SOFT FUZZY SETS IN MULTI-OBSERVER, MULTI-CRITERIA DECISION MAKING FOR ARMED FORCE RECRUITMENT

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ABSTRACT

Applications in technology and social sciences involve data which may not be precise and deterministic in nature. The reason is they are humanistic and have a subjective approach to it so, they require a different way of mathematical representation. Some of the recent theories developed for handling problems with imprecise data are interval mathematics, fuzzy sets, rough sets etc. But it has been observed that there exists some inherent limitations to their applications. They lack the parameterization tool. Hence the paper introduces a "Soft set theory" having parameterization tools for dealing with various non-deterministic data that involve multiple agents for the purpose of evaluation. The evaluation is done on multiple criteria. The paper considers a hypothetical scenario of recruitment process in the armed forces. It demonstrates the application of soft fuzzy sets in multi-criteria and multi-observer, decision making. The selection decision also varies depending on the various deputations that the candidate can undergo. Each deputation has graded priority of proficiency for identified parameters of evaluation.

KEYWORDS -Fuzzy Systems, Fuzzy Sets, Membership Functions, Soft Sets, Fuzzy Soft Sets, Multi-Criteria, Multi-Observer Decision Making

1. INTRODUCTION

The concept of fuzziness allows a smooth transition, say, from 0 to 1, rather than an abrupt change between binary values of 0 and 1.In ordinary logic, a proposition is binary like true (which may be represented by a 1) or false (which may be represented by a 0). Fuzzy systems incorporate partial truthfulness. Fuzzy logic allows complete lack of information will not support any decision making using any form of logic. For hard problems, conventional non-fuzzy methods are usually expensive and depend on mathematical approximations (e.g. linearization of non-linear problems), which may lead to poor performance. Under such circumstance, fuzzy systems often outperform conventional methods such as a proportional, integral, and differential (PID) control. Fuzzy logic approach allows in representing descriptive and qualitative expressions such as "slow" or "moderately fast". These expressions and representations are more natural than mathematical equations for many human judgmental rules and statements. When fuzzy systems are applied to proper problems, particularly the type of problems described in the paper, their responses are typically faster and smoother than with conventional systems. This translates to efficient and more comfortable operations for such tasks as controlling temperature, cruising speed, and so forth. Furthermore, this will save energy, reduce maintenance cost, and prolong machine life. In fuzzy systems, describing the control rules is usually simpler and easier, requiring fewer rules, and thus these systems execute faster than conventional systems. Fuzzy systems often achieve robustness, and overall low cost. In turn, all of these factors contribute to better performance. In short, conventional methods are good for simpler problems, while fuzzy systems are suitable for complex problems or applications that involve human descriptive or intuitive thinking.

2. Fuzzy Logic and Decision Making

Fuzzy logic allows decision making with estimated values under incomplete information. Decision making involves identification of a decision problem, identifying its alternatives, anticipating the consequences to each of the alternatives and finally making a decision based on the anticipation. This decision made must also be evaluated for its consequences. This will include an element of learning – whether the decision made was the best decision? The decision may not be correct, and this evaluation allows it to be changed at a later time when additional information is available.

2.1 Fuzzy Sets

It refers to partial truthfulness. In an ordinary (non-fuzzy) set, an element of the universe either belongs to or does not belong to the set. That is, the membership of an element is crisp - it is either yes or no. A fuzzy set is a generalization of an ordinary set by allowing a degree (or grade) of membership for each element. A membership degree is a real number on [0, 1]. Such generalized characteristic functions are more usually called membership functions, and the corresponding "sets" are called fuzzy sets. In extreme cases, if the degree is 0 the element does not belong to the set, and if 1 the element belongs 100% to the set. A fuzzy set is a pair

(U, m) where U is a set and $m{:}U\to [0,1]$ .For each $x\in U$ the value $m(x)$ is called the grade of membership of x in (U,m). For a finite set $=\{x1,\ x2\ldots..\ xn\}$ the fuzzy set $(U,\ m)$ is often denoted by $\{\ (x1\ )/x1\ ,\ \ m(x2\ )/x2\ \ldots.\ m(xn\ )/xn\ \}$.

2.2 SOFT SETS

Let U be an initial universe, (U) be the power set of U, E be the set of all parameters and $A\subseteq E$ .Then, a soft set F_A over U is a set defined by a function f_A representing a mapping $f_A{:}\,E \to P(U)|\ f_A(x) =\ \emptyset\ if\ x \notin A$. Thus, a soft set F_A over U can be represented by the set of ordered pairs $F_A\ = \{(x,\ f\ (x)) : x\ \in E,\ f_A(x) \in\ P(U)\}$

2.3 FUZZY SOFT SETS

Let U be an initial universe, E be the set of all parameters, $A \subseteq E$ and $\gamma_A(x)$ be a fuzzy set over U for all $x \in E$. Then, anfs $-$set $\Gamma_{A.}$ over U is a set defined by a function $\gamma_A$representing a mapping:

$\Gamma_A = \ \left\{\left(x,\ \gamma_A(x)\right) : x \in E,\ \gamma_A(x) \in F(U)\right\}$. Fuzzy soft set possess parameterization tool which can be applied to solve decision making problems.

3. ARMED FORCE RECRUITMENT

Fuzzy soft sets which possess parameterization tool are applied to solve a multi-observer, multi-criteria decision making problem. A hypothetical model of armed forces recruitment is visualized. Candidates during the selection camp are tested against pre-defined criteria. The selection of candidate will be done only if the candidate performs above the minimum prescribed level. The armed forces follow this principle to ensure quality standards of candidates even if they are not able to fill the vacancies in absence of suitable candidates. Armed Forces judge the candidates on the following parameters

- Height
- Running Stamina
- Eyesight
- Swimming Skills

The evaluation of the candidates in each of the above parameters is done by 3 senior members of the armed forces:

- General
- Brigadier
- Colonel

Certain fraction of total marks awarded to each candidate contains marks awarded to them by the General, Brigadier and Colonel. E.g. the marks of a candidate will comprise of 50% marks given by Gen, 30% by Brigadier and 20% by Colonel. Thus the final decision will be computed from evaluation by multiple observers which are the General, Brigadier and Colonel. These observers will evaluate each of these candidates on multiple criteria, called selection parameters. Now the armed forces constitute an array of deputations where the selected candidates may be posted. Each of these deputation demand a graded proficiency in certain relevant parameters only. E.g. A deputation of a candidate as a vessel navigator may require proficiency to a certain degree in eyesight skills and swimming skills, while may not require proficiency in height. Similarly, for deputation as a royal guard to the president of nation, height is a relevant proficiency. Since the recruitment of all deputations is through the same selection camp, candidates are evaluated on all parameters. But each of the deputation has a matrix that contains the weighted priority of each parameter. The paper considers the following deputations:

- DAF (Desert& Forest Commandoes)
- NAF (Navigators& Naval Guards)
- RG (Royal Guards)
- AMR (Pilots)

The model presented is a simplified demonstration of the real application. It can constitute numerable number of parameters and more observers evaluating the candidate.

4. Mathematical Modelling

Supposethere are m candidates $P = \{P_1, P_2, P_3, \ldots . P_m\}$ participating in the selection camp and the selection criteria as $S = \{S_1, S_2, S_3, \ldots . S_l\}$ for the preference evaluation of the candidates. Their performance is expressed as a fuzzy set (F, S) over P, where $F: S \to I^P$, for each evaluator. The membership values in the fuzzy set are created by normalising the marks given by the evaluator to the statistical range of the marks awarded over the years. This technique of normalisation shall work in these scenarios as it is assumed that the mean performance by the candidates of the years is the same. Evaluation matrix by evaluator 1 will be:

$$R_1 = \begin{array}{c} p_1 \\ p_2 \\ p_3 \\ p_4 \\ p_5 \end{array} \begin{bmatrix} a_{11}^{(1)} & a_{12}^{(1)} & \cdots & \cdots & a_{1l}^{(1)} \\ a_{21}^{(1)} & a_{22}^{(1)} & \cdots & \cdots & a_{2l}^{(1)} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{m1}^{(1)} & a_{m2}^{(1)} & \cdots & \cdots & a_{ml}^{(1)} \end{bmatrix}$$

Similarly, for other evaluators. Thus the comprehensive matrix by the evaluators- General, Brigadier and Colonel will be the following

$$\boldsymbol{R} = \mathbf{0.5}(\boldsymbol{R_1}) + \mathbf{0.3}(\boldsymbol{R_2}) + \mathbf{0.2}(\boldsymbol{R_3})$$

Now, to get the comprehensive decision matrix D, the transpose of R is multiplied by the preference weighted matrices such that

$$D = (a_{ij} * w_j)_{m\text{X}4}$$

The preference weighted matrix for each deputation is different. (Values in the order of the order of parameters listed in IV(a))

- *Wd= [.2 .5 .3 0]* preference matrix for DAF
- *Wn= [.1 .1 .4 .4* preference matrix for NAF
- *Wr= [.6 .2 .2 0]* preference matrix for RG
- *Wa= [.4 .4 .2 0]* preference matrix for AMR

$$D = \begin{array}{c} p_1 \\ \vdots \\ p_m \end{array} \begin{bmatrix} d_{11} & d_{12} & d_{13} & d_{14} \\ \vdots & \vdots & \vdots & \vdots \\ d_{m1} & d_{m2} & d_{m3} & d_{m4} \end{bmatrix}$$

In the case of this paper we will obtain four decision matrices, one for each deputation of the forces.

4.1 SCORE CALCULATION

The row sum of a product p_i, denoted by r_i, and is calculated by $\text{r}_i = \sum_{j=1}^{m} c_{ij}$

Clearly, r_i indicates the total number of parameters in which p_i dominates all the members of p_i.

Similarly the column sum of a product p_j , denoted by c_j , is calculated by $c_j = \sum_{i=1}^{m} c_{ij}$

r_i indicates the total number of parameters in which p_i dominates all the members of P. The integer c_j indicates the total number of parameters in which p_i is dominated by the members of P. The score of the candidate is denoted by $r_i - c_j$.

REFERENCES

[1] Zadeh, L.A. *"Fuzzy sets". Information and Control 8 (3),1965, 338–353*

[2] P.K. Das, R. Borgohain, "*An Application of Fuzzy Soft Set in Multicriteria Decision Making Problem", International Journal of Computer Applications, Vol 38*-No 12, 2012

[3] .D.K. Sut, *"An Application of Similarity of Fuzzy Soft Sets in Decision Making", Int.J.Computer Technology & Applications, Vol 3(2), 742-745*