Reflex Model of Online Learning

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Abstract

Given the increasing popularity of learning through web-services, a large number of researches is devoted to solving the scientific problems of online learning. Such problems include, for example, convergence and interoperability in terms of research of various forms of convergence (organizational, technological, pedagogical, sectoral, institutional, etc.). The article considers what is online learning and what is its current state and trends. Modern scientific methods of online learning are shown. It is highlighted that commonly used methods such as Big Data, intelligent data analysis, and analytical training. According to the article, data science methods have received the highest priority in online learning studies. The model of the reflex expert system of online learning management based on the theory of non-force interaction is proposed and two stages in the technology of its functioning are considered.

Keywords [1]

online learning, data science, data analytics, big data, reflex model

1. Introduction

The COVID-19 coronavirus pandemic and the self-isolation regime have led to a real stir in the field of online learning. According to the GetCourse platform, which hosts distance courses of hundreds of online schools, sales of e-courses grew by 20% in the second half of March 2020 compared to the first half of the month. The number of users trying to organize their courses increased by 30%. But even under normal conditions, interest in online learning is actively growing from year to year [1].

Online learning is a system of education using information and electronic technologies. There is a definition given by UNESCO experts: “ Online Learning - learning using the Internet and multimedia”.

Online learning includes:

- independent work with electronic materials using a personal computer, PDA, mobile phone, DVD-player, TV, and other electronic materials;
- receiving advice, advice, assessments from a remote (geographically) expert (teacher), the possibility of remote interaction;
- creation of a distributed community of users (social networks) conducting common virtual educational activities;
- timely round-the-clock delivery of e-learning materials; standards and specifications for e-learning materials and technologies, distance learning tools;
- formation and improvement of information culture among all heads of enterprises and divisions of the group and their mastery of modern information technologies, increasing the efficiency of their usual activities;

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- mastering and popularizing innovative pedagogical technologies, transferring them to teachers;
- the ability to develop educational web resources;
- the opportunity at any time and in any place to receive modern knowledge located in any accessible point of the world;
- the availability of higher education for persons with special psychophysical development [2].

Current online learning research brings together pedagogical, technical, and organizational concerns within a wider set of socio-cultural factors. Understanding issues &challenges in respect of online learning is of significant importance to the research communities involved in online learning and will have a significant role in forming future practices [3].

It is presented in the article definition of online learning, its advantages, and issues of it, and modern researches of it.

2. Materials and Methods

Today, among scientists there are differences in the definition of «online learning». Authors [4] describes the differences and presents main views on «online learning»: Some prefer to distinguish the variance by describing online learning as "wholly" online learning [5], whereas others simply reference the technology medium or context with which it is used [6]. Others display direct relationships between previously described modes and online learning by stating that one uses the technology used in the other [7]. Online learning is described by most authors as access to learning experiences via the use of some technology [8]. Authors identify online learning as a more recent version of distance learning which improves access to educational opportunities for learners described as both nontraditional and disenfranchised. Other authors discuss not only the accessibility of online learning but also its connectivity, flexibility, and ability to promote varied interactions [5]. These authors in particular not only elude to online learnings' relationship with distance learning and traditional delivery systems but then, like [8] makes a clear statement that online learning is a newer version or, an improved version of distance learning.

We will use the definition of authors [9] who identify online learning as a form of distance learning or distance education, which has long been a part of the American education system, and it has become the largest sector of distance learning in recent years.

The fact is that online learning has several advantages over face-to-face learning.

The advantages are described in the paper [4]. Here are some of that:

1. Enhancing student-to-student and faculty-to-student communication.
2. Enabling student-centered teaching approaches.
3. Providing 24/7 accessibility to course materials.
4. Providing just-in-time methods to assess and evaluate student progress [10].

Compared to the number of studies that found positive or no significant effects for student learning outcomes in the online format, the number of studies that found mixed or negative significant effects is much smaller, by a full order of magnitude. Some of these studies are direct contradictions of the studies with positive results: they find that students performed worse in the online format compared to the traditional format. Some studies' findings are more nuanced. They find that there are negative effects for certain groups of students and null findings for others. There are studies discussed in this section that systematically examine the ubiquitous self-selection bias of online learning: the endogeneity of learning environment choice. Most studies on distance or online learning do not examine this selection bias, which some researchers posit as a culprit for the "no significant difference" phenomenon [11].

Due to the increasing popularity of online learning and its ever-greater penetration into the sphere of education of the whole world appear a strong interest from the scientists' side in questions of measurement, collection, analysis, and reporting of data about students with aim of understanding and optimization of learning and conditions in which it occurs. Let's consider existing methods of online learning.

In addition to optimization tasks, in online learning, it is necessary to use data processing methods and learning analytics, which are used to study and build models of the online learning system.

At its core, learning analytics (LA) is the collection and analysis of usage data associated with student learning. The purpose of LA is to observe and understand learning behaviors to enable appropriate interventions. The reports that an LA application generates can be very helpful for instructors (about student activities and progress), for students (feedback on their progress), and administrators (e.g. aggregations of course and degree completion data). The main elements of LA include (fig.1) [12]:

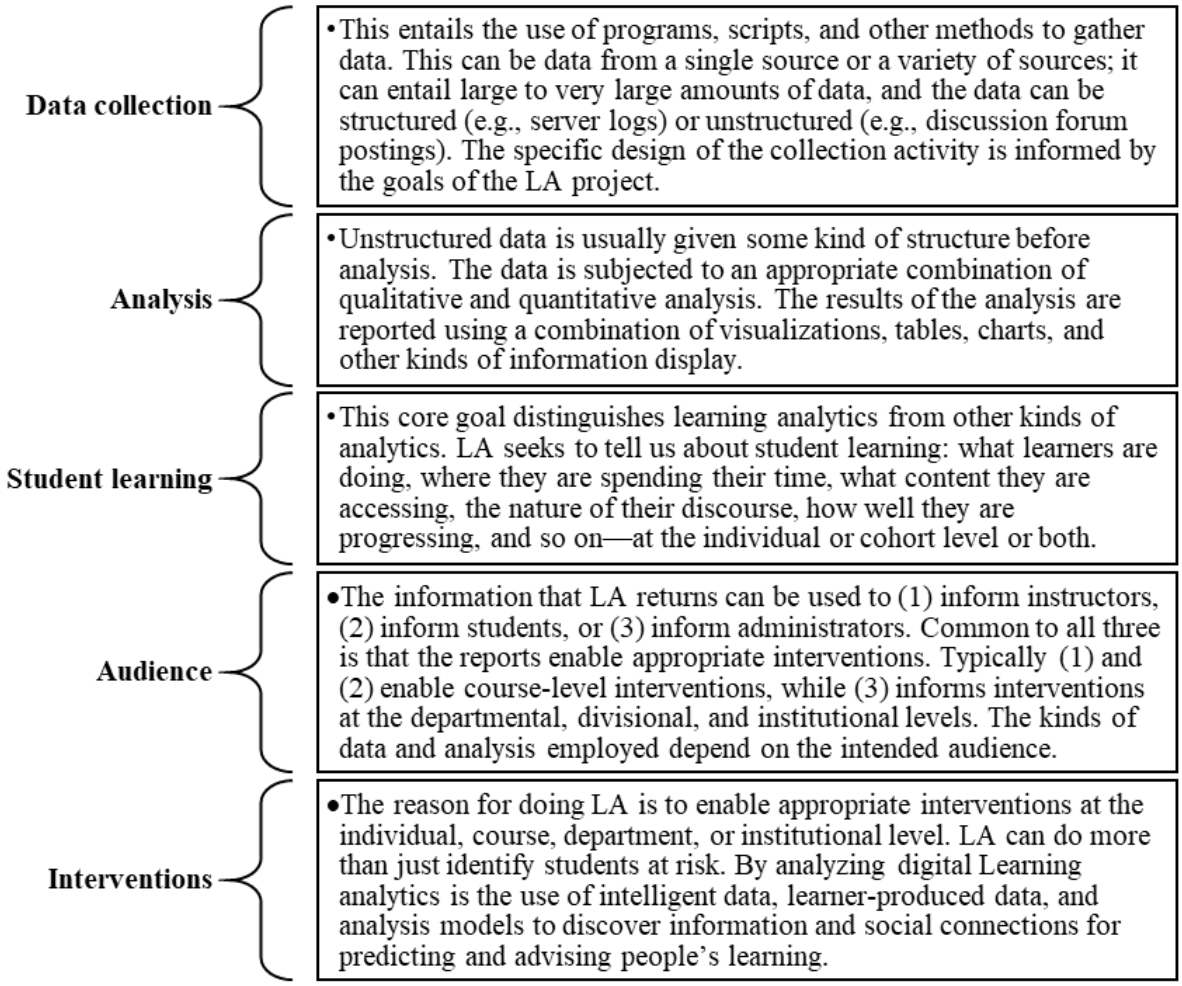

Figure 1: The main elements of learning analytics

Despite the enormous potential they hold to improve education, learning analytics is not without concerns. Privacy for learners and teachers is a critical issue. While I see analytics as a means to improve learner success, opportunities exist to use analytics to evaluate and critique the performance of teachers. Data access and ownership are equally important issues: who should be able to see the analysis that schools perform on learners? Other concerns relate to error-correction in analytics. If educators rely heavily on analytics, effort should be devoted to evaluating the analytics models and understanding in which contexts those analytics are not valid [13].

Essentially, for learning analytics to have a broad impact in education, the focus needs to move well beyond basic analytics techniques such as those found in Google Analytics. An integrated learning and knowledge model is required where the learning content is adaptive, prior learning is included in assessment, and learning resources are provided in various contexts (e.g. "in class today you studied Ancient Roman laws, two blocks from where you are now, a museum is holding a special exhibit on Roman culture”). The profile of the learner, not pre-planned content, needs to drives curriculum and learning opportunities [13].

Current online-learning research brings together pedagogical, technical, and organizational concerns within a wider set of socio-cultural factors. These factors influence the research agenda in the e-learning system. Understanding these broader social and cultural issues is of significant importance to the research communities involved in e-learning and will have a significant role in informing future practices. In consulting the research community, several research issues emerged (fig.2) [3]:

Interdisciplinary, and the notion of multiple voices, is a defining characteristic of the area.	• How do different research perspectives influence the overall area? How do problems in the practice of different disciplines differ in the adoption and use of learning technologies?
Access and inclusion include issues around the widening participation agenda.	• What are the barriers to inclusion and what are the issues surrounding the extent of the digital divide?
Change, and its relationship to learning technologies.	• How does change impact motivational issues? What are the drivers and rationales for change? What are the appropriate strategies for managing changes and mechanisms for their implementation?
Convergence and interoperability, in terms of exploration of different forms of convergence (organizational, technological, pedagogical, sectoral, institutional, etc).	• How well do they understand issues of globalization and scalability standards to support interoperability? These are complex relationships. The current focus is also on standardization across the pedagogical, technical, organizational, and human aspects versus critique of convergence.
Interactivity and social interaction	• How do the interactivity of different tools relate to, or impact upon, the nature of the medium? How is interactivity expressed at different levels of organizations, and how have organizational boundaries and functional groupings blurred as a consequence of new technologies? What potential do the new technologies have to enhance communication and collaboration and also creating new communities and networks?

Figure 2: Research issues of online learning

3. Model of Reflex Expert System of Online Learning Management

As was shown and proved by biologists based on the functioning of living organisms lies the formation of reflexes to various influences. A **reflex,** or **reflex action**, is an involuntary and nearly instantaneous movement in response to a stimulus.

At the level of simple biological objects, reflexes provide the forming of a “necessary” reaction to the state of the environment.

At the human level, reflexes are formed not only on physical influences but also on the impact of the socio-political sphere, on the information impacts of other people, for example, teachers at school, colleagues, wives, etc.

Of course, these reflexes are very complex, not unambiguous, cannot be represented by a simple model of “impact” – “reaction”. Rather, this model looks like “a lot of influences” – “the most profitable reaction, from the position of obtaining a positive attitude”. In the non-force interaction theory, a mathematical apparatus has been developed that allows one to describe the mechanism of producing reflexes and the “behavior” of technical systems on this basis.

By assumption, the interaction of neurons is based on the same laws and is realized by the developed model of non-force interaction. And this found its realization in reflex intelligent systems capable of accumulating information about the functioning environment and forming an adequate response (reflexes) to everything that happens in this environment.

This is a system for evaluating investment proposals in development; natural language access to databases; assessment of the influence of harmful substances in the water resources of the region on the health of the population; forecasting the results of sports events. Their main advantage is the simplicity of development and the effectiveness of solving a variety of intellectual problems.

These systems are represented in Figure 3.

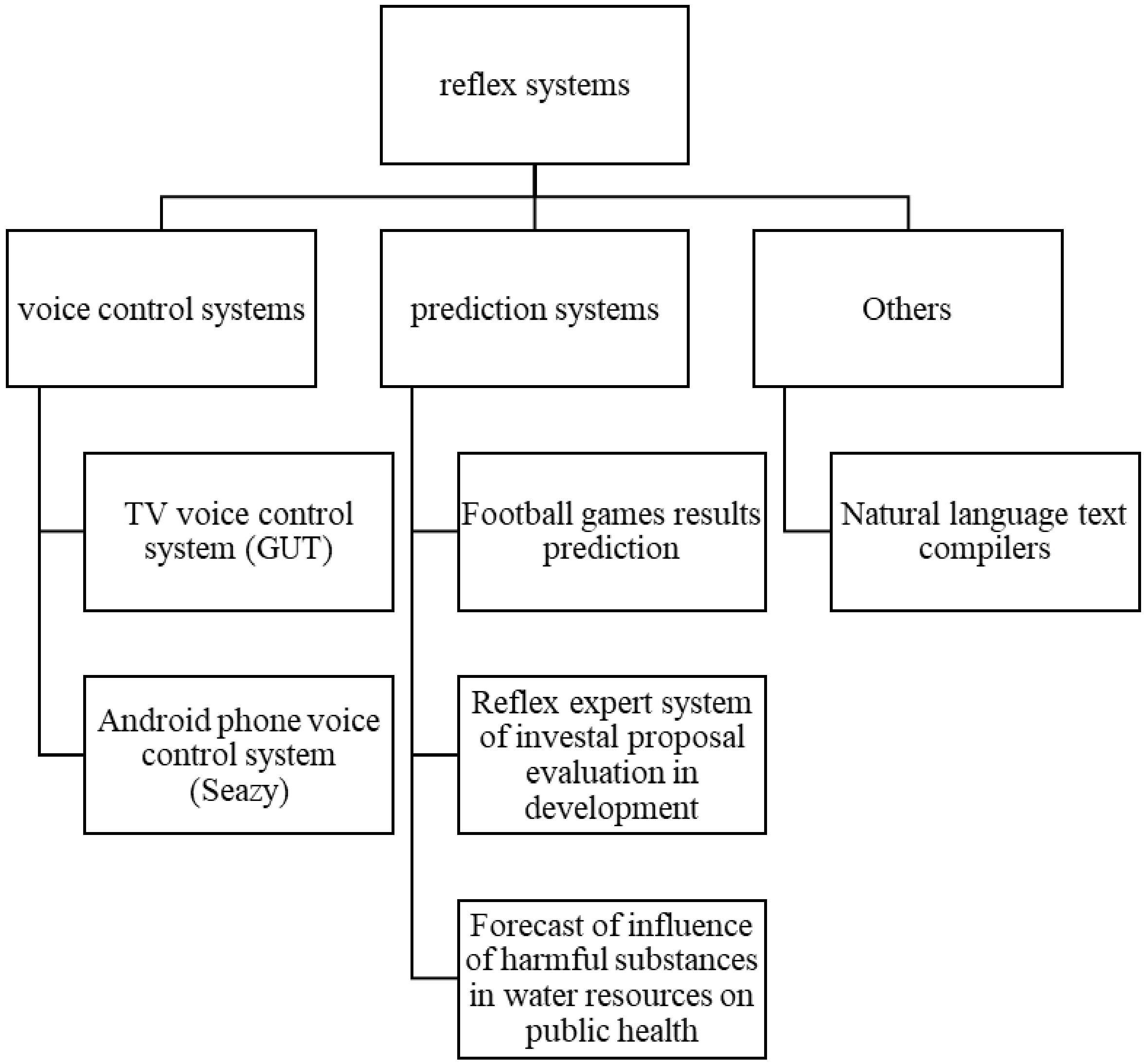

Figure 3: Reflex systems

Let us review the voice control systems.

The question arises whether it is possible to present the process of voice interaction using the models that are developed in the non-force interaction theory?

Traditionally, speech recognition systems are based on the principle: “spoken language” → “representation of speech as a set of linguistic constructions” → “speech understanding”.

Based on the non-force interaction theory the other model of natural language recognition can be suggested: “spoken language” → “estimation of non-force (informational) impact on the reaction” → “reaction (understanding or behavior)” = REFLEX [14].

The principal scheme of the reflex voice control system is presented in figure 4.

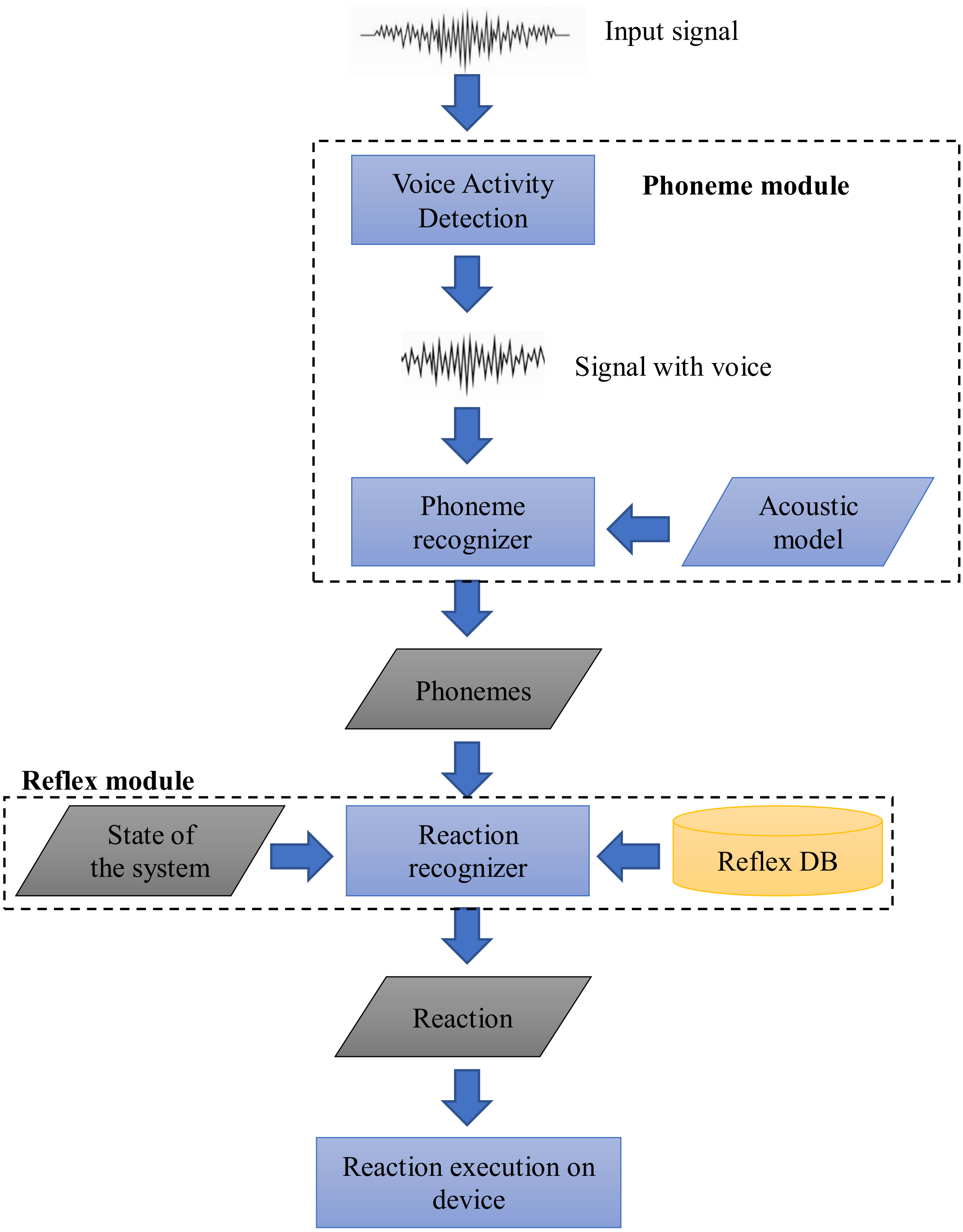

Figure 4: The principle scheme of the reflex voice control system

In essence, the reflex voice control system consists of two modules. The first module is a **phoneme module**. It receives sound signals from the microphone, through the voice activity detection algorithm detects voice in the input signal, and then transforms the input signal into a phoneme sequence and sends these phonemes to the reflex module. It is possible to use different phoneme modules, for example, CMUSphinx or google speech recognition API, or other systems. The second module is the reflex module. In the input of the module is the sequence of phonemes and in the output of the module is a reaction. And then the voice control system executes the reaction on the device, for example, mute sound. The reflex module uses the reflex database and state of the system to determine the reaction. The module does not include grammar rules or a language dictionary.

Because dictionaries and the analysis of the words (grammar) are not needed there is no need to create a mining model text, such systems are relatively traditional:

- easier;
- cheaper;
- does not require restrictions on the language;
- use a universal algorithm that can be used to create many recognition devices and not just speech;
- easy to learn;
- good to extract any useful information of the speech stream;
- conversely, do not react to the noise, the speech that does not contain any commands, chatting;
- angling for useful information in a stream of free speech;
- allow the course to add new commands;
- respond appropriately to the surrounding speech and voice background (ie, extraneous information not relevant to the management unit);
- tolerant to the errors in the speech of the speaker;
- allow you to reprogram the behavior of the voice;
- learn from their mistakes;
- perform fixation, analysis, and correction of recognition errors;
- perform speaker identification;
- adjust to the style and habits of the speaker [15].

As can be seen from these results, it possible to speak of the importance of spreading the ideas of the above in the scientific world. And about the possibility of applying this experience to create online training systems.

The authors suggest a method for constructing a reflex expert system for managing individual online training. Such a system will reflect the knowledge of trainees in some software and information environment, which provides the forming of necessary reactions. Let us introduce several definitions

Definition 1. **Informed agent (IA),** the model of the trainee in the information base of the reflex expert system of individual online learning management (RESL) in the context of courses, capable of forming the RESL reaction.

The informed agent is an interrelated collection of data and knowledge reflecting the real or abstract trainee, as a result of the interaction of elements of which the RESL reaction is formed.

Definition 2. **RESL reaction** is a course unit (topic, lecture) that must be studied by the informed agent.

Write

$$I = \{I^x\}, j = \overline{1, q}, \qquad (1)$$

where I^x – informed agent; I – RESL informed agents; q – number of informed agents.

$$R = \{r_k\}, k = \overline{1, w}, \qquad (2)$$

where r_k – RESL reaction; R – possible RESL reactions; w – number of possible RESL reactions.

$$\forall I^x \in I \; \exists r_k \in R : \Omega(I^x, r_k) = true, \qquad (3)$$

where $\Omega(I^x, r_k)$ – predicate that defines reaction of the informed agent

Definition 3. Under the **management of online learning**, we will understand the automatic definition of RESL course units (topics, lectures) that need to be studied by the trainee in the course.

Now solve the problem of how to determine the reaction of an informed agent? To do this, we need to formally submit an informed agent. We assume that an informed agent consists of three data and knowledge areas:

$$I^x = I_1^x \cup I_2^x \cup I_3^x, \qquad (4)$$

where I_1^x – test results (data); I_2^x – interview results (knowledge); I_3^x – list of elements of the form of training and / or course units that need to be studied (RESL reaction).

$$I_3^x = \{r_{k_l}\}, l = \overline{1, m_j}, \qquad (5)$$

where m_j – number of RESL reaction in the informed agent I^x

$$I_1^x \cup I_2^x = \{y_j\},\ j = \overline{1, s}, \tag{6}$$

where s – number of combinations of trainee responses contained in the results of the interview/questioning and testing; y_j – the combination of the trainee's answers contained in the results of the interview/questioning and testing.

The combination of answers is understood as the combination of answers of the trainee. For example, if there were 3 questions in the test (or interview) that were answered:

1) A.
2) B.
3) A.

Then the informed agent will contain a combination of answers:

1A; 2B; 3A; 1A2B; 1A3A; 2B3A; 1A2B3A.

For informed agents who have the same test results and interview reactions should be the same.

$$\exists I^x, I^s \in I:\ I_1^x = I_1^s, I_2^x = I_2^s \Rightarrow I_3^x = I_3^s \tag{7}$$

But in general, if the course units that need to be studied by different informed agents are the same, the test results and / or the interview results may not be the same.

$$\exists I^x, I^s \in I:\ I_3^x = I_3^s \Rightarrow I_1^x \neq I_1^s \vee I_2^x \neq I_2^s \tag{8}$$

So, if some informed agent must determine a comfortable form of training and course units that need to be studied, it is required in the set of all informed agents to find one that has the same content in the context of test and interview/questioning results. In general, no such informed agent will be found. After all, it is quite difficult to find two trainees who know the same discipline. Then, to determine the RESL reaction, we use the results obtained in the theory of non-force interaction.

We assume that the reactions are formed in the informed agent as a result of the non-force (informational) influence of the trainee's knowledge, embodied in the model of the informed agent. More precisely, in the part of this model that corresponds to the results of testing and questioning/interview

$$I_3^x = f(I_1^x, I_2^x) \tag{9}$$

Then using the mathematical apparatus of the theory of non-force interaction, it is possible to calculate the magnitude of the influence of the state of the trainee, embodied in the results of testing and interviews on the RESL reactions. And choose the reactions to which the effects are most significant.

There are two stages in the technology the RESL operation.

1. Stage of training.

1.1. Information agents test results and / or interview results are put into the RESL.

1.2. For each information agent, the teacher indicates which course unit he should study (the reactions of the RESL are indicated). As a result, with a significant number of information agents, unconditional and conditional probability of RESL reactions are calculated:

$$p_0^x \approx \frac{n_0^x}{m}, \tag{10}$$

where n_0^x – the number of informed agents for which the reaction R_x was chosen; m – number of informed agents; p_0^x – unconditional probability of choosing reaction R_x

$$p_j^x \approx \frac{n_j^x}{\sum_{k=1}^{w} n_j^k},\ j = \overline{1, s}, \tag{11}$$

where n_j^x – how many times the R_x reaction was chosen, provided that the a combination of answers y_j was found in the results of the questioning/interview and testing; n_j^k – how many times the R_k reaction was chosen, provided that the a combination of answers y_j was found in the results of the questioning/interview and testing; s – number of different combinations of answers.

The conditional probability of an R_x reaction occurring provided that a combination of answers y_j was found in the results of the survey/interview or testing.

$$p_j^x = p(R_x / y_j) \tag{12}$$

2. Stage of management.

2.1. From the known probabilities of the RESL reactions, certainty (13) and the awareness (14) of RESL are calculated regarding these reactions.

$$d_j^x = \begin{cases} 0{,}5 \cdot \sqrt{\dfrac{p_j^x}{1-p_j^x} + \dfrac{1-p_j^x}{p_j^x} - 2}, p_j^x \geq 0{,}5 \\ \hline -0{,}5 \cdot \sqrt{\dfrac{p_j^x}{1-p_j^x} + \dfrac{1-p_j^x}{p_j^x} - 2}, p_j^x < 0{,}5 \end{cases}, \; 0 < p_j^x < 1, \; j = \overline{0,s}; \tag{13}$$

$$i_j^x = \frac{1}{2\sqrt{p_j^x \cdot (1-p_j^x)}}, 0 < p_j^x < 1, \; j = \overline{0,s}, \tag{14}$$

where $d_j^x, \; j = \overline{1,s}$ – certainty of an R_x reaction, provided that a combination y_j was found in the answers (d_0^x – certainty of reaction in the absence of action on an informed agent).

2.2. The calculation of the total increment of certainty, for all non-force actions on an informed agent,

$$\Delta d^x = \sum_{j=1}^{s}(d_j^x \cdot i_0^x - d_0^x \cdot i_j^x) = i_0^x \sum_{j=1}^{s} d_j^x - d_0^x \sum_{j=1}^{s} i_j^x \tag{15}$$

where Δd^x – a total increment of certainty of the informed agent, given by the influence of all combinations of responses $I_1^x \bigcup I_2^x$.

2.3. The calculation of the increment of awareness of the informed agent (from formula 14)

$$\Delta i^x = \sqrt{\left(d^x\right)^2 + 1}, \tag{16}$$

where i^x – increment of awareness of the informed agent.

2.4. Calculation, according to the formula (13), of the new Rx reaction certainty, which is created by all combinations of answers $I_1^x \bigcup I_2^x$

$$\overline{d^x} = \Delta d^x \cdot i_0^x + d_0^x \cdot \Delta i^x, \tag{17}$$

where $\overline{d^x}$ – new R_x reaction certainty.

2.5. Calculation by the formula (14) of the new awareness of the R_x reaction, which is given by knowledge of the impact of all combinations of answers $I_1^x \bigcup I_2^x$

$$\overline{i^x} = \sqrt{\left(\overline{d^x}\right)^2 + 1}, \tag{18}$$

where $\overline{i^x}$ – a new awareness of the informed agent.

2.6. From formula (8), we estimate the probabilities of the reaction R_x

$$\overline{p^x} = p \; (R^x / I_1^x I_2^x) = 0{,}5 + \frac{\overline{d^x}}{2 \cdot \overline{i^x}}, \tag{19}$$

where $\overline{p^x} = p\left(R_x / I_1^x \bigcup I_2^x\right)$ – estimation of the R_x reaction probability with actions $I_1^x \bigcup I_2^x$.

2.7. Selection of reactions for which the probability estimation is greater than the threshold value

$$\exists R^x \in R : \overline{p^x} \geq p_{\min,}, \tag{20}$$

where p_{min} – the minimum acceptable value of the reaction probability estimation.

4. Conclusion

According to the study, methods of data science got the highest priority in online learning research. In these areas, lots of development has to be made. As technology is growing day by day, learner interest in online learning increases very rapidly. Now researcher has begun to work on designing new online learning models that can work according to learners' interests and preferences. It is a perspective direction of further researches.

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