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**Using Artificial Intelligence Technologies to Analyze Technical and Tactical
Actions in Boxing**

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***Abstract.** The article discusses the potential of technologies for analyzing technical and tactical actions in boxing, with an emphasis on the theoretical aspects of their implementation and use. **The purpose of the study** is to explore the capabilities of modern machine learning algorithms, computer vision, and big data analytics to improve the accuracy of boxing technique assessments and reduce the subjectivity of traditional analysis methods. **Research methods** include theoretical approaches such as analysis, synthesis, abstraction, induction, and deduction, as well as empirical methods involving the use of real data on the technical and tactical actions of boxers. **The results of the study** indicate the significant potential of artificial intelligence technologies in the development of individual training programs that take into account the specific needs of boxers. The article analyzes modern AI-based training applications that offer a variety of features to improve athletes' physical performance and technical skills. The use of video analysis, motion tracking, and biometric monitoring systems allows coaches to obtain detailed information about the execution of technical elements. Key data for collection, such*



*as the speed and accuracy of punches, as well as physiological indicators, are identified, enabling the creation of structured analytical reports for coaches, which may include graphical representations of data and recommendations for optimizing the training process. **The study's findings** emphasize that the introduction of artificial intelligence technologies can significantly improve the effectiveness of boxer training, but there are challenges related to the high cost of equipment, the need to train coaches and athletes, and ethical issues regarding data collection and use. Further research should focus on developing strategies to overcome these challenges and optimize the use of artificial intelligence in boxing.*

Keywords: *boxing, technical and tactical actions, machine learning, computer vision, big data analytics, video analysis, individualized training, biometric monitoring, training effectiveness.*

Використання технологій штучного інтелекту для аналізу техніко-тактичних дій у боксі

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Анотація. *У статті розглядається потенціал технологій для аналізу техніко-тактичних дій у боксі з акцентом на теоретичних аспектах їх упровадження та використання. **Мета дослідження** полягає у вивченні можливостей сучасних алгоритмів машинного навчання, комп'ютерного зору та аналітики великих даних для підвищення точності оцінок боксерських технік і зменшення суб'єктивності традиційних методів аналізу. **Методи дослідження** охоплюють теоретичні підходи, такі як аналіз, синтез, абстрагування, індукція та дедукція, а також емпіричні методи, що*



*передбачають використання реальних даних про техніко-тактичні дії боксерів. **Результати дослідження** свідчать про значний потенціал технологій штучного інтелекту у формуванні індивідуальних програм тренувань, які враховують специфічні потреби боксерів. У статті проаналізовано сучасні додатки для тренувань, створені на базі штучного інтелекту, які пропонують різноманітні функції для вдосконалення фізичних показників і технічних навичок спортсменів. Використання систем відеоаналізу, трекінгу рухів і біометричного моніторингу дає можливість тренерам отримувати детальну інформацію про виконання технічних елементів. Визначено ключові дані для збору, такі як швидкість і точність ударів, а також фізіологічні показники, що дає змогу створювати структуровані аналітичні звіти для тренерів, які можуть містити графічні представлення даних і рекомендації щодо оптимізації тренувального процесу. **Висновки дослідження** підкреслюють, що впровадження технологій штучного інтелекту може суттєво підвищити ефективність підготовки боксерів, однак існують виклики, пов'язані з високими витратами на обладнання, необхідністю навчання тренерів і спортсменів, а також етичними питаннями щодо збору та використання даних. Подальші дослідження повинні зосередитися на формуванні стратегій для подолання цих викликів та оптимізації використання штучного інтелекту в боксі.*

***Ключові слова:** бокс, техніко-тактичні дії, машинне навчання, комп'ютерний зір, аналітика великих даних, відеоаналіз, індивідуалізація тренувань, біометричний моніторинг, ефективність підготовки.*

Problem statement. In the modern sports environment, particularly in boxing, there is an increasing integration of artificial intelligence (hereinafter referred to as AI) technologies into the analysis of athletes' technical and tactical actions. This is due to the need to improve the effectiveness of boxers' training,



optimize training processes, and improve performance in competitions. However, despite significant progress in the development of machine learning and computer vision algorithms, there is still a lack of research that systematically studies the specifics of AI implementation in boxing.

The relevance of this problem is caused not only by the need to improve methods of analyzing sports actions, but also by the importance of ensuring the competitiveness of athletes at the international level. In the context of rapid technological development, insufficient adaptation of traditional methods of analyzing technical and tactical actions can lead to a loss of potential opportunities for improving results.

In addition, given the globalization of sport and the increasing competition between countries, there is a need to introduce innovative technologies into the training process, which will not only improve the quality of boxers' training, but also ensure more accurate monitoring of their achievements and identification of weaknesses in their technique. Therefore, research into the application of AI technologies for analyzing technical and tactical actions in boxing is of great importance both for the development of theoretical aspects of the sport and for the formulation of practical recommendations for coaches and athletes.

Analysis of recent studies and publications. Since boxing is a complex sport that requires a high level of technical and tactical training, it is important to determine the possibilities of applying artificial intelligence technologies to improve these aspects of the training process.

In modern research, there is a noticeable trend towards combining pedagogical, psychological, and digital approaches. In particular, in the work of A. Vorontsov [1], a system of specialized tests is proposed for assessing the technical and tactical skills of female boxers at the basic training stage. As part of a pedagogical experiment, the author proved the effectiveness of the module for determining the level of technical preparedness of athletes.



In the context of the development of innovative means of technical and tactical training in combat sports, D. Petrushin and E. Krenikova [2] investigated the socio-historical foundations of the formation of multimedia technologies that provide for the processing of large amounts of data and the modeling of competitive situations. Similar attention to digital tools is demonstrated by L. P. Dolzhenko and K. R. Masyuk [3], who analyze the advantages of distance learning, gamification, and virtual reality in the physical education of students.

The development of digital analytics in sports in Ukraine is considered in the works of D. S. Volsky [4], which substantiates the need to create complex algorithms for optimizing sports training and studies international experience in their application. V. S. Starikov, M. L. Bugayova, and O. M. Polyanychka [5] summarized approaches to the technical, physical, and psychological training of athletes, systematizing current research trends in the field of boxing.

Within the framework of interspecies analysis, O. Broyakovsky, O. Alekseev, and A. Rebryna [6] studied the implementation of artificial intelligence in table tennis, emphasizing its role in the formation of personalized training programs through the analysis of athletes' technical and tactical actions. At the same time, N. Y. Zozulia, A. M. Tregub, and I. V. Telelima [7] are researching the impact of digital technologies on social communications, in particular the transformation of interactions between people and organizations under the influence of artificial intelligence.

A special emphasis on the ethical and prognostic aspects of the application of artificial intelligence is made in the work of A. Chepelyuk, V. Bigun, and O. Golub [8], which examines the issues of sports event analytics and the moral and legal challenges of digitalization. Further research by P. Yu. Andreeva, O. V. Dubovoy, and V. V. Dubovoy [9] discusses the need for active use of digital technologies in physical education, professional training, and adaptation of the educational process to the conditions of the COVID-19 pandemic.



In conclusion, Yu. O. Kharitonova, O. I. Kharitonova, and Yu. O. Tolmachevskaya [10] draw attention to the expanding role of artificial intelligence in sports, particularly in the organization of the training process and the development of new forms of sports activities, such as e-sports. The authors emphasize the need for legal regulation to ensure the fairness of competitions and compliance with ethical principles in sports.

Given the limitations of previous scientific research, the proposed study emphasizes the need for a systematic approach to the use of artificial intelligence technologies in boxing. Such an approach can significantly improve the effectiveness of competitive activities and the overall level of preparedness of athletes. The scientific value of the work lies in the development of new methods for analyzing and evaluating the technical and tactical actions of boxers, which will contribute to their professional growth and strengthen their competitive positions in the international arena.

Identification of previously unresolved parts of the general problem.

Despite a significant number of studies, there is insufficient attention in the scientific literature to the integration of artificial intelligence technologies into the systematic analysis of sports performance. Most works focus on traditional assessment approaches, such as video analysis or subjective observations by coaches, which limits the possibilities for a deeper understanding of the specifics of technical and tactical actions in boxing. Existing publications hardly take into account the potential of machine learning and computer vision algorithms capable of automating the analysis process and minimizing the subjectivity of evaluation. This lack of analytical approaches creates gaps in knowledge about the effectiveness of various boxing techniques and tactics.

In this context, the aim of the proposed study is to overcome these limitations by introducing innovative methods of analyzing boxing actions using artificial intelligence technologies. The use of machine learning algorithms not only



automates the process of data collection and processing, but also ensures a more accurate and objective assessment of the technical and tactical components of training.

Thus, the implementation of this approach will contribute to the formation of new knowledge in the field of sports science, opening up prospects for improving the training process, increasing the effectiveness of coaches' management decisions, and increasing the competitiveness of athletes in the international arena. Thus, this work is important for modernizing the system of training boxers and developing intellectual technologies in sports practice.

Formulation of the article's objectives (task setting)

The purpose of the article is to analyze the potential of artificial intelligence technologies in the study of technical and tactical actions in boxing, taking into account the theoretical principles of their implementation and practical application.

The tasks of the article are

- 1) to investigate how modern machine learning and computer vision algorithms are used for detailed analysis of the technical and tactical actions of boxers, increasing the accuracy of assessments and reducing the subjectivity of traditional methods;
- 2) to formulate recommendations for the implementation of artificial intelligence technologies in the training of boxers, in particular the creation of a system for collecting and processing data on technical and tactical actions;
- 3) describe the potential benefits of using artificial intelligence technologies and outline the challenges and limitations associated with their application in a sports context, with a view to developing strategies for further research in this area.

Presentation of the main research material. Sport is undergoing significant transformations thanks to the integration of modern technologies, among which AI plays an important role. This innovative approach opens up new opportunities for



analyzing and improving the technical and tactical actions of athletes, which is especially important in such rapidly changing disciplines as boxing. Tracking groups of tactical actions using AI is carried out through the analysis of boxers' preparatory, offensive, and defensive actions. Preparatory actions, which include taking an advantageous position and using introductory movements, are identified using computer vision and machine learning algorithms, which makes it possible to determine the optimal strategies for attack or defense. Offensive actions, such as punches to the head or torso, as well as combinations of punches, are classified and analyzed to identify the effectiveness of attacking techniques. Defensive actions, which include dodging, blocking, and retreating, are studied to improve a boxer's response to an opponent's punches.

AI is actively being integrated into various sports disciplines, including boxing. Technology makes it possible to analyze boxers' techniques, improve training processes, and optimize combat strategies. Table 1 provides an overview of the main AI technologies used in sports.

Table 1

Overview of AI technologies in sports

Technology	Analysis
Machine learning	Algorithms that enable systems to learn from data
Computer vision	Technologies that enable computers to detect and analyze images
Natural language processing	Analysis of comments and feedback on speeches, automation of reports
Robotics	Use of robotic systems for training or analysis
Big data analytics	Data analysis to identify patterns and trends

Source: [11, p. 35; 12; 13, p. 194].



As can be seen from Table 1, AI technologies have unique characteristics that contribute to improving the efficiency and accuracy of the analysis of technical and tactical actions in boxing. Machine learning is a powerful tool for processing large amounts of data about boxers. Thanks to algorithms that identify patterns in historical data, coaches obtain valuable information about the strengths and weaknesses of athletes, which allows them not only to optimize training programs, but also to make predictions about future performances. For example, analyzing fight results can reveal trends that help in preparing for specific opponents [11, p. 35].

Computer vision also plays an important role in the development of boxing. The use of video analysis to evaluate striking and defensive techniques allows coaches to provide athletes with objective feedback, which is especially important in boxing, where even minor changes in technique can significantly affect the outcome of a fight. Computer vision automates the analysis process, significantly reducing the time spent on manual data processing [11, p. 35].

Natural language processing opens up new opportunities for analyzing communication and feedback about boxers. The use of natural language processing technologies makes it possible to automate the collection and analysis of textual information from social networks, news articles, and fan comments, giving coaches quick access to public opinion and sentiment, which is useful for shaping the image of an athlete or team [12].

Robotics in boxing also shows significant potential. The use of simulators and trainers allows boxers to practice in conditions that are as close as possible to real fights, without the risk of injury. This is especially important for contact sports, where injuries can be frequent. In addition, robotic systems provide variety in training, which helps to maintain the motivation of athletes [13, p. 194].

Finally, big data analytics allows for the processing of vast amounts of information not only about boxers' performances, but also about general trends in



the sport. This technology can be used to identify new opportunities for improving training and fighting strategies. For example, by analyzing data on audience behavior and preferences, competition organizers can optimize marketing campaigns and increase audience engagement. The integration of AI into boxing is becoming a key factor for success and innovation in this field [11, p.135].

AI-based boxing training apps offer a variety of features to help improve physical performance and technical skills. Boxing timers, in particular, allow you to organize your training process by setting the number of rounds and the duration of breaks, which increases the effectiveness of your workouts. Apps such as Boxing Training and Cyber Boxing provide instructional videos and voice prompts to help improve punching technique and physical fitness. Tools for creating personalized training programs, such as PunchFit and Boxtastic, allow users to tailor their workouts to their needs. Data analysis features in apps like Everlast and PIQ allow boxers to get detailed information about their punches, which helps them improve. That is why AI-based apps are becoming important tools for boxers of all levels, contributing to their progress in the sport [14].

The use of AI algorithms enables in-depth analysis of boxing techniques to improve athletes' performance. The main areas of application of AI in the analysis of boxing techniques include video processing and motion analysis, as well as comparing the accuracy of AI-generated assessments with traditional methods.

Video analysis systems such as Dartfish and Coach's Eye use computer vision algorithms for detailed frame-by-frame analysis of boxing techniques. The platforms allow coaches and athletes to carefully study each punch and movement, identifying mistakes and shortcomings in execution. AI algorithms automate the analysis, significantly reducing the time required to evaluate exercise performance. One key aspect is the use of motion tracking systems such as MyoMotion and Xsens. These technologies make it possible to analyze the speed, trajectories, and amplitude of a boxer's movements. With biometric monitoring, including heart rate (HR), stress



levels, and blood oxygen levels via Polar, Garmin, or WHOOP devices, coaches get extra info on the athlete's physical condition during training. Cloud platforms such as Kinduct and Smartabase provide storage, analysis, and exchange of training data, making it possible to create personalized training programs based on the data obtained and the individual needs of the athlete [15, p. 10].

Traditional methods of analyzing boxing technique often rely on the subjective assessment of a coach, which can lead to errors in identifying technical flaws. AI algorithms, on the other hand, provide an objective approach to evaluating exercise performance. Studies show that the accuracy of assessments obtained using AI can be significantly higher than traditional methods. For example, frame-by-frame analysis of punches and movements using AI allows even minor technical errors to be identified that may go unnoticed during normal observation. In addition, AI algorithms are able to adapt to the individual characteristics of an athlete, making them more effective in predicting fatigue and adjusting training plans. AI-based systems such as Kitman Labs and Zone7 use data on an athlete's physical condition to personalize workloads and prevent injuries [15, p. 11].

AI also opens up new opportunities for training athletes. One of the key elements of successful training for boxers is the development of a data collection system that provides detailed analysis of technical and tactical actions. To do this, it is important to identify the necessary data for collection. These include technical indicators such as types of punches, their speed and accuracy, as well as tactical aspects such as positioning in the ring and reaction to the opponent's actions. Physiological indicators, such as heart rate and fatigue levels, are also important for a comprehensive analysis of an athlete's training.

The next step in implementing AI technologies is to develop analytical reports for coaches. These reports should be structured and understandable, containing graphical representations of data, such as diagrams and tables, to help visualize the results of the analysis. The content of the reports should include a detailed analysis



of the performance of technical elements, comparisons with previous results, and the identification of trends and errors. In addition, it is important to provide specific recommendations for the athlete based on the data obtained.

Coaches must learn to use these analytical reports effectively to optimize the training process, which includes personalizing training programs according to the individual needs of the athlete, monitoring progress, and regularly evaluating results to adjust training plans. Setting achievable goals based on data analysis is also an important aspect of a coach's work. Thus, the introduction of AI technologies into the training of boxers through the creation of a data collection system and the development of analytical reports has the potential to significantly increase the effectiveness of the training process and the results of athletes.

The use of AI technologies to analyze technical and tactical actions in boxing opens up new opportunities to increase the effectiveness of training and improve competition results. AI can help identify weaknesses in boxers' techniques, optimize training programs, and provide detailed analysis of opponents. However, along with the advantages, there are certain challenges that can affect the successful implementation of these technologies. Table 2 contains a comparative analysis of the advantages and challenges associated with the use of AI technologies for analyzing technical and tactical actions in boxing.

Table 2

Advantages and challenges of using AI technologies in boxing

Advantages	Challenges
In-depth analysis of boxing techniques	High costs of equipment and software
Individualization of the training process	Need to train coaches and athletes
Increased reaction speed and decision-making	Complexity in data processing and interpretation



Increased competitiveness of athletes	Dependence on technology
Optimization of combat strategies	Ethical issues regarding data collection and use

Table 2 presents the key aspects of using artificial intelligence technologies to analyze technical and tactical actions in boxing, grouped into two areas: advantages and challenges. One of the main advantages is the ability to conduct an in-depth analysis of the technical elements of boxing. Thanks to artificial intelligence algorithms, coaches receive detailed information about the execution of movements, which allows them to identify mistakes in a timely manner, correct technique, and increase the effectiveness of the training process. An important advantage is the individualization of athlete training, as intelligent systems can adapt training programs to the physical characteristics, fighting style, and level of preparedness of each boxer. In addition, increased reaction speed and decision-making during competitions are also significant positive aspects. Algorithms are capable of analyzing data in real time, which ensures a faster response to changes in the tactical situation and contributes to the optimization of combat strategy. As a result, this increases the competitiveness of athletes and the quality of their training.

At the same time, the use of artificial intelligence technologies comes with a number of challenges. Significant financial costs for the purchase of equipment and software can be an obstacle for sports clubs and federations. In addition, the implementation of such systems requires additional resources and time to train coaches and athletes to work effectively with them.

Another significant limitation is the complexity of data processing and interpretation. Without proper experience, users may draw false conclusions or misinterpret results. Excessive reliance on technology can weaken an athlete's intuitive perception of their own actions during a fight. The ethical aspects of using



artificial intelligence require special attention, in particular the issue of athlete data confidentiality and preventing possible misuse of the information collected.

Thus, artificial intelligence technologies open up significant opportunities for improving the effectiveness of the analysis of technical and tactical actions in boxing, but their implementation requires a balanced approach that takes into account both the advantages and potential risks in order to ensure ethical and effective application in sports practice.

Conclusions. The study made it possible to justify the feasibility of using artificial intelligence technologies in the training system for boxers. The use of machine learning and computer vision algorithms provides a qualitatively new level of analysis of athletes' technical and tactical actions, making it possible to move from subjective assessment to the use of objective quantitative indicators. This contributes to a deeper understanding of the structure of movements, more accurate correction of technique, and more effective development of individual training programs.

It has been found that the use of intelligent systems in boxing creates a basis for the development of new approaches to modeling the training process and integrating biomechanical and psychophysiological parameters into a single analytical platform. At the same time, the application of such technologies is accompanied by a number of limitations, ranging from the high cost of equipment to the need for special training of users and the regulation of data ethics issues.

The results confirm that the introduction of artificial intelligence into sports practice is not only practical but also conceptual in nature: it changes approaches to understanding the training process, opens up new opportunities for the scientific justification of technical and tactical training, and forms the basis for the digital transformation of modern sports.

Further research may focus on optimizing data processing, training coaches and athletes to work with intelligent technologies, and studying the ethical aspects of their use. The implementation of such areas will not only contribute to increasing



the competitiveness of boxers, but also to forming a deeper understanding of the impact of technology on the quality of sports results.

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