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Knowledge Navigator for Intelligent Collaborative E-Tutoring: A Proposed Framework using Fuzzy Cognitive Agent

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Abstract: ***With access to wide-ranging technologies, tremendous web data from heterogeneous sources and different learning abilities, it is desired to develop learner oriented knowledge navigation based tutoring system. The present study suggests a fuzzy cognitive agent based knowledge navigator for intelligent tutoring in a collaborative environment. It can be used to provide an insight to the cognitive aspects of tutor and learner during knowledge navigation, knowledge access and their response to social interactive collaborative environment. The system referred as KNICETS, simulates thought process during collaborative activity; and thus, navigates relevant, unambiguous content using BDI (Belief-Desire-Intention) Model. It is also proposed that based on the empirical data gathered during the tutoring session, the system must suggest an appropriate learning path for learner and effective tutoring strategy for tutor. It attempts to model learner's and tutor's cognitive process; analyses the similarities and differences in the learning paths followed by different learners; acquires this new knowledge to fed to the agent by the instructional designer. The system uses fuzzy cognitive map to assist the learner in knowledge navigation by becoming more aware of the learners' cognitive ability and attitude towards collaborative environment and thus, make strategies for efficient navigation based on experience. It can be used to determine the correlation between learning pattern and tutor's efficacy. The impact of self paced and collaborative E-Tutoring on learner's cognitive capability can also be traced. Aiding the acquisition of cognitive abilities is an important issue within the teaching-learning process. It develops an effective simulation of the problem solution in a given domain, from the human point of view and thus helps to control the way collaborative process is executed.***

Keywords: BDI, E-Tutoring, Fuzzy Cognitive Agent, ICT, ITS

1. Introduction

The model for information access in teaching-learning process has changed with the emergence of Web2.0 and the technologies of communication. It not only demands information supplying but its suitability to the individual learner. The teaching-learning process aims at finding some scientific skills, methods for self-guidance, co-operative learning, learner and tutor involvement in learning process, collaborative knowledge production [11]. ICT has globalized and eased the distribution and access to space free, time free and unlimited information. Its rewards have been realized in terms of knowledge management, knowledge based system, knowledge production and co-operative learning [11].

To guarantee the success of E-tutoring, it is critical to research and understand : learner's requirements, cognitive complexities involved in teaching-learning, cognitive mechanism for self regulatory learning, tracing available knowledge and ensuring its availability, application of existing knowledge, and learning resources ; and effect of different tutoring paths on learning ability.
Limited attention has been paid to examine the effect of different tutoring paths on learner's knowledge acquisition. Since human beings have different understanding about the world, and have varied interests, so it is necessary to have variety of tutoring paths to suit an individual cognitive level.

This emphasis on the need to design a new tutoring system with enough reflection of the tutor's and the learner's cognitive aspects. Thus, it is recommended to re-design the ICT model for tutoring by incorporating a cognitive layer to[1] implement the functionalities for understanding the tutors' and learners' cognitive ability during the collaborative process.

The ingress of cognitive agents in tutoring suggests valuable prospects in the domain of education resulting in increase of efficiency and identifying more innovative tutoring methods. In the proposed framework, the cognitive agent can identify the type of learner and thereby suggest suitable tutor; path / course of learning process and collaboration with peers to suit the learner's cognitive ability. Additionally, it can also suggest the type of the tutoring model to be used:

- Dependent (tutor oriented);
- Self-regulatory(learner oriented);
- Self-evaluator;
- Collaborative and knowledge generative.

The proposed framework provides the following advantages:

1. Learners
2. Content Management: creation, storage, access to and use of learning resources.
3. Personalization of the learning experience: curriculum mapping and planning (lesson planning, assessment) to

[1] It gives personalized suggestions based on the learner's current personal preferences, other learners' common preferences, and expert domain knowledge. The agent represents the knowledge via extended fuzzy cognitive maps, to learn learner's preferences from most recent cases and to help them make inferences and decisions through numeric computation instead of symbolic and logic deduction [3].

guide the learner on the basis of the individual strengths and weaknesses.
4. Learner Engagement, Administration and Counseling: manages access to learner information and resources, tracking of progress and achievement and thereby managing learner's record.
5. Communication and Collaboration: emails, notices, chat.
6. Educators: Identifies training needs and provides teacher training using computer assisted instructions.
7. Quality Assurance Mentors: content relevance and quality check, decision making and educational planning.

This paper argues that the concepts and features of cognitive agents be incorporated in the expert systems designed for enabling E-Tutoring. Finally a Fuzzy Cognitive Agent based Knowledge Navigator has been suggested for Intelligent Collaborative E-Tutoring.

2. Review of Literature

Intelligent Tutoring Systems (ITS) are intelligent tutors designed based on knowledge to serve as a guide in learning process [5]. They monitor the performance of learner, know learner's learning style, current knowledge level and then deliver personalized instruction using appropriate teaching strategy [10]. In spite of the advances in ITS in nineties, its practical applications are still limited due to its design complexity.

The potential for studying human intelligence and implementing it to develop Knowledge Navigator in teaching-learning process has been identified. John Sculley has described the term Knowledge Navigator as a tool for adaptive teaching and personalized learning which would help to explore the superhighway of knowledge by exploring the interests, needs and insights of the learner and its own knowledge. Learning element in the agent would help the Knowledge Navigator in turning information to useful knowledge as desired by the user [8].

2.1 Need to develop cognitive model to understand different roles in knowledge navigation during the tutoring process

SOPHIE a tutor based on black box expert uses a general purpose electronic simulator which works on a set of equations to teach the students to find failures in an electronic circuit. It only provides the learner with the measure of the correctness of the result i.e. whether or not the operation executed is correct and, possibly the next adequate move [1]. There is no way to access the detailed explanation as to why the decision was taken. Later a causal model of circuits was incorporated in SOPHIE [2] to allow detailed explanation of decisions. It is not just enough in tutoring process to tell whether the decision is correct or incorrect, but the tutor must know the critical points and when they should be explained in detail to the learner depending on the cognitive ability of the learner.

During the development of GUIDON an expert system for teaching medical diagnosis, Wenger highlighted that for the success of a tutoring system, the presentation of knowledge is equally important as representing the knowledge. Hence, the knowledge must be presented to the learner by the expert system in the same way as presented by humans [8]. Using expert systems in ITS only for tutorial process limits the capability of an ITS[4]. This reflects to use cognitive models for efficient knowledge navigation in the tutoring process by developing an effective simulation of the problem solution in a given domain, from the human point of view. The work by [9] suggests that in order to improve the tutoring process, the instructor must be aware of the different processes taking place during knowledge navigation and the different roles played by learners and tutors in those processes. To epitomize different roles played a study was performed using Checkland's CATWOE mnemonic and the SIPOC model from lean operations theory on six key university teaching and learning processes. The study exemplifies the following roles: learners as customer, actor, supplier, raw material and end product and instructor as supplier, actor and customer. It also suggests accepting the multiplicity of roles played by the learners and thus act according to the role to enhance the teaching-learning processes [10]. The characteristics of cognitive agent provides a convenient platform to embody different roles of learner and tutor during the process and thereby help in selecting peer for collaborative process.

MAKATSINÁ (Laureano and de Arriaga, 1999; Laureano and de Arriaga, 2000) is an ITS which uses cognitive model to learn the ability to solve triangular structures by the node method, in accordance with reactive philosophy (Beer, 1990). Cognitive models have been used in the ITS with the purpose to clarify the teaching process (Fletcher and Harris, 1996), (Gott, 1989).

2.2 Agents for providing personalized web assistance to the learner

Letizia [7] assists the learner during browsing by proactively fetching the links from the page currently being viewed by the learner, and recommends those links that may be of interest to a particular learner, by analyzing the learner's browsing activities. Web Watcher [6] searches the web autonomously on behalf of the learner, and provides interactive assistance using machine learning techniques. These techniques are modeled from the Information Retrieval Perspective, and have not generally considered the information needs of the learner.

Collaborative filtering techniques are used by agents to recommend Web pages navigated by other learners with similar cognitive ability. Most of the approaches followed have not focused on estimating the learner's knowledge-level, behaviour, work habits and task complexities to accomplish tutoring. The approach is to identify and establish the parameters for estimating the complexities behind human cognitive model which will serve as a representation of the learner's and tutor's knowledge with respect to a given task and help to perform the task continuously without much human intervention.

3. Research Design

It is an exploratory study undertaken to obtain an insight to the learner's cognitive aspects during knowledge navigation

and willingness to learn in a collaborative environment. It allows learning depending on the learner's ability and provides desired knowledge. The system allows the learner not only to update knowledge about the subject but also about one's own cognitive process.

3.1 Framework for Knowledge Navigator for Intelligent Collaborative E-Tutoring based on Fuzzy Cognitive Agent (KNICETS)

Label 1: Task Specification
Let T be the Task for which knowledge is to be explored by the learners' L1, L2, ----, Ln through the Knowledge Navigator in collaborative tutoring process. The task T initiates a session. The aim of the suggested framework is to analyse the cognitive process of the learner during the collaborative tutoring process. Based on the experience gathered about the learner by the Knowledge Navigator (using the Learner database) and Human Expertise (HE), it allows the learner to select a peer and a tutoring mode.

Label 2: Session Module
The Session Module (SM) provides learner-friendly and lively communication through menus, graphical interface etc. The knowledge is stored in a format that cannot be easily understood by the learner; so the Session Module performs the translation of the knowledge in the learner understandable format and presents it to the learner. Components of Session Module are: User Interface, Inference Engine, Simulator (Tutor), Learner Module.

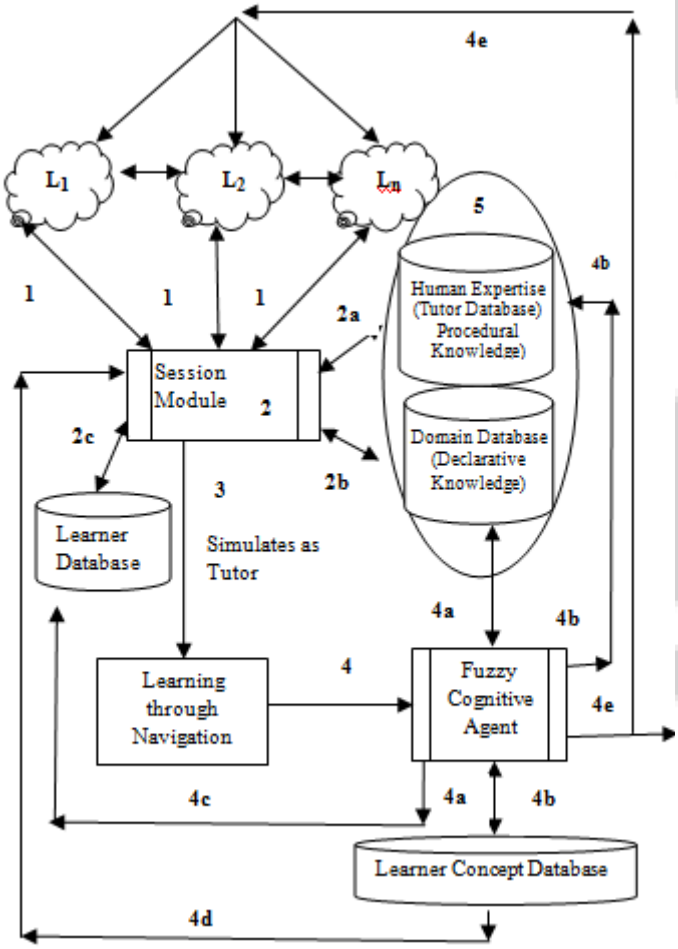

Figure 1: Activities performed in the framework

Session Module has an Inference Engine (IE) which is the stimulated brain of the system. It searches the Keyword(s) in the learner specified task T, performs semantic and syntactic analysis using the available knowledge in the Domain Database (DD) and finally presents the knowledge to the learner. If the learner is navigating the task T for the first time, then it ranks the learner and provides a level (score/grade) to the learner. The allotted level is stored in the Learner Database. It helps to analyse and select: the peer learners for collaborative tutoring and a tutoring path.

Knowledge Navigation: For every learning session executed with peer or tracking and following a tutoring path, re-ranking and evaluation of the learner is performed by the Inference Engine and the Learner Database is updated. The Learner Database (LD) includes the following data about the learner corresponding to every unique task T: content searched, time spent on content, no. of links followed, in between transactions, questions answered, questions generated, no. of peer interactions, tutoring path followed and the level assigned to the learner. The database can be used :

- to analyse and compare the level of the learner before and after collaborative tutoring process.
- to suggest the peers with similar learning pattern.
- to perform a comparative analysis of the effect of different tutoring paths on the learner's acquired knowledge level.

If the level assigned is N (naive), it represents that the learner requires basic knowledge about the task and hence, collaborative process should not be enabled for the learner at the moment.

Label 3: Tutor
After assigning an initial level to the learner, the Session Module (SM) initiates the tutoring process by presenting knowledge to the learner from the Domain Database using the path selected by the Human Expertise (HE) and then recording the cognitive process of the learner and tutor using the fuzzy cognitive agent.

Label 4: Fuzzy Cognitive Agent
Web-based E-Learning is a complex activity and the present structure of the information retrieval process on the web imposes high cognitive load on the user. It demands higher levels of cognitive functions and human thought process which can be easily implemented using a cognitive agent. A cognitive agent is Autonomous (Self Directive) , Responsive, Adaptive ,Continuous, has Machine Learning, Collaborates (with learner) , Communicate and Co-operate with other agents and (possibly) humans via some kind of agent communication language. The task specified by the learner through the interface is accepted by the agent.

4a: The fuzzy cognitive agent uses extended cognitive maps to represent learner's knowledge about the task and stores it in Learner Concept Database (LCD). It consists of Path matrix (path followed to reach the goal), Time matrix (time spent on the task), Link matrix (links followed), Question matrix (questions asked by the learner). Fuzzy operators can be used to obtain Learner Concept Database.
4b: Compare Learner Concept Matrix with Human Expertise. If new knowledge is generated then goto label 5.

4c: Make inferences based on Learner Concept Matrix: modify the learner's level (if changes persists).
4d: The Learner Concept Database is used for collaborative tutoring process among the peers by selecting the learners with similar cognitive process.
4e: Agent interacts with the user.
Label 5: Knowledge Generation (KG): If any new piece of knowledge is generated by the learner during the collaborative process, then the Session Module triggers to check the novelty of the generated knowledge. If the uniqueness of the new generated knowledge is verified, then it is written in the Domain Database.

4. Challenges

- Reduced personal interaction among peers.
- Suppression of communication mechanisms such as body language.
- E- content development and Quality check.

5. Suggestions

Mapping of learners knowledge navigation process to provide different techniques for collaborative process.

6. Conclusion

Knowledge navigation in collaborative process can be more efficient with the use of fuzzy cognitive agent based system. The system described in the study focuses on each learner individually and keeps track of the learning pace.

7. Future Work

In future, there will be high demand for people who can develop learner friendly multi-lingual courseware and efficient tutoring systems to cater the demands of learners with varying psychological needs and cognitive process.

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