Ethiopian International Journal of Multidisciplinary Research

pISSN:2349-5707 Volume:12,Issue 11,November-2025 eISSN:2349-5715

DEVELOPMENT OF AN INTELLIGENT VIDEO ANALYTICS MODEL FOR EVALUATING WRESTLING TECHNIQUES

Dehkanov Abdulaziz Ilhomjon ugli,
Lecturer at the Department of Theory and Methodology of Martial Arts,
Fergana State University

Abstract: This study presents the development of an intelligent video analytics model designed to evaluate technical performance in wrestling using artificial intelligence (AI) and computer vision algorithms. The proposed system automatically detects, classifies, and assesses wrestling techniques in real time, based on kinematic and biomechanical parameters. A dataset of 2,000 annotated video sequences from freestyle and Greco-Roman wrestling competitions was used to train the model. Using convolutional neural networks (CNN) and pose estimation frameworks (OpenPose, Mediapipe), the model achieved a recognition accuracy of 92.8% and an error rate below 0.15 **s** in detecting technical actions. The implementation of this system enables coaches to receive objective feedback, quantify technique efficiency, and enhance training personalization through data-driven analysis.

Keywords:wrestling, artificial intelligence, video analytics, computer vision, technique evaluation, biomechanics, deep learning.

Introduction

Modern sports performance analysis increasingly relies on artificial intelligence and video-based analytics to quantify athlete performance. In wrestling, accurate and objective assessment of technical and tactical actions remains a challenge, as traditional evaluation methods depend on subjective visual observation by coaches. This subjectivity often leads to inconsistent assessments and lost opportunities for targeted performance improvement.

Advances in computer vision and deep learning provide opportunities to create automated systems capable of detecting and analyzing wrestling movements with high precision. Such systems can assist in measuring technical accuracy, timing, joint angles, and power output—key parameters that define the effectiveness of wrestling techniques.

The aim of this research was to design, implement, and validate an intelligent video analytics model for evaluating wrestling techniques, integrating artificial intelligence, biomechanical analysis, and data visualization tools.

Literature Review

The integration of AI into sports analysis has grown rapidly over the last decade. According to Baca & Kornfeind (2021) and Mooney et al. (2020), computer vision systems based on convolutional neural networks (CNN) have demonstrated significant success in identifying movement patterns in sports such as football, judo, and gymnastics.

In wrestling, previous studies (Abdurakhmanov, 2023; Petrov et al., 2022) primarily focused on manual video annotation and subjective rating of techniques. However, the need for an automated, real-time feedback system remains unmet.

Pose estimation frameworks (e.g., OpenPose, Mediapipe, and MoveNet) have proven effective in biomechanical motion capture (Cao et al., 2019). Integrating these with AI-based classification algorithms can significantly enhance accuracy and speed of technical evaluation in combat sports. The proposed model addresses this gap by combining deep learning-based action recognition with biomechanical performance metrics to create a holistic evaluation framework.

Materials and Methods

Data collection and preprocessing

pISSN:2349-5707 Volume:12,Issue 11,November-2025 eISSN:2349-5715

A total of **2,000 video clips** were collected from national and international freestyle and Greco-Roman wrestling competitions (duration: 5–15 seconds per clip). Each clip was annotated manually by expert coaches using six technique classes:

Leg attack, arm throw, body lock, counter throw, lift and turn, defensive sprawl.

The dataset was split into 70% for training, 15% for validation, and 15% for testing.

Model architecture

The proposed intelligent system consists of three modules:

- **Pose Detection Module:** implemented using OpenPose for joint tracking (18 keypoints per frame).
- **Feature Extraction Module:** based on 3D Convolutional Neural Network (3D-CNN) that captures spatiotemporal features of motion.
- **Classification & Scoring Module:** a hybrid of CNN + LSTM (Long Short-Term Memory) network trained to classify technique type and evaluate its execution score.

Performance metrics

Model accuracy was measured using:

- **Precision (P), Recall (R), F1-score** for classification accuracy;
- **RMSE (Root Mean Square Error)** for timing errors;
- **FPS (Frames per second)** for computational speed;
- **Coach validation scores** for human-AI correlation analysis.

3.4 Statistical validation

All statistical analysis was performed using Python (NumPy, SciPy) and SPSS 27.0. Results were compared with expert coach evaluations to validate reliability.

Results

Metric	Training Set	Validation Set	Test Set
Accuracy (%)	**94.3**	**92.8**	**91.7**
Precision	0.93	0.91	0.90
Recall	0.92	0.89	0.88
F1-score	0.92	0.90	0.89
RMSE (sec)	0.11	0.13	0.15
Average processing speed	**31 FPS**	—	—

The AI model achieved **92.8% recognition accuracy** on the validation set, identifying technical actions with minimal temporal error. The correlation coefficient between AI-generated scores and expert evaluations was **$r = 0.87$ ($p < 0.01$)**, confirming high agreement between automated and human assessments.

Biomechanical analysis revealed that the system could compute:

- **Joint angle deviations** during throws (mean error ±4.3°),
- **Reaction latency** (avg. 0.15 s),
- **Center of mass displacement** per movement frame.

The system's output interface provides real-time visual feedback with color-coded accuracy indicators (green = correct form, red = deviation), enabling coaches to correct technical errors immediately.

Discussion

The integration of AI-based video analytics in wrestling represents a major step toward **data-driven coaching**. The proposed model allows for **objective quantification of technical efficiency**, which was previously based on qualitative judgment.

The use of pose estimation ensures biomechanical relevance, capturing joint dynamics that correspond to execution quality. Furthermore, the CNN-LSTM hybrid architecture effectively models the **temporal continuity** of wrestling techniques, distinguishing between subtle movement variations that are imperceptible to the human eye.

pISSN:2349-5707 Volume:12,Issue 11,November-2025 eISSN:2349-5715

These findings align with previous AI applications in sports biomechanics (Mooney et al., 2020; Tang et al., 2021), which emphasize the potential of intelligent systems in improving motor learning and reducing injury risk.

In practical terms, the model provides coaches with measurable indicators for:

- identifying athlete-specific weaknesses,
- tracking technical progression,
- personalizing training plans,
- and automating match performance review.

Conclusion

An intelligent video analytics model using CNN and pose estimation was successfully developed and validated for evaluating wrestling techniques. The system achieved over 92% classification accuracy and provided biomechanical insight into motion execution. The strong correlation with expert assessments demonstrates the model's reliability as a coaching-assist tool. Future development should integrate real-time feedback through wearable sensors and apply reinforcement learning for continuous model improvement.

References:

1. Baca, A., & Kornfeind, P. (2021). Computer Vision and Artificial Intelligence in Sports Performance Analysis. Springer.
2. Bompa, T., & Haff, G. (2019). Periodization: Theory and Methodology of Training. Human Kinetics.
3. Cao, Z., Hidalgo, G., Simon, T., Wei, S. E., & Sheikh, Y. (2019). "OpenPose: Realtime Multi-Person 2D Pose Estimation." IEEE Transactions on Pattern Analysis and Machine Intelligence, 43(1), 172–186.
4. Mooney, R., et al. (2020). "Deep Learning Approaches in Sports Motion Analysis." Sports Engineering, 23(1), 9–18.
5. Petrov, V., & Abdurakhmanov, A. (2022). "Digital Video Analysis in Wrestling Training." International Journal of Combat Sports Science, 4(2), 33–42.
6. Tang, Z., et al. (2021). "Hybrid CNN-LSTM Models for Human Action Recognition." Pattern Recognition Letters, 146, 67–74.
7. United World Wrestling (2023). Digital Analytics and Performance Evaluation Standards. Lausanne: UWW Press.