CLASSIFICATION OF DISTANCE LEARNING AGENTS

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Abstract. Implementation of agent based intelligent technologies in the environment of distance learning can individualize learning, enable the optimal use of learning resources and ensure effective interaction with all participants of the learning process. The paper presents agent classification for the modern distance learning environments, based on Anderson and Garrison’s model of interaction modes in distance learning process. All components of the learning process model and the interaction of agent groups are distinguished, and the functions of such groups are described.

Keywords: distance learning, agent, classification.

1 Introduction

In distance learning there is an attempt to replace human relations, which appear in direct contact with a learner in traditional studies, by effective interaction with the learning environment. However, the need for monitoring a learner, following his progress, providing timely relevant information, offering assistance, and communicating remains. These problems in distance learning are solved by implementing and applying technologies based on intelligent software agents. Furthermore, a lot of routine and time-consuming functions of a teacher and student can be computerised, especially those relevant in application of virtual learning environment.

An intelligent agent is a computer system situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives [16]. Imam and Kodratoff [15] define an intelligent agent as “a system or a machine that utilizes inferential or complex computational methodologies to perform the set of tasks of interest to the user”. According to Weiss [25], “as an intelligent entity, an agent operates flexibly and rationally in a variety of environmental circumstances given its perceptual and effectual equipment. Behavioral flexibility and rationality are achieved by an agent on the basis of key processes such as problem solving, planning, decision making, and learning. As an interacting entity, an agent can be affected in its activities by other agents and (perhaps) humans.”

Hence, intelligent agents are used to model rational behaviour in a certain operation diapason. Intelligence also means that agent activities are based on certain logics which can be compared to human logics; the software developed according to certain objectives simulates human logics and activities and thus software technologies approach human perception, intelligence and operation.

Intellectualization and individualization of learning by applying agent technologies enable us to eliminate the barriers naturally emerging in the distance learning process. Effective learning environment would be the one which creates clear, purposeful and support-based learning environment, though the student studies alone, and enables him to interact efficiently with other participants of the learning process.

Although there are a number of works on agent technologies applied in distance learning, a single generalising approach is still missing. For example, there is no single classification for educational agents. An established classification system would allow systemising the approach and would facilitate the analysis of agent technologies and application in distance learning.

This paper suggests classifying learning environment agents on the grounds of the Anderson and Garrison’s model [1] of the interaction modes in the distance learning process. The most frequently used general agent classifications are introduced in part 2 of this paper; the conception of agents applied in the learning and existing educational agent classifications are presented in part 3; the expanded model of interaction modes in the learning process, which illustrates current distance learning process, is presented in part 4. Agent classification, on the grounds of expanded learning process, is given in part 5.

2 Diversity of Agent Classification

It is clearer to analyse and use agents in different environments by making reference to their division into certain classes according to their general characteristics, i.e. by classifying them. There are different classification schemes that may be used to define agents. Nwana’s conception of agent typology, classification according to the types, is used the most widely in scientific literature.

Classification by Nwana. Nwana [20] identifies some aspects for agent classification:
- agent mobility. According to their capability to move among networks, agents are devided into static and mobile;
- agents can be deliberative and reactive;
- agents may be classified by their key characteristics: cooperation, learning and autonomy. Four agent types can be singled out according to these minimal characteristics (Figure 1): collaborative agents, collaborative learning agents, interface agents, and smart agents. However, an agent that belongs to a specified class may also combine other characteristics.

**Figure 1. A Part View of an Agent Typology [20]**

- agents may be classified by their key roles. For example, WWW agents that are called information or Internet agents. There may be other classes by minor roles: report agents, presentation agents, help agents, etc.
- the category of hybrid agents, which covers philosophies of two or more agents, is also included.

According to all the examined categories of agent types Nwana [20] has identified seven agent types, considering that this list is more arbitrary than definitive:

1. Collaborative agents.
2. Interface agents.
4. Information/Internet agents.
5. Reactive agents.
6. Hybrid agents.
7. Smart agents.

In accordance with Nwana, there might be some applications in which agents from two or more categories are combined and we refer to these as heterogeneous agent systems.

**Classification by Brustoloni.** In Brustoloni’s [6] taxonomy there are three agent classes: regulation agents, planning agents and adaptive agents. Regulation agents do not plan and learn; they simply react to some changes and always know what to do. Planning agents plan and use elements of artificial intelligence. Adaptive agents not only plan but also learn.

**Classification by Gilbert et al.** In order to determine agent characteristics, Gilbert et al. [13] have introduced model 3D in which the agency can be roughly qualified by the agent’s position in 3D space where intelligence, autonomy and social ability correspond to the dimensions. So that the agent would be assigned to the system, it must meet a minimum level of characteristics of each dimension.

**Classification by Franklin and Graesser.** Franklin, Graesser [12] have presented the classification according to the biological and computational model emphasizing major autonomous agent classes: biological agents, robotic agents and computational agents. In turn, in the dimension of the type they have classified computational agents in software agents and artificial life agents, and in the dimension of the class divided software agents into task-specific agents, entertainment agents and viruses. The authors consider that further subclassifications can be made taking into account the control structure, environments (database, file system, network, the Internet), language of design or application.

**Classification by Davis.** The classification according to Davis [8] is based on three intelligent characteristics of the agent: reflective, reactive and meditative.

**Classification by Wooldridge.** Wooldridge [27] introduces four classes of agents:
- logic based agents;
- reactive agents;
- belief-desire-intention agents;
- multi-dimensional architecture (decision-taking is implemented via different software dimensions each of which rate the environment by particular abstraction level).

**Classification by Russell and Norvig.** Russell and Norvig [21] classify agents in four categories, from simple to complex:
- simple reflex (stimulus-response) agents. These agents respond to stimulus. They have no memory, they simply respond to the changes in the environment;
- reactive state agents ("agents that keep track of the world");
- goal-based agents. The agents can plan their activities in their environment;
There also exist other agent classifications, but their essence, in accordance with Wooldridge [27], is that they shift from abstract agent definition to more precise definitions of structure and agent operation, and also to analysis of advantages and disadvantages of architecture. For example, there are many agents developed to operate on the Internet, their type is the same; however, their denotation and functions of performance are different.

Quite often agents are defined by the roles they perform. Although, according to Wooldridge, Jennings, and Kinny [28], agent roles is more abstract definition than agent types. The authors compare agent roles with persons’ roles in the company, i.e., the company has roles such as “president”, “vice president”, and so on. In the company the individual may provide different roles in different periods, but in a small company he can execute various roles at the same time. One or another role is defined by four attributes: responsibilities, permissions, activities, and protocols.

Usually agent roles depend on the functions they perform.

3 Educational agents

The common goal of the educational agents is to facilitate the learning and support the learner’s activities. There is no single agent classification or unified classification system based on defined agent roles. The definition of the educational agent is also rather broad. According to Chou et al. [7], “an educational agent is a kind of computational support, which enriches the social context in a social learning environment either by providing virtual participants to enhance the member multiplicity of communities or by supporting facilities to foster communication among real participants”. In her definition Landowska [17] indicates common characteristics of the agent such as intelligent and autonomous and appeals to agent functions: “An educational agent is an intelligent and autonomous part of a learning environment introduced in order to assist a student or a teacher in the completion of their tasks. An agent can also autonomously perform tasks related with the management of learning resources or the achievement of internal educational goals”.

Dowling [9] notes that in the learning environment both the teachers and the students can perform different roles at the same time. Electronic environment allows identifying these specific roles and distinguishing different functions that can be accomplished via different agent configurations.

Many scientists refer to the classification of educational agents introduced by Chou et al. [7] which is based on agent operation roles and functions in the learning process. In this classification agents are distinguished into pedagogical agents and personal assistants. In turn, pedagogical agents are distinguished into two groups: authoritative teachers (tutor, coach and guide) and learning companions or co-learners (peer tutor, tutee, simulated student, collaborator, competitor, trouble-maker, critic and clone). Personal assistants are grouped into teacher’s assistant and student’s assistant [7].

Other authors use either more common (teacher agents, pedagogical agents) or more precise terms (recommender agent, learning companion, collaborative learning agent, monitoring agent, facilitator agent, etc.) which are ungrounded by any classification scheme but simply defined by the functions performed by agents. An animated agent is also often called a pedagogical agent [5], [24].

For example, Lee et al. [18] states that in collaborative e-learning environment agent roles may be of two categories: facilitating learning process and facilitating the social interaction. Baylor [4] presents two types of educational agents: agents as intelligent tutors and agents as cognitive tools. Erlin, Norazah and Azizah [11], on the grounds of works of many authors, identified the following roles of agents in the collaborative learning environment: monitoring agent, facilitator agent, mobile agent as, an artificial tutor agent, information agent, question agent, assistant agent, student agent, teacher agent, etc. „The architecture of the system and the role given to each agent depend on both the type of application and the global functionalities of the system” [11]. According to these derived roles, the authors sort all the agents into four wider agent groups: a) information and internet agents, b) collaborative agents, c) mobile agents, d) and interface agent.

Sometimes there is no deep interest in precise agent definitions on the whole and the term ‘pedagogical’ is satisfactory, same as widely used Johnson’s definition, cited by Dowling: pedagogal agents are autonomous agents that support human learning by interaction with learners in interactive learning environment [10].

Consequently, agents model existing and eventual student and teacher roles; and diversity of these roles depends on the mode to learning, objectives and multimedia. In traditional learning both the teacher and the student perform various roles and functions in different situations; therefore, innovations, dynamism and various skills continually raise new roles and demand for new functions. However, alternation of roles in traditional learning is more conventional due to direct interaction with the learner. In distance learning the role and functions of intelligent agents should be defined clearer. General classification of educational agents is too abstract. Consequently, it would be purposeful to carry out the classification of educational agents closely with the learning process.
4 Expanded model of interaction modes in distance learning process

Modern distance learning environment is complex – a student becomes a part of the heterogeneous environment: he/she interacts with the computer, the teacher, other learners and learning content, and all this process is surrounded by a large flow of information. Also the learning process requires an active student role and his/her ability to communicate successfully and learn independently: it means to choose the information and learning material according to the learning aims, define learning terms and learning pace personally, etc. These tasks are not easy.

Distance learning processes are the subject of research of many scientists [19], [14], [26], etc. It is widely used the Anderson and Garrison’s [1] model of interaction modes in distance learning process. The authors expanded the Moore’s [19] structure of three distinct types of interaction in distance education: learner-content, learner-instructor, and learner-learner. In the Anderson and Garrison’s [1] model of interaction the three main components of the learning process (student, teacher and content) and the six types of interactions (student-student, student-teacher, student-content, teacher-teacher, teacher-content and content-content) are distinguished and described (Fig. 2). This structure is considered to be classic in distance learning, however, it is also appropriate for traditional teaching.

Anderson [3] has expanded [1] the model for the semantic network. The author has introduced student, teacher and content agents with their special functions. This model is a theoretical option for possible agent application.

Erlin, Narazah and Azizah [11] have applied [2] the model, which basically corresponds to the Anderson and Garrison [1] model of interaction modes, to classify the interaction-related agents. The authors have linked communication tools and their use in asynchronous and synchronous communication with cluster of agents: interface agent, information agent and the Internet agent (to make the interaction of the model) and cooperation agent (it operates on behalf of student, teacher, and content). As we can see, the object of the authors is interaction and they do not analyse the agents related with the components of the learning process.

Since the environment plays an important role in the modern distance learning, Targamadze and Cibulskis [23] have extended the Anderson and Garrison’s [1] model of interaction modes in distance learning process by adding to it the learning environment and possible interaction links (Figure 3).

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Figure 2. Modes of interaction in distance education [2]

Figure 3. Expanded model of interaction modes in distance learning process [23]
According to the authors, “limited interaction between student and teacher in distance learning process is usually compensated through higher interaction with learning content. Application of information technologies in distance education has brought another type of interaction – interaction with learning environment. Students’ and teachers’ interaction with learning environment is as much important as interaction with learning content and can partially compensate weaker interaction between teacher and students. In some cases environment can also interact with learning content by performing automated content modification and adaptation to learners needs” [23].

5 Classification of educational agents on the basis of expanded model of interaction modes in distance learning process

The expanded model of interaction modes in the distance learning process, proposed by [23] Anderson and Garrisson [1], better reflects the modern distance learning process. The components of the model of interaction are supplemented with the environment and the interaction list – with three new interactions: student-environment, teacher-environment and content-environment. This extended model of the distance learning process illustrates the links among all the components included in the distance learning (student, teacher, environment, and content) and the interactions between them. The learning environment is a system which includes all the implements (service, search systems, communication environment, etc.) in virtual environment used by the learner. Content is the variety of learning materials (lecture syllabus, tasks, document sets, diploma works, e-books, videos, etc.). Interaction, mutual influence, is an integral part of the learning process in which, besides knowledge creation and exchange of information, there are other social activities: enhancing student motivation, support, assistance, etc. Interaction has direct impact both on the learning process itself and on the consequent student outcomes. However, assurance of interaction is quite complex. There is a common problem in the distance learning when the learners are unable to have actually effective social interaction due to lack of skills (including the information technology skills) and the lack of the ability and motivation to communicate with teachers and peers. When design of the interaction in the learning environment is completed and functions of interaction are transferred to intelligent agents, it can be achieved that all possible types of interactions are ensured and all objects are used more efficiently. According to Sharp and Huett [22], “interaction does not just happen; it must be facilitated by intentional efforts on the part of the designer.”

By adding agents to the model, we can design a learning system in which each part of the learning process can be constructive for the learner and used to help him/her learn. This expanded model of interaction modes in distance learning process can be used for classification of distance learning agents (Figure 4).

![Figure 4. Expanded model of interaction modes in distance learning process, using agents](image-url)
Learning process agents are divided into two types: component agents and interaction agents. Component agents are divided into groups depending on learning subjects or objects (student agents, teacher agents, content agents, and environment agents). Interaction agents are divided into nine groups according to interaction links (student-content interaction, student-teacher interaction, teacher-content interaction, student-environment interaction, teacher-environment interaction, content-environment interaction; and student-student, teacher-teacher and content-content interactions). Agents division into types and groups and descriptions of group functions are presented in Table 1.

Table 1. Components of learning process, groups of agents and agent functions in an expanded model of interaction modes in distance learning process

<table>
<thead>
<tr>
<th>Category</th>
<th>Group of agents</th>
<th>Functions of agents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Environment agents</td>
<td>Recording of interactions, maintenance of operation in different environments, analysis of applied environments.</td>
</tr>
<tr>
<td>Interaction agents</td>
<td>Student - Content interaction agents</td>
<td>Delivering content according to individual goals or needs. Individualization of learning. Processing, sorting, selecting and/or suggesting materials from various sources.</td>
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<tr>
<td></td>
<td>Student - Teacher interaction agents</td>
<td>Supporting and motivating the interaction between student and teacher.</td>
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<tr>
<td></td>
<td>Teacher - Content interaction agents</td>
<td>Assisting a teacher in developing and updating the content. Informing the teacher about changes of materials in environments which are monitored by agent.</td>
</tr>
<tr>
<td></td>
<td>Teacher - Environment interaction agents</td>
<td>Assisting and guiding a teacher in interaction with the environment.</td>
</tr>
<tr>
<td></td>
<td>Content - Environment interaction agents</td>
<td>Assisting and guiding a student in interaction with the environment.</td>
</tr>
<tr>
<td></td>
<td>Content - Content interaction agents</td>
<td>Supporting and facilitating the application of the material used in the environment. Monitoring the content and environment, coherence analysis between sources, supplying links to additional sources.</td>
</tr>
<tr>
<td></td>
<td>Student - Student agents</td>
<td>Activating student collaboration, encouraging group learning and communication. Discussion support. Formation of a group model from single student models. Mobilization of students similar needs.</td>
</tr>
<tr>
<td></td>
<td>Teacher - Teacher agents</td>
<td>Maintaining thematic teacher networks activity.</td>
</tr>
<tr>
<td></td>
<td>Content - Content agents</td>
<td>Maintaining cohesion of learning objects.</td>
</tr>
</tbody>
</table>

The table above indicates summarized agent’s functions when the agent operates as assistant. Student and teacher models provide certain information about these teaching process subjects as users, help to recognize, evaluate and attribute them to users group, and they also initiate certain actions in connection with the groups. A lot of other roles may be allotted to agents: learning companion, critic, troublemaker, etc. When agent roles are different, their functions change as well; besides, the types of interaction can also be changed. Different types of agents used in agent systems operating together facilitate to achieve tasks and tackle problems in a more flexible way. They can also ensure the system’s higher reliability: if one of the agents is unable to solve the problem, the other ones takeover the task. Distribution of functions among different types of agents is in progress during the system design process.
6 Conclusions

Agent classification enables systemising the approach to them and facilitates to perform more purposeful analysis and application of agent technologies. There are different classification principles; however, there is no common classification. Usually scientists refer to the classification scheme by the agent types according to Nwana [20].

Neither definition of educational agents nor classification is well-established. The ground for agent classification is different and miscellaneous.

The classification of agents presented in this paper and based on the Anderson and Garrison’s model of interaction modes in distance learning process reflects learning activities better and helps to identify necessary agent functions more accurately. There are two types of agents in the learning process: component agents and interaction agents. Agents of components of the learning process (student, teacher, content, and environment) act as assistants of teacher and student; they update, choose, accumulate content, maintain work and analyse different environments. Interaction is mutual impact between components such as student-content, student-teacher, teacher-content, student-environment, teacher-environment, content-environment, student-student, teacher-teacher and content-content; and agents maintain and strengthen these interactions and operate as activators of the learning process.

References


