Artificial intelligence for objective assessment of acrobatic movements: How to apply machine learning for identifying tumbling elements in cheer sports

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Summary

Cheerleading is a professional, competitive sport with growing global popularity. Evaluating tumbling elements is a complex task relying on both objective measures and subjective judgement. Artificial intelligence (AI) offers precise data-driven analyses, yet its application in acrobatic sports remains limited despite significant potential for enhancing performance evaluation and coaching. This study investigates the feasibility of using an AI-based approach with data from a single inertial measurement unit worn at the pelvis to accurately identify tumbling elements. Over a 4-week seasonal preparation period, 1,000 tumbling elements of 18 participants (15 females, 3 males) from a collegiate coed team were recorded. Various ML algorithms were employed to classify the tumbling manoeuvres. Results indicate that certain ML models can effectively identify different tumbling elements despite inter-individual variability and data noise, achieving high accuracy. These findings demonstrate the significant potential for integrating AI-driven assessments into cheerleading, providing objective metrics to complement traditional judging methods.

Introduction

Over the past four decades, cheerleading has evolved from a sideline activity at major sporting events into a professional, competitive sport with growing global popularity. Evaluating tumbling elements in cheerleading relies on both objective measures and subjective judgments, such as difficulty and execution quality. However, the complexity of tumbling—encompassing team synchronicity, ground interactions, choreography, and artistic expression—makes objective assessment challenging. Artificial intelligence (AI) has revolutionized various scientific fields and industries through precise data-driven analyses, yet their application in acrobatic sports remains limited despite significant potential for enhancing performance evaluation and coaching. This study investigates the feasibility of using an AI-based approach with data from a single inertial measurement unit to accurately identify and objectively assess tumbling elements in standard cheerleading routines.

Methods

A sample of 18 participants (15 female, 3 male) from a Division I collegiate cheerleading team wore a single IMU at the dorsal pelvis. Over a 4-week seasonal preparation period, 1,000 tumbling elements were recorded during regular practice sessions. Using triaxial accelerations and rotational speeds, various ML algorithms were employed to classify and evaluate the execution of tumbling manoeuvres.

Results and Discussion

Results indicate that certain ML models can effectively identify different tumbling elements despite inter-individual variability and data noise, achieving high accuracy. These findings demonstrate the significant potential for integrating AI-driven assessments into cheerleading and other acrobatic sports, providing objective metrics that complement traditional judging methods.

Figure 1. Chronophotography of a tumbling element studied.

Conclusions

This study shows that machine learning can objectively classify tumbling elements in cheerleading using data from a single IMU. Over 1,000 recorded elements from 16 athletes, triaxial acceleration and rotational speed data were transformed into the frequency domain for improved classification. Gaussian Process Classification achieved high accuracy, generalizing well to unseen athletes. While challenges remain in distinguishing similar maneuvers, these results highlight the potential of artificial intelligence to complement traditional judging. Future work should focus on refining feature extraction, expanding datasets, and integrating models that assess not only element classification but also execution quality and technical precision, ultimately supporting more objective and consistent scoring in competition and training.

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