Incorporating Agent Negotiation into Adaptive Learning Environment to Balance the Perspectives between Learners and Instructors

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Abstract

This paper integrates the concept of agent negotiation into adaptive learning to support effective learner-instructor interaction. It intends to capture the interactions that are real between learner and instructor, but often simplified or even ignored in most adaptive learning approaches. An iterative negotiation protocol is employed to reconcile mutual thinking and cognitive differences between learner and instructor and then to dynamically produce the most appropriate learning sequences. To delineate the proposed framework, an example relevant to Java programming course is provided to illustrate how the adaptive learning environment with negotiation mechanism can improve the effectiveness of learning.

1. Introduction

Adaptive learning usually is a web-based system that provides a personalized learning environment by navigating through the alternative learning contents on the basis of each individual’s profile and feedback [1]. It can dynamically reorganize learning resources to meet specific learning objectives so as to improve learning satisfaction. Following this notion, most previous studies in adaptive learning have been focusing on the design of adaptation model for constructing personalized learning sequences through monitoring learner’s behavior, performance, or learning styles etc. [2]. While the results of these approaches seem to be effective to some extent, there are still rooms to be improved. Of which is that most adaptation models, if not all, are tilted towards the perspectives of a tutor. The reasons behind this could be summarized as follows.

- A misconception about who should decide the learning sequences: In general, an instructor will normally monitor the performance of students along with their learning profile to dynamically adjust instructional techniques, but the design of instructional strategies are traditionally seen as the expertise of a tutor. It seldom involves any direct discussion with the learners and, thus, the perspectives of students are often overlooked.

- Limitation of web-based systems for supporting iterative interactions: This is especially true for the more complicated interactions such as it needs to iteratively coordinate the mutual thinking and cognitive differences between learner and instructor in adaptive learning.

- Lack of cost-effective computation model for adaptation: Not only it will take too much time for knowledge acquisition to find out all appropriate adaptive rules, if we take all factors or perspectives that affect personalized learning into consideration; such a system will also be too complex to be realized for practical application [3], because the dependencies between learning resources and learner’s characteristics and perspectives are too complex to exhaust all possible combinations.

The results of these are certain elements that are important for adaptation, are overlooked and, thereby, the learning sequences generated for adaptive learning are deviated. To extend the horizon of current systems and develop more student-centered adaptive learning environments, this paper integrates the concept of agent negotiation into adaptive learning to support effective learner-instructor interaction. It allows students to articulate their understanding and engage more actively in learning activities [4]. But, the diversity (e.g., inconsistency and conflicts among mutual ideas) could arise during the interaction and thus it is essential to have a framework that can coordinate effectively for some divergence. To that end, the concept of agent negotiation seems to be an appropriate model to resolve these cognitive differences by trying to reach a consensus on some matter of common interest [5]. Thus, in this paper, a
fuzzy constraint-directed iterative negotiation protocol is employed to reconcile mutual thinking and cognitive differences between learner and instructor and then to dynamically generate the most appropriate learning sequences for adaptive learning.

2. Agent Negotiation in Supporting Adaptive Learning

Figure 1 indicates a proposed framework for incorporating agent negotiation model into adaptive learning environment to balance the perspectives between learner and instructor. The learner profile contains the learning records and characteristics (e.g., learning goals and styles) of each individual in general, as well as, the log file (e.g., browsing path and learning time) of a learner for the current course. The learning materials contain course contents and relevant information for tutor and learner to develop their instructional and learning strategies, respectively, in supporting the adaptive learning. The tutor agent develops the appropriateness of content, instructional strategies and requirements through exploring learner’s feedbacks along with the information from the learner profile. On the other hand, the learner agent can explore learning goals, concepts, and other course relevant information from the knowledge base. After studying certain contents or units, the learner gives feedbacks through questionnaire or tests to the tutor for performance assessment. But, apart from passive feedbacks and indirect interactions (titled towards tutor’s perspectives), the proposed framework includes a negotiation model to facilitate a direct and iterative interaction between tutor and learner throughout the process of adaptive learning. The core of this negotiation is a fuzzy constraint-directed negotiation mechanism to reconcile the cognitive differences from a range of issues between learner and tutor. The negotiation results are then delivered to the adaptation model in which, together with information from the tutor agent and learner’s profile, dynamically reorganizes the learning sequence. Inside the adaptation model, it describes the structural relationships between facts and learning resources (concept and content maps). It not only includes concept reasoning rules to infer learning concepts which correspond to learners’ characteristics, but also contains the decision rules of learning objects to propose personalized learning sequence which correspond to the tutor’s judgments and negotiation agreements between learner and tutor.

3. Illustrative Example

To delineate the proposed framework in practical sense, the following scenario is designed to illustrate how the agent negotiation can be applied to the adaptive learning. A Java programming course includes three parts (part A: Basic Java; part B: Object-oriented programming concepts; and part C: I/O & Networking programming) and each part contains different course concepts (for example, part A includes concepts A_1, A_2, ..., and A_3). Each concept then contains several learning objects (for example, concept A_1 has learning objects A_{11}, A_{12}, ..., A_{16}). The potential deal is the tutor and learner are trying to negotiate and then hopefully generate the most appropriate learning sequence. The follow steps present the process of personalizing learning sequence.

**Decide learning concepts.** According to the learning goal (i.e., to learn the object-oriented programming concept), the adaptation model provides the learner the appropriate course contents B_1, B_2, ..., and B_3 in part B from the course framework and rules.

**Select appropriate learning objects.** Following the learning styles of the learner (active/reflective, sensing/intuitive, and sequential/global), the adaptation model provides the appropriate learning object B_{12} to the learner. The system generally provides the fixed learning sequences (B_{12}→B_{22}→B_{42}→B_{52}) to learners without applying negotiation mechanism. However, the adaptation model incorporates agent negotiation into personalizing learning sequences. Therefore, after studying the learning object B_{12}, the learner is required to propose his/her cognition about the knowledge level by answering five questions. The result shows that the
Propose individual cognition. The learner responds his/her confidence in the studied learning object by selecting the appropriate knowledge level (very low, low, medium, high, or very high). The learner is required to state the level that best matches his/her confidence after studying a learning object. On the other hand, the tutor assesses the learner’s knowledge according to the accuracy of learner’s reply. The assessment of the learner’s knowledge is maintained as a continuous value between 0 and 10. In order to facilitate negotiation, this knowledge value is also converted to five levels (very low, low, medium, high, or very high) using the same scales as in learner’s confidence. However, the tutor also can modify the assessment levels which correspond to his/her preference. In this example, the learner selects the “high” level and the tutor regards the “low” level as the learner’s knowledge level.

Negotiation of knowledge levels. The learner’s and the tutor’s cognition is different. Therefore, in order to reach mutual agreement, they are required to refine and negotiate their beliefs about the learner’s knowledge. The negotiation model applies fuzzy constraints and concession strategy to attempt to arrive at a mutual agreement. The concession strategy is used to generate a new proposal by reducing demands, thereby moving the negotiation toward a consensus. According to the learner’s learning time (25 minutes), the tutor makes a concession by decreasing its satisfaction value (0.1) to generate an offer from a certain solution space. Through several rounds of negotiation, the agreement is reached over the knowledge level at 6.0. On the other hand, if the learner and the tutor cannot reach mutual agreement, the learner is required to restudy the learning object or answer more questions to convince the tutor to modify its belief. According to the constraints of learning objects, the tutor uses the reached agreement to look for the next learning concept. But, two answers are incorrect, and thus the adaptation model will provide the learning object in next concept.

Process of learning concepts. The learning sequence is constructed as (B_{12}→B_{13}→B_{22}→B_{32} →B_{33}→B_{32}→B_{33}). Due to the limited space of this paper, we abbreviate the concept map.

The result suggests that the proposed approach, involving fuzzy constraint relaxation and similarity, helps the tutor and learner in reaching an agreement that maximizes the overall degree of satisfaction in arranging learning sequences.

4. Conclusions

In this paper, we have presented a framework of incorporating agent negotiation mechanism into adaptive learning environment and demonstrate the usefulness. The advantages of our framework are concluded as follows: Firstly, the interaction between the tutor and learner for cognitive difference is conformed to the practical instructional activities in adaptive learning environment. Then, introduction of fuzzy constraint-directed agent negotiation mechanism into adaptive learning can help to support effective interaction between tutor and learner in cost effective manner. Finally, together with negotiation model, adaptation model with fuzzy reasoning rule can search appropriate learning sequences and course units efficiently to meet the expectation of a tutor and the preference of learner simultaneously.

References