СЕКЦІЯ «ІННОВАЦІЙНІ ТЕХНОЛОГІЇ У ФІЗИЧНОМУ ВИХОВАННІ РІЗНИХ ВЕРСТВ НАСЕЛЕННЯ»

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ANALYSIS OF THE POSSIBILITIES FOR INTRODUCING ARTIFICIAL INTELLIGENCE IN CROSS-COUNTRY SKIING

Анотація. *Розглянуто сучасні технології ШІ, що застосовуються в лижних гонках. Наведено конкретні приклади алгоритмів машинного навчання, які можуть розпізнавати технічні рухи, класифікувати та надавати об'єктивну оцінку. Проведено опитування. Результати показали, що спортсмени зацікавлені у використанні ШІ на тренуваннях, але не застосовують ці технології через перевагу традиційних методів тренувань (46,4%) і відсутність знань у цій галузі (35,7%).*

Ключові слова*: бігові лижі, штучний інтелект, нейромережа, машинне навчання, технічний патерн*

Abstract

The article discusses modern AI technologies applied in cross-country skiing. Specific examples of machine learning algorithms that can recognize technical movements, classify them, and provide an objective assessment are given. A survey of professional skiers was conducted. The results showed that athletes are interested in using AI in training but do not apply these technologies due to their preference for traditional methods of training (46.4%) and lack of knowledge in this area (35.7%).

Key words: *cross-country skiing, artificial intelligence, neural network, machine learning, technical pattern*

Introduction. The modern high-performance sport is evolving against a background of rapid technological progress. In recent years, digital technologies and big data analytics have become an integral part of athlete training. A special place among them is occupied by artificial intelligence (AI), which opens new opportunities for improving the efficiency of the training process, optimization of competitive activities, and individualization of preparation.

Cross-country skiing (XCS) is one of the most physiologically and technically complex cyclical sports, requiring high coordination of movements, endurance, rational distribution of effort, and precise tactical thinking. In a highly competitive environment, even minimal advantages can have a decisive impact on the outcome. That is why the introduction of artificial intelligence systems has become a relevant development area for this sport.

The application of AI in XCS covers a wide range of tasks: analysis of mobility techniques, biomechanical modeling of movements, forecasting of sports form, monitoring of functional condition, selection of optimal training loads, and tactical solutions.

Related work. Artificial intelligence is a field that has been introduced everywhere in modern life. XCS is no exception. There are many different methods of introducing AI tools into the training process by racers and coaches. Similar tools are used to improve the efficiency of the training process by monitoring the athlete's physiological indicators, analyzing the biomechanics of movements, and individualizing loads. This approach allows for the identification of hidden patterns in transportation techniques, as traditional methods may not be sufficiently indicative or subjective. The use of machine learning algorithms has a positive effect in terms of technical accuracy, reduced injuries, and increased competitive performance. In the case of neural networks, monitoring is carried out by means of video analysis systems and hand-held sensors that collect and process data sets [1].

The high accuracy of the results ensured the development and testing of a machine learning model to classify the level of training of skiers of different ages and optimize their training plans. Physical, technical, and psychological indicators were assessed. The experiment was carried out using the MLP-Attention-SVM (Support Vector Machine) methodology, where in the first sector, high-level feature representations are extracted, then weighed by the Attention mechanism, and at the end classified into five levels of readiness. The model outperformed manual assessment and basic methods. Ranking machine learning as a model yielded much better results. However, the evaluation results may be distorted by incorrect tests and formal completion of questionnaires [2].

There are machine learning algorithms that can perceive, classify, and correct technical patterns of skiers. One such system is YOLOv3- OpenPose-Simple Neural Network (SNN). Such a system works on the following criteria: recognition of an athlete in the frame, assessment of his position in the frame, classification and comparison of correct patterns of techniques with investigated options. Such an algorithm is able to recognize a technique with a lateral and frontal ratio with an accuracy of 81.48% and 81.78%, respectively [3].

The results of an experiment on the introduction of smart ski poles into the training process have made conclusions about their high accuracy in machine recognition, ergonomics and portability. Smart ski poles use the already mentioned SVM algorithm, which in this study gave an accuracy of 99.5%. The model of ski poles includes a uniaxial load cell and an inertial measurement unit that acts as an accelerometer, gyro, and magnetometer. This sensor allows you to determine the push phases, measure the angles of the ski poles, read the

frequency of movements and distinguish between five types of mobility techniques: Diagonal Stride (DS), Double Poling (DP), Kick Double Poling (KDP), Two-stroke Glide (G2), and Five-stroke Glide (G5) [4].

The ski pose recognition system was developed by integrating mobile information technology and inertial measurement systems (IMU). The novelty of this system consists of applying attitude estimation algorithms to analyze skiers' movements and combining data from sensors and video cameras with subsequent motion visualization in Unity3D. The study demonstrates that the use of mobile information technology increases the accuracy of pedagogical control, creates preconditions for the digitalization of ski training, and reduces the dependence of technique evaluation on the subjective opinion of trainers [5].

Materials and Methods. For the preparation of the article, a survey was conducted in which 94 respondents participated. Among them, 58.5% had a career in ski racing of more than 7 years, 29.8% – 4 to 6 years, 9.6% – 1 to 3 years, and 2.1% – less than one year.

The sample structure predominantly included professional athletes (85.1 per cent). In addition, amateurs (9.6%), coaches (7.4%), other sports professionals (3.2%), and service staff representatives (2.1%) participated in the study.

Data collection was carried out using an online questionnaire developed and hosted on the Google Forms platform.

Results. The results of a survey on the use of AI in the training process were as follows. Of the 94 participants in the study, 20.2% rated their interest in AI at a maximum of 5 points on a five-point scale (where 1 – no interest, 5 – high interest). Assessment 4 was given by 23.4% of respondents, 34% chose the average level (3 points), 16% – 2 points and 6.4% indicated minimum interest (1 point).

When asked about the practical use of AI services, 88% reported using language neuronets, 38% applied universal sports AI tools, 3.3% – specialized solutions for XCS, and 7.4% did not use AI at all.

Functionally, 40 people use AI for psychological support. In addition, 38.8% use it for training planning, 37.6% – to optimize the training process, 27.1% – when selecting exercises, 22.4% – to select technical materials, and 18.8% – to analyze motion techniques.

Assessing the potential impact of AI on the training process, 11.8% of participants gave a maximum score (5 points), 17.2% – 4 points, 43% – 3 points, 20.4% – 2 points and 7.5% rated the impact as minimal (1 point).

Among the possible risks of using AI, 70.7% noted a lack of «human» feedback. 37% indicated a lack of individual approach, 26.1% – a lack of creative component. A small percentage of respondents (1.1% each) mentioned issues

such as frequent errors and data averaging, lack of scientifically validated evaluation of the effectiveness of AI in training and competition activities, and total absence of risks.

Regarding the format of AI implementation in athlete training, 53.3% prefer to rely entirely on a coach. 41.3% consider it optimal for a coach to work together using AI tools. 3.3% are willing to work with an AI program compiled under the coach's supervision, and only 2.2% expressed a willingness to fully entrust the training process to artificial intelligence.

Most respondents (79.3%) believe in the further development of AI and its potential to improve the training process, while 20.7% doubt the prospects for progress.

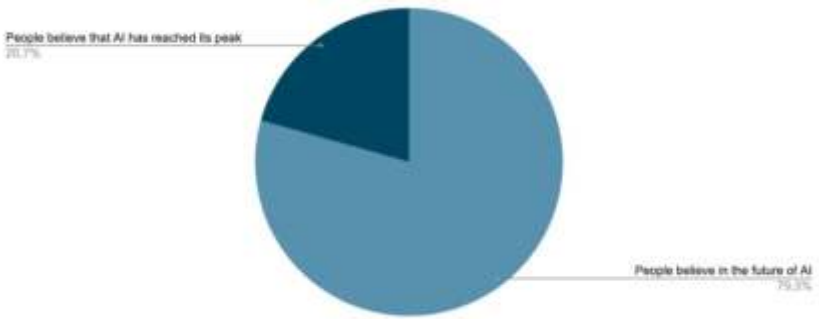


Figure 1 – Respondent's views on AI opportunsties

When a new suitable AI tool appeared, 19.6% of respondents expressed full readiness to use it (5 points), 23.9% rated their readiness at 4 points, 34.8% at 3 points, 17.4% at 2 points, and 4.3% at 1 point.

When talking about the shortcomings of modern AI systems, the participants in the study highlighted such characteristics as lack of «humanity», memory and contextual understanding of the situation, impossibility of demonstration and adjustment of techniques, lack of practical experience, Doubts about the reliability and objectivity of information, limited sports knowledge, insufficient data collection, lack of individualization and feedback, paid access to functions, as well as insufficient realism and detail.

Among the reasons for not using AI, 46.4% prefer traditional training methods. 35.7% believe that they do not have sufficient knowledge and competencies to implement AI in the training process, while 9.5% have difficulty analyzing data.

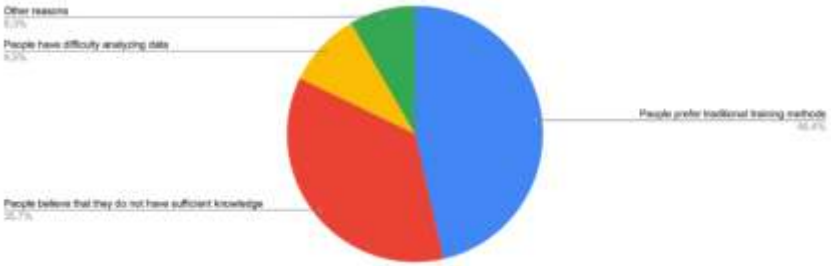


Figure 2 – Reasons why people don't use AI training

Meanwhile, 48.3% of respondents said that they were more likely to try AI tools, 21.3% expressed a strong intention to use them, 21.3% were less interested in such an experience, and 9% preferred exclusively traditional training methods.

The most interesting areas of possible application of AI are considered by survey participants to be optimization of training process (23.1%), selection of technical tools (19.8%), analysis of movement techniques (18.7%), planning of training (13.2%), psychological support (12.1%), physiological monitoring (1.1%) and comprehensive use in all directions (1.1%).

Conclusion. The findings indicate that AI technologies are increasingly being implemented in XCS. A review of the scientific and methodological literature shows that AI systems are primarily focused on classifying movements and correcting technical errors. The experiments reviewed demonstrate high accuracy, ranging from 81% to 99.5%. The studies most commonly employ IMU sensors and machine learning algorithms such as SVM, MLP, SNN, YOLOv3 [4-6].

IMU can distinguish up to 5 different ski techniques. However, there is a problem of recognizing the transition between different techniques [6].

The survey conducted among skiers, amateurs, and coaches shows that despite a high level of interest, most respondents adhere to traditional methods of training.

Most respondents prefer to trust only the coach, and only a small percentage are willing to trust AI completely. 41.3% are willing to work with a trainer using AI tools. That is, AI is perceived as an additional means of help, not a full professional replacement.

Despite the small percentage of people fully prepared to work with AI, most respondents (79.3%) believe in its further development. Respondents believe in technological progress, but due to a lack of experience and knowledge for working with AI do not want to include modern training tools in the training

process.

The most promising approach involves integrating multiple neural network algorithms with sensor technologies, video analysis, and physiological monitoring, as this comprehensive method helps maintain individualized training [1-3].

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