Case-Based Reasoning for E-learning Systems: State of the art.

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***Abstract*— Nowadays E-learning systems have known a notable progress in term of learning adaptation. Several systems were proposed in this context and different methods were adopted for the generation of customized learning paths. CBR is a problem-solving paradigm that is distracting increasing attention in the field of systems' personalization in various domains including E-learning. In this regard, this paper presents a survey of different CBR systems treating dynamic cases in diverse domains in addition to different approaches to be combined with the CBR approach for an efficient adaptive E-learning system building.**

Keywords—Case-Based Reasoning (CBR), Adaptive E-learning systems, E-learning.

I. INTRODUCTION

Recently, Case-Based Reasoning had been growing impressively. Today, there are more than one hundred CBR systems reported in the literature. This technique had been adopted by different systems in diverse domains because of its flexibility where it can be adapted to environment needs. Furthermore, CBR presents a set of advantages in term of knowledge acquisition, capacity of reasoning in a non-fully described domain, clear presentation of system's new requisite, and that what make of it a good choice for different systems.

However, CBR is not a ready solution to use, Cases and reasoning are different from an application to another. In fact, the construction of CBR system basically consists of Case representation, Case indexation to facilitate the retrieving operation, Similarity definition between target and source cases, and the integration of the CBR in the needed system or organization.

The basic idea of CBR is to solve a new problem by adapting existing similar solutions previously used. Cases used in this approach for reasoning could be static or dynamic cases. We are interested in this paper by CBR systems dealing with dynamic cases to provide a customized use of the system.

This article is organized as follow: in section II we present a state of the art of CBR systems, in section III we present different approaches to be combined with CBR to create an efficient CBR E-learning system. Finally, we draw some conclusions and perspectives in section IV.

II. STATE OF THE ART

A. Case-Based Reasoning Approach

Case-Based Reasoning is an Artificial Intelligence approach adopted by several systems in various domains (such as E-learning) as a solution to the adaptation problem. The goal of the CBR approach is to solve a current target problem called "target case" by using a similar solved problem called "source problem" and its solution "source solution". The pairs (source_problem, source_solution) are called "source cases" and the set of source cases is called "Case Base".

This resolution process can be modeled by a cycle of five phases [1] based on a knowledge base of the field of application :

- Elaborate: Reformulate a clear description of the target case from the submitted request.
- Retrieve: Extract similar cases to the description of the problem to solve.
- Reuse: Select the adequate case for the target case from the retrieved cases and reuse it as a solution.
- Revise: Evaluate the proposed solution (it can be: accepted, corrected or rejected).
- Retain: Store the final solution as a new case for future use.

B. CBR Application Domain treating Dynamic Cases

For systems dealing with dynamic cases in various domains, the Case-Based reasoning approach had been used as a method for several type of applications that can be used to perform tasks of different kinds, such as web service security as for S-MAS [2], a multi-agent distributed CBR system dealing with DoS attacks in Web Service environments. This system provides an adaptive approach combining the advantages of multi-agent systems with the adaptation and learning capabilities of CBR systems for blocking malicious SOAP messages. We cite additionally robot navigation as for

978-1-5386-4385-3/18/$31.00 ©2018 IEEE

Mobile Robot system [3] and SAPED [4] a system for the assistance of wheelchairs' users considered to be severely physically disabled and mentally handicapped. By providing an intelligent vehicle capable to move in a totally unknown environment. Based on reproducing frequently used routes. This system allocates to each source case a variable having for values (success, failure) indicating the quality of the case. Otherwise, Mobile Robot is an integrated system which consisted of environmental perception, dynamic decision and planning. This system allows a robot-navigation in an unknown, complex and changing indoors environment in a proper way by adopting the Case-Based Reasoning methodology to endow robots with an efficient decision structure aiming of selecting the best maneuver to avoid collisions. We also identify systems for users' navigation adaptation on the net like for CASEP2 [5] a system for the prediction of the behavior of a user from web pages already visited. It aims at dynamically adapt an e-commerce website. A case, in CASEP2, represents a precise experiment (in one sequence) in the navigation sequence that corresponds to information on the page visited by the user. Furthermore, CBR is used for knowledge management as for MCBR (Multi Case Base Reasoning) [6]a generic system adopting CBR approach dealing with distributed systems to predict the prices of travel packages, where several case bases could be queried for the same task without corresponding to the same problem.

Moreover, the CBR approach was adopted as a decision support that represents our interest from the use of this approach, especially for E-learning systems. As for IDCBR-MAS [7] a Distributed Dynamic CBR system for dynamic cases, adopting the multi-agent approach to implement the dynamic CBR cycle. IDCBRMAS had been applied on an intelligent tutoring system as a solution for the learning adaptation problem, using learner's traces resulting from learner's interaction with the Moodle platform as a knowledge source for the adaptation procedure. So as well for [8] a mobile agent e-learning system adopting static CBR approach for dynamic cases (learner's profile) in a distributed environment considering a modified profile as a new target case, this system proposes a learner profile modelling presenting learners' needs, preferences and goals from the pedagogical training.

III. CBR IN E-LEARNING DOMAIN

E-learning systems are drawing more and more attention to personalizing the delivered content, and that. On the one hand, improve the quality of learning and minimize its cost. On the other hand, to give a new form to the teaching-learning process by providing students an intelligent and interactive learning environment, without space-time constraints. Therefore, the use of CBR approach as a method for the prediction and adaptation of pedagogical content will widely help to create an interactive environment that cooperatively helps the learner in his various tasks while ensuring the providing of a tailored learning process to learner's needs.

In addition to Artificial Intelligence techniques, Adaptive E-learning systems (Adaptive Hypermedia and Intelligent Tutoring systems) make use of other approaches to enhance the efficiency of the system and reduce its complexity.

A. Multi-Agent Paradigm

This paradigm provides an appropriate architecture for the design and implementation of adaptive educational systems, as it regulates the increased complexity of the local problem-solving process required in such domains. The organization of a Multi-Agent System (MAS) is the collection of roles, relationships, and authority structures which govern its behavior. MASs comprise a group of intelligent agents working towards a set of common global goals or separate individual goals [40]. Agents forming the organization of the multi-agent system may not have the individual ability to achieve a global goal and/or their goals, due to their imperfect and partial view of the problem-solving situation. Hence, necessitating a coordination among the set of agents.

B. Semantic Web

Educational systems are gradually incorporating Semantic Web (SW) technologies aiming to provide a more adaptable, personalized and intelligent learning environment. This incorporation is illustrated by the use of ontologies for knowledge description. Such representation of information helps the process of its analyzing, extracting, and integrating on the Web, and simplify the creation of solid knowledge bases that intelligent services can rely on to support users' needs [9]. The employment of ontologies allows knowledge reusing and sharing across other systems. This helps intelligent educational systems to move towards semantics aware environments.

For that, Adaptive Educational systems make use of several types of ontologies that response to their needs:

- Learner Ontology: To represent the characteristics of learners including their learning styles, degrees, goals, preferences, progression and all the needed information for the generation of an adaptive learning process.
- Learning Object Ontology: For the description of pedagogical resources adapted to learner's profile information to specify the adequate pedagogical content for the learner.
- Competencies Ontology: Describing the different competencies that a learner may want to improve.
- Pedagogical Training Ontology: Describing the different sequences of learning objects for a specific goal or for a particular competence improving.

C. Pedagogical Approaches

With the aim of improving the efficiency of distance learning, Adaptive Educational Systems adopt various pedagogical approaches as methods for the structuring of a customized learning process satisfying learner's needs.

Two main pedagogical approaches are available:

1) Objectives-Based Approach: A pedagogical approach that breaks up a complex teaching module into simple essential elements to facilitate the assessment and the teaching/learning process. The decomposition of the learning objects is performed on the basis of educational objectives. Students must submit their needs in the form of pedagogical goals, defining the results that they want to achieve from the required training. Students' intentions are then formulated as objectives classified on three hierarchical levels *[10]* (General, Specific and operational pedagogical objectives).

2) Competence-Based Approach: This approach seeks to develop learners' acting ability in order to make them capable to use their required knowledge for solving real problem situation *[11]*. Therefore, it contextualizes learning and allows learners to share, exchange and cooperate with each other during the various learning processes.

However, CBR researches realized in E-learning domain don't give a big importance to system modelling or pedagogical approaches for pedagogical content structuring. In fact, relatively little research of CBR is focused on the E-learning domain.

Different Educational Systems adopting CBR for static cases were created, for instance [12] an intelligent speech-enabled E-Learning application adopting CBR for intelligent processing, and [13] an E-learning system adopting CBR for personalized knowledge database and summative assessment analysis. We cite as well [14] and [15] Q&A (Questions and Answers) systems adopting CBR to provide adequate answers to learners' questions about the learned courses.

Yet, only few works had been carried out in E-learning domain for CBR systems dealing with dynamic cases. According to our research, we have found two E-learning systems using CBR for dynamic situations. in the table below we illustrate a comparative study of these two systems

TABLE I. COMPARATIVE TABLE: E-LEARNING SYSTEMS ADOPTING CBR FOR DYNAMIC CASES

E-learning systems adopting CBR	***Dynamic Case***	***System Modeling***	***Multi-Agent Approach***	***Pedagogical Approach***	***Similarity measurement***	***CBR Cycle***
IDCBR-MAS[7]	Yes	Learner Model	Yes	No	ILCSS function (Inverse Longest Common SubSequence)	Dynamic
Mobile Agent E-learning System [8]	Yes	Learner Profile, Learning ressources	Yes	No	Nearest Neighbour (NN) matching function	Static

IV. CONCLUSION

The CBR approach shows a significant promise for improving the effectiveness of complex and unstructured decision making. Therefore, it can be an appropriate approach to aid in curriculum design dealing with the e-learning system environment. Despite proved efficiency, researches conducted on E learning domain is still limited specially for the processing of dynamic cases.

For that, this article presented the different uses of this technique in diverse domains including e-learning. Additionally, we identified various techniques and approaches to be combined with CBR to create an integral Adaptive E-learning System.

We prospect an adaptive architecture based on the Artificial Intelligence technique, Case-Based Reasoning for dynamic cases in a distributed way, to ensure a personalized learning object and learning process according to learners' preferences and needs.

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