Intelligent Decision Support Agent Based on Fuzzy Logic in Athletes' Adaptive E-Learning Systems

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Abstract

Currently in Ukraine there is a need to design and develop adaptive e-learning systems for theoretical and tactical training of athletes in the chosen sport. The developed user profile model, which combines both individual user parameters and user actions in the system, allows to take into account all qualitative and quantitative information about the user without losses.

Developed rules and method of intellectual agent to support decision making to provide adaptive learning content based on fuzzy logic provide efficiency in the formation and development of logical, associative, tactical thinking, improving the tactical and theoretical training of athletes. Such rules and method formalize the decision making process for the provision of adaptive learning content and are the theoretical basis for the development and design of adaptive e-learning systems for theoretical and tactical training of athletes in the chosen sport.

Keywords

Intelligent agent, adaptive e-learning systems, fuzzy logic, decision support.

1. Introduction

The modern system of sports training is a complex system characterized by progressive principles, a wide range of interdependent tasks scientifically substantiated selection of means and methods, perspective long-term planning, high organization of control, maintenance of hygienic conditions, etc. [1]. Sports training is carried out for individual sections, which have independent features, namely the aspects of training: physical, technical, tactical, theoretical, moral and volitional and integral [2].

Theoretical and tactical training of athletes is one of the leading places in the current process, in this regard, the planning of the training process of athletes, which allows more systematic selection of tools and methods of training, as well as to determine criteria for monitoring the level of training of athletes.

Today's realities in the context of the COVID-19 pandemic have made adjustments in the planning and conduct of theoretical and tactical training of athletes. Therefore, the use of information technology in the training of athletes is relevant today.

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The use of information technology allows for the training of athletes in compliance with all quarantine requirements. In the system of training athletes, much attention is paid to the use of information technology.

But the vast majority of domestic works are devoted to the review, prospects of application and opportunities that can provide information technology in the system of training athletes. Foreign experts pay more attention to the personal assistants of the athlete, who allow by measuring and calculating certain parameters, to provide recommendations for physical training. Thus, in [5] the authors propose a digital coach for skiers, which improves the technique of skiing.

In the article [6] the authors consider personal assistants for amateur athletes and elite athletes who help athletes improve their physical fitness.

In [7] the author investigates the use of associative mining rules to control the physical training of athletes, which allows to identify the features of physical fitness and the main factors that affect this process.

The work [8] is devoted to the analysis of the relationship between the physical capabilities of athletes and technical and tactical capabilities based on data mining. The study [9] is devoted to assessing the physical fitness of taekwondo athletes using multi-agent systems.

In [10] the authors investigated the use of virtual reality in the system of training and competitive activities of athletes. From the review it can be concluded that the vast majority of research is aimed at using information technology to monitor the physical fitness of athletes, their competitive activities and assistance to coaches.

If we talk about the theoretical and tactical training of athletes, the vast majority of domestic research suggests either the use of multimedia and cloud technologies for such training [11, 12] or the use of computer training and control programs in physical education and sports. It is proved in the works that student-athletes who studied with the use of computer programs mastered the material better and more successfully than those student-athletes who practiced without their use.

As an effective tool for theoretical and tactical training of athletes, the authors propose the use of an adaptive intelligent e-learning system.

Any educational platform aims to provide users with the necessary information to increase their active knowledge of a particular subject area. However, the learning process is a variable that depends on previous knowledge, motivation and individual needs of users [14].

This raises the question of the importance of developing an adaptive system that takes into account the effective process of learning and acquiring knowledge.

The development of learning materials and their availability on the Internet is insufficient, more importantly, the knowledge materials must be adapted to different characteristics of users, such as their learning style.

Existing e-learning systems are designed to prepare students in relevant specialties, such as 017 Physical Education and Sports, contain in the courses general information about sports, features of techniques and tactics and provide an opportunity to test student's knowledge in the form of tests. In the system of theoretical and tactical training of athletes, such a generalized approach is insufficient. According to the literature review, none of the known e-learning systems is designed for theoretical and tactical training of athletes in the chosen sport.

To increase efficiency in the formation and development of logical, associative, tactical thinking, improving tactical and theoretical training of athletes based on the formation of special knowledge about tactics, types of technical and tactical actions, competition rules, history of various sports (martial arts, cyclic sports, sports games), it is necessary to take into account the level of training of the athlete, his abilities and capabilities. This work is devoted to solving this urgent problem.

2. User profile model and construction of training material profile

In adaptive e-learning systems, such a concept as the system user model is widely used [15]. A user model is a set of specific user parameters [16].

The difference between the concepts of «user model» and «user profile» are considered in the works of the authors [17]. The user profile is preferably considered as a set of certain information about the user, such as skills, cognition, preferences, features of interaction with the system, and the

user model is seen as the goal of knowledge, which includes user actions. In conclusion, we can say that the user model is an abstract view of the individual differences of users.

In this paper, the authors propose the concept of «user profile model», which combines both individual user parameters and user actions in the system.

The user profile model is represented by a set (1):

$$MPK = \{IPK, DK\}, \quad (1)$$

where *IPK* – set containing the athlete's personal information;
DK – set that characterizes the activities of users in the system.

$$IPK = \{OI, MS, LS, Y\}, \quad (2)$$

where *OI* – set containing the athlete's personal information;
MS – methods of perception of educational material;
LS – learning style;
Y – progress (number of passed levels in the system).

The set that characterizes the activities of users in the system is represented by a formula:

$$DK = \{kr, kg, kt, kp\}, \quad (3)$$

where *kr* – number of completed thematic sections;
kg – number of games played;
kt – number of tests passed;
kp – number of points scored in games.

The set containing the athlete's personal information is described by a formula (4):

$$OI = \{sn, nm, vs, sr\}, \quad (4)$$

where *sn* – surname;
nm – name;
vs – kind of sport;
sr – sports categories.

A set representing the methods of perception of educational material:

$$MS = \{pr, tpr, trtpr, tt\}, \quad (5)$$

where *pr* – practice;
tpr - first theory then practice;
trtpr - theory together practice;
tt – theory.

A set representing the learning style is described by a formula (6):

$$LS = \{vz, kn, ay, vr, lg, sc, sp\}, \quad (6)$$

where *vz* – visual;
kn – kinesthetic;
ay – audible;
vr – verbal;
lg – logic;
sc – social;
sp – separated.

The information contained in the user profile model is not only quantitative but also qualitative, the best solution for its processing will be the use of fuzzy logic. Mamdani's method was chosen as a fuzzy conclusion [18]. According to the Mamdani's method for decision making quantitative variables are translated into linguistic terms by phasing and then operations with them are carried out as with qualitative indicators. After that, a knowledge base is built, which contains fuzzy production rules of the form:

$$P_i = IF\ x_1\ is\ A_1\ AND\ \dots x_j\ is\ A_j\ AND\ \dots x_k\ is\ A_k\ THEN\ y_i\ is\ R_i, \quad (7)$$

where P_i – production rule, $i = 1 \dots g$, g - number of rules;

x_j – input parameters, $j = 1 \ldots k$, k – number of input parameters, $X_k = \{x_j\}$;
A_j – fuzzy variable (term of a linguistic variable);
y_i – output parameters, $i = 1 \ldots n$, n – number of output parameters;
R_i – consequence of the rule.

An important aspect in providing adapted content is to build a profile of educational material. The profile of the training material is assigned a weight according to the level of theoretical and tactical material contained in the profile. The values of the weights are distributed as follows: $p = 1$ – low level, $p = 2$ – medium level, $p = 3$ – high level.

Processing of qualitative and quantitative information can be carried out using a fuzzy logic device, intelligent agents or neural networks [19]. A combination of these technologies is also often used to increase the efficiency of information processing.

The use of an intelligent agent in complex systems allows you to partially eliminate human participation in the processing of information, avoid the loss of important information, minimize errors in the processing of large amounts of information [20].

Intelligent agents are widely used in various applications. In the article [21] is intended to provide a practical decision support system framework, based on multi agent system and intuitionistic fuzzy logic, useful for implementation in the healthcare area. The process of starts with the determination of the linguistic variables afforded by the medical experts' caregivers of intensive therapy. Then, the building of the rules base, with regard to the citied above steps, is realized by the assist of medical expert knowledge. Thereafter, the expert agent calculates membership degree, nonmembership degree, and hesitation margin to determine the degree of risk. Finally, the expert agent transmits the output variable (normal, large, and high) to the doctor agent to provide the suitable treatments to the patient.

The paper [22] focuses on introducing the concept of fuzzy agent: a classical architecture of agent is redefined according to a fuzzy perspective. A pedagogical illustration of fuzzy agentification of a smart watering system is then proposed. Authors presented a model of fuzzy agents proposed for the modelling and design of complex systems (intelligent/smart systems, distributed systems, cooperative systems, assistance systems, etc.), where uncertainty and imprecision are considered.

The approach to the development of intelligent decision support systems using ontology knowledge bases consisting of such systems in the article [23] is considered. An adaptive ontology is proposed to define as an ontology with concepts and relations weighted according to its importance for a given subject domain.

In study [24], a novel intelligent-agent-based fuzzy group decision making model is proposed as an effective multicriteria decision analysis tool for credit risk evaluation. In this proposed model, some artificial intelligent techniques, which are used as intelligent agents, are first used to analyze and evaluate the risk levels of credit applicants over a set of pre-defined criteria. Then these evaluation results, generated by different intelligent agents, are fuzzified into some fuzzy opinions on credit risk level of applicants. Finally, these fuzzification opinions are aggregated into a group consensus and meantime the fuzzy aggregated consensus is defuzzified into a crisp aggregated value to support final decision for decision-makers of credit-granting institutions.

The study [25] introduces a novel mobile agent-based cross-layer anomaly detection scheme, which takes into account stochastic variability in cross-layer data obtained from received data packets, and defines fuzzy logic-based soft boundaries to characterize behavior of sensor nodes. This cross-layer design approach empowers the proposed scheme to detect both node and link anomalies, and also effectively transmits mobile agents by considering the communication link-state before transmission of the mobile agent.

Thus, intelligent agents are good at solving a variety of problems, especially when combining different technologies. Given that adaptive e-learning systems need to process different volumes and types of information, both quantitative and qualitative, in this paper, the authors propose the use of an intelligent agent for the decision-making process in adaptive e-learning systems for athletes.

The decision making process of an intelligent agent is based on the analysis of a fuzzy logical conclusion. The result of the agent's work will be a decision to provide the athlete with adapted training content.

The structure of the intelligent decision support agent based on fuzzy logic in athletes' adaptive e-learning systems is represented on Fig.1.

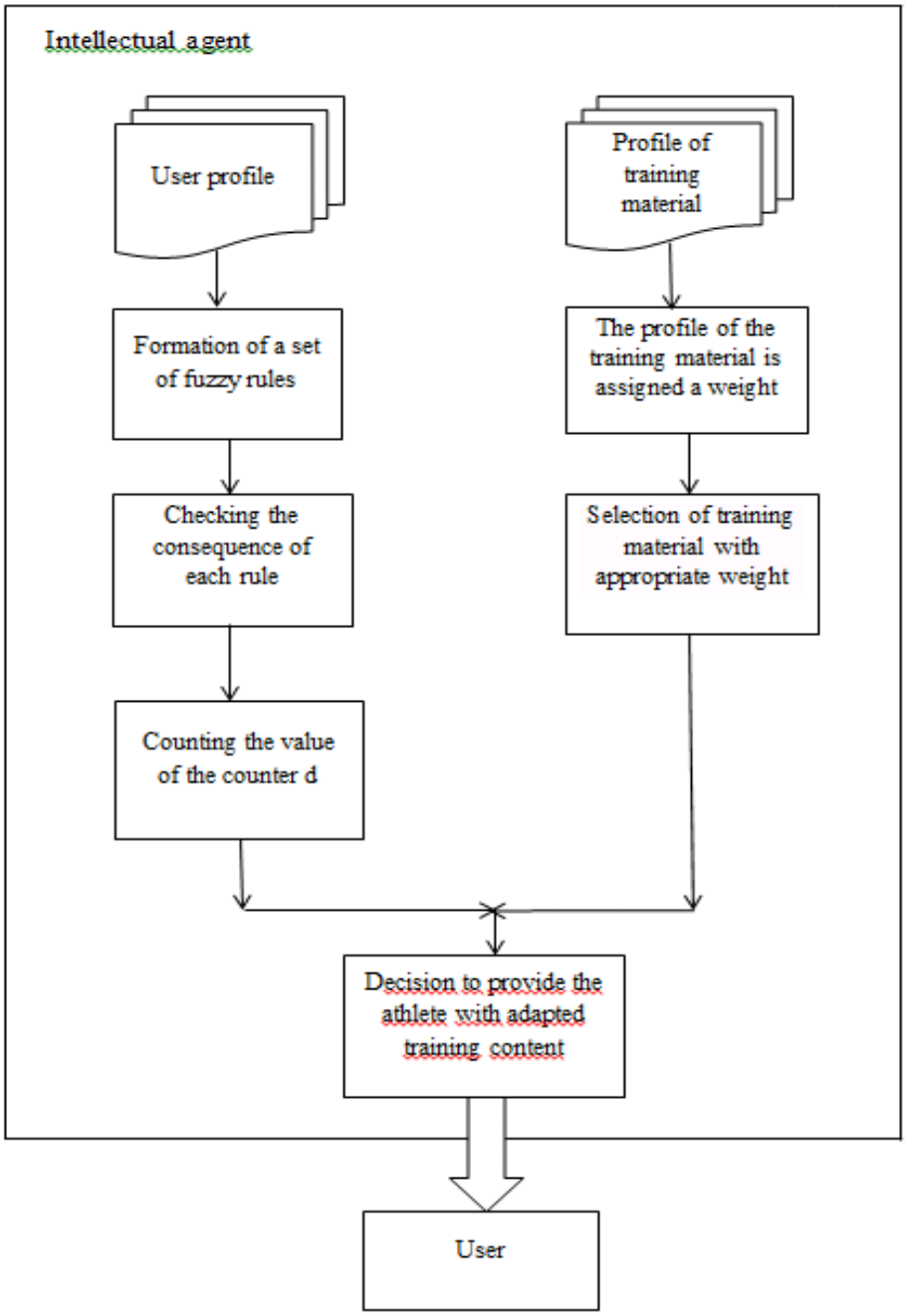

Figure 1: Structure of the intelligent decision support agent based on fuzzy logic in athletes' adaptive e-learning systems

3. Method of activity of intelligent agent for support of decision making

The intelligent agent models the decision-making process based on fuzzy production rules.

The intelligent agent takes into account the previous experience of the player, analyzing the model of his profile and the profile of the training material.

The method of decision support by an intelligent agent to provide adaptive content to the athlete consists of the following steps:

- the user profile is analyzed in a set of production rules to support decision-making on the possibility of providing adaptive content, the consequence of each rule is checked, according to which the counter is counted d;

- the profile of training material is analyzed, which contains materials on theoretical and tactical training of athletes, which are divided into appropriate levels;
- if the value of the counter is $d < 10$, then adapted content is provided, where the weight of the profile of the training material $p = 1$, that is low level;
- if the value of the counter $10 \leq d < 15$, then the adapted content is provided, where the weight of the profile of the training material $p = 2$, that is the middle level;
- if the value of the counter is $d \geq 15$, then adapted content is provided, where the weight of the training material profile is $p = 3$, that is a high level.

4. Experiment

As an example, consider how an intellectual agent forms a conclusion about providing an athlete with adapted educational content. Consider the following rules:

$$P_1 = IF\ kr\ is\ 2\ AND\ kg\ is\ 5\ AND\ kt\ is\ 2\ AND\ kp\ is\ low\ THEN\ y\ is\ low\ level$$

$$P_2 = IF\ kr\ is\ 3\ AND\ kg\ is\ 5\ AND\ kt\ is\ 4\ AND\ kp\ is\ low\ THEN\ y\ is\ low\ level$$

$$P_3 = IF\ kr\ is\ 3\ AND\ kg\ is\ 7\ AND\ kt\ is\ 2\ AND\ kp\ is\ low\ THEN\ y\ is\ low\ level$$

$$P_4 = IF\ kr\ is\ 2\ AND\ kg\ is\ 5\ AND\ kt\ is\ 2\ AND\ kp\ is\ average\ THEN\ y\ is\ low\ level$$

$$P_5 = IF\ kr\ is\ 4\ AND\ kg\ is\ 6\ AND\ kt\ is\ 4\ AND\ kp\ is\ average\ THEN\ y\ is\ middle\ level$$

$$P_6 = IF\ kr\ is\ 6\ AND\ kg\ is\ 6\ AND\ kt\ is\ 5\ AND\ kp\ is\ average\ THEN\ y\ is\ middle\ level$$

$$P_7 = IF\ kr\ is\ 8\ AND\ kg\ is\ 7\ AND\ kt\ is\ 7\ AND\ kp\ is\ average\ THEN\ y\ is\ middle\ level$$

$$P_8 = IF\ kr\ is\ 10\ AND\ kg\ is\ 7\ AND\ kt\ is\ 9\ AND\ kp\ is\ average\ THEN\ y\ is\ middle\ level$$

$$P_9 = IF\ kr\ is\ 10\ AND\ kg\ is\ 8\ AND\ kt\ is\ 10\ AND\ kp\ is\ average\ THEN\ y\ is\ high\ level$$

$$P_{10} = IF\ kr\ is\ 12\ AND\ kg\ is\ 8\ AND\ kt\ is\ 12\ AND\ kp\ is\ average\ THEN\ y\ is\ high\ level$$

$$P_{11} = IF\ kr\ is\ 12\ AND\ kg\ is\ 10\ AND\ kt\ is\ 10\ AND\ kp\ is\ high\ THEN\ y\ is\ high\ level$$

$$P_{12} = IF\ kr\ is\ 13\ AND\ kg\ is\ 11\ AND\ kt\ is\ 10\ AND\ kp\ is\ high\ THEN\ y\ is\ high\ level$$

$$P_{13} = IF\ kr\ is\ 12\ AND\ kg\ is\ 9\ AND\ kt\ is\ 14\ AND\ kp\ is\ high\ THEN\ y\ is\ high\ level$$

After analyzing the above rules, the intelligent agent calculates the value of the counter, which for low level is 4, for middle level is 4, for high level is 5. Thus, after analyzing all the rules of the knowledge base, built for a particular athlete, the final value of the counter d is obtained, according to which the adapted content is provided. If the value of the counter is $d<10$, then adapted content is provided, where the weight of the profile of the training material $p=1$, that is low level. If the value of the counter $10 \leq d<15$, then the adapted content is provided, where the weight of the profile of the training material $p=2$, that is the middle level. If the value of the counter is $d \geq 15$, then adapted content is provided, where the weight of the training material profile is $p=3$, that is a high level. If the knowledge base does not have enough rules for analysis to form the value of the counter, then the training content is provided at a lower level.

Two experimental groups were used as an experiment in the effectiveness of using an intelligent agent to support decision making in adaptive learning systems. The first group was engaged in conventional systems without the use of an intelligent agent, the second - with the use.

At the beginning, both groups underwent initial testing. The first group could independently choose the order of topics to study, as well as the level of the game to test knowledge. After that, both groups passed the final test to check the level of knowledge. As the analysis of the results showed, the players of the first group did not always assess their level correctly, there were repetitions in the test tasks, the transition to the next level of the game was carried out by the player, that is there was a lack of system, which led to low quality knowledge.

The second experimental group used an intelligent agent in their training, who analyzed the user profile and the training material file and suggested, depending on the results of the profile analysis, the transition to the next level or repetition of the material where the lowest number of points was scored. As a result of the final tests, the players of the second group showed a higher and systematic level of knowledge of tactics and techniques of a particular sport.

5. Conclusions

Currently in Ukraine there is a need to design and develop adaptive e-learning systems for theoretical and tactical training of athletes in the chosen sport. The developed user profile model, which combines both individual user parameters and user actions in the system, allows to take into account all qualitative and quantitative information about the user without losses. Developed rules and method of intellectual agent to support decision making to provide adaptive learning content based on fuzzy logic provide efficiency in the formation and development of logical, associative, tactical thinking, improving the tactical and theoretical training of athletes.

Such rules and method formalize the decision making process for the provision of adaptive learning content and are the theoretical basis for the development and design of adaptive e-learning systems for theoretical and tactical training of athletes in the chosen sport.

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