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Autonomous and adaptive e-learning agents design using neural modeling

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SUMMARY
Our efforts are directed towards development and evaluation of a user interface neural agent for adaptive and autonomous distance learning platforms design and development, to build intelligent e-learning interfaces for ontology banks on various topics using Internet. A methodological framework is presented for the construction of an autonomous neural agent according to the learning needs and functionality preferences expressed by learners in e-learning platforms. Information gathering is performed via web electronic questionnaires designed for this purpose and the proposed autonomous agent construction is based on neural networks. Experimental results are presented from the provisional evaluation of the PEDITOP Telepediatrics portal design.

KEY WORDS: *semantic web, intelligent agents, neural modeling, on line surveys*

INTRODUCTION
The design of intelligent e-learning platforms incorporates a plethora of requirements for environments, tools and techniques. Intelligent software systems are required to proactively anticipate the information needs of users and deliver it on a periodic basis, support synchronous and asynchronous communication, provide co-ordination and co-operation, enable co-operative decision making in the sharing of distributed heterogeneous information and knowledge sources and effectively handle real time multimedia broadcasting.

The IEEE Learning Objects Meta-Data Specification (IEEE LOM-1484-12-1, 2002) allows description of the learning objects in a common format. The main concept of the Semantic Web (Fensel, Hendler, Lieberman & Wahlster, 2002) is to provide a unifying semantic knowledge representation of the heterogeneous Web. Semantic web supports the ontology concept, which is a collection of information that describes objects and relationships between them. In the Semantic Web Technology knowledge structuring is achieved using RDF (Resource Description Framework) documents and software agents (Jennings, Sycara, & Wooldridge, 1998) that come across expressing meaning of sources.

Innovations faced in Semantic Web include among others, software agents able to negotiate and collect information, as well as markup languages that can tag many more types of information in a document, and knowledge systems that enable machines to read Web pages and determine their reliability (Fensel, Hendler, Lieberman & Wahlster, 2002).
Furthermore the Internet Engineering Task Force with the support of the National Library of Medicine issued a draft with a new scheme for quasi-permanent naming of web-based information objects. The Archival Resource Key draft is entitled *The ARK Persistent Identifier Scheme* (Internet Engineering Task Force & National Library of Medicine, 2003). Three ARK *services* are defined, gaining access to: (i) the object, (ii) a description of the object (metadata), and (iii) a description of the commitment made by the Name Mapping Authority (NMA) regarding the persistence of the object (policy).

Nowadays, agent technology (Solomos & Avouris, 1999) may carry out part of the task. Automation to react *on demand* according users interest is the core concept of a semantic web (Dolog & Nejdl, 2003). To get Internet knowledge relevant for user domains, agents retrieve whatever conforms the dynamically updated researcher profile. These notions are present in many Semantic Web languages existing today.

Herein, a methodological framework is investigated and evaluated for the construction of autonomous user interface agents based on neural networks (Aleksander & Morton, 1995) according the adaptation preferences expressed by learners in e-learning platforms. This study is a provisional investigation to combine neural agents technology with Semantic web technologies.

METHODOLOGY FOR SEMANTIC WEB CREATION

Following Semantic web objectives (Fensel, Hendler, Lieberman & Wahlster, 2002), the information should be structured is such a way that computer could understand its content and carry out an automatic semantic content evaluation. Searching web data require *metadata* (date into date) tags. Those *describe* the available *resources* facilitating automatic search which functionality will be enhanced using *ontologies* capable of being handled by *agents*.

Ontology is a *specification of a conceptualisation*; its description requires a vocabulary capable to represent and communicate knowledge content and relationship through a hierarchical tree of relations of the various concepts. In semantic web, ontologies written in RDF language define relationships and logical rules among web elements through the architecture of *object-attribute-value*. Every object is linked to an attribute and a value capable to be recognized and understood by computers. The hierarchy of the ontologies that describe the Telepediatrics content include the MeSH vocabulary (Lowe & Barnett, 1994) adapted to the Telepediatrics body of Knowledge, developed in the framework of the European Union LEONARDO DA VINCI PEDITOP project.

The RDFs were constructed using visual tools. The one chosen is *Protègè 2000*, an open source that allowed us to define ontologies inside of the RDF code while building the semantic web. In the approach adopted herein, terminologies were used as common ontologies in achieving sharable, reusable knowledge. Terminologies are foundational ontologies to be shared and reused by servers, allowing retrieval of related concepts (parent, child, sibling, cousin and uncle concepts) and synonyms, querying and cross-mapping multiple terminologies/ classifications at the same time. Concept mapping is also supported by processing free text queries which corresponding terms are identified in controlled vocabularies. Attributes and enhanced data management is made following the Dublin Core Metadata Element Set standardization (DC, 2003) and the Health Services/Technology Assessment Text (HSTAT, 2003). HSTAT is a free, web-based resource to access full-text documents including the organization of document titles by subject (plus alphabetically or by organization), using software agents to expand the queries with terms from the Unified Medical Language System Meta-thesaurus (UMLS, 2003). UMLS was selected because it is a machine-readable knowledge source, representing multiple biomedical vocabularies organized as concepts in a common format. Therefore, it provides an immensely rich terminology resource in which terms and vocabularies are linked by meaning. Learning Objects Management (IEEE LOM-1484-12-1, 2002) and Learning Information Profiles (IMS-LIP, 2003) were considered essential to personalize individual training material. Various agents were constructed for this purpose performing different functions (Table 1). All agents were developed using *JADE 3.01b* (Java Agent Development Environment toolkit, 2003) as software agent building tool.

Name	Functions
User Manager Agent	Is a user agent containing Learning Information Profiles together with user patterns, user platform and any other user information that might be of interest.
Look-Up Agent	Finds the data into the knowledge base according to semantic definitions, searches syntax and filters rules according the parameters stated by User Manager Agent and Package Monitor Agent.
Knowledge Delivery Agent	Is able to deliver Knowledge objects according the User Manager Agent, User Interface Agent and Interchange Agent Manager.
Package Monitor Agent	Controls the Knowledge Objects (KO) and their metadata content. Is capable of add-on Knowledge Objects and updates the index and the identifiers.
Interchange Agent Manager	It is in charge to coordinate the activity and message interchange between agents. Brings the Common Agent Interface (CAI) publicity that allows agents to find other agents able to provide the required services in order to complete their processes.

Table 1: Agents definition

WEB SURVEY AND NEURAL AGENT DESIGN CONSIDERATIONS

An electronic questionnaire was designed for the determination of the distance trainee e-learning interface adaptation preferences, taking into account that our target group are adult Pediatricians who have different learning assets motivations (goals, preferences and objectives) to attend these courses and also have different requirements related to the functionality of the system. The proposed questionnaire was used in order to allow us to design the User Interface Agent of the e-learning platform based only on user adaptation indicators outputs produced by a neural network.

The selected software for the on line questionnaire web implementation was *AA9PW FCC Amateur Radio Practices* (Twigger, 2003).

The questions defined are categorized in three sections, namely learning assets (goals/preferences/objectives), functionality and profile adaptations preferences (Table 2).

The questionnaire was filled from 120 students during a distance learning experiment. Information gathering resulted to the construction of a database that was used for autonomous neural agents construction.

AUTONOMOUS AND ADAPTIVE NEURAL AGENT CONSTRUCTION

The design of an agent-based neural network system to successfully classify adaptation indicators for an e-learning platform is a complex task. Success in designing such a system depends on a clear understanding and knowledge of learner needs. That was the reason for the construction of the on-line questionnaire (Table 2) and the web survey. The web-gathered data (120 questionnaires) were used for training, cross-validation and testing. The training set was used by the neural network to learn the patterns present in the data. During training the neural network learned to classify correctly the training sample data. As inputs to the network, the *learning assets* (goals/preferences/objectives) and the *functionality questions* were used and the profile *adaptations preferences* questions were selected as outputs (Table 2).

Questions	Coding Schemes
Learning assets: Goals/Preferences/Objectives	
Q.1. Access introductory learning material	0 no 1 yes
Q.2. Access intermediate learning material	0 no 1 yes
Q.3. Access advanced learning material	0 no 1 yes
Q.4. Access practical learning material	0 no 1 yes
Q.5. Access theoretical learning material	0 no 1 yes
Q.6. Access technical learning material	0 no 1 yes
Q.7. Access managerial learning material	0 no 1 yes
Q.8. Search for detailed learning material	0 no 1 yes
Q.9. Search for overview material	0 no 1 yes
Functionality	
Q.10. Suggestions of which part to study next	0 no 1 yes
Q.11. System uses your self-test to make decisions at various points in the content	0 no 1 yes
Q.12. Your prior knowledge causes sections to be hidden	0 no 1 yes
Q.13. A pre-test determines what you do not know and you are only presented with parts	0 no 1 yes
Q.14. Revealing of different sections as you progress (i.e. some materials hidden to start with)	0 no 1 yes
Q.15. Different style of presentation (e.g. using diagrams instead of text)	0 no 1 yes
Q.16. New materials are suggested when they are published (if they are relevant)	0 no 1 yes
Q.17. Marking of sections as advanced material until you have progressed	0 no 1 yes
Q.18. Different learning style (e.g. using examples instead of theory)	0 no 1 yes
Q.19. Only materials are presented that much your objectives	0 no 1 yes
Q.20. Would you like to be able to enable/disable monitoring?	0 no 1 yes 2 don't care
Q.21. Would you like to be able to view your profile?	0 no 1 yes 2 don't care
Profile adaptations preferences	
Q.22. Your time available	0 no 1 yes 2 don't care
Q.23. Your preferences	0 no 1 yes 2 don't care
Q.24. Your goals	0 no 1 yes 2 don't care
Q.25. The results of your on-line tests	0 no 1 yes 2 don't care

Table 2: On-line questionnaire paradigm for e-learning interface adaptation

A simple neural network architecture was used herein, namely the *multiplayer perceptron* (MLP) for training, cross-validation and testing. A supervised classification problem was solved training the neural network to correctly determine each adaptation preference given a learning assets and functionality criteria input pattern.

The neural network model (figure 1) was derived using the Neurosolutions Developer software (NeuroDimension Inc., 1994-2003). The back propagation of errors was used to train the MLP for 1000 epochs. The custom solution code generation was made in Microsoft Visual Basic .net environment after successful cross-validation and testing. The CGI code was optimized and transformed into active server pages for synthesis into the e-learning platform under development.

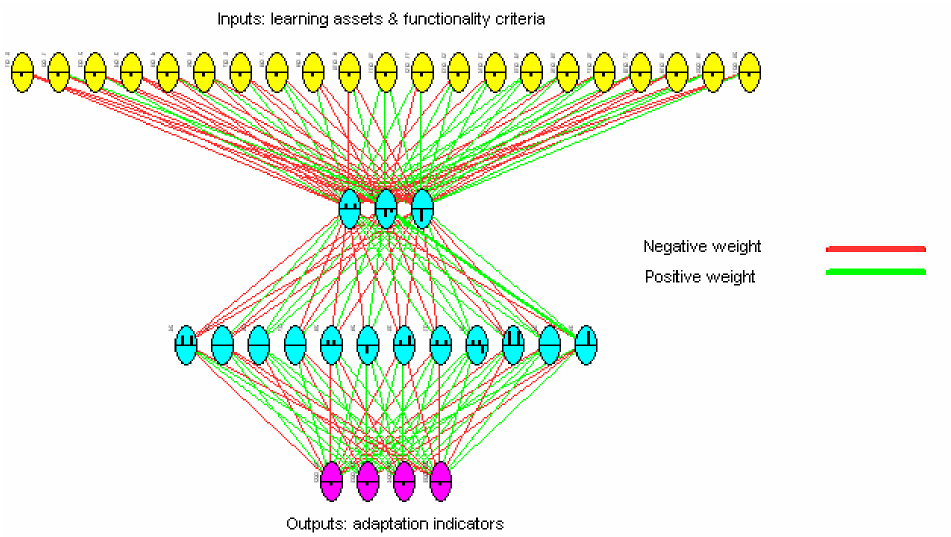

Figure 1: The anatomy of the neural agent

The proposed neural User Interface Agent, formats and organizes the data to be displayed in the user interface according only to the learning assets and the functionality criteria preferences filled by the user in an on-line questionnaire. This means that the agent automatically processes the questionnaire via the proposed neural network model (figure 1) that is capable extract measurements for the adaptation indicators. This automatic extraction of the adaptation indicators justifies the concept of autonomy (the agent has its own will) and the interaction ability (social ability) is achieved via parameter value transfer of these adaptation indicators to the Knowledge Delivery Agent and all the other agents comprising the e-learning platform (Table 1).

EXPERIMENTAL RESULTS

An independent sample of 96 students was used for evaluation of the proposed adaptive and autonomous neural agent. Provisional statistical analysis based on an on-line evaluation questionnaire designed for this purpose and using Spss (Spss Inc., 1994-2001) resulted to the extraction of the distant learners opinions about the system. The percentages in the various questions related to learner opinion for usability, functionality and adaptability of the system, support the finding that most of the learners constituting this sample characterize the system easily handled using support documentation. Examination of the learner opinion for usage time and learning effectiveness, results to the finding that most of them rather agree on usage time and learning effectiveness issues. These findings reveal a new research path for the further improvement of the system *optimizing* both the neural agent and its interactions with the other agents of the platform.

CONCLUSIVE REMARKS

In this effort, we described a methodological framework for mining questionnaire data for interface adaptability purposes in e-learning platforms. We have succeeded in training, evaluating and implementing an intelligent controller that according to the learning motives and functionality preferences of the user adapts autonomously the learning environment. The proposed neural agent model ensures a uniform description of data and patterns and the controls effectively the manipulation of the data and patterns transferred to interface customisation algorithms of learning objects according to semantic information. Evaluation results support that the proposed neural agent is effective for extracting adaptation indicators when used in web visualization implementations.

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