# ARTIFICIAL INTELLIGENCE IN FITNESS AND SPORT CONTEXT: THE LOSS OF RELATIONSHIPS

## INTELLIGENZA ARTIFICIALE APPLICATA AL FITNESS E ALLO SPORT: LA PERDITA DELLE RELAZIONI

**Nicola Lovecchio**
**University of Bergamo**
**nicola.lovecchio@unibg.it**

**Matteo Crotti**
**University of Bergamo**
**matteo.crotti@unibg.it**

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**ABSTRACT**
The applications use smartphones, GPS systems and gyroscopes to analyse movement: speed, angles and arrangement of body segments. These tools allow you to compare movements with ideal models and provide customized feedback. AI in sports contexts is impressive (both for angular analysis and for total body detection in large areas) but it cannot replace the interactive and interpretive role of people and the real teacher-student relationship.

Le applicazioni sfruttano smartphone, sistemi GPS e giroscopi per l'analisi dei movimenti: velocità, angoli e arrangiamento dei segmenti del corpo. Questi strumenti consentono di confrontare i movimenti con modelli ideali e forniscono feedback personalizzati. L'IA in contesti sportivi è impressionante (sia per analisi angolari sia nel rilevamento total body in grandi aree) ma non può sostituire il ruolo interattivo e interpretativo delle persone e la vera relazione tra docente e discente.

**KEYWORDS**
Video feedback, relationships, human interaction, interpretation
Video, relazione, interazione umana, interpretazione

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## Introduction

The theoretical foundations of Artificial Intelligence (AI) had already been established in 1936, when the English mathematician Alan Turing conceived the famous "Turing Machine" (Hopcroft, 1984). This abstract model, capable of executing algorithms and equipped with a potentially infinite tape for reading and writing symbols, is now considered a fundamental pillar of computability and computational theory (Mitchell, 2024). Later, in the 1940s, the concept of "cybernetics" emerged for the first time in history, defined as the study of communication and control processes common to both living organisms and machines. The term was coined by mathematician Norbert Wiener, who focused on analyzing self-regulation and control mechanisms, highlighting surprising analogies between biological organisms and artificial systems. These latter systems are, in fact, capable of adapting to changes in their external environment through behavioral modifications: just like living beings (Carradore, 2013).

Among the first significant contributions in this field was the pioneering work of 1943 by Warren McCulloch and Walter Pitts, who proposed a theoretical model of a neural network inspired by the functioning of the human brain (Wilson, 2008). In their model, each biological neuron is represented as a simplified logical unit: each artificial neuron receives input signals from other neurons through connections (synapses), processes them according to predefined rules, and generates an output (activation) only when the overall signal exceeds a certain threshold. This vision effectively laid the groundwork for the development of modern artificial neural networks (McCulloch & Pitts, 1943).

A further step forward occurred in 1951 thanks to Marvin Lee Minsky, who created the first computer based on neural networks: the "SNARC" (Stochastic Neural Analog Reinforcement Computer). This machine was capable of simulating a network made up of 40 artificial neurons, a remarkable technological milestone for its time (Minsky, 2000). In the following decade, the first functional prototypes of neural networks were developed: mathematical and computational systems designed to emulate, at least partially, the functions of biological neurons (Kelemen, 2007). These experiments opened the door to the emergence of AI, understood as the ability of machines to carry out cognitive operations very similar to those of human beings.

In 1950, Turing took another crucial step by proposing the renowned "Turing Test," (Turing, 2016). The test involved evaluating whether a machine could simulate

human intelligence to the point of being indistinguishable from a human during a conversation: if a human examiner could not tell the difference between the answers given by a human and those given by a machine, the latter could be considered intelligent.
The official birth of AI as a scientific discipline occurred in 1956, during the famous “Dartmouth Summer Research Project on Artificial Intelligence.” This conference is considered the true founding event of the field and brought together scholars from various disciplines, leading to the formalization of the term “Artificial Intelligence” (Moor, 2006).
Another important example is the chatbot Eliza (1966), developed by Joseph Weizenbaum, which was one of the first programs capable of simulating a human conversation through linguistic rules and textual patterns. The program identified keywords in the user’s phrases and responded with pre-set structures, creating the illusion of coherent dialogue. Although it lacked true semantic understanding and merely reformulated the user’s statements, Eliza represented a key milestone in natural language processing and sparked debates about the potential of machines to simulate human intelligence (Berry, 2023).
In the 1970s, the first Expert Systems appeared, designed to replicate human decision-making processes in specific domains. These systems solved problems using structured knowledge bases and inference engines capable of processing logical rules and drawing consistent conclusions (Lindley, 1987). They were successfully adopted in fields such as diagnostic medicine, engineering, and industrial planning
However, by the 1980s, the first limitations began to emerge: these systems were inflexible, difficult to update automatically, and heavily dependent on manual programming while in the 1990s, with the global spread of the Internet and the introduction of GPUs — which provided increased computing power at lower costs — a new era began for AI.
These advancements made it possible to develop increasingly sophisticated algorithms and neural networks capable of tackling complex tasks such as voice recognition, large-scale data classification, and computer vision (Luckin, 2016).
Machine learning, in particular, become a key tool for advanced applications such as robotics, search engines, machine translation, and recommendation systems (Trachna & Asan, 2020).
Today, AI is one of the main driving forces behind technological and social progress. Its impact spans numerous key sectors — from medicine to manufacturing, from

education to cybersecurity, from entertainment to sports science (Lovecchio, 2024a). Thanks to its ability to solve complex problems, optimize processes, and generate innovation, AI continues to redefine the boundaries of what is possible, becoming increasingly integrated into our daily lives (Tuomi, 2019).

## 1. From origins to definitions

Following its development, AI can be defined as the set of systems capable of exhibiting intelligent behavior by analyzing their environment (comprising people) and acting autonomously - at least in part - in order to achieve specific goals (Floridi, 2021). One of the central elements of this definition is the reference to Cognitive Computing, a field that includes advanced technological platforms grounded in scientific disciplines related to AI, such as Machine Learning, Deep Learning, and Signal Processing (Xu et al., 2021). The latter refers to the ability to interpret, transform, and understand complex signals coming from the environment.

Another authoritative definition is provided by the Encyclopedia Britannica, which describes AI as: "The ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings" (www.britannica.com). In other words, it refers to the ability of a digital computer or a robot controlled by a computer to carry out tasks that would normally require human intelligence.

## 2. The impact on leisure time

In recent years, AI has established itself as one of the most pervasive and transformative technologies, capable of deeply influencing not only the professional and industrial sectors but also the more intimate and personal aspects of everyday life, such as leisure time (Makridakis, 2017). In this context, AI is radically redefining the way people entertain themselves, nurture their passions, discover new interests, and improve their mental and physical well-being (Lovecchio, 2024a).

The applications of AI in leisure activities aim to make experiences more personalized, accessible, and engaging, thanks to the ability of intelligent systems to dynamically adapt to the user's preferences, habits, and goals. One emblematic example of this transformation is the integration of artificial intelligence into video and music streaming platforms. Through sophisticated machine learning algorithms, these platforms continuously analyze user behavior (such as viewing history, time spent on specific content, interactions, and ratings) to generate personalized recommendations (Rai, 2020). The result is an increasingly intuitive interface that not only facilitates access to favorite content but also encourages the discovery of films, series, documentaries, or songs that the user might never have found otherwise. Another rapidly growing field regarded the informal learning: AI now makes it possible to acquire new skills (ranging from learning a foreign language to practicing a musical instrument) through interactive, adaptive, and highly engaging paths. Virtual tutors, for instance, can identify specific user difficulties, adjust the difficulty level of exercises, and provide real-time personalized feedback, making learning more effective and accessible even for those with limited time or resources (Wang et al., 2023).

However, the impact of AI on leisure time goes far beyond entertainment. It is increasingly playing a central role in supporting personal well-being. Applications for fitness, relaxation, and meditation leverage predictive models and adaptive algorithms to monitor the user's physical and mental state, offering personalized training or mindfulness programs (Farrokhi et al., 2021). These systems not only adapt to the user's fitness level but can also adjust exercises based on progress, time availability, and established goals, promoting better adherence to wellness routines (Mokmin, 2020).

The growing use of artificial intelligence in leisure activities represents only the beginning of a cultural and technological revolution that is bound to expand in the coming years. Leisure becomes an increasingly rich, meaningful dimension, deeply connected to the digital evolution of our society.

## 3. The impact on physical education

Although AI has been widely explored in educational settings (Ali et al., 2024), its application in gym and sports environments remains relatively limited, with few documented examples of its use in teaching and motor learning (Lovecchio, 2024a). It is undeniable that, in some innovative cases, teachers make use of explanatory videos to engage students in musical routines or to demonstrate complex technical movements such as the high jump using the Fosbury technique. But can we truly believe that simple, repeated viewing (no matter how precise) can replace the role of a teacher in interpreting and conveying the subtle nuances of a learning objective (Lovecchio, 2024a)?

Some applications have succeeded in optimizing the use of smartphone cameras, reducing bulk while leveraging advanced features to perform detailed kinematic analyses. These Apps provide data on segment speed, joint angles, and body part arrangement, allowing users to compare their performance both with elite athlete models and with their own progress over time (Craig, 2013). However, can we really claim that the essence of physical education (aimed at refining motor gestures through) should be filtered through a screen? After all, in a competitive context, an athlete performs in the real world, with the presence of an audience and the pressure of competing participants (Vandoni et al., 2022).

It is undeniable that certain platforms offer highly engaging 3D anatomical learning experiences. Nevertheless, the true innovation of AI applied to sport and physical education lies in Virtual Reality. It can simulate and allow users to experience movement in a way that includes sensations of displacement and interaction with objects, bringing them closer to realistic situations (Craig, 2013). However, neither sport nor friendly competition can be entirely virtual (Lovecchio, 2024a). These activities require physical, contextual interaction, fully immersed in the dimensions of space and time—unless one chooses to embrace the growing trend of E-sports (Russo et al., 2021).

Physical education is, by its very nature, an experiential form of teaching that combines theoretical knowledge with the development of practical skills through direct experience. While it certainly includes a theoretical component, the discipline is strongly oriented toward personal practice, creativity, and the ability to explore (Lovecchio, 2024b). At present, AI is not yet capable of replacing the direct experience and human interaction that are essential in sports education (Lovecchio, 2024a).

Furthermore, a teacher must always consider the individual physical conditions of students, their previous activity levels, their psychological state, and the specific context they are in (the hic et nunc). It is through experience and direct observation that the teacher imparts essential practical criteria for developing the decision-making skills needed to solve problems in real time (Giuriato & Lovecchio, 2020). Sport, in fact, is a constant exercise in problem solving, where decisions and actions must occur within split seconds, with no time to stop and consult an AI system. No matter how advanced, such a system cannot replicate the immediacy and adaptability of human intervention in a dynamic environment.

## 4. The impact on physical education

The integration of AI in sports is profoundly transforming: many aspects of management, performance analysis, and training are now current. It offers tangible benefits both in terms of individual athletic performance and team strategies (Antalamarad & Upadhye, 2024). Below are some of the main areas in which AI is being applied:

a) Performance optimization

- Physiological and performance monitoring: AI-based systems collect and analyze vast amounts of data related to athlete performance, such as heart rate, speed, distance covered, and other physiological indicators. These data points enable training optimization and allow for highly personalized programs aimed at enhancing athletic performance (Santicchi et al., 2024).

b) Injury monitoring and prevention

- Workload management: AI technologies allow real-time monitoring of athletes' workloads, helping prevent overtraining and reducing the risk of repetitive strain or fatigue-related injuries (Seshadri et al., 2021).
- Predictive analysis for athlete health: Through predictive models, AI can anticipate injury risks, making it possible to implement preventive measures and create personalized recovery plans (Teixeira et al., 2021).

c) Talent Identification and development

- Biomechanical and performance assessment: AI technology supports the scouting process by analyzing movement patterns and physical performance. Tools based on biomechanical analysis allow for comparisons between individual performances and those of elite athletes (Nunes Rodrigues et al., 2020).

d) Game Analysis and Strategy

- Game analytics: The analysis of sports events, known as "match analysis" uses AI algorithms to process large datasets, providing accurate forecasts and new insights into player performance and game strategies. These technologies help identify gameplay patterns and adapt tactics in real time (Magni et al., 2024).

e) Individual performance monitoring

- Personalized training and nutrition: AI makes it possible to tailor training programs and dietary plans to the specific needs of each athlete, significantly enhancing the customization and effectiveness of their preparation and development (Stacco et al., 2022).

Integration of Virtual Reality

-Performance simulation and review: Virtual Reality provides simulated environments where coaches and players can train, develop strategies, and review technical content in an immersive way. These environments offer valuable opportunities for tactical and technical preparation in controlled, realistic settings (Scharfen & Memmert, 2019), although they cannot fully replace the experience of actual competition (Lovecchio et al., 2023).

Overall, the use of AI in sports marks a major advancement in how athletic performance is understood, enhanced, and managed, combining data-driven precision with new training and development possibilities (Kunz & Santomier, 2020).

## 5 Examples in specific sport

In addition to its general application across various disciplines, Artificial Intelligence is being used in specific, high-profile sports to provide advantages to coaches and teams (Dhar, 2017). These sport-specific applications are particularly evident in disciplines with widespread popularity and strong media interest. Below, some examples:

- Cricket: technologies such as LBW, Hawk-Eye, and Ultra Edge use AI algorithms to predict the ball's trajectory, significantly enhancing umpiring decisions and informing strategic play. These systems analyze motion data to determine whether a ball would have hit the stumps, with accuracy and reducing human error during critical match moments (Uzor et al., 2024).
- Kabaddi: infrared imaging systems, such as the Hot Spot system, continuously capture images during matches to monitor player performance and identify movement patterns. This helps coaches understand player dynamics and develop more effective tactics in a sport that relies heavily on agility and contact timing (Mali & Dey, 2020).
- Basketball: AI is employed to evaluate shot accuracy and provide real-time feedback, assisting athletes in refining their shooting techniques. By analyzing biomechanics and movement efficiency, AI can highlight flaws or improvements in

posture and release, contributing to improved scoring rates and performance under pressure (Yan et al., 2023).

- Football (Soccer): In this sport, player performance monitoring includes the analysis of running speed, acceleration, and tactical behavior. AI systems assess how players position themselves, react to opponents, and contribute to team formations, allowing coaches to tailor training and match strategies with data-backed insights (Santicchi et al., 2024).

These sport-specific examples highlight how AI is not only revolutionizing performance analysis but also enhancing decision-making and training processes with targeted, high-precision tools tailored to the unique dynamics of each sport (Magni et al., 2024).

## 6 The impact on fitness

The integration of AI into the fitness sector has introduced a completely new dimension in how people experience physical training, making it more personalized, accessible, and technologically advanced. Numerous studies and research programs show that AI-powered applications have a significant impact on individuals' exercise habits, helping to improve adherence to workout routines and the effectiveness of training sessions. These applications stand out for their ability to provide precise recommendations and immediate feedback (Magni et al., 2024). Mobile applications developed with AI technologies allow users to experience training sessions similar to those with a personal trainer - but in a virtual format - eliminating the costs associated with hiring professionals or maintaining gym memberships. These tools, easily accessible via smartphones or tablets, use intelligent algorithms to estimate body posture and offer personalized instructions to ensure exercises are performed correctly, reducing the risk of injury (Mroz et al., 2021). For example, through the use of Blaze-Pose technology (Kim, 2025), users can receive real-time guidance on movement accuracy, with targeted feedback that helps improve posture and technique during workouts. The result is a continuous and engaging interaction between the user and the AI, capable of transforming the fitness experience into something entirely new.
Beyond motor activity, the evolution of AI-based training software is increasingly including personalized nutrition management, creating more comprehensive programs that consider both physical activity and dietary needs. The goal is to offer

accessible solutions to a wide audience through affordable platforms available on any device. One of the most innovative applications in this area is Trainensor (Isiaq, 2022), designed to deliver customized exercises, real-time feedback, automatic rep counting, and posture correction suggestions. It provides continuous support for home or gym workouts. AI makes it possible to develop guided programs that accompany the user in daily practice, reducing the risk of injury through intelligent, real-time movement monitoring (Xiao et al., 2025).

These technologies use deep learning models capable of recognizing, analyzing, and correcting posture with great precision. For example, tools such as MediaPipe (Ram et al., 2024) ecan monitor movement during complex exercises like squats, helping user perfect technique and avoid improper execution. The app essentially becomes a virtual coach that observes, corrects, and guides in real time. This all occurs through systems equipped with motion sensors and algorithms that process visual data collected via the device's camera, providing users with an immersive, interactive, and highly personalized experience (Kim, 2025).

In addition, many of these apps are designed to function on various operating systems, such as Android, with the aim of ensuring not only effective training but also ease of use and economic accessibility.

Another significant advantage is the ability to adapt exercises to the physical characteristics of each person. For instance, some applications calculate the Body Mass Index and generate personalized workout routines based on the results. This capacity to respond instantly to the user's needs during exercise is made possible by image and video processing technologies, which allow real-time performance evaluation. The system offers continuous guidance throughout the workout, simulating the interaction with a human coach while fully leveraging the potential of digital technology (Song, 2024).

Artificial Intelligence applied to fitness is radically reshaping the physical training experience. The digital solutions currently available go far beyond simply suggesting exercises - they offer intelligent and dynamic interactions that can adapt to each user's level and goals. The emergence of AI-based technologies thus represents a fundamental step forward in the evolution of the fitness sector, paving the way for increasingly effective, accessible, and personalized workouts.

With progress in computer science and machine learning, algorithms are continuously updated and reconfigured by developers to be integrated into virtual training programs. However, despite these technological advantages, there can sometimes be an emotional disconnect between the user and the product: a sense of dehumanization that may affect user engagement and the perceived value of the service (Kim & McGill, 2024). Indeed, modern apps also employ image and video processing methods (through libraries such as OpenCV; Ram et al., 2024) to track user movements via smartphone cameras, offering immediate feedback on exercise execution.

AI-based fitness applications can identify activities, estimate poses, and classify exercises using machine learning algorithms. They can also integrate data from external sensors, cameras, or wearable devices to perform real-time performance analysis in real-world settings.

These applications offer features such as automatic exercise correction when errors are detected, progress tracking, and personalized exercise suggestions based on user needs and results. The introduction of AI in this context also enables the analysis of overall user data, such as training level and activity history, to generate relevant and motivating suggestions. This marks a significant shift toward a new fitness experience.

## 6.1 Limitation

Despite their many potential benefits, AI technologies in the fitness sector also present some limitations. One of the most significant concerns is the data dependency: algorithms require massive amounts of labeled data in order to learn effectively. This makes them unsuitable for contexts where data is scarce or of poor quality (Nivedhaa, 2024). Furthermore, true personalization can be lacking: many algorithms rely on generalized models that do not always adapt well to the specific needs or preferences of each person.

Another challenge lies in real-world validation. Many AI solutions have yet to be thoroughly tested in concrete educational or athletic settings, making field-based research essential to verify their actual effectiveness: people, instead, perform action in their room or in domestic space (Kim & McGill, 2024). While the technology offers great potential, technical issues persist. For example, pose estimation accuracy can vary significantly: incorrect movement recognition can negatively affect the quality of training and lead to misleading feedback.

The process of collecting and annotating data is also complex and often subject to bias (Nivedhaa, 2024), which can compromise the quality and reliability of AI-generated recommendations. Additionally, these applications may be limited in

their usefulness for users who fall outside standard physical parameters or who have injuries, health conditions, or specific motor limitations.
Moreover we have to consider, also, external factors, such as camera quality, lighting conditions, or internet connectivity, can also impact the effectiveness of AI-based virtual instruction. Moreover, individuals who are less technologically savvy may struggle to use applications that are too complex or not intuitive enough. These limitations underline the need for ongoing technical and pedagogical advancements to make AI-driven fitness solutions more inclusive, adaptable, and user-friendly.
Despite these challenges, AI-powered fitness applications are playing a crucial role in transforming the way people approach physical training, offering innovative tools that continue to evolve and improve.

## 7 Consideration in education

As a quick and immediate reflection we can express that AI cannot replace the empathy, adaptability, and nuanced judgment of a qualified human instructor/trainer.
AI in sport is somewhat like a new star player arriving on the team, promising to solve every problem: faster, more accurate, able to analyze every movement and even predict what's going to happen on the field. At first, it seems like the perfect revolution. But then, the first questions begin to arise: is it becoming too intrusive? Will athletes end up reduced to mere numbers in a database? Will coaches trust algorithms more than their own experience? And above all: will sport still be fun, or will it turn into a cold battle of data, percentages, and graphs?
Today, sport is no longer just about sweat, effort, and instinct. It's also about numbers, algorithms, and interactive dashboards. Every gesture of an athlete can be recorded, measured, broken down, and reconstructed as data that describes exactly what needs improvement and how to do it. Where once the keen eye of a coach could spot a drop in performance; now it's Ai speaking its scientific language: "-10% about endurance, -3% about power, compromised sleep quality." Very useful from a performance point of view, but also unsettling, because when everything is monitored and measured, the risk is that the pursuit of numerical perfection might overshadow the pure joy of the game (Ascione, 2023).
And what happens if the machine suggests an improvement of speed by 2%, but the athlete just can't? Do you develop a form of digital performance anxiety? Do

you feel inadequate? Do you self-recover for “underperformance”? One of the major promises of AI is personalization: tailor-made workouts based on each individual athlete’s unique characteristics. Gone are the one-size-fits-all programs. Now each plan considers joint load, effort distribution, recovery habits. But here comes another doubt: what if the athlete feels in top form, but the algorithm says it’s time to rest? Or, conversely, if they need a rest period, and AI insists there's still 7% energy left to burn? Who has the final say: the human brain or the processor?
To this, we must add the delicate issue of privacy. Where do all the collected data go? Do they remain within the coaching staff’s devices, or can they be accessed by managers or sponsors: perhaps to influence contract decisions or roster changes? Imagine a basketball player sitting in the court to negotiate a renewal and being shown a graph indicating a 1.5% drop in average high jump performance. Sport risks becoming a giant data marketplace, where athletes are assessed not for their human and technical value, but for their statistics.
Even the role of the coach is at risk of being diminished. Once a guide, a motivator, an emotional and strategic reference point, the coach might now be reduced to a data analyst, more focused on spreadsheets than on the look in a player’s eyes. A computer might tell you an athlete ran less than usual but does it know they had a fight with their partner that morning? Does it recognize if they’re going through a period of insecurity, if they need to be heard or encouraged with a word, rather than a new training chart?
Technology is undoubtedly a valuable resource, but it can never replace the sensitivity, intuition, and empathy at the heart of the educational and sporting relationship. We risk introducing a new form of performance pressure: not just from the coach or the fans, but from the algorithm itself. If the machine define an improvement of 3% and you don’t manage it, what happens? You feel inadequate, frustrated, maybe even guilty. The obsession with data could turn sport into a contest against numbers rather than opponents, undermining the psychological safety of athletes.
And then there's the theme of unpredictability. AI is designed to reduce uncertainty, to analyze opponents, predict strategies, and neutralize surprises. But it’s exactly the unexpected, the creative error or the unplanned genius passage, that make sport; so special. If both teams analyze everything down to the millimeter and prepare perfect counter-strategies we’ll be watching matches that are increasingly similar, calculated, and less exciting. Where will creativity, intuition go?

## Conclusions

AI can be an extraordinary tool, but it must be managed with balance and awareness. Coaches must remain guides, not just data interpreters. Athletes must still be able to listen to their bodies and their instincts, without becoming prisoners to statistics. And sport must continue to be human, with all its contradictions, surprises, and genuine emotions. Because no algorithm, no matter how advanced, will ever be able to calculate the adrenaline of a last-second goal or the unrepeatable joy of an unexpected victory.

## Author contributions

The text is the result from a common reflection. In particular, Nicola Lovecchio wrote the introduction and the paragraph 1 and 3 while Matteo Crotti wrote the paragraphs 2, 4, 5, 6, 7. The conclusion are the result of joint work.

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