Wearable Sensors and Machine Learning Algorithms to Assess Tai Chi Performance Proficiency

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Purposes

1. Designing an array of wearable accelerometers to objectively capture torso, head and limb movement while performing a set Tai Chi training regimen,
2. Utilizing machine learning algorithms to estimate proficiency of performance with reference to gold-standard scores provided by Tai Chi experts.

Experimental Setup

Subjects between 60 and 85 years of age with different level of proficiency in Tai Chi, in good general health and able to walk for 15 minutes without an assistive device, were recruited.

They were instructed to perform 12 different exercises based on six traditional Tai Chi choreographies while wearing 13 sensors, which recorded acceleration and angular velocity.

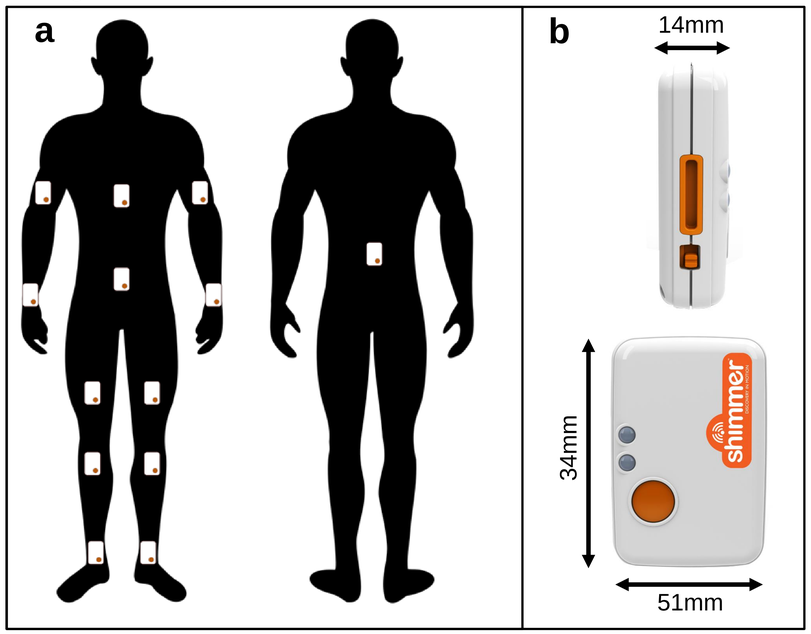

Figure 1. **a)** Position of the 13 sensors used to estimate the proficiency performance of the exercise. **b)** Photo of a Shimmer3 IMU utilized in this study.

Methods

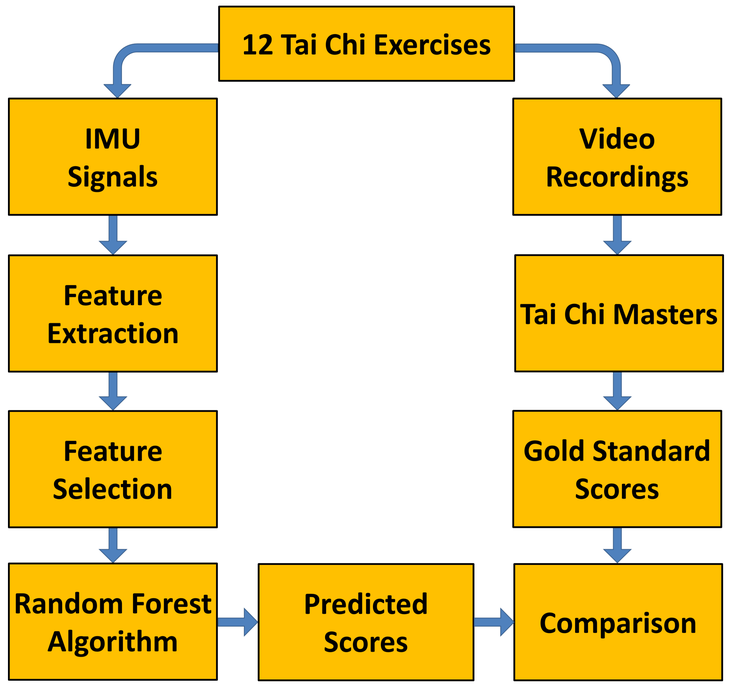

Figure 2. Project Flow chart.

The IMU signals were filtered to remove artifacts and segmented using digital markers corresponding to the beginning and end of each exercise.

Data features were derived for each sensor axis from time and frequency domain. To select the most relevant data features, the minimum redundancy, maximum relevancy feature selection algorithm was applied. A regression based random forest machine learning model was trained to predict the proficiency scores generated by the experts.

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Results

Thirty-three older adults with a mean age of **69.7±5.0** years were enrolled.

Tai Chi proficiency scores estimated by the two Tai Chi experts were highly consistent (intraclass correlation of total scores **0.99 (0.96, 1.00)**.

The machine learning algorithm predicted the proficiency scores with an average accuracy of **97.2±0.8%** (mean ± standard deviation) when using the full set of data features and of **93.7±1.0%** when training the model only using the data features derived from the sensors positioned on wrists, ankles, and chest.

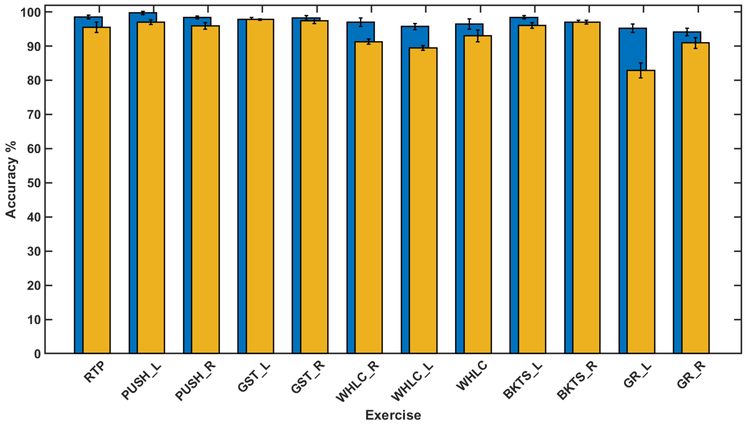

Figure 3. Machine learning algorithm performance for the 12 different exercises. The blue bars represent the accuracy with the full set of sensors the yellow ones considering only 5 units.

Conclusion

This study is part of a larger project aiming to virtually deliver and monitor safety and quality of home practice of Tai Chi.

The results demonstrated the feasibility of objectively assessing proficiency of Tai Chi performance using wearable sensors. This feature could be used to characterize learning trajectories and provide feedback to Tai Chi practitioners during home-based interventions.