Human Motion Recognition in Badminton: A Machine Learning Approach

Rambely A.S.[1], Law Y.S.V.[1], & Yahya A.B.[1]
[1]Department of Mathematical Sciences, Faculty of Science & Technology, Universiti Kebangsaan Malaysia (UKM), Bangi, Selangor, Malaysia
Email: asr@ukm.edu.my

Summary

This study applies machine learning to classify footwork in badminton jump smashes using kinematic data from top-world ranking badminton players. Three movement phases which are preparation, airborne, and landing were analyzed. The Random Forest model achieved the highest F1-score (95.53%), demonstrating the potential of AI in sports performance analysis.

Introduction

Human Motion Recognition (HMR) is widely used in healthcare, daily activities [1], and sports such as karate [2]. In badminton, precise footwork and coordination are crucial, especially for high-intensity movements like the jump smash. A powerful smash relies on efficient energy transfer through the kinetic chain, from the legs to the wrist. Identifying key movement phases, which are preparation, airborne, and landing, can help athletes and coaches enhance performance. Machine learning (ML) offers an automated approach to classify these movements, eliminating the need for manual observation. This study aims to train and evaluate supervised ML models, which are Decision Tree (DT), Random Forest (RF), Support Vector Machine (SVM), and K-Nearest Neighbor (KNN), to classify jump smash phases and improve performance analysis in badminton.

Methods

This study focuses on analyzing footwork during successful jump smashes using kinematic data from top world-ranking professional players from Korea and Denmark during the Thomas Cup Badminton Competition. The dataset consists of three movement phases, preparation, airborne, and landing [4], identified based on biomechanical features. The dataset includes 17 successful smashes, each averaging a shuttle speed of 220 km/h.

Spatial features such as joint angles, angular velocities, and accelerations of lower limb segments were extracted to form the dataset. A total of 30 data points were selected based on performance metrics emphasizing biomechanical efficiency and technical precision. The dataset includes linear accelerations of the hip, knee, and ankle joint points in the *x*, *y*, and *z* directions. Data labeling was performed manually according to the predefined movement phases. Given the dynamic nature of badminton, an expert with domain knowledge was required to classify movements accurately.

Results and Discussion

The classification models were implemented using the scikit-learn library in Python. The DT, RF and SVM models were trained using 42 bagged classifiers, each trained on the three movement phases. The KNN model employed the Minkowski metric with Euclidean distance (p = 2) and k = 5, assuming equal voting weights for all neighbors. In the DT and RF models, the Gini index was used as the splitting criterion.

A supervised ML approach was successfully developed to classify footwork movements in the badminton jump smash. Model performance was evaluated using accuracy, precision, recall, and F1-score metrics. Among the models, the RF classifier demonstrated the highest performance, achieving an F1-score of 95.5%, followed by the KNN, DT and SVM models with scores of 90.1%, 80.7% and 79.2%, respectively.

Cross-validation using five-fold validation further confirmed the reliability and robustness of RF model (Figure 1).

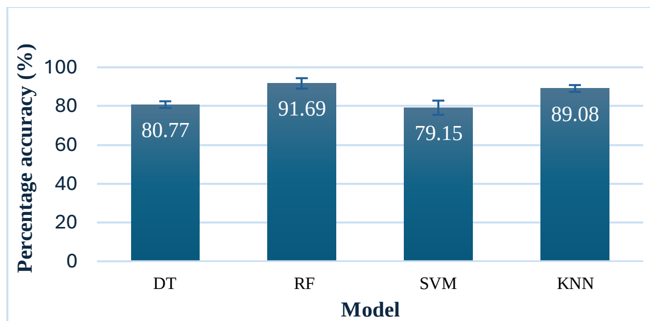

Figure 1: Mean accuracy of ML models using cross-validation.

Conclusions

The HMR model effectively classified footwork movements during the jump smash, highlighting the potential for integrating ML into sports analysis. This study provides a foundation for future research to explore advanced movement analysis and decision-making in sports.

Acknowledgments

The research was supported by UKM with code GUP-2017-112 and GP-K007147.

References

[1] Kumari N., *et al*. (2024). Human motion activity recognition and pattern analysis using compressed deep neural networks. *Comp. Methods In Biomech. And Biomed. Eng: Imaging & Vis.*, **12**(1): 2331052.

[2] Żelawski, M. and Hachaj, T. (2021). The application of topological data analysis to human motion recognition. *Tech. Transac.*, e2021011.

[3] Rambely, A. S., Wan Abas, W. A. B., & Yusof, M. S. (2005). *The Analysis of the Jumping Smash in the Game of Badminton*. *ISBS Conference Proceedings*, Beijing.