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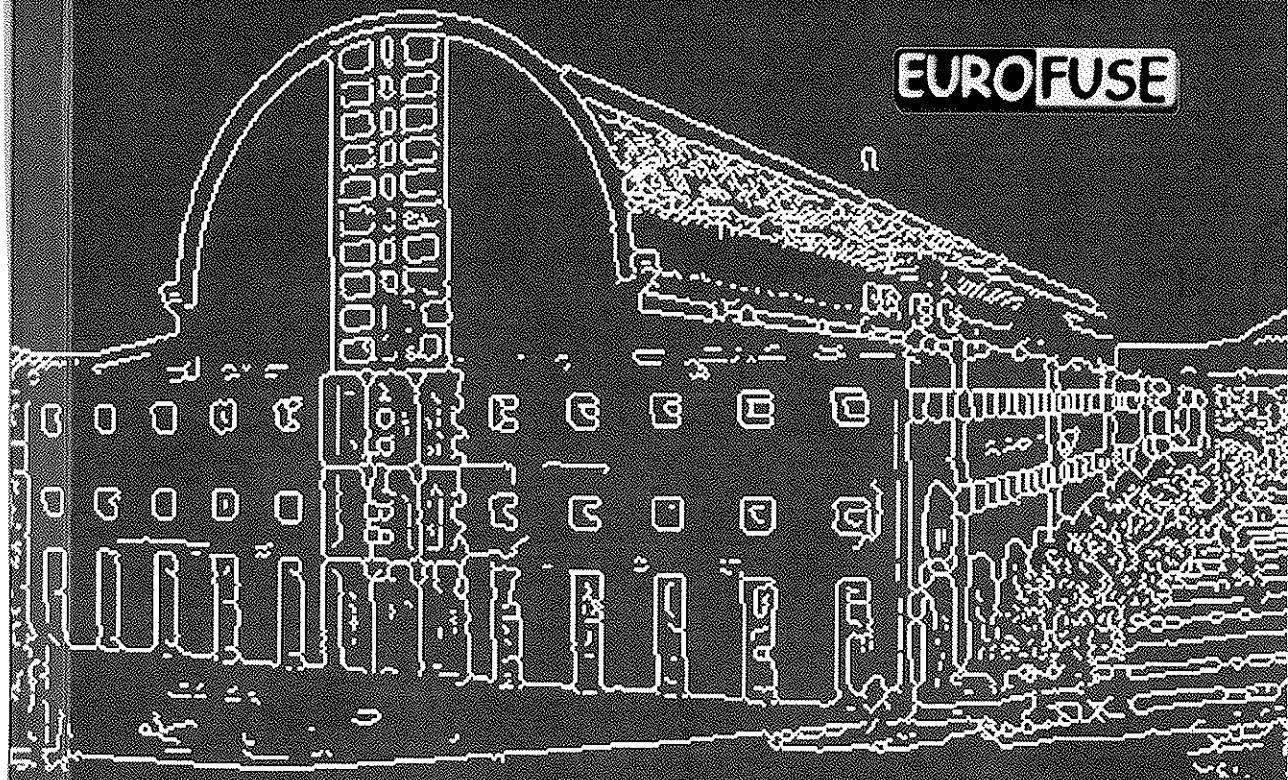

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Applying Fuzzy Linguistic GDM Models in Academic Library Management

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Abstract

The aim of this paper is to improve the quality of service in academic libraries. To do so, we present an application of decision support system that aids general manager to decide about funding distribution taking into account the staffs opinions. We assume a fuzzy linguistic modelling to represent the staff's opinions and apply automatic tools of fuzzy computing with words to obtain a collective solution to improve the quality of service by distributing the funds in the most appropriate way.

Keywords: Group decision making, decision support system, linguistic modelling, academic libraries.

1 Introduction

The main goal of an academic library as a service organization is to maintain a level of service quality that, satisfying its users, will ensure funding for the existence and development of the library [3]. Hence, there is a need to determine the value and measure the performance of the library to distribute the funding between the different offered services. The funding distribution is a complex task, because it is necessary to adapt the distribution to the users' needs, which are different in each case. It is not the same to manage a library which users are students of engineering that do the management in one that is frequented by specialists in history because the resources and the information are different.

Usually, the person in charge to distribute the funding, called general manager, ask to the staff of the library about their opinions because they deal directly with the users and they know their needs and worries about the library services. Moreover, the general manager has confidence in the staff to consider their criteria about the distribution of the budget.

Taking into account the above factors, the main problem for the general manager is to rank the different library services in order to distribute the funds between them according to the staff's opinions. This problem can be seen as a group decision making (GDM) problem because it includes all the necessary requirements for this kind of problems.

GDM models are used to obtain the best solution(s) for a problem according to the information provided by some decision makers. Usually, each decision maker (expert) may approach the decision process from a different angle, but they have a common interest in reaching an agreement on taking the best decision. Concretely, in a GDM problem we have a set of different alternatives to solve the problem and a set of experts which are usually required to provide their preferences about the alternatives by means of a particular preference format [5].

In the case of the funding distribution between library services, the alternatives are

these services, and the set of experts of the problem is the staff of the library. To generalize the method, we divide the library services following the libqual+ survey model [9, 10], which distinguishes three different groups of services: i) affect of service (AS) ii) information control (IC) and iii) library as place (AP). Furthermore, we add a fourth service group depending of the local services of the library. Nowadays all the libraries are changing into digital libraries, and thus, we choose the new technologies access (NT) as the last group of library services.

The main of this paper is to apply a GDM model to improve the academic library management. This application uses subjective criteria related to the services offered by the library. We assume that the need to invest in a library service is measured through staff's perceptions about the needs of the users. For this reason, we use a *fuzzy linguistic modelling* [7] to represent the staff's perceptions. This kind of modelling is an approximate technique which represents qualitative aspects as linguistic values by means of *linguistic variables*, that is, variables whose values are not numbers but words or sentences in a natural or artificial language [7]. To compute the quality assessments we use tools of computing with words based on the linguistic aggregation operators.

In order to do so, the paper is set out as follows. Some considerations about library services, GDM problems and the linguistic approach are presented in Section 2. Section 3 deals with the library application of the model. Finally, Section 4 draws our conclusions.

2 Preliminaries

In this section we present some considerations about the quality of library services, GDM problems and the fuzzy linguistic approach.

2.1 Overview about Academic Library Services

The libraries have drastically changed from the storehouses of books to the powerhouses of knowledge and information since the middle of 20th century. The information and communication technology, which is responsible for this revolution, has drastically changed the organization, management and operation mode of modern libraries. The existence of a library is fully dependent on the satisfaction of users. Therefore, libraries are now more concerned about the library customers, their satisfaction, the quality of libraries and information products and services and their proper marketing. An user is satisfied when the library is able to rise to his/her expectations or meet the actual needs. The library and information professionals have to properly understand the customers, what they want, how they want it and when they want the documents or information from a library. So, the library has to consider the individuality of the customers, responsiveness of staff and the relationship of the customer with the library very seriously as it effects the quality of library products and services heavily [3, 11].

Therefore, it is necessary to have a system through which the customer needs are taken into account and these must be used to improve the quality of the libraries by distributing the funding according to these needs. There are several methods, tools or techniques to measure, control and improve the quality of a library. The quality can be perceived from the organizational level, user level or both [9, 10]. The libqual+ survey model [9, 10] is a popular method to evaluate the quality of the libraries according to the user satisfaction.

We propose a tool managed by the general manager but are the staff members who give their preferences about the needs of funds in each service with the final gap to distribute the funding according to the customer needs and, in such a way, to improve the quality of service in academic libraries.

2.2 Group Decision Making Models

In a GDM problem we have a finite set of feasible alternatives. $X = \{x_1, x_2, \ldots, x_n\}$, $(n \geq 2)$ and the best alternatives from X have to be identified according to the information given by a set of experts, $E = \{e_1, e_2, \ldots, e_m\}$, $(m \geq 2)$.

Usual resolution methods for GDM problems are composed by two different processes [5] (see Figure 1):

1. *Consensus process:* Clearly, in any decision process, it is preferable that the experts reach a high degree of consensus on the solution set of alternatives. Thus, this process refers to how to obtain the maximum degree of consensus or agreement among the experts on the solution alternatives.

2. *Selection process:* This process consists in how to obtain the solution set of alternatives from the opinions on the alternatives given by the experts.

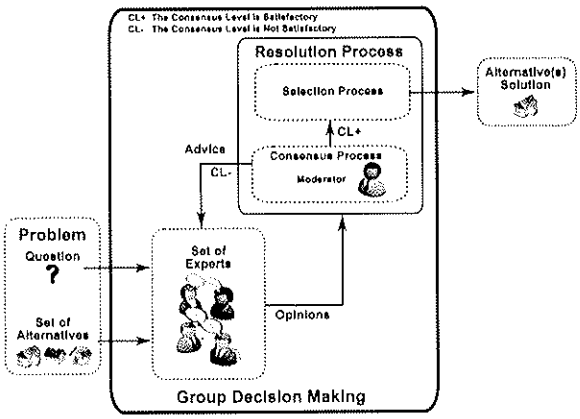

Figure 1: *Resolution process of a GDM*

In this paper, we apply a selection process to obtain a ranking of academic library services by using the preferences given by the staff of the library.

2.3 Fuzzy Linguistic Modelling

There are situations in which the information cannot be assessed precisely in a quantitative form but may be in a qualitative one. For example, when attempting to qualify phenomena related to human perception, we are often led to use words in natural language instead of numerical values, e.g. when evaluating quality of a restaurant, terms like *good*, *medium* or *bad* can be used. In other cases, precise quantitative information cannot be stated because either it is unavailable or the cost for its computation is too high and an "approximate value" can be applicable, eg. when evaluating the speed of a car, linguistic terms like *fast*, *very fast* or *slow* can be used instead of numeric values [1].

The use of Fuzzy Sets Theory has given very good results for modelling qualitative information [13]. The fuzzy linguistic modelling is a tool based on the concept of linguistic variable to deal with qualitative assessments. It has proven its usefulness in many problems, e.g., in decision making, quality evaluation, information retrieval models, etc.

The ordinal fuzzy linguistic modelling [7] is a very useful kind of fuzzy linguistic approach proposed as an alternative tool to the traditional fuzzy linguistic modelling which simplifies the computing with words process as well as linguistic aspects of problems. It is defined by considering a finite and totally ordered label set $S = \{s_i\}, i \in \{0, ..., g\}$ in the usual sense, i.e., $s_i \geq s_j$ if $i \geq j$, and with odd cardinality (usually 7 or 9 labels). The mid term represents an assessment of "approximately 0.5", and the rest of the terms are placed symmetrically around it. The semantics of the label set is established from the ordered structure of the label set by considering that each label for the pair (s_i, s_{g-i}) is equally informative [1]. For example, we can use the following set of seven labels to represent the linguistic information:

S = { N=*Null*, VL=*Very Low*, L=*Low*, M=*Medium*, H=*Hight*, VH=*Very Hight*, P=*Perfect*}.

In any linguistic modeling we also need some management operators for linguistic information. An advantage of the ordinal fuzzy linguistic modeling is the simplicity and speed

of its computational model. It is based on the symbolic computational model [7] and acts by direct computation on labels by taking into account the order of such linguistic assessments in the ordered structure of labels. Usually, the ordinal fuzzy linguistic model for computing with words is defined by establishing i) a negation operator, ii) comparison operators based on the ordered structure of linguistic terms, and iii) adequate aggregation operators of ordinal fuzzy linguistic information. In most ordinal fuzzy linguistic approaches the negation operator is defined from the semantics associated to the linguistic terms as

$$NEG(s_i) = s_j \mid j = (g - i)$$

and there are defined two comparison operators of linguistic terms:

1. *Maximization operator:* $MAX(s_i, s_j) = s_i$ if $s_i \geq s_j$; and
2. *Minimization operator:* $MIN(s_i, s_j) = s_i$ if $s_i \leq s_j$.

Using these operators it is possible to define automatic and symbolic aggregation operators of linguistic information, as for example the linguistic ordered weighted averaging (LOWA) operator [6]. This operator, defined in [6], is based on the ordered weighted averaging (OWA) operator defined by Yager in [12], and on the convex combination of linguistic labels defined by Delgado et al. in [2].

3 Fuzzy Linguistic Group Decision Models Applied in Academic Library Management

3.1 Problem description

The funding distribution problem in academic libraries environment to improve the quality of service can be modeled like a GDM problem in which the experts are the staff members, the alternatives are the library services and the general manager acts like moderator. With this kind of model, if the experts reach a consensual collective solution, the problem can have a quickly and precise solution.

To do so, we present a tool that collects the individual staff's opinions about the funding needs of the library services and shows to the general manager the computed ranking of these services. We follow the libqual+ survey model [9, 10] to establish the library services to be assessed by the staff members. In libqual+ model three library services are considered:

- Affect of service (AS): In this case new funds could contribute to improve the staff knowledge by mean of courses, to hire new staff, etc.
- Information control (IC): In this case new funds could contribute to buy new books, to subscribe new journals, etc.
- Library as place (AP): In this case new funds could contribute to buy new furniture, to build new rooms, etc.

Furthermore, by considering the advance of use of new technologies in traditional academic libraries we identify other library service related with the development of the new technologies in the library activities

- New technologies access (NT): In this case new funds could contribute to actualize the old computers, to make new web services, etc.

Therefore, we consider four library services which could be potential receptors of funds depending on the general manager's decision.

We assume that each staff member e_h provides his/her preferences on library services $X = \{x_1, x_2, x_3, x_4\}$ by means of a fuzzy linguistic preference relations (FLPR) P^h characterized by a membership function [7]

$$\mu_P : X \times X \longrightarrow S$$

where the value $\mu_{P^h}(x_i, x_k) = p_{ik}^h$ is interpreted as the preference degree of the library service x_i over x_k for the expert e_h.

FLPRs are widely used in this kind of problems because they are more informative than

preference orderings or utility functions, allowing the comparison of the alternatives in a pair by pair basis. Thus, experts have much more freedom when giving their preferences and they can gain expressivity against other preference representations.When cardinality of X is small, the preference relation may be conveniently represented by an $n \times n$ matrix $P^h = (p^h_{ik})$.

For example, using the set of seven labels introduced in Section 2 a staff member e_h could provide the following FLPR

$$P^h = \begin{pmatrix} - & N & H & M \\ P & - & L & M \\ L & H & - & VL \\ M & M & VH & - \end{pmatrix}$$

According to $p^h_{24} = M$ and $p^h_{21} = P$ e_h considers that x_2 is equally preferred to x_4 and x_2 is absolutely preferred to x_1 in the funding distribution, respectively.

3.2 A selection process in academic libraries

When all staff members $E = \{e_1, \ldots, e_m\}$ have provided their FLPRs $\{P^1, P^2, \ldots, P^m\}$ about the four library services we can obtain a ranking of library services applying a selection process [4]. The selection process is composed of two different phases [4, 7]: (i) *aggregation*, and (ii) *exploitation*.

3.2.1 Aggregation of individual FLPRs

The aggregation phase defines a collective preference relation, $P^c = (p^c_{ij})$, obtained by means of the aggregation of all individual linguistic preference relations $\{P^1, P^2, \ldots, P^m\}$. It indicates the global preference between every pair of library services according to the majority of staff members' opinions. The aggregation is carried out by means of a LOWA operator [2, 6].

A LOWA operator of dimension n is a function $\phi : S^n \rightarrow S$ that has a weighting vector associated with it, $W = (w_1, ..., w_n)$, with $w_i \in [0, 1]$, $\sum_{i=1}^{n} w_i = 1$, and it is defined according to the following expression:

$$\phi_Q(p_1, \ldots, p_n) = \sum_{i=1}^{n} w_i \cdot p_{\sigma(i)}, \quad p_i \in S.$$

being $\sigma : \{1, ..., n\} \rightarrow \{1, ..., n\}$ a permutation defined on linguistic values, such that $p_{\sigma(i)} \geq p_{\sigma(i+1)}, \forall i = 1, ..., n-1$, that is, $p_{\sigma(i)}$, is the i-highest linguistic value in the set$\{p_1, ..., p_n\}$.

A natural question in the definition of OWA operators is how to obtain W. In [12] it was defined an expression to obtain W that allows to represent the concept of fuzzy majority by means of a fuzzy linguistic non-decreasing quantifier Q:

$$w_i = Q(i/n) - Q((i-1)/n), \; i = 1, \ldots, n. \quad (1)$$

Therefore, in our model the collective FLPR is obtained as follows:

$$p^c_{ij} = \phi_Q(p^1_{ij}, \ldots, p^m_{ij}) \quad (2)$$

3.2.2 Exploitation of collective FLPR

The goal of the exploitation phase is to choose the best alternatives from P^c. In our framework, we look for to identify the best library services that could be improved with the fund distribution. Usually, the exploitation in GDM is modeled using *linguistic choice functions* which allow us to characterize the alternatives and to separate the best ones [8]. Then, we have to develop two tasks:

1. *Obtain a rank ordering among the library services by means of a linguistic choice function:* So, we use the choice function called *quantifier guided dominance degree* to rank library services from the collective FLPR P^c. This choice function quantifies the dominance that one alternative has over all the others in a fuzzy majority sense:

   $$X^c = \{(x_1, \mu_{X^c}(x_1)), \ldots, (x_4, \mu_{X^c}(x_4))\}$$

   being $\mu_{X^c}(x_1) \in S$ the linguistic quantifier guided dominance degree of x_i obtained as

   $$\mu_{X^c}(x_i) = \phi_Q(p^c_{i1}, \ldots, p^c_{im}).$$

2. *Choose the best alternatives according to the established rank ordering.* It obtained as follows:

   $X^s = \{x_i \in X | \mu_{X^c}(x_i) = \mathrm{Max}_{x_j \in X}\{\mu_{X^c}(x_j)\}\}$.

   Sometimes it is necessary to apply more choice functions [1, 8]

4 Conclusions

In this paper we have presented a linguistic GDM application based on staff perceptions to evaluate the funding needs of the academic libraries to improve the quality of services. In the future, we will use incomplete information models and avoid the impartial preferences by using weight values which change depending on experts and the services evaluated.

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