Theoretical Framework of Open Virtual Worlds for Professional Development

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Abstract. This paper discusses an attempt for formalization of the decision making process, evaluation and scaling of the components and parameters of Lifelong learning systems and services. Fuzzy logic techniques are used for the formal method representation. The parameterization and rules generation are based on preliminary research of the golden standards and surveys among the users and professionals in the field. The especially designed and implemented system is used for experiments.

Keywords: Intelligent systems, Formal methods and parameterization, Fuzzy Logic, Lifelong Competence Development

1 Introduction

Emerging technology developments in society over the last decades have created the need for increased Lifelong learning (LLL) initiatives. As a result, the advanced technologies are used in many of these initiatives. On the other hand relying only to technologies to solve this task is not a solution of the real problem, because they just support the process, but itself it doesn't care how it can be adopt and applied. It is important what technology is appropriate in different cases of professional development and how to decide are they.

Formalization and parameterization of the professional development is one of the wais to deal with this problem. It is very complex task requiring non standard solutions and usage of innovative techniques. The presented model and system design are our first attempt to deal with this problem.

2 Theoretical Framework

The main goal of this research is to find appropriate solutions and models for particular context to achieve professional development. The major task is to find appropriate integration of technologies and methodologies in order to meet objectives for professional development of particular user. For that purpose the theoretical framework of Open Virtual Worlds (OVW) for professional development is proposed. The components are Technology, User, Methodology and Objectives. We need to investigate their characteristics, correlations and impact in the context.

The components characteristics are not clearly defined set, which is not closed for further extension. On the other hand some of the characteristics can vary in their interpretation. In such complex task the traditional knowledge representation models for automate processing like formal models are not appropriate. It is impossible to represent the concepts sets in formal language by defining crisp sets. That's why the chosen model relies on fuzzy logic theory. Fuzzy logic is a product of a rational thinking and entirely subjected to its "IF-THEN" rules of inference. It works satisfactorily when dealing with the fuzziness of the human perceptions and words and has been used to put into the computers' memory as much as possible of the experts' practical knowledge and competence, then using them for the purpose of designing and controlling intelligent engineering systems and robots [1]. In the social sciences, fuzzy logic was first applied to the problem of social choice and self organization in the early 1970's [2]. They propose a method applying fuzzy logic in the domain of management and business, where human interactions are too complex in their scope and scale to be understood even by those who seem to be in control, and produce effects and consequences in the lives of everyone in today's global society.

First we need to define for each component its characteristics (linguistic variables), their values and membership functions. Values and variables collections are generated in result of experience from EU projects like Kaleidoscope [3], I*Teach ([4], [5]), TENCompetence [6] as well as research in the field of intelligent adaptive e-learning systems development [7]. Experts from research organizations, universities, leading companies in Technologies Enhanced Learning area participated in surveys concerning the main e-learning systems functionalities and their essential values. The findings were refined by experts. On that base was created the theoretical framework parameters, which are described in details in the subsections below.

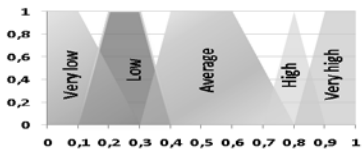
Technology component of OVW can vary depending on several characteristics. Most important variables related to them are show in Table 1:

Table 1. Technology linguistic variables, description and values.

Variable	Description	Values
Utilization	Level of technology applied in practice	Weak, Desirable, Strong
Complexity	Level complicatedness to apply given technology	Low, Intermediate, High
Functionality	Number of functions proposed by technological solution	Single, Multiple, Universal
Cost	The user interpretation of the price of the technology decision	Very Low, Low, Average, High, Very High
Technology Dependency	Level of dependency of chosen technology by other technologies	{Fully/Almost} Independent, {Slightly/Very} Dependent
Methodology Dependency	Level of dependency of chosen technology from methodology intended to be apply	{Fully/Almost} Independent, {Slightly/Very} Dependent
User Dependency	Level of dependency of chosen technology from user expectations	{Fully/Almost} Independent, {Slightly/Very} Dependent

Each of the variables described above is associated with the range of possible values. For instance, the Table 2 represents the cost values:

Table 2. Sample of technology linguistic variable - cost values set.

Linguistic variable: Cost – c			
Linguistic value:	**Notation**	**Numerical Range (normalized)**	**Fuzzy Sets of c**
Very Low **Low** **Average** **High** **Very High**	VL L A H VH	[0, 0.3] [0.1, 0.4] [0.3, 0.8] [0.7, 0.9] [0.8, 1]	

User component of the OVW model depends on characteristics described in the personal profile. Most important variables related to them are show in Table 3:

Table 3. User linguistic variables, its description and values.

Variable	Description	Values
Qualification	Level of experience of the user	Beginner , Intermediate, Advanced , Expert
Motivation	Level of user conviction and desire	Little, Slightly, Very, Extremely
Professional Factors	Level of professional influence	Indifferent, Asset, Desirable, Required
Personal Reasons	Level of individual interests	Indifferent, Slightly Interested, Interested, Intended, Very Intended

The objectives component of OVW model concerns learning goals and general aims of the professional development. Its primary variables are Skills, Knowledge, Competence and Educational Level.

Even *educational level* values are not quite difficult to distinguish on base of official documents non-formal learning should be taken into account. These leads to overlapping of the values numerical ranges, which include: Basic (School), Advanced (University), Specialized (Professional) and Improved (LLL).

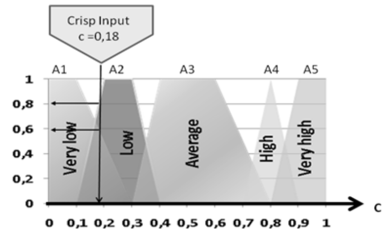
Methodology variables are actors involvement, activities type, delivery model, time constrains and goals orientation. Their detailed description is not presented in the article and is a subject of separate publication discussion.

2 Exploring Values Relations and Rules Definitions

Rule-based fuzzy logic is used for complicated decision making. The rules influenced by experts' best practices define relations between variables. These rules deal with complexity and uncertainty of the life unfolding, because usage of logic closer to the way of human thinking and perceptions.

Mamdani-style [8] fuzzy inference four step process (slightly modified and adapted) is performed:

- *Fuzzification of the input variables* (sample is given on Figure 1)



$$\mu_{(c=A1)} = 0{,}6$$
$$\mu_{(c=A2)} = 0{,}8$$

Fig. 1. Fuzzification of input variable cost.

- *Rule evaluation*

The representation of a fuzzy rule is based on notational conventions. In a classical fuzzy rule-based classifier, the antecedent part of a rule defines the operating region of the rule in the *M*-dimensional input feature space while the consequent part of the rule describes one of the *K* classes, indicating a crisp class label from the label set $\{c^1, c^2, ..., c^K\}$. Compared with the classical fuzzy rule-based knowledge, the probabilistic fuzzy rule has the following form in (1):

$$\begin{aligned} &R_i : If\ x^1 = \tilde{A}_i^1\ and\ x^2 = \tilde{A}_i^2, \ldots, and\ x^M = \tilde{A}_i^M \\ &then\ \Pr(y = c^1 \mid x = \tilde{A}_i) = P_i^1, \Pr(y = c^2 \mid x = \tilde{A}_i) = P_i^2, \ldots, \\ &\Pr(y = c^K \mid x = \tilde{A}_i) = P_i^K, i = 1, \ldots, N \end{aligned} \quad (1)$$

where $x = (x^1, x^2, \ldots, x^M)$, $\tilde{A}_i = \{\tilde{A}_i^1, \tilde{A}_i^2, \ldots \tilde{A}_i^M\}$, *and* R_i denotes the *i* th rule. Note that the vector fuzzy set is assumed to have its membership function with shape of multivariate Gaussian function. To simplify the expression, we also assume that the covariance matrix has diagonal terms only in the fuzzy set. It is remarked that an ordinary fuzzy rule can be considered a special case of a rule expressed in (1).

The totality of rules: $R_i, i=1, ..., N$ is called the probabilistic fuzzy rule base (PFRB).

- *Aggregation of the rule outputs*

We use a PFRB to assign a feature vector *x* to the class c^{k^*} using (2).

$$k^* = \arg\max_{k=1,2,\ldots,K} \sum_{i=1,2,\ldots,N} m_{\tilde{A}_i}(x) \Pr(y = c^k \mid x = \tilde{A}_i) \quad (2)$$

- *Defuzzification* – using the most popular centroid technique

Currently about 30 the rules are included in the system developed. They are tested with training corpus of 50 vectors and test corpus of 25 vectors.

3 Conclusion and Further Work

OVW for professional development aims to help in suggestion of more appropriate consistent set of technology, methodology and objectives satisfying user needs. Fuzzy logic provides a powerful way for analysis and control of such complex systems.

As being a work in progress we cannot give many evaluation results at the moment. We are expecting, after finishing the implementation stage of the systems - probably next academic year, to be able to make some tests with real users and experts. The further work includes refinement of the rules set, scenarios development, and testing.

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