait activity classification. In this approach, the progression of a periodic activity is characterized by a single-phase variable. The authors utilize the thigh angle in the sagittal plane as the input signal for activity classification. The thigh angle is represented in the integral phase space, where the signal is a function of its derivative. A simple closed curve in the phase space is formed by integrating the thigh angle.

Experimental assessments were conducted with seven healthy subjects performing multiple gait activities, including level walking at different speeds, stair ascent, and stair descent. The proposed phase variable approach was compared to a linear discriminant analysis (LDA) pattern recognition approach. Classification results demonstrated the effectiveness of the phase variable method, particularly when trained with nonsubject-specific data.

Conclusion:

The paper presents a phase variable approach for IMU-based locomotion activity recognition. The method utilizes a phase-variable-based set of features and demonstrates improved classification accuracy compared to LDA when trained with nonsubject-specific data. The proposed approach offers potential applications in gait classification and activity monitoring using wearable IMUs, contributing to advancements in patient monitoring and healthcare technologies.