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The Use of Computational Linguistics in Developing Artificial Intelligence Tools for Adaptive Sports

DAOUD Messaoud ^{1*}

¹ University of Algiers 2 – Abou El Kacem Saadallah (Algeria),
messaoud.daoud@univ-alger2.dz

Abstract:

The study of the role of computational linguistics in developing artificial intelligence tools directed at adaptive sports addresses a central issue: How can computational linguistics be employed to develop AI systems that support the practice of adaptive sports by blind individuals? The importance of language emerges as a fundamental motor interface for the blind, enabling them to interact with the sports environment through precise auditory instructions.

The study showed that technologies such as Text-to-Speech (TTS), Automatic Speech Recognition (ASR), and Natural Language Processing (NLP) contribute to building intelligent systems capable of real-time interaction with blind athletes. The results also emphasize the necessity of designing specialized linguistic databases and conducting phonetic analysis of sports discourse to provide effective and safe guidance. The study calls for strengthening collaboration between the fields of applied linguistics, artificial intelligence, and physical education sciences in order to develop an inclusive sports environment adapted to the needs of visually impaired individuals.

Keywords: Computational Linguistics; Artificial Intelligence; Adaptive Sports; Blind Individuals.

**Corresponding author*

1. Introduction:

Amidst rapid technological transformations, sports have become one of the vital domains witnessing increasing openness to intelligent solutions, particularly regarding the inclusion of people with disabilities. Among the emerging trends that have gained growing importance is the concept of adaptive sports, which focuses on adjusting sports activities to suit the abilities and needs of individuals with physical or sensory impairments. This includes the blind, for whom sports represent an effective means of social integration, psychological balance, and self-confidence enhancement.

Adaptive sports for the blind rely primarily on activating sensory alternatives, most notably hearing, which makes verbal communication and auditory interaction central elements in the conduct of athletic activity. The blind athlete depends on auditory instructions received during movement, replacing visual cues. This makes language a motor interface with a dual function both cognitive and physical. Hence, a complex and precise relationship emerges between language, communication, and movement one that requires careful linguistic engineering within specific sports contexts.

In this regard, artificial intelligence has positioned itself as a promising support tool by enabling the development of intelligent voice-based applications to guide blind individuals during sports practice, accompany them during training or competition, and analyze their motor performance in real time. However, the effectiveness of these tools remains conditional upon their ability to understand and generate natural language accurately and contextually—this is where computational linguistics plays a critical role, as the field that bridges linguistic sciences and computer sciences and aims to enable machines to understand, generate, and analyze human discourse.

Thus, the central issue of this study is defined by the following question: How does computational linguistics contribute to the development of artificial intelligence tools directed at adaptive sports?

This includes sub-questions concerning the nature of sports language addressed to the blind, the characteristics of auditory-motor interaction, and the extent to which computational linguistic models can simulate this type of discourse.

The significance of this topic lies in its contribution to the intersection of multiple fields: language, artificial intelligence, physical education, and disability studies. Moreover, this study offers an opportunity to consider the development of

more precise and effective intelligent training tools that help improve the performance of blind individuals and enhance their independence. The article will adopt a descriptive-analytical approach, presenting theoretical concepts and analyzing practical models within an integrative perspective that connects language, technology, and movement.

2. Computational Linguistics and Natural Language Processing:

Computational linguistics is a scientific field that brings together the study of language and computing. It aims to analyze natural languages using artificial intelligence techniques and mathematical algorithms. This field began to emerge seriously with the advancement of computing in the twentieth century and has now become essential in the development of educational tools, machine translation, and text analysis.

2.1. Computational Linguistics:

Computational linguistics can be defined as “an interdisciplinary system between linguistics and computer science. One part belongs to linguistics, concerned with language, and the other to computing, focused on translating language into mathematical symbols and relationships understandable by machines, or adapting natural language to serve as a means of dialogue with the computer thus enabling the machine to perform many of the linguistic tasks carried out by humans” (Mahmoudi, 2014, p. 108).

It is a field concerned with applying computing technologies to the analysis and use of natural languages in various technological applications such as machine translation, text analysis, speech recognition, and search engine design. This field is based on developing algorithms and software capable of processing language in ways similar to human behavior and analyzing the components of linguistic texts, whether at the level of words, sentences, or full texts. This contributes to developing tools that support e-learning and big data analysis related to language.

2.2. Natural Language Processing:

Natural Language Processing (NLP) is one of the most prominent areas of artificial intelligence that aims to enable machines to understand and interpret human language. These technologies have evolved rapidly over recent decades and now play a vital role in daily applications such as search engines, machine translation, and intelligent voice assistants.

“NLP is witnessing the emergence of innovative approaches. Some of these are based on linguistic principles that seek to understand the rules and structures of language, while others adopt machine-based perspectives that model language at its various levels. In reality, the methods used in NLP are characterized by a degree of flexibility that allows for the integration of linguistic and statistical data in a way that achieves optimal results in natural language computing applications” (Amer & Hamdan, 2020, p. 476).

NLP is also defined as a subfield of artificial intelligence that focuses on human-computer interaction through language. It involves developing algorithms capable of analyzing and understanding linguistic texts and speech with the aim of enabling natural and smooth communication between humans and machines. It relies heavily on traditional linguistic studies such as grammar and semantics and requires the use of statistical analysis and machine learning techniques to understand different contexts.

2.3. Fields of Computational Linguistics and Natural Language Processing:

Computational linguistics is an interdisciplinary domain combining linguistics and computer science, concerned with studying natural language using computational tools and techniques. The goal is to enable computer systems to analyze, understand, and generate human language, whether written or spoken, in ways that allow for the development of intelligent applications capable of efficient linguistic interaction with humans. This field is considered a foundational pillar in building AI systems that interact with language, such as machine translation, voice assistants, interactive robots, and search engines.

One of the most prominent fields within computational linguistics is automatic speech processing, which includes converting spoken language into written text (Automatic Speech Recognition – ASR) and vice versa (Text-to-Speech – TTS). This is achieved using language models capable of recognizing and analyzing sounds in various contexts. Computational linguistics also includes an important subfield: Natural Language Processing (NLP), which aims to make machines capable of understanding the implicit meaning of texts and inferring semantic and structural relationships between words and expressions.

Additionally, acoustic modeling focuses on building accurate digital representations of spoken language by analyzing the physical features of human speech (such as pitch, speed, and frequency). This enables the design of speech systems that sound more natural and closer to human speech.

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The importance of computational linguistics lies in its direct relationship with Human–Machine Interaction. The results of this field are used to improve the ability of intelligent systems to understand users and respond to them in a linguistically natural way especially in cases where language is the only communication channel, as with the blind in technological environments. Thus, computational linguistics is considered the cornerstone for developing intelligent voice interfaces that are context-aware and adaptable to users' need

4. Definition of Artificial Intelligence:

Artificial intelligence (AI) is a broad and complex field within computer science that aims to develop systems capable of performing tasks that typically require human intelligence. These tasks include learning, reasoning, problem-solving, understanding, and perception. The definition of AI varies depending on the context in which it is used, but it generally focuses on the ability of machines to process data and make decisions in a manner similar to that of humans.

4.1. Definition of Artificial Intelligence:

Artificial intelligence is defined as “a branch of computer science concerned with designing systems, programs, and applications capable of performing tasks and operations usually considered attributes of human intelligence. It seeks to enhance the performance of computer systems so they can learn from data and experiences and perform tasks autonomously and intelligently” (Bougalem, 2024, p. 18). This definition highlights AI's capacity to learn from data and extract results that can be used to improve performance in various tasks. It also clarifies that AI is not limited to executing programmed commands but extends to the development of new strategies and adaptation to changing information.

4.2. Applications of Artificial Intelligence in the Sports Field:

AI applications span a wide range of fields from healthcare and manufacturing to education and media. In healthcare, AI is used to develop systems capable of analyzing medical images and diagnosing diseases with high accuracy.

"AI can accelerate the process of identifying and developing new drugs, in addition to repurposing existing drugs for new uses. It also improves diagnosis and treatment, enhances fetal health, predicts and monitors epidemics and chronic diseases, improves primary healthcare services, and supports medical research and drug discovery" (Al-Asad, 2023, p. 170).

In the field of education, “there is potential for learning and self-development through AI programs such as learning machines, logic, self-correction, and self-programming” (Moqatel & Hosni, 2021, p. 121).

Currently, “AI applications in sports have gone beyond early products, which were limited to wearable chips used by players to track distance covered, physical condition, movement on the field, and heart rate. New applications now include analyzing technical errors during matches, monitoring competitors, analyzing their performance, and identifying their mistakes through data analysts who provide coaches with results in a compact disc saving time and enabling a more professional and high-quality coaching process, especially in improving technical performance during training sessions” (Al-Iyadhi Issam & Oshb Al-Khadr, 2021, p. 97).

“No one disputes that preparation for tournaments involves training camps to study strengths and weaknesses of sports teams. However, such preparations can be influenced by other variables such as the type of sports facilities like the playing surface and sometimes refereeing decisions that can impact the entire match. In light of current technological developments, using AI in sports facilities has become essential, through technologies such as Goal Line Technology (GLT) and Video Assistant Referee (VAR), which provide additional support for referees by helping them make faster and more accurate decisions. GLT enables precise assessments of whether the ball has crossed the goal line, and VAR allows for reviewing decisions differing from traditional offside VAR in that humans make decisions regarding frame selection or line placement” (Al-Iyadhi Issam & Oshb Al-Khadr, 2021, pp. 99,100).

“Smart systems have become the global language in sports facility management and are now a key factor in determining the identity and value of sports venues. These include smart gates, electronic sports archiving, logistics services, lighting systems, and intelligent field surface technologies” (Al-Iyadhi Issam & Oshb Al-Khadr, 2021, p. 100).

In recent years, the sports field has witnessed remarkable development due to the integration of AI technologies, which have become essential in supporting training, improving performance, and developing evaluation methods. AI enables systems to analyze motor and physical data, provide real-time feedback, and customize training plans individually based on each athlete’s actual performance. These technologies are now widely used across various professional sports,



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contributing to injury prevention, improved physical readiness, fatigue monitoring, and tactical planning.

AI applications in sports include tools such as movement pattern recognition using smart sensors, physical performance assessment software, augmented reality systems, and virtual training platforms. Machine learning and natural language processing techniques have also contributed to developing voice interaction interfaces, allowing athletes to interact with training systems through voice commands enhancing usability and response speed.

In adaptive sports, AI has gradually begun to support athletes with disabilities through tools specifically designed to accommodate their physical and sensory needs. These tools include talking devices that provide real-time voice instructions for the blind during training, motion-tracking systems that rely on sound instead of visuals, and intelligent voice-guided applications that assist athletes in navigating the sports space. Other innovations include talking balls, interactive headsets, and wearable devices that translate motor signals into voice instructions enabling more autonomous interaction for blind users.

Thus, AI is paving the way for a new sports experience based on voice interaction and real-time processing, highlighting the need for linguistic and technical precision. This underscores the central role of computational linguistics in developing such applications

5. Definition of People with Special Needs:

The term "people with special needs" is a modern designation for individuals who experience deficiencies in physical, mental, psychological, behavioral, educational, or linguistic abilities compared to their peers in society. Their performance is lower than that of ordinary individuals in certain areas of life, and they therefore require assistance to adapt to society and be able to live normal lives. The term "disabled" is no longer widely used in most countries, including within institutions and agencies especially those involved in health, educational, or social care due to its stigmatizing connotations and its implication of deformity or disorder. The term "disabled" also carries negative connotations that can cause psychological harm to the person with special needs. (Fayram Al-Tayeb, , 2021, pp. 286,287)

5.1. Individuals with Visual Impairments:

From a medical perspective, a blind person is defined as one whose visual acuity in the better eye, even after correction, is less than 6/60 or 20/200, or whose

visual field is narrower than 20 degrees. This definition is legally adopted in the United States and most European countries.

5.2. Total Blindness:

A totally blind person is unable to perceive light and learns through senses other than sight. Education is conducted using tactile methods such as the Braille system for reading raised letters.

5.3. Partial Blindness:

A partially blind person learns through vision but with the help of visual aids. They may be able to distinguish light from darkness or identify some colors with difficulty. Their visual acuity does not exceed 3/60, according to medical testing.

6. The Concept of Adapted Sports:

This refers to sports and games that are modified to the extent that individuals with disabilities who cannot participate in standard sports can do so. These include various developmental and preventive programs that involve sports and games modified to suit the type and severity of disability, and are adapted according to the interests, capabilities, and limitations of the individuals concerned. (Ben Abdallah, El Hadi, and Habara, , 2018, p. 339)

Adapted sports refer to the process of developing and modifying sports practices to suit the abilities of individuals with special needs, based on the type and degree of disability. This involves a series of procedures applied to some sports activities, including physical performance adjustments or legal modifications, allowing individuals with disabilities to participate in sports in a safe and effective manner. (Fayram, 2021, p. 286)

“Sports activities are considered an essential part of general education. Games have been modified to improve environmental development and general health and fitness. These include various developmental and preventive programs that encompass sports and games tailored to different types and degrees of disability.” (Jaami, Ousmaïl, and Moissi, 2022, p. 338)

Adapted sports aim to achieve a range of objectives that go beyond improving physical fitness or health. They also seek to enhance self-confidence, strengthen social interaction, and develop motor and cognitive skills. These activities contribute to the integration of people with disabilities into public life and offer them equal opportunities to exercise their right to physical activity and recreation.

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The groups benefiting from these sports include individuals with physical, visual, auditory, and intellectual impairments. Among these, the blind are among the most in need of adapted physical activity, as most traditional sports rely heavily on sight. This underscores the importance of using alternative senses primarily hearing and touch as well as adopting precise auditory guidance strategies.

Despite existing efforts, blind individuals still face several challenges in practicing sports. These include the absence of visual guidance, difficulty navigating within sports spaces, and the need for immediate verbal instruction responses. The lack of specialized equipment and the scarcity of qualified coaches further hinder their full participation. Hence, there is an urgent need to utilize smart, voice and language-based technologies to assist this group paving the way for the role of computational linguistics and artificial intelligence in supporting this domain

7. Applications of Computational Linguistics and Artificial Intelligence in Adapted Sports:

Applications of computational linguistics and artificial intelligence in adapted sports represent an emerging field aimed at creating more effective training experiences for the blind. In this context, language plays a central role in facilitating communication between the user and the machine. This interaction is built upon a set of auditory and cognitive technologies that allow the blind user to interact in real time with the digital sports environment.

7.1. Speech Systems and Auditory Sports Guidance:

These systems rely on advanced speech processing technologies, most notably Text-to-Speech (TTS) and Automatic Speech Recognition (ASR). TTS technology enables the machine to convert written commands into clear auditory instructions that the user can hear and execute, while ASR allows for the recognition and automated analysis of spoken user commands, facilitating fast and dynamic interaction. These technologies are currently used in sports training applications for the blind as well as in refereeing and guidance tasks during games or competitions, where voice is the sole communication channel between the athlete and the environment.

7.2. Natural Language Understanding in the Training Environment:

Effective interaction in adapted sports requires that the system be capable of generating and interpreting auditory commands within specific movement

contexts. This means the application must distinguish between the athlete's intentions and different movement patterns. Voice commands are not isolated from physical actions but are either accompanied by or immediately precede them. Therefore, intelligent systems rely on Natural Language Processing (NLP) techniques to analyze and interpret the sentences addressed to or by the user based on the training context, allowing for accurate and automatic guidance.

7.3. Analysis of Spoken Sports Discourse:

The language used in sports contexts, especially when directed at the blind, has particular linguistic features: it is concise, direct, and context-based. Therefore, analyzing spoken discourse in this environment requires understanding sentence structures and identifying key words that elicit immediate physical responses. Computational linguistics contributes by analyzing the syntactic, semantic, and functional properties of commands, aiding in the development of language models capable of predicting and precisely executing the expected responses from the athlete.

7.4. Designing Intelligent Voice Communication Interfaces:

To ensure effective interaction between the blind athlete and the intelligent system, it is essential to design voice communication interfaces based on linguistic databases tailored to the sports context. These databases should reflect the nature of the activities, include common commands, and be adapted to the temporal pace of training sessions. Here, phonetics and applied linguistics play a crucial role in analyzing human speech and adjusting its pitch, speed, and intensity to create synthetic voices that closely resemble natural human speech. These sciences also assist in evaluating the effectiveness of speech models through simulation of the blind athlete's real-world experience

8. Challenges and Future Prospects:

Despite the promising opportunities offered by computational linguistics and artificial intelligence (AI) technologies for the development of adapted sports for the blind, this field still faces several technical, social, and educational challenges that hinder the realization of fully efficient and effective applications. This situation calls for a review of these obstacles and the proposal of future developmental perspectives.

8.1. Technical and Linguistic Challenges:

Artificial intelligence represents a major opportunity to improve efficiency and productivity across various fields by analyzing large-scale data and providing precise insights that help improve decision-making and reduce human error. As



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noted, “AI systems can process vast amounts of data quickly, accurately, and simultaneously, enabling faster and more efficient computations” (Hashmi & Miliani, 2024, p. 51).

However, AI faces a range of technical and ethical challenges. One of the most significant is algorithmic bias, where skewed data can lead to unfair outcomes. It is worth noting that “bias arises when AI systems make more precise decisions, which may be unfair to individuals or certain groups. Although bias existed previously in society, concerns have grown that AI might amplify its scale” (Benin, 2024, p. 208).

Sports environments are dynamic and complex, which presents major difficulties for intelligent systems in accurately recognizing speech. Noise from movement, players’ voices, or echoes in enclosed spaces all affect the system's ability to distinguish voice commands. Moreover, the speed required for interaction allows no delay between voice command input and machine response, necessitating extremely real-time and precise linguistic analysis and interaction systems.

Another challenge lies in the limited synchronization between language and movement when the system fails to instantly link a spoken sentence with its expected physical context. Even a split-second delay between linguistic and physical action can confuse the trainee and negatively impact performance or safety.

8.2. Social and Educational Challenges:

The challenges are not limited to the technical dimension; they also extend to the human and educational dimensions. Many blind users may express hesitation or resistance to using AI technologies, either due to a lack of confidence or insufficient technological skills. Interaction with intelligent voice systems requires dual training: linguistic (in terms of understanding and pronunciation) and physical (in terms of real-time response to instructions).

8.3. Future Prospects:

AI is among the fastest-developing fields in modern technology, with ongoing advances in learning and adaptability. “Artificial intelligence is characterized by many features that distinguish it from traditional software, including intelligence, self-learning, decision-making, perception, creativity, innovation, and problem-solving” (Hashmi & Miliani, 2021, p. 50). It is expected

that the use of AI will continue to expand into new fields, leading to radical transformations in how tasks are performed and data are analyzed.

Despite current challenges, the future prospects remain promising. One of the most anticipated developments is the design of multilingual and multidialectal linguistic interfaces that enable more flexible and inclusive interaction for users from diverse linguistic backgrounds. Additionally, these systems are expected to integrate technologies capable of interpreting voice tone and emotional state, adapting interaction accordingly. Research is also heading toward personalized intelligent training systems that consider each individual's motor and linguistic particularities, providing tailored and precise audio-motor interaction.

Thus, the future of adapted sports under the influence of artificial intelligence hinges on researchers' ability to overcome present challenges and build humane technological systems that account for both linguistic and motor contexts simultaneously.

9. Conclusion:

The foregoing analysis demonstrates that integrating computational linguistics into AI-based tools for adapted sports is not merely a technical option but a fundamental necessity for enabling blind individuals to participate in sports more independently and effectively. Automated language processing allows intelligent systems to comprehend athletes' commands and generate precise and timely auditory responses that align with the nature of physical performance and the conditions of the sporting environment.

It has become evident that language plays a central role in human-machine interaction, particularly for the visually impaired, who primarily depend on auditory cues for communication, movement, and responsiveness. Hence, any linguistic shortcoming or flaw in voice system design may undermine effectiveness or even pose risks during practice. Consequently, computational linguistics constitutes a structural component in the development of intelligent applications capable of producing natural artificial speech, understanding physical context, and engaging in real-time user interaction.

In light of these findings, there is an urgent need to strengthen interdisciplinary scientific research that bridges applied linguistics, artificial intelligence, and physical education sciences. This will allow for the development of integrated training models that consider the specificity of language, the complexity of motor performance, and the demands of voice-based interaction in sports settings. Investment in this domain not only advances technical innovation

but also reinforces values of inclusion and equality, offering the blind community new horizons of presence and participation.

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