Nikitina Sofiia Dmitrievna
student
Iliasova Kristina Fanzelevna
student
Zhdanov Andrei Mikhailovich
student
Koldenkov Kirill Aleksandrovich
student
Scientific adviser
Cherniavskaia Natalia Evgenevna
senior lecturer
MIREA – Russian Technological University
Moscow

INTELLIGENT WEB SERVICES AND SEMANTIC TECHNOLOGIES IN DIGITAL EDUCATIONAL RESOURCES

Abstract: *the article explores the principal aspects of Web Intelligence (WI) in the context of Artificial Intelligence in Education (AIED). The study demonstrates that WI creates new possibilities for personalization of learning, adaptive educational services and semantic integration of learning materials. Special attention is devoted to components such as ontologies, intelligent Web services, semantic markup and Web mining. The architecture of intelligent educational servers INES is proposed, and usage scenarios are described. The authors conclude that the introduction of WI methods into e-learning systems increases adaptability, automation and learner comfort.*

Keywords: *Web Intelligence, Semantic Web, ontologies, artificial intelligence in education, pedagogical agents, Web mining, intelligent Web services, adaptive learning.*

Никитина София Дмитриевна
студентка
Ильясова Кристина Фанзелевна

студентка
Жданов Андрей Михайлович
студент
Колденков Кирилл Александрович
студент
Научный руководитель
Чернявская Наталья Евгеньевна
старший преподаватель
ФГБОУ ВО «МИРЭА – Российский технологический университет»
г. Москва

ИНТЕЛЛЕКТУАЛЬНЫЕ ВЕБ-СЕРВИСЫ И СЕМАНТИЧЕСКИЕ ТЕХНОЛОГИИ В ЦИФРОВЫХ ОБРАЗОВАТЕЛЬНЫХ РЕСУРСАХ

Аннотация: *в статье рассматриваются ключевые аспекты интеллектуального Веба (Web Intelligence, WI) в контексте применения технологий искусственного интеллекта в образовании (AIED). Показано, что WI открывает новые возможности для персонализации обучения, адаптивных образовательных сервисов и семантической интеграции учебных материалов. Основное внимание уделяется таким компонентам WI, как онтологии, интеллектуальные веб-сервисы, семантическая разметка и веб-майнинг. Предложена архитектура интеллектуальных образовательных серверов INES, описаны сценарии их использования. Сделан вывод о том, что внедрение методов WI в системы электронного обучения повышает адаптивность, автоматизацию и комфорт обучающегося.*

Ключевые слова: *интеллектуальный веб, семантический веб, онтологии, искусственный интеллект в образовании, педагогические агенты, веб-майнинг, интеллектуальные веб-сервисы, адаптивное обучение.*

1. Introduction.

Web Intelligence (WI) is a scientific field that studies the role of artificial intelligence (AI) and advanced information technologies in the development of the next-generation Web [7]. WI covers areas such as ontological engineering, Web agents, Web

mining, semantic markup, and intelligent Web services. In education, these technologies can substantially enhance e-learning by offering personalization, flexibility, and automation of many processes that currently require manual intervention by the teacher or the learner.

There are four conceptual levels of WI [3]:

– Network level – adaptation to the user's navigation behavior;

– Interface level – intelligent human-Web interaction (personalized multimedia representation);

– Knowledge level – representing and processing the semantics of Web data in machine-readable formats;

– Social level – discovering user communities and interaction patterns.

This study concentrates on ontologies, semantic markup, intelligent Web services, and Web mining, as well as their application for creating new educational systems.

2. The Semantic Web as a Foundation for WI.

The Semantic Web is an evolution of the current Web in which information is expressed in a precise, machine-interpretable form, allowing software agents to process, share, reuse, and understand the meaning of terms [6]. Key components of the Semantic Web are:

– a unifying data model – most often RDF (Resource Description Framework);

– ontologies – formal specifications of domain terminology;

– markup languages (OWL, DAML+OIL);

– semantically annotated Web resources.

In February 2004, the W3C adopted OWL (Web Ontology Language) as a recommendation. In November 2003, the second version of WSDL (Web Services Description Language) was published. These standards form the foundation for building intelligent educational systems.

3. WI-Related Research in AIED.

The AIED community has long studied several issues relevant to WI. First of all, pedagogical agents – autonomous software entities that interact with learners and teachers, helping to locate, select, and integrate learning materials [4]. Web-based

intelligent tutoring systems (ITS) such as ELM-ART, PAT Online, and ActiveMath are also well known. They demonstrate personalization, adaptive navigation, and collaborative learning support.

A separate direction is educational ontologies. Ontologies provide the backbone for knowledge bases and reusable Web content. The most notable work in this area comes from the Mizoguchi Lab at Osaka University and from T. Murray.

4. Architecture of Educational Servers Based on WI.

An effective configuration for Web-based education includes distributed educational servers, pedagogical agents, and client workstations (learners, teachers, authors). Pedagogical agents act on behalf of the learner, accessing educational servers through high-level Web services. Educational content is pedagogically structured material, and an educational service is a Web service designed to support a specific learning goal.

An educational server should possess sufficient intelligence to plan content presentation, adapt it, and build a student model. Semantic markup of learning resources should be performed using appropriate tools, ideally transparent to the author. Examples of such tools are the Briefing Associate and ITtalks.

5. Personalization of Learning.

Adaptivity of Web systems occupies a major role in WI. Educational servers should track the learner's actions, recent visits, and topics, and adjust interaction accordingly. Moreover, a server may pre-fetch materials from other servers based on observed navigation patterns. This belongs to the network level of WI. At the interface level, adaptivity includes cross-language processing and personalized multimedia.

Trausan-Matu et al. proposed an ontology-based approach to enhance network- and interface-level WI in a computer-assisted language learning system.

6. Ontological Engineering.

Developing and deploying ontologies for educational systems is an engineering discipline that includes conceptualization, design, implementation, and maintenance [2]. Manual ontology construction is often time-consuming. WI suggests automating this process through ontology learning using machine learning, data mining, and

statistical tools [5]. Ontologies can be learned from free text, dictionaries, XML documents, and even database schemas.

7. Intelligent Web Services.

Web services represent autonomous, platform-neutral computational elements that may be characterized, published, identified, and invoked using XML artifacts [6]. In the context of AIED, we propose the use of intelligent Web services that allow learners, teachers, and authors to see the Web as a collection of educational resources with clear interfaces. A specialized dialect EWSDL (Educational Web Services Description Language) may even be created. Educational services register themselves in a directory, and learner agents query the directory to dynamically invoke services (Figure 1).

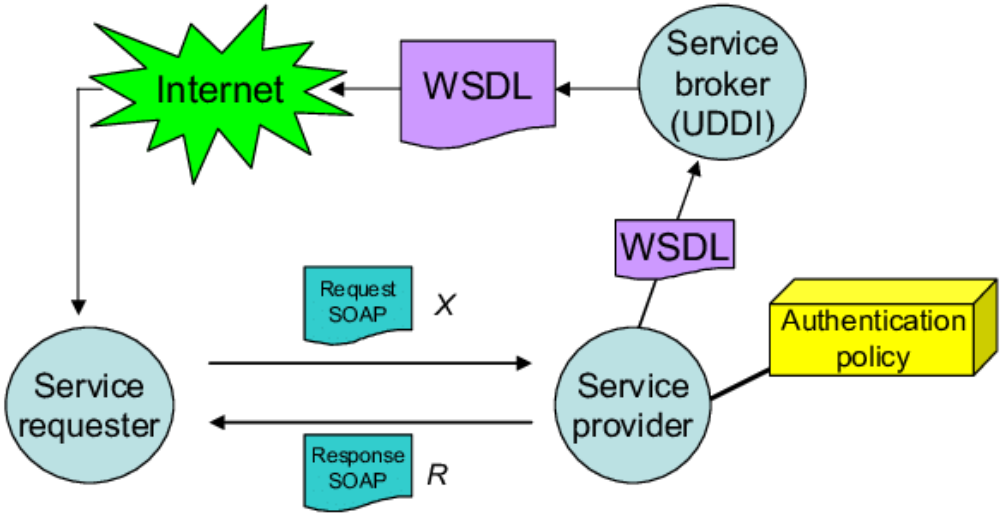

Fig. 1. Architecture of client-directory-service interaction

8. Intelligent Educational Servers and Portals (*INES*).

Based on the ideas presented, the INES (INtelligent Educational Servers) architecture is proposed. The main categories of educational services are shown in Table 1.

Table 1

Classification of educational services

Service category	Examples
Learning	Course offering, integration of educational materials, tutoring, presentation
Assessment	Online tests, performance tracking, grading
Reference	Search, libraries, repositories, portals
Collaboration	Group formation, class monitoring

Hypothetical usage scenario. A learner wants to deepen knowledge of Greek mythology. His/her pedagogical agent contacts an INES server, requests the «Greek mythology» ontology. The learner refines the query to «Titans». The agent invokes the appropriate services (learning, reference), collects information from heterogeneous sources, builds an initial student model, and starts a tutor. All technical complexity remains invisible to the learner.

9. Web Mining and Social Networks.

Web mining is the process of identifying potentially valuable knowledge from Web data [1]. It includes:

– Web content mining – extracting information from text, documents, and media;

– Web structure mining – analyzing hyperlinks and page authority;

– Web usage mining – analyzing server logs and navigation patterns.

All these types are beneficial for AIED. For example, agents can collect distributed content to populate educational servers. Structure mining combined with ontologies helps reorganize link directories. Usage mining can relate learner difficulties to the pedagogical strategies used.

Social networks create a self-managed structure of learners, experts, and resources. They provide a natural basis for next-generation portals that combine ontologies, agents, and intelligent search.

10. Conclusions.

Web Intelligence creates a promising environment for AIED research. The key advantages of applying WI methods are enhanced adaptivity and learner comfort. WI enables course sequencing based not only on the learner model but also on the most up-to-date Web content. Automatic discovery, invocation, and composition of educational Web services help relieve learners from routine operations. Ontologically supported learning significantly automates the activities of teachers and authors.

Although many of the considered components (pedagogical agents, educational ontologies, intelligent services) remain mostly experimental, Web technologies continue developing rapidly. With the emergence of XML-based educational modeling

languages, authors will be able to structure learning materials even more easily and flexibly.

References

1. Cooley R., Mobasher B., Srivastava J. Web Mining: Information and Pattern Discovery on the World Wide Web // Proceedings of the 9th IEEE International Conference on Tools with Artificial Intelligence (ICTAI'97). Los Alamitos, CA, USA: IEEE Press, 1997. Pp. 474–477.

2. Devedžić V. Understanding Ontological Engineering // Communications of the ACM. 2002. Vol. 45. No. 4. Pp. 136–144.

3. Hendler J. Agents and the Semantic Web // IEEE Intelligent Systems. 2001. Vol. 16. No. 2. Pp. 30–37.

4. Johnson W.L., Rickel J., Lester J.C. Animated Pedagogical Agents: Face-to-Face Interaction in Interactive Learning Environments // International Journal of Artificial Intelligence in Education. 2000. Vol. 11. Pp. 47–78.

5. Maedche A., Staab S. Ontology Learning for the Semantic Web // IEEE Intelligent Systems. 2001. Vol. 16. No. 2. Pp. 72–79.

6. Preece A., Decker S. Intelligent Web Services // IEEE Intelligent Systems. – 2002. Vol. 17. No. 1. Pp. 15–17.

7. Zhong N., Liu J., Yao Y. In Search of the Wisdom Web // IEEE Computer. – 2002. Vol. 35. No. 11. Pp. 27–31.