

Personalized Recommendation for Learning Resources Based-on Case Reasoning Agents

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Abstract—Ample online resources for e-learning provide students with choices and initiative, which however results in much challenge in matching the needs of students with different backgrounds and learning preferences due to information overload. Facing diverse learning resources, students have difficulties in making appropriate choices to meet their learning objectives. This paper proposes a framework of multi-agents collaboration case-based reasoning (MACBR) for personalized recommendations of e-learning resources, taking into account of characteristics of the learner. The paper firstly presents a workflow of Case-based Reasoning (CBR) for learning resource recommendation, and then proposes the collaboration framework of MACBR, finally illustrates the application of MACBR for personalized recommendation in e-learning.

Keywords- Case-Based Reasoning; E-learning; Multi-agent System; Resource Recommendation

I. INTRODUCTION

Personalized recommendation initially originates from the electronic commerce, which is an effective way to reduce the information overload [1]. It can provide personalized information and products to assist consumers in making decisions in terms of consumers' interests and preferences. As a matter of fact, the product recommendation can be regarded as a kind of map and binary relationship, that is, the map from users' requirements and problem features to the products available, and this binary relationship can be built using personalized recommendation through matching target users' needs. This research aims to combine personalized recommendation strategy into the personalized recommendation for learning resources in E-learning from the perspective of solving information overload. One reason is that there are abundant online learning resources for students in e-learning. There are vast approaches available to acquire learning resources; however, students can easily get disoriented when they confront with the vast and diverse learning resources, thereby they have difficulties in making choices. Another reason is that there are tremendous differences in students' backgrounds, requirements and preferences. These differences are caused by students' learning styles, previous experiences and dissimilar needs. Even the identical student may have different requirements to meet their work needs. All these are impossible to elaborate with a suit of structured rules. A framework of multi-agent collaboration case-based reasoning (MACBR) is proposed in this paper to investigate the personalized recommendation in E-Learning. All these agents

with diverse roles cooperate with each other to offer personalized information services through case-based reasoning, which is a new perspective to the solution of the learning resources recommendation.

II. WORKFLOW OF CBR FOR PERSONALIZED RECOMMENDATION

Case-Based Reasoning (CBR) is a kind of algorithm solving problem [2], besides that, CBR is also a learning technique based on case, which is enlightened by the way that people deal with problems. In general, people solve problems through retrieving the prior similar scenarios to reason the solution for the current setting. The essence of CBR is a transplant behavior about the similar problem settings, CBR can be regarded as a complementary reasoning mechanism for the rule-based reasoning. The form of if-then-else is a way used by the reasoning based on rules to seek solutions, while the CBR is an unstructured reasoning pattern to generate the final solution for the problem presented.

Figure 1 shows the workflow of CBR for personalized recommendation of learning resources. A structural representation for learning resources is needed based on students' requirements; furthermore, a target case needs to be denoted in this formal representation. The extent of similarity between existing cases and the target case is computed based on this kind of representation. Personalized learning resources can be recommended to the target student through retrieving and matching cases according to the similarity result.

The key technology of case reasoning includes the following aspects:

(1) The representation of a target case: a target case needs to be represented formally due to the basic information of online students, learning preferences and learning requirements.

(2) Case retrieving: the core task of this process is to retrieve case database, extract those cases related to the target case, adjust and process the set of feature-value for the target case.

(3) Case matching: the case matching is a reasoning process, and the case reasoning engine is responsible for computing the similarity among cases, sorting the cases according to the value of similarity, conducting match operation and seeking the final resolution proximal to the target case.

(4) Solution and updating: the key task of this process, after conducting successful matching among existing cases and the target case, is to deliver the final solution to the case database,

update the case database to serve the coming reasoning process.

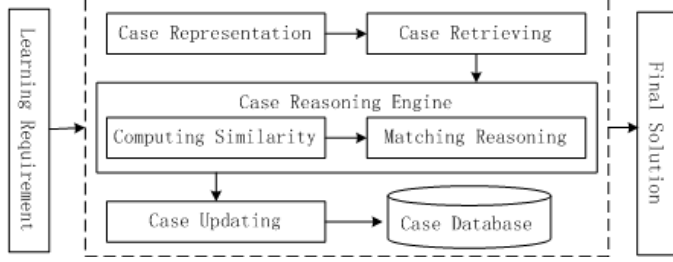


Figure 1 Work Flow of CBR

III. THE PROPOSED COLLABORATION FRAMEWORK

Figure 2 shows the framework of multi-agent collaboration case-based reasoning, and we name the framework as MACBR.

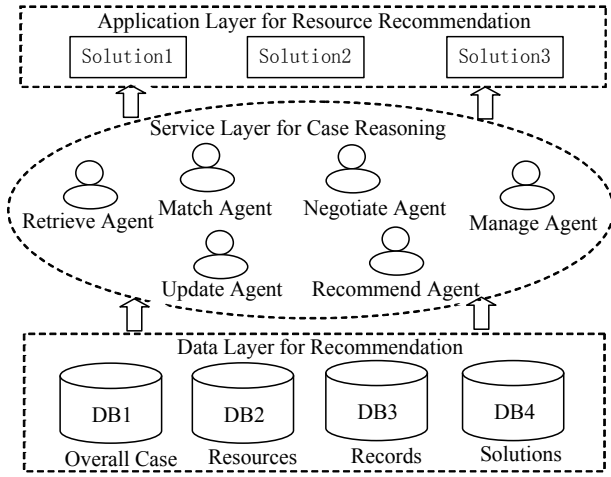


Figure 2 Three Layers Framework for MACBR

The framework includes three layers, respectively named as data service layer, case reasoning layer and application layer for resources recommendation. The data service layer can provide data services required by case reasoning, it is made up of case database, resource database, student records and solutions database; the case reasoning layer takes charge of case retrieving, matching, collaborating, updating and recommending, which is the core layer of MACBR and combines the retrieving, matching, merging and recommending operation into an integrated service to achieve the final recommendation solution for the target student; the application layer is a layer which provide the final solution to the target student due to the learning requirements.

IV. KEY ISSUES AND SOLUTIONS IN MACBR

A. Case Representation

One key issue in CBR is to represent a case [4], which is the precondition to elaborate formally the resource requirements and features about students, and the aim is to generate accurate recommendations for the students. Due to the characteristics of personalized recommendation, the information of features and requirements needs to be

considered in building the case representation model. In the study, a case is represented with the formalized structure, and on which can build the case database to serve the utilizing of learning resources. The case structure is denoted as the following six tuples:

$$CASE = \left\{ \begin{array}{l} case_id, stu_type, res_list, stucha_list, \\ case_cont, case_rating \end{array} \right\}$$

Each tuple is denoted by BNF pattern in the research:

case_id : the unique identifier of an online student.

case_id ::= {< caseid >}

stu_type : describes the type of online students, including the newly registered and members.

stu_type ::= {< new_stu >|< member_stu >}

res_list : describes the resource requirements from online students, including the type of learning resources, discipline, resource format and the utilizing objective.

res_list ::= {< type >|< discipline >|< format >|< goal >|< ... >}

stucha_list : describes the basic information of online students, including sex, age, profession, learning style, learning preferences and cultural background.

stucha_list ::= {< sex >|< age >|< profession >|< style >|< preference >|< edu_level >|< ... >}

case_cont : describes the records about using learning resources, including using time, discipline, resource type and number, and the frequency of using resources.

case_cont ::= {< use_time >|< discipline >|< resourcetype >|< resid >|< casefreq >|< ... >}

case_rating : record online students' evaluation to the learning resources of, including the rating to the ease of use, perceived usefulness, convenience and friendly interface of the recommender system.

case_rating ::= {< usability >|< easibility >|< facility >|< interactivity >|< ... >}

B. Computing the Similarity for Case Matching

As mentioned above, one key issue of CBR is to define the representing manner of a case. And another key task of CBR is to seek related methods to compute the similarity among cases. The major task of the case matching is to compute the similarity of cases. The core task of computing the similarity is to calculate the similar degree of each tuple among cases, then to compare the similarity of cases through sorting the summed similar value among tuples, as is in the formula (1).

$$SIM(i, j) = \frac{\sum_{k=1}^n R_{i,j,k}}{\sqrt{\sum_{k=1}^n R_{i,j,k}^2}} \quad (1)$$

Here, $R_{i,j,k}$ denotes the similar degree between case i and case j in the k tuple, $R_{i,j,k}$ can be calculated by the formula (2):

$$R_{i,j,k} = \frac{1}{\sum_{l=1}^m N_{i,j,k}^l} \quad (2)$$

Here, $N_{i,j,k}^l$ denotes the similar degree of the l^{th} indicator in tuple between case i and case j , if the l^{th} indicator of case i and case j is similar or the same, then $N_{i,j,k}^l$ equals to 1, otherwise equals to 0.

C. Reasoning in Case Matching

The collaboration process of agents includes two aspects in the research. One aspect is to consider the necessity to merge distributed cases. Each agent has its own distributed case database, that is, a local case database, and the set of features is different among cases. Actually, each local case database is a view of the overall case database serving the various agents. The first step of the case matching is to conducting the retrieving and matching operation in their respective local case database of each agent, if find the matched case, then to retrieve the overall description about the case related to the target case grounded on the unique ID of each case, then the recommendation agent takes charge of delivering the final solution to the target student. When the online students submit the learning requirements to the recommender system, each agent firstly retrieves their local distributed case database to reason and match the cases, if can seek the case related to the target, it is unnecessary to conduct merging operation, that is, each collaboration among agents is determined by the learning and merging requirements, because it may not generate the final solution when merges a partial overall case with a distributed case, and it is possible and necessary to merge cases when the similarity of the final merged result is higher than that of partial overall case, that is, only when the similarity before the merging operation is higher than that of the unmerging, then it is necessary to merge.

Another aspect of collaboration is to initialize the case merging operation. Agents make the personalized recommendation for learning resources through using the related information and merging the distributed cases. However, to achieve the aim, each agent needs to select a case with the highest similarity as a seed to initialize the merging operation, which can serve the following merging operations. After initialization, the selected case, as a partial overall case, is used to further merge or match. Based on the analysis above,

the merging about distributed cases is a synchronous sequence, and includes the following steps:

① If the matching operation for the distributed cases failed, the system needs to conduct the merging operation between the case with the highest similarity and the existing partial overall cases. Each potential merged case is called temporary case, which will be stored into the temporary case database. In the merging operation, the system selects the temporary case with the highest similarity to merge according to the rule of merge-if-promising. If the similarity of the selected case is higher than that of before the merging operation, the selected case will be inserted into the overall case database to be used by the recommendation agent.

② The merging operation is conducted constantly between the partial overall cases and the selected distributed cases till the merging operation is over. The match agent is responsible for computing the similar degree for each merged case, and delivers the final sorted results to serve the recommendation based on the similarity value.

V. ILLUSTRATION OF RECOMMENDING LEARNING RESOURCES USING MACBR

Based on the collaboration framework and merging algorithm mentioned above, an application process using the MACBR will be illustrated through taking an online learning website for example. The website is used to serve some discipline for online learning, and the application is to demonstrate the using process of the MACBR for personalized recommendation. The learning website can make accurate personalized recommendation according to the needs and preferences of online students. In the website, the students are divided into two types: newly registered students and member students, and the recommendation strategies for learning resources are different for these two types.

The retrieve agent is responsible for searching cases when a newly registered student submits his preferences and resource requirements, and then seeks the cases related to the target case in the case database. However, the core task of the agent is to calculate the similar degree among the related cases to get the optimal solution. If not retrieving the related cases, the recommendation agent will negotiate with the updating agent. The aim of negotiation is to fetch the top ten cases successfully that have been matched from the local case database maintained by the updating agent to the target student. The target student can get the solution proximal to his preference, meanwhile, the updating agent simultaneously formalizes the learning requirements as a case based on the case representation rule, and then stores it into the overall case database. Figure 3 shows the application process of MACBR for the learning resource personalized recommendation.

The following section will further illustrate the recommendation process respectively for newly registered students and member students:

(1) Recommendation for newly registered students: Assuming that $Stu1$ is the ID of newly registered student, the recommender system of MACBR begins to work when a target student submits the learning requirements. The retrieving agent searches the case database, seeks related cases, and submits these cases to the match agent. Then the match agent begins to

calculate the similar degree between the target case and the related cases. After that, the system seeks the case similar to the Stu1 through sorting the similarity value.

Now, assuming that the top 4 cases with the highest similarity value are the candidate cases used to match the final solution, and the solution list to the target case is the following form: $SIM(Stu1)=(Stu3,Stu5,Stu9,Stu6)$, the meaning of this expression is that the learning resources recommended to the Stu3, Stu5, Stu9 and Stu6 will be recommended to Stu1 according to the sorted order based on the similarity value. If the target student is unsatisfied with the recommended result, the recommender system needs to adjust and amend the solution, then recommends the modified result to the target student, and then stores this case into the case database for updating the case database.

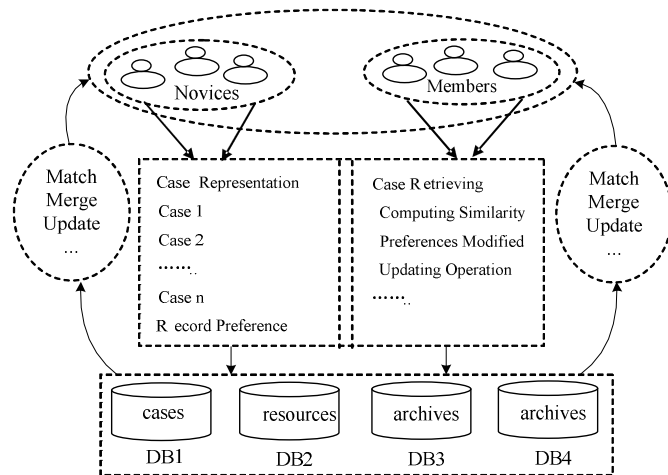


Figure 3 Application Process of MACBR

(2)Recommendation for member students: Assuming that the ID of a member student is Stu4, and the top 4 candidates with the highest similarity value to the target case is the following form: $SIM(Stu4)=(Stu4,Stu6,Stu8,Stu11)$. It is apparent that the case with the highest similarity is the Stu4 itself, and the personalization is the topmost compared to the other cases. If the preference of the target student changes, it is needed to update the preference information, based on which the recommender system needs to retrieve, match, compute and sort again, and then recommends the updated result to the target student.

In the research, there is no need to evaluate the indicators related to the learning resources in the personalized recommendation based on the CBR. The major task of the system is to compute the similarity value among cases to math the case reasoning. This solving plan differentiates from the collaboration filtering technology which overmuch rely on the rating data from users. Through illustrating the application process of MACBR, we can conclude that the personalization degree of using learning resources is promoted through using the CBR technique, which can improve the satisfaction level of the target student in using efficiency and effectiveness.

VI. CONCLUSIONS AND FURTHER RESEARCH DIRECTIONS

The paper investigates the personalized recommendation for learning resources in e-learning context, presents the research architecture MACBR, and analyzes the key issues and solutions of personalized recommendation based on CBR. The research also offers an effective solution for the information overload of the e-learning context, what is foremost is that it is a helpful investigation to research and seek an effective method to promote the utilizing level and effectiveness for learning resources. The personalized recommender system bridges an intermedium to associate the students with the online learning resources, and the recommendation effectiveness can be improved constantly through making full use of feedback information provided by the students, which can enhance the satisfaction and loyalty of the students. However, there still exists some problems in implementing the function of personalized recommendation based on CBR, such with the increasing number of online students, the scale of case is going up quickly, which will delay the response time and decrease the retrieving efficiency, thereby influence the quality and timely of recommendation; in addition, the scale of case should be considered when design and select the measuring ways used to calculate the similarity between the target case and the existing cases.

To the future research, amounts of work should be done to investigate the effective representation manner about a case, which is the key for CBR. Likewise, seeking and designing efficient methods to compute the similarity is a challenging work for researchers to improve the service and personalization level of CBR in the future. To maintain the satisfaction and loyalty of the target students, it is necessary to offer the explanation to the reasoning process and recommended results, which will make the target student more confident and disburdened in choosing the learning resources, all these research topics are very valuable to do in the future. Reducing the information overload is a multi-perspective research field, the solution of CBR is just a kind of way, and there are more chances and spaces to do in the personalized recommendation.

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