Advances in AI for Isometric Training: Towards Explainable Models and Injury Prevention in Sports Science using Fuzzy Logic

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Abstract. Isometric contractions involve the static manifestation of force. Recent advances and developments in Artificial Intelligence (AI), especially in force manifestation through isometric movements, can detect behaviour patterns and provide insights into certain situations resulting from over-training. These tools can be applied to sports science to address typical problems, such as ligament ruptures in knees in football or shoulder injuries in handball. This article showing how AI has been applied to injury prevention and we contextualise our line of research, which focuses on addressing the challenges and limitations of pattern detection by exploring the extension of these studies by adding explainable to the models depending on isometric strength exercises. The ultimate goal is to provide explainable results, allowing us to decide about specific aspects of any exercise studied.

Keywords: Artificial Intelligence · fuzzy logic · explainability · isometric force movement · sport science

1 Introduction

The emergence of Artificial Intelligence (AI) has led to an increase in the study of scientific research in sports sciences in recent years. One area that demands scientific research is prevention. High-performance activities can provoke injuries and extreme fatigue, which may lead to further complicated injury scenarios.

Isometric methods play a crucial role in sports science, traditionally focusing on peak muscular effort. These methods facilitate the analysis of muscular responses during critical moments. They have proved to be essential in developing effective training programs to enhance performance and prevent injuries. Prior studies have primarily focused on examining effort peaks.

Our study goes above this, presenting a proposal on applying fuzzy logic to this research topic, aiming to provide a sophisticated approach for modelling and analysing sports data. AI can assist in processing large datasets within defined intervals, especially in machines like Myoquality M1[6], that are capable of taking 1000 measurements per second during an athlete's exercise routine.

We can improve the analysis of isometric methods thanks to generations of linguistic variables [9]. They involve assigning descriptive labels to numerical or qualitative values to enhance a system's interpretation and to make it more comprehensive. In strength movements using isometric methods, adding linguistic approach to the results obtained by AI models allows non-experts in data science to interpret the results, maximising individual performance.

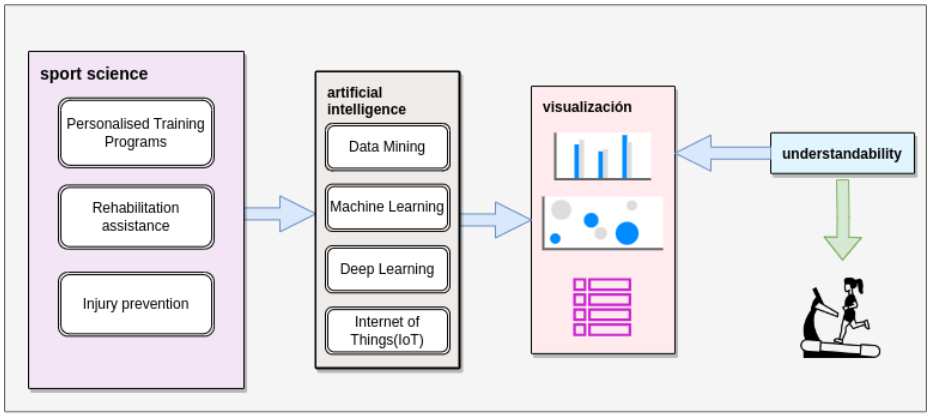

Fig. 1. Understandability in AI for sports science.

2 Explainable Models and Injury Prevention in Sports Science using Fuzzy Logic

AI has been crucial in various areas like injury prevention. Throughout this section, we explore some contributions of AI in these domains, aiming to understand and improve the effectiveness of health and sports performance-related strategies. This study provides a valuable perspective on the continued advancement of sports science through the intelligent application of occurring technology.

In injury prevention, numerous AI-based studies have been conducted with the contributions of various researchers. Utilising wearable technology, researchers such as [4] have tracked athletes' efforts and performance comprehensively. This approach facilitates the analysis of athletes' states during specific preparation phases [2].Understanding an athlete's condition is the key to reducing the risk of injuries, as [3] emphasised.

Most of the work to date in which AI is applied to sports science focuses on executing algorithms and providing a crisp numerical output when displaying the results after execution. This outcome makes it challenging for other researchers who are not experts in data science to interpret the results of our experiment easily [10]. This approach is particularly useful in situations where precise definitions are impractical or impossible, such as in natural language processing or control systems. By using linguistic labels such as "high injury risk" or "somewhat strong" to describe fuzzy sets, Fuzzy Logic enables and augments

the overall understanding and human-like representation of data and decision-making processes, making it valuable in various applications, including expert systems, pattern recognition, and decision support systems.

Fuzzy logic can also play a crucial role in injury prevention by developing and anticipating risks assuming multiple variables, including collected fatigue, physical condition, and environmental conditions[5]; prevention programs can adapt in real-time to minimise the risk of injuries[8].

Explainability and human interaction are crucial in data science because many models, such as deep neural networks, can be inherently complex and challenging to interpret [1]. The importance of explainable lies in the trust and acceptance of the model. To achieve explainability, data scientists can use specific techniques, such as feature interpretation, data visualisation, and methods that simplify the model complexity without compromising its interpretation. The ability to explain and understand results improves confidence in the model and facilitates the identification and correction of potential biases or errors [7].

Isometric methods do not involve movement; instead, they involve applying tension to a specific muscle and detecting how much force it can resist. The study of these types of movements has many therapeutic applications, as they can detect disorders in the muscle, allowing the identification of overexertion that may lead to injury over time or that is not observed visually.

Various parameters can be obtained to help understand what is happening to the muscle, such as evaluating its fatigue index, which consists of a negative slope in the generation of the records that occurs when the muscle force starts to decrease until the end of the exercise. Maximum isometric force, representing the maximum tension the muscle can resist, typically exhibits more vertical declines. Protection indicators involving our neuromuscular system use muscles called spindles that provide information about the tension exerted through fibres.

If we focus on prevention, we can primarily study strength by applying isometric force movements to the athlete. This approach allows us to centre the analysis efforts on athletic prevention and care by examining data obtained from a series of exercises performed over a specific period. We measure the force that the analysed body part can resist.

Fuzzy logic allows us to insert a range of linguistic labels within a set of values, thus increasing the clarity of our results. Obtaining understanding in our system is essential as it enables us to articulate our findings with words that nearly align with the field of sports science, making it understandable for both coaches and athletes.

3 Conclusion

This study emphasises the role of fuzzy logic techniques in explaining and improving the enhanced understanding of AI-based approaches. We have focused on a particular research topic, isometric force manifestation, that aims to prevent significant injuries in sports people. Our study reveals that this area can

primarily benefit from fuzzy logic approaches due to their capability to facilitate a better understanding of modelling and the possibility of constructing explainable models.

From a prevention perspective, understandable aims to obtain behaviour patterns and achieve a result that can provide an improved comprehensibility insight into the athlete's condition. This opens up a range of possibilities to focus our attention in three main directions: Detecting patterns of improperly executed exercises that may pose the risk of long-term injury. Systems that can compute the real-time execution of exercises. The potential to predict the chance of maintaining an injury provides the opportunity to anticipate and modify the training plan before it occurs.

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