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FCRS: A Fuzzy Case-based Recommender System for SMEs

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***Abstract*— Training course recommendation is one of the important steps in training planning for SMEs. In this process, an expert analyzes SME's current and desired status, and recommends training courses that can help to improve its productivity. However this process has 3 drawbacks; first is the *access* problem. It's because SMEs often don't have the possibility to employ permanent training experts so they have difficulties in reaching experts. Second is the *loss of knowledge* problem. It's because most SMEs are not concern about issues like accumulating knowledge in organizations. So even if SME employs an expert for a while, as the expert leaves the company his knowledge is gone too. And third is the *locality* problem, which is because SMEs often have a very little relation with other successful SMEs and their decisions are limited to their own experiences.**

To refine these drawbacks, this paper proposed a training course recommender system based on the hybridization of Case-based reasoning and Fuzzy logic. CBR methodology uses the past experiences to solve new similar problems. FL on the other hand helps to cope with the uncertain and imprecise characteristics of SMEs. It is used to enhance case representation and case retrieval in CBR cycle.

FCRS, as a computer application can solve the *access* problem. Each incubator can provide one for its SMEs. It can solve the *loss of knowledge* problem by accumulating expert's knowledge in the form of the past experiences and reuse them to design a new Training plan. It also can solve the *locality* problem by recommending successful training plans that other similar SMEs has taken.

Keywords-Training Course Recommendation ;Case-based reasoning; Fuzzy logic; Knowledge-based SMEs.

I. INTRODUCTION

Training is one of the fundamental goals of human resources development in companies. It tends to activate employees to improve their abilities and to help them perform more efficiently [1]. It is important for companies to train their employees and ensure that all categories of employees have an up-to-date skills and knowledge. Training programs will improve productivity and also lead to a better use of resources.

One of the steps in planning a training program is the training course recommendation. It is a critical activity, because of the large number of available training courses, the large numbers of skills employees needs to learn, and the limited time they can spend on learning.

Training course recommendation is done by analyzing the current and desire status of company, determining which trainings are needed to progress from the current status to desired status and achieve optimum performance.

SMEs need training course recommendation more than large companies, because quite often their employees lack a large number of necessary skills and knowledge [2]. So it is crucial to detect the most important missing skills which have the most effect on SMEs performance in a specific time.

SMEs also face more challenge in selecting the right training courses for training their staff. Because first, they often do not have the possibility to employ permanent training experts [2] and they have to use outside training experts. So they have difficulties in *access*ing experts. Second, they usually have a simple structure so the knowledge of training experts is not saved in organization for future reuse. This leads to a *loss of knowledge* problem. Third, they often have a very little relation with other successful SMEs and their decisions are limited to their own experiences because of this *locality* problem.

To refine these three problems this paper proposed a Fuzzy-Case based recommender system. Fuzzy-Case based recommender systems are focused in some researches in the past few years [4, 5, 6, 7, 8, 9, and 10].

Fuzzy is a theory which is conceived by Zadeh [11] to cope with uncertainty in situations that precise numerical information are not available for modeling the problem. It can deal with reasoning that is approximate rather than precise. A more complete description of Fuzzy logic can be found in [12].

Case-based reasoning on the other hand is a methodology that provides the ability to use past experiences to solve new problems. In CBR approach, problems are solved by adapting solution of prior problems to new problem's context. The four fundamental steps of the CBR process are [13]:

- *Retrieve* some cases based on a similarity measure;
- *Reuse* the selected cases to solve a given problem;
- *Revise* the proposed solution if needed, based on the fact that the new problem and matched case partially differ;
- *Retain* the problem and its solution as a pair in case-base.

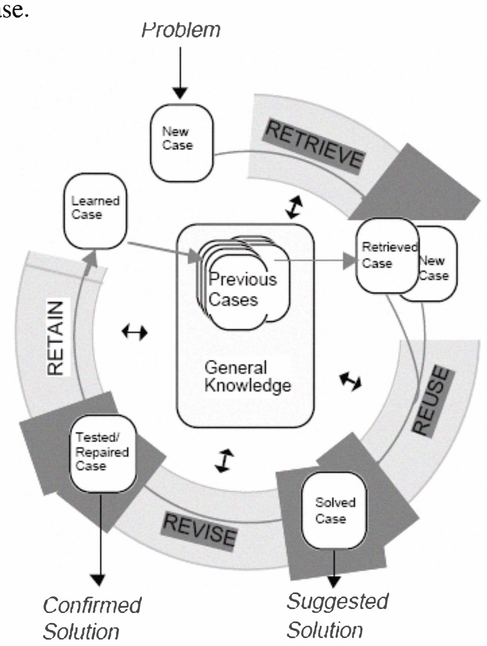

Figure 1: CBR cycle [13]

The hybrid Fuzzy-CBR approach is well suited for the problem of Training course recommendation because of:

- The number of researches with promising result applying Case-based reasoning on this problem [13, 14].
- The philosophy of CBR methodology [13] which has the potential to refine course selection problems. The *access* problem is refined using the Fuzzy-CBR software as a training course recommender system. The *loss of knowledge* problem is solved by accumulating the knowledge of experts through time. And the *locality* problem is handled by retaining all the cases in the case library of the system and recommending the similar cases to SMEs.
- The potential of Fuzzy logic which can handle the uncertainty in business domain and SMEs characteristics.

There are some related researches which tried to address the course recommendation problem in academic domain. ACCORN [15] is a Case based recommender system for course recommendation. RARE [16] is using association rules to recommend appropriate courses. CourseAgent [17] applies social navigation approach to deliver recommendation to courses. XARS [18] apply XML Link Language (XLink) to assist student on planning semester courses. In business domain, TRIMAR [14] is a web based system for training SMEs based on Case-based reasoning.

The paper is organized as follows. The architecture of system is presented in section II. The implementation of the model is described in section III. Finally in section IV several conclusions of work are presented.

II. FCRS: System Architecture

FCRS is a training course Recommender System, based on Fuzzy logic and Case-based reasoning. It is designed to refine training course recommendation problems for SMEs.

As it is shown in figure 3, the system has 2 main modules:

- **SA** (Session Analyzer): It interacts with SME and analyzes its status by asking a set of questions. These questions are selected from a *question bank* based on SME's age. SA generates a new case for Fuzzy-CBR engine based on the SMEs answers. SA will be explained in details in section *II.C*.

- **Fuzzy-CBR engine**: It is the core module of system. Its main process is based on the classic CBR cycle but The Fuzzy logic gets to enhance the following CBR steps:
  - In *case representation* to describe the imprecise and uncertain characteristics of SME.
  - In *case retrieval* to calculate similarity between cases through Fuzzy Similarity Function.

  Fuzzy-CBR engine will be discussed in section *II.D*.

A. Case Structure

The first issue in CBR methodology is to represent the case. Each case has two parts: the problem, and the solution.

In FCRS, each SME is assumed as a case. The *Fuzzy case problem* is represented by 34 attributes. These attributes are extracted based on EFQM model [19]. Table 1 shows these attributes in detail. The values of attributes are trapezoidal fuzzy numbers. Fuzzy because asking SMEs to provide a crisp numerical value to attributes leads to imprecise information and poor reasoning. Trapezoidal because this form of fuzzy numbers can describe information in this format:

- The value for attribute X is belongs to [*b*, c] with a high degree of membership. It is neither less than *a,* nor greater than *d.*

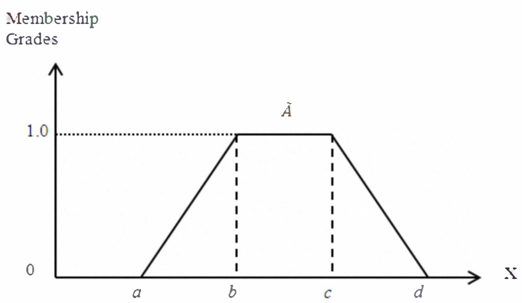

Figure 2: a trapezoidal fuzzy number [22]

Table 1: SMEs attributes based on EFQM model [19]

<table>
<tr><th>Area</th><th>Filed</th><th>Sub Filed</th><th colspan="2">Attribute</th><th>Type</th><th>#</th></tr>
<tr><td rowspan="18">Enablers</td><td colspan="2" rowspan="7">Management</td><td colspan="2">Managerial Team</td><td>QL</td><td>1</td></tr>
<tr><td rowspan="5">Direct manager's Skills</td><td>Project Management</td><td>QL</td><td>2</td></tr>
<tr><td>Business Plan Preparation</td><td>QL</td><td>3</td></tr>
<tr><td>Decision Making</td><td>QL</td><td>4</td></tr>
<tr><td>Financial and Accounting</td><td>QL</td><td>5</td></tr>
<tr><td>Communication and Marketing</td><td>QL</td><td>6</td></tr>
<tr><td colspan="2">Documentation Of Vision, Missions, Goals, and Strategies</td><td>QL</td><td>7</td></tr>
<tr><td colspan="2" rowspan="4">Human resource</td><td colspan="2">Key Human Resources</td><td>B</td><td>8</td></tr>
<tr><td colspan="2">Specialized Team</td><td>QL</td><td>9</td></tr>
<tr><td colspan="2">Adaptability Between Work Team and Progress of Key Idea</td><td>QL</td><td>10</td></tr>
<tr><td colspan="2">Using Consultant</td><td>QL</td><td>11</td></tr>
<tr><td rowspan="7">Activities</td><td rowspan="4">Organizational</td><td colspan="2">Organizational Chart</td><td>B</td><td>12</td></tr>
<tr><td colspan="2">Insurance List</td><td>B</td><td>13</td></tr>
<tr><td colspan="2">Having Administration and Financial Patterns</td><td>QL</td><td>14</td></tr>
<tr><td colspan="2">Information Activity</td><td>QL</td><td>15</td></tr>
<tr><td rowspan="3">Economical</td><td colspan="2">Market Analysis</td><td>QL</td><td>16</td></tr>
<tr><td colspan="2">Marketing Plan</td><td>QL</td><td>17</td></tr>
<tr><td colspan="2">Planning to Provide Financial Resources</td><td>QL</td><td>18</td></tr>
<tr><td rowspan="16">Results</td><td colspan="2" rowspan="3">Internal Environment</td><td colspan="2">Permanence of Personals</td><td>QL</td><td>19</td></tr>
<tr><td colspan="2">Interaction with Other Tenants</td><td>QL</td><td>20</td></tr>
<tr><td colspan="2">Equity Share</td><td>QN</td><td>21</td></tr>
<tr><td colspan="2" rowspan="3">Process</td><td colspan="2">Adaptability Between Performance and Financial Plan</td><td>QN</td><td>22</td></tr>
<tr><td colspan="2">Having Updated Work Plan</td><td>QL</td><td>23</td></tr>
<tr><td colspan="2">Having Tax Return</td><td>B</td><td>24</td></tr>
<tr><td rowspan="6">External Environment</td><td rowspan="2">Scientific</td><td colspan="2">Membership in Scientific Groups</td><td>B</td><td>25</td></tr>
<tr><td colspan="2">Having Research Paper</td><td>B</td><td>26</td></tr>
<tr><td rowspan="4">Financial</td><td colspan="2">Amount of Financial Contracts</td><td>QN</td><td>27</td></tr>
<tr><td colspan="2">Portion of Key Idea Contracts to Total Contracts</td><td>QN</td><td>28</td></tr>
<tr><td colspan="2">Amount of Financial Recourses Attraction from Governmental and Private Centers</td><td>QN</td><td>29</td></tr>
<tr><td colspan="2">Attraction of Foreign Partner</td><td>B</td><td>30</td></tr>
<tr><td colspan="2" rowspan="4">Key Performance</td><td colspan="2">Consistency to Goals, Mission and Strategies</td><td>QL</td><td>31</td></tr>
<tr><td colspan="2">Progress of Key Idea in Scheduling</td><td>QN</td><td>32</td></tr>
<tr><td colspan="2">Profit Margins</td><td>QN</td><td>33</td></tr>
<tr><td colspan="2">Total Number of Contracts</td><td>QN</td><td>34</td></tr>
</table>

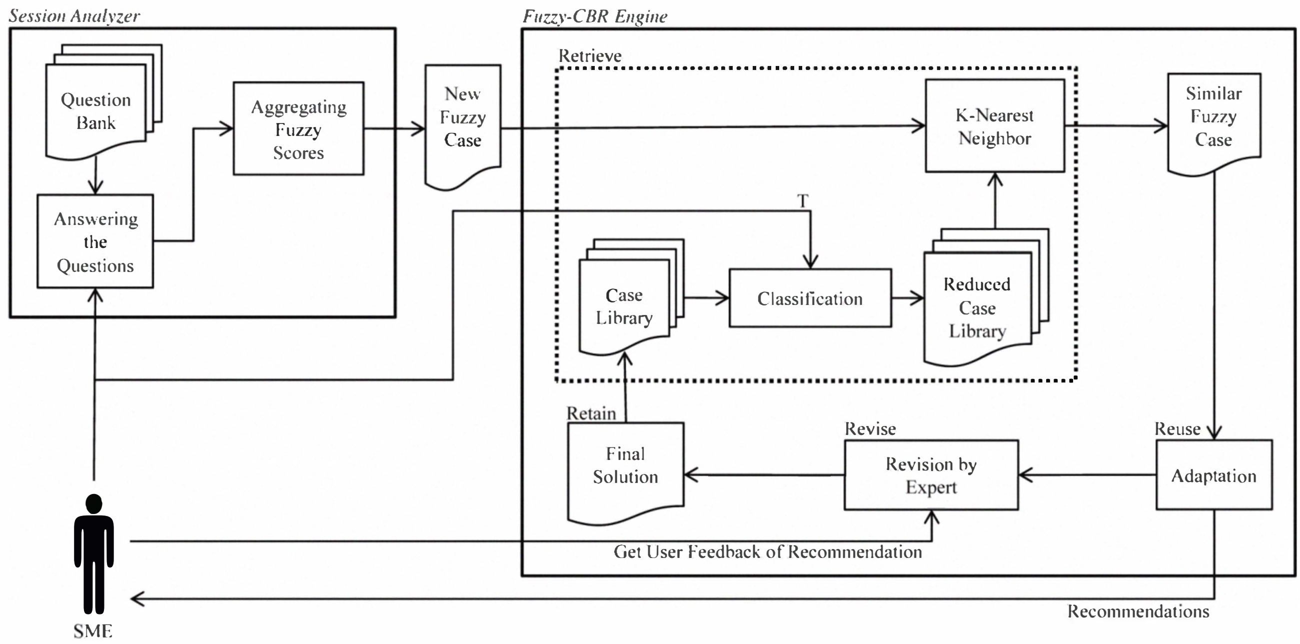

Figure 3: systems architecture

This format is well suited for acquiring information from SMEs because it contains a wide range of numbers with different degree of memberships thus reduces errors of reminding and uncertainty. Figure 2 shows a trapezoidal fuzzy number.

The *case solution* is represented by 3 training courses. These training courses are recommended to SME based on its needs. The training courses are bound to 3 because SME have only 6 month to pass the courses and number of recommendation should be rational.

B. Case Library

The data collection included a five-page, self-administered mail questionnaire and a structured interview of selected knowledge-based SMEs throughout the country (Iran). Case library's cases are then classified in to 6 classes based on SMEs *Age*. The *Age* ranges are [0-6], [6-12], [12-18], [18-24], [24-30] and [30-36] month, which are defined applying expert's opinion. Each of these ranges formed a class in the case library.

C. SA: Session Analyzer

SA generates a *Fuzzy case problem* according to SMEs status. For doing this, attributes of SMEs have to be measured. For this purpose, a set of measurable *indicators* are defined for each attribute. These indicators are measured by asking user a related question. The questions are multi choice, and each choice has a particular *Fuzzy score*.

By selecting each choice, a user gets its fuzzy score. The aggregation of these fuzzy scores is the Fuzzy value of the attribute. This value is calculated according to the average fuzzy number of *n* trapezoidal numbers $\tilde{A} = \left(a_1^{(i)}, a_2^{(i)}, a_3^{(i)}, a_4^{(i)}\right)$ whereas $i = 1,2, \dots, n$, as follows [20]:

$$\tilde{A} = \frac{\left(\sum_{i=1}^{n} a_1^{(i)}, \sum_{i=1}^{n} a_2^{(i)}, \sum_{i=1}^{n} a_3^{(i)}, \sum_{i=1}^{n} a_4^{(i)}\right)}{n} \qquad (1)$$

D. Fuzzy-CBR Engine

Retrieve: In the first step, a *fuzzy case problem* is compared with fuzzy cases in the case library and the most similar case is retrieved.

For this purpose, the *k*-nearest neighbor algorithm is used where k is considered as 1, and the similarity calculation is applied for finding most similar cases.

The degree of similarity $S(\tilde{A}, \tilde{B})$between the generalized trapezoidal fuzzy numbers $\tilde{A}$ and $\tilde{B}$ can be calculated as follows [21]:

$$S(\tilde{A}, \tilde{B}) = \left[\sqrt[4]{\prod_{i=1}^{4} (2 - |a_i - b_i| - 1)}\right] \times \frac{min\left(y_{\tilde{A}}^*, y_{\tilde{B}}^*\right)}{max\left(y_{\tilde{A}}^*, y_{\tilde{B}}^*\right)} \qquad (2)$$

Where $y_{\tilde{A}}^*$ and $y_{\tilde{B}}^*$ are calculated as follows [21]:

$$y_{\tilde{A}}^* = \begin{cases} \dfrac{w_{\tilde{A}} \times \left(\frac{a_3 - a_2}{a_4 - a_1} + 2\right)}{6}, & if\ a_1 \neq a_4\ and\ 0 < w_{\tilde{A}} \leq 1 \\ \dfrac{w_{\tilde{A}}}{2}, & if\ a_1 \neq a_4\ and\ 0 < w_{\tilde{A}} \leq 1 \end{cases} \qquad (3)$$

The greater value of $S(\tilde{A}, \tilde{B})$ shows the more similarity between $\tilde{A}$ and $\tilde{B}$.

Reuse: In this step a solution of a retrieved fuzzy case will be adapted to new problem context. Many reuse techniques are introduced by researchers. For further information about reuse techniques, see [22]. In FCRS a substitutional adaptation is done using the domain knowledge. This knowledge is based on the fact that a training course cannot be recommended if the pre-requisite courses have not been passed yet. Table 2 shows the pre-requisite relations between attributes. For example if SME has a week status in attribute number 31, system won't recommend a training courses to improve this attribute. It will recommend training courses that helps to improve attribute number 7.

Table 2. Pre-requisite relations

Number of pre-requisite attribute	Number of current attribute
7	31
13	19
10	32
8	32
18	29
7	32
2	23
32	22
12	14
6	34

In reuse step, first three recommendations will be checked so if any of them, have the related attribute in column 2 of table 2. Then the score of related pre-requisite attribute will be checked. If the SME has the low score on pre-requisite attribute, the training course related to current attribute will be omit and the training course which is related to pre-requisite attribute will be placed in the solution structure of retrieved case. This way the solution will be adapted to current SME.

Revise: Expert revises the solution that system has presented, by considering a feedback of SME on presented recommendation. If the solution is not satisfactory, it will be edited by expert.

Retain: The new Fuzzy case which is revised by expert will be compared with cases in the case library. If no similar case does exist in the case library, this new case will be stored. In fact, system learns through this step. When new fuzzy cases added to case library, knowledge of system will be increased.

III. IMPLEMENTATION

The system is implemented with C# in Microsoft visual studio 2008 environment. The software is designed in object oriented framework. A database with SQL server 2008 is designed for case library. Figure 5 shows a snapshot of the software.

For model testing purposes the system is implemented as an application for windows platform. However the architecture and framework of system have the potential to be implemented as a client/server application. This potential is considered in the system because the case library needs to be connected to server and gets regular updates during time.

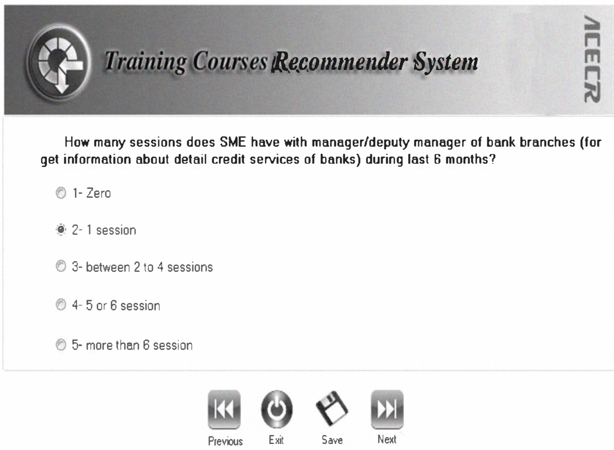

Figure 5. An Interface of questionnaire form of FCRS

IV. CONCLUSION

Training planning is one of the main challenges in organizations. With the increased pressure to contain costs, it is critical to find more effective ways to plan a training program and fill the gap between the current and the desired status. Especially for SMEs which need more guidelines in order to improve their skills and stay as a high-performance and competitive business unit.

Training course selection is an important step in planning a training program. When SMEs are the end users this step is even more important, because their employees often lack more skills and knowledge. In this situation selecting the most important missing skills and recommending the related training courses to improve those skills is a critical issue.

SMEs also face more challenges in selecting the training course which meets their needs in specific times.

First, they often have limited *access* to training experts. Most of them can't afford to employ an expert mostly in their early life time. However in the world of technology this problem can be handled through computer-based solutions. FCRS, as a software is proposed to overcome the *access* problem.

Second, most SMEs have a simple structures and most often they are not concern about issues like accumulating knowledge in organizations. This inattention can lead to a *loss of knowledge* problem, which means even if SME employs an expert for a while, as the expert leaves the company his knowledge is gone too. FCRS, which is applied Case-based reasoning methodology, is accumulating the knowledge of experts in its case library. This knowledge is then reused whenever a similar situation shows up.

Third, SMEs often have a very little relation with other business units due to their low age. This matter may limited SME to its own experiences and causes the *locality* problem. FCRS helps SMEs to reuse the past successful experiences and cope with this problem.

This analysis shows that the problem of training course recommendation to SMEs can be addressed by designing a recommender system [3] applying the hybrid Fuzzy-CBR approach.

There were also some limitations in designing the system. Prior poor data gathering previously done in the incubator [19] resulted lack of data to construct the case library. This limitation was overcome by gathering new data from SMEs through a five-page, self-administered mail questionnaire and a structured interview. Also the case structure in [19] was partly different from the structure of the gathered data in FCRS project. A revision process by experts was employed to prepare data in the new form.

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