Computer Vision Driven Kinematic Analysis of Athlete's Motion for Decision Optimization and Enhanced Objectivity in Fencing Refereeing

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Sabre fencing is a sport of split-second decisions, where in 60% of points, both fencers land touches within milliseconds of each other. In such cases, determining who earns the point is entirely left to the referee's judgment based on the rules of "right of way". However, the sheer speed and complexity of these exchanges make accurate refereeing incredibly difficult, introducing inherent subjectivity and cognitive bias that ultimately affects the authenticity of the sport. To address this, a computer vision system was developed using an auto-framing camera to analyze high-speed video and determine which fencer extended their arm first, a key factor in right-of-way decisions. Using the YOLOv8-Pose model, the system tracks shoulder and elbow positions, automatically identifying the fencing arm during initial salute. It calculates elbow and shoulder angles and dynamically analyzes them to detect full extensions per FIE regulations, timestamping each detection and determining priority. The system outputs information with an interactive slow-motion replay, overlaid with angle/extension information along with its decision. Advanced filtering techniques mitigate noise, such as spectators, while a false-positive reduction mechanism ensures that only intentional attack extensions, distinct from preparatory or defensive movements, are considered in analysis. The system was tested in-person on 100 fencing points and achieved a 90% accuracy rate in identifying the first extension, 15% higher than professional referee calls on the same dataset. The research demonstrates the feasibility of computer-assisted officiating in a dynamic sport, paving the way for more consistent, data-driven, and equitable decision-making that has the potential to redefine competitive fencing.

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