Modeling of Learning Analysts in e-Learning

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Abstract. *We consider the development of learning analytics tools for distance learning using the agent-based and neural network approaches. It is proposed a hybrid agent-based model with built-in artificial neural networks. The model aims to support the computer simulation experiments evaluating the trends of production and dissemination of knowledge of the participants (agents) of three types: the authors, tutors and students of online courses. We study the efficiency of the software implementation of this model as an example of one of the higher education institutions.*

Keywords

learning analytics, e-learning, hybrid agent-based model, artificial neural network, simulation software of learning analytics

1 Introduction

At present, the production technology and the use of educational analysts in e-learning are very modest. Many researchers say about the essence of the concept of "learning analytics", but few consider the possibility of increasing the efficiency of the electronic or distance learning based on the learning analytics [1]. Existing approaches to the implementation of the training analysts point to significant opportunities to generate new understanding of learning and vital educational practices [2] - [3].

Wikipedia provides the following definition: "Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimization learning and the environments in which it occurs" [4]. The special attention of a number of researchers began differentiation in educational data mining (EDM) and learning analytics (LA) [5] - [7].

Learning analytics cover a wide range of analytic, who can define the macro-, meso- and micro- levels (Fig. 1). As the figure shows, what we now see taking place is the integration of, and mutual enrichment between, these layers. Company mergers and partnerships show business intelligence products and enterprise analytics capacity from the corporate world being integrated with course delivery and social learning platforms that track micro- level user activity. The aggregation of thousands of learners' interaction histories across cohorts, temporal periods, institutions, regions and countries creates meso + macro level analytics with an unprecedented level of fine-grained process data. In turn, the creation of such large datasets begins to make possible the identification and validation of patterns that may be robust across the idiosyncrasies of specific contexts. In other words, the breadth and depth at the macro + meso levels add power to micro-analytics.

We want to consider the use of methodological approaches to the production of web analytics in e-learning, such as agent-based model with a built-in artificial neural networks. The creation of such a hybrid agent-based model is designed to carry out computer experiments or simulations, which are aimed at assessing trends in the knowledge production and dissemination by the e-learning participants in the *Moodle* virtual learning environment [8].

Agent-Based Model (ABM) is a new tool for the extraction of knowledge in various fields [9]. While designing the ABM one must adhere to the basic principles, which can guarantee the autonomy of the micro-level agents, bounded rationality of their behaviour and their functioning within a particular "habitat". The ultimate goal of the ABM design is to collect a certain set of rules of conduct of specific agents, representing an artificial community. Wikipedia defines this concept as: "Artificial Society is the specific agent-based computational model for computer simulation in social analysis" [10].

Among the ABM software the most popular packages are SWARM and AnyLogic. The first package is a collection of open source software libraries created at the Institute of Santa Fe and available on its website [11]. AnyLogic is a commercial package. Its special AnyLogic agent based library allows specifying the required functionality of the model's agents [12].

2 Theoretical Part

Agent-based models are constructed to create an artificial society in which the following types of agents interact: A1 – authors of e-learning courses, A2 – tutors involved in the learning process and A3 – students participating in distant learning courses. We assume that the agents of the artificial society function autonomously. They make decisions, act and interact with other e-learning agents. To complete an action, any decision by the agent is sufficient. Group decisions are necessary to carry out the interaction between agents. Group decisions are made in accordance with relevant rules, which should be specified in our case.

Key assumptions in the model design are as follows:

– in terms of decision-making, e-learning agents move in a two-dimensional space and have a finite horizon of vision;

– agents of the e-learning courses interact in a virtual environment by the defined rules, and have an expiration date;

– the purpose of an e-learning course author, or the first type of agent, is to produce as much knowledge as possible and to transfer it to the tutor and students. A tutor (A2) aims to spread the knowledge among the largest possible number of students. Finally, the goal of a student, or the third type of agent, is to use as much knowledge as possible.

A formal description of the agents' behaviour and the results of computational modelling in a *SWARM* environment are presented in the paper [13].

We aim to investigate the effectiveness of the *AnyLogic* package for designing a hybrid agent-based knowledge model, which assesses the participants of e-learning courses on the basis of neural networks, which belong to the new frontier of artificial intelligence. The review of scientific papers in this area suggests that the results of neural networks, which are based on a large number of observations, reflect reality better than expert models, which survey a small number of experts, or fuzzy logic systems, which use the rules laid down by several people.

With the purpose of designing artificial neural networks, we use the data from the activity of web-centre users in one of Ukraine's higher education institutions [14]. Based on the number of clicks, published in the Moodle event log system, it is possible to monitor the performance of the e-learning agents over the past 12 months. It is possible to monitor how the e-learning course resources were viewed, updated, or what was deleted and added to the tasks. Our research uses the data which characterizes 117000 actions by more than 500 agents. Almost 10% of the agents are authors, approximately 20% are tutors, and the rest are students.

We have chosen the *STATISTICA Neural Networks* package among other software that is designed to build neural networks [15]. There is a tool called "Problem Solver" in the package, which provides for the construction of neural networks sets with superior characteristics.

Neural networks, which are designed using *STATISTICA Neural Networks*, have the same architecture - it's multi-layered perceptrons. The differences between these neural networks are in the number of hidden layer neurons and some other parameters.

Agent-based hybrid model was developed in the *AnyLogic* environment. Among utility tools are variables, timers and statecharts (flow charts or diagrams). Variables reflect the change in the characteristics of e-learning course agents. Timers are set for a specific time interval, after which the specified action will be performed. Statecharts make possible to visually present agent's behaviour in time, under the influence of events or conditions, which consists of graphic states and transitions between them. Any complex behavioural logic of the agents in the hybrid model designed in *AnyLogic* can be expressed by a combination of utility tools, as well as embedded code functions of three previously designed neural networks.

The designed agent-based model for e-learning allows participants to observe visually their actions. To view the values of characteristic variables for any agent, you can use the control panel system to pause the simulation.

With the help of created model, we may see how much knowledge per type of agent was produced in general and on average (see Fig. 2). Here, the upper graph shows the dynamics of change in the number of agents of each type. The X axis shows time of courses, and the axis Y - number of agents. The middle graph represents the amount of knowledge

produced by each type of agents. Such a large number of consumed knowledge among the students, represented in the graph, is due to the fact that students rate in comparison with others is remarkably higher: number of students - 140, number of tutors – 40, authors of distance learning courses (DK) – 20. The pie chart represents the average number of produced and consumed knowledge for each type of agents.

Fig. 3 illustrates some results of a simple experiment with a designed agent-based model hybrid, which assesses the knowledge of e-learning participants. The results of the knowledge and the e-learning contact between agents are illustrated through the example of a specific (fourth) tutor.

2.1 Figures

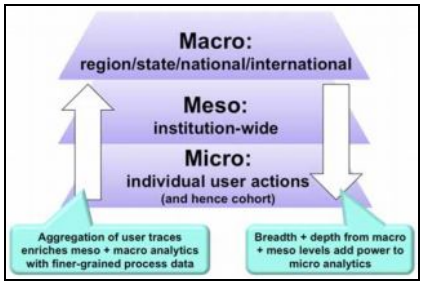

Fig. 1. The hierarchical model of learning analytics.

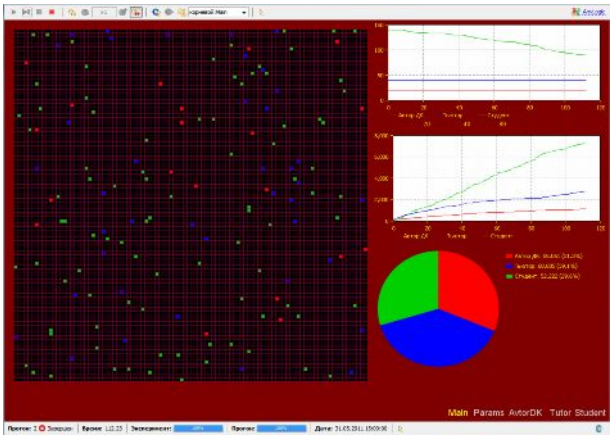

Fig. 2. The main window of computer experiments.

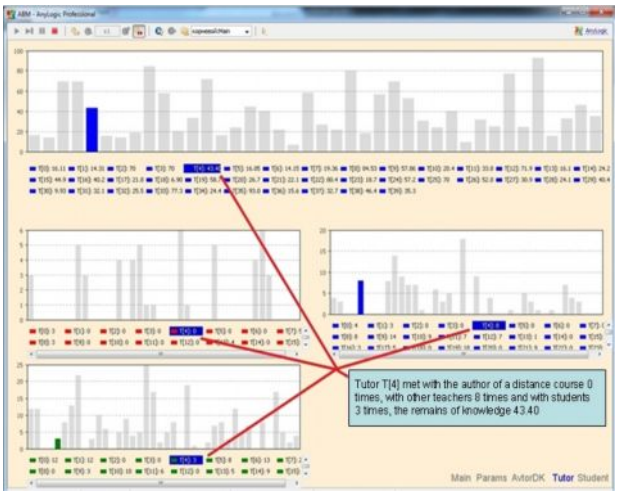

Fig. 3. Diagrams of the resulting knowledge and e-learning agents contact through the example of the e-learning course tutors.

3 Conclusion

The results of the study lead to the following conclusions and generalizations.

1. It is critically important to enhance the dialogue between researchers and practitioners in order to guide the development of new tools and techniques for analytics.

2. Agent-based modelling and artificial neural networks are effective tools in developing learning analytics in the production and dissemination of knowledge of the participants of e-learning.

3. Experiments with a hybrid prototype ABM show possible ways for its practical application for determine needs in the redesign of distance learning courses to improve their quality on the basis of adaptive mechanisms of interaction between agents of e-learning, among which an important role is played chats, webinars, case discussions, etc.

In the future we intend to continue to explore effective ways to use the package for the construction of *AnyLogic* considered a hybrid of ABM in order to assess the production and dissemination of knowledge to the distance learning.

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