B4

Technological and Biomechanical Synergies in Evaluating Anticipatory Decision-Making in Sports

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Anticipatory decision-making (ADM) is a critical cognitive-motor skill enabling athletes to rapidly interpret perceptions and execute effective actions under pressure (Roca et al., 2011). This research reviews AI-driven computer vision and multimodal sensors in ADM through a systematic literature review, framing it as the interaction of perception, cognition, and movement, guided by human factors, real-time data, and decision-making models like OODA (Observe–Orient–Decide–Act) model. To date, 84 SCOPUS articles have been reviewed, with 130 more from IEEE, ACM, and SPORTDiscus under thematic analysis. SCOPUS findings show VR, EEG and motion capture technologies are commonly used perceptual-motor, cognitive, and biomechanical evaluation respectively. Of these, 59 directly address ADM in sports; 58% focused on team sports, 33% on individual sports and 9% on recreational sports. Since 2019, publications have surged, with sports action prediction increasingly explored through VR, machine learning, EEG, and deep learning. A significant gap exists in using eye-tracking and computer vision for holistic ADM, as more than 80% of studies were found to focus on isolated training components rather than integrating perceptual, cognitive and motor domains. While biomechanics contributes to motor skill development (Knudson, 2021), its influence on ADM outcomes remains underexplored. This is largely due to the complexity of modelling context-sensitive judgments, dynamic cues, and real-time decisions under uncertainty—challenges conventional machine learning and signal processing struggle to capture. Addressing these requires interdisciplinary approaches spanning biomechanics, machine learning, and human-computer interaction. This research moves beyond basic prediction to explore whether athletes can be systematically profiled based on perceptual-motor behaviour and unique movement signatures. In this presentation, I will share early SLR findings and discuss emerging questions around player predictability, biomechanical complexity, and individualised perception-action coupling. These insights will guide future experimental design for profiling decision-making under uncertainty using AI and sensor-based methods.

Keywords
Anticipatory Decision-Making (ADM), AI in Sports, Biomechanics, Cognition, Perception, Performance Prediction

References

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