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Faculty Performance Analysis by Implementing Optimization Technique on Multi Criteria Satisfaction Analysis

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ABSTRACT

The field of operations research models known as multi-criteria analysis, also known as Multi-Criteria Decision-Making or Multi-Criteria Satisfaction Analysis deals with the process of making decisions when there are numerous objectives. The conflicting criteria, incomparable units, and challenges in designing/selecting alternatives are all aspects of these methods, which can manage both quantitative and qualitative criteria. The MUSA approach is an ordinal regression analysis-based preference disaggregation model. Based on their values and expressed preferences, the integrated methodology assesses the level of satisfaction of faculty at engineering institutions. The MUSA approach aggregates the various preferences in special satisfaction functions using data from satisfaction surveys. The paper presents a faculty performance analysis by implementing optimization technique known as PSO on Multi Criteria Satisfaction Analysis and shown performance analysis.

Keywords: **MUSA, PSO, MUOMUSA, Optimization Technique**

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I. INTRODUCTION:

Multi Criteria Decision Making is concerned with structuring and resolving planning and decision-making issues using numerous criteria. The survey on MUSA, the primary goal is to assist decision-makers in situations where there are numerous options available for dealing with an issue. When there is no one best solution for these challenges, it is typically required to leverage the decision maker's desire to distinguish between options [1]. The act of solving a problem using MUSA can be under standing in various ways. It might be equivalent to selecting the "best" option from a group of options (where "best" might be understood as "the most desired option" of a decision maker). Another way to define "solving" is to select a small number of viable options or organise potential solutions into several preference groups.

The requirements cover teaching, research and publication, as well as community and academic services. To thoroughly assess higher education institutions' innovation performance, the author [2, 16] built an innovation support system. It provides a novel conjunctive Multiple Criteria Decision-Making (MCDM) strategy that takes into account the interdependencies between each measurement criterion. In order to create an Innovation Support System (ISS) that takes into account the interdependence and relative weights of each measurement criterion, they use a decision making trial and evaluation laboratory, a fuzzy analytical network process and a technique for order preference by similarity to an ideal solution.

The faculty satisfaction is one of the most important issues concerning educational institutions of all types, which is justified by the faculty-orientation philosophy and the main principles of continuous improvement of modern educational system. For this reason, faculty satisfaction should be measured and translated into a number of measurable parameters. Faculty satisfaction measurement may be considered as the most reliable feedback system, considering that it provides in an effective, direct, meaningful and objective way the employee' preferences and expectations. In this way, faculty satisfaction is a baseline standard of performance and a possible standard of excellence for any educational institution [3-5, 25].

II. MUSA METHOD

The MUSA approach is an ordinal regression analysis-based preference disaggregation model. Based on their values and expressed preferences, the integrated methodology assesses the level of happiness of a group of persons (customers, employees, etc.). The MUSA approach aggregates the various preferences in special satisfaction functions using data from satisfaction surveys. The process of aggregation and disaggregation is completed with the fewest faults feasible [6-7, 14].

The main objective of the MUSA method is the aggregation of individual judgment into a collective value function assuming that faculty'soverall satisfaction depends on a set of *n* criteria or variables representing service characteristic dimensions.

This set of criteria is denoted as:

$$X = (X_1, X_2, X_3, \ldots\ldots\ldots\ldots X_n)$$

where a particular criterion i is represented as a monotonic variable X_i. In this way, the evaluation of faculty's satisfaction can be considered as a multicriteria analysis problem.

The required information is collected via a simple questionnaire through which the faculty evaluates provided service, i.e. they are asked to express their judgment, namely their global satisfaction and their satisfaction with regard to the set of discrete criteria. A predefined ordinal satisfaction scale is used for these faculties' judgment.

The MUSA method assesses global and partial satisfaction functions Y* and X_i* respectively, given faculty' judgment Y and X_i. It needs to be noted that the method follows the principles of ordinal regression analysis under constraints, using linear programming techniques [4, 17]. The ordinal regression analysis equation has the following form:

$$Y^* = \sum_{i=1}^{n} b_i X^*{}_i$$
$$\sum_{i=1}^{n} b_i = 1$$

where $b_i$is the weight of the i-th criterion and the value functions Y* and X_i*are normalised in the interval range [0, 100], so that

$y^{*1} = x_i^{*1} = 0$ and $y^{*\alpha} = x_i^{*a} = 100$ for $i = 0, 1, 2, \ldots\ldots\ldots$

Furthermore, because of the ordinal nature of Y and Xi, the following preference conditions are as :

$$y^{*m} < y^{*m+1} \sim y^m < y^{*m+1} \; for \; m = 1,2, \ldots \ldots . \alpha - 1$$

$$x^{*k} < x^{*k+1} \sim x^k < x^{*k+1} \; for \; k = 1,2, \ldots \ldots . \alpha - 1$$

where < means "less preferred or indifferent to".

2.1 MODEL DEVELOPMENT

The MUSA method infers an additive collective value function Y*, and a set of partial satisfaction functions X_i* from faculty' judgment. The main objective of the method is to achieve the maximum consistency between the value function Y* and the faculty' judgment Y. Based on the modeling presented in the previous section, and introducing a double-error variable, the ordinal regression equation becomes as follows:

$$Y^* = \sum_{i=1}^{n} b_i X^*{}_i - \sigma^+ + \sigma^- \qquad (1)$$

where Y is the estimation of the global value function Y, and $\sigma^+$and $\sigma^-$are the overestimation and the underestimation error, respectively.

Equation (1) holds for a faculty who has expressed a set of satisfaction judgment. For this reason, a pair of error variables should be assessed for each faculty separately.

A careful inspection of equation makes obvious the similarity of the MUSA method with the principles of goal programming modeling, ordinal regression analysis, and particularly with the additive utility models of the UTA family [8].

According to the aforementioned definitions and assumptions, the faculty' satisfaction evaluation problem can be formulated as a linear program in which the goal is the minimization of the sum of errors, under the constraints:

(i) ordinal regression equation for each faculty,
(ii) normalization constraints for Y* and X_i* in the interval [0, 100], and
(iii) Monotonicity constraints for Y* and X_i*.

By removing the monotonicity constraints, the size of the previous proposed method can be reduced in order to decrease the computational effort required for optimal solution search. This is effectuated via the introduction of a set of transformation variables, which represent the successive steps of the value functions Y*and X_i*. The transformation equation can be written as follows:

$$z_m = y^{*m+1} \text{-} y^{*m} \; for \; m = 1, 2, \ldots \ldots \ldots, \alpha - 1$$

$$w_{ik} = b_i {x_i}^{*k+1} \text{-} b_i {x_i}^{*k} \; for \; k = 1, 2, \ldots \ldots \ldots, \alpha - 1$$

It is very important to mention that using these variables, the linearity of the method is achieved since w_{ik} presents a non-linear model (the variables b should be estimated).

Using equation (1), the initial variables of the method can be written as:

$$Y^{*m} = \sum_{i=1}^{m-1} z_t X^*{}_i \; for \; m = 2,3, \ldots \ldots . . \alpha \qquad (2)$$

Therefore, the final form for the LP of the MUSA method can be written as:

$$F = \sum_{j=1}^{M} {\sigma_j}^+ + {\sigma_j}^- \qquad (3)$$

Where t_j and t_{ji} are the judgment of the j-th faculty for global and partial satisfaction w_i.

2.2 IMPLEMENTATION OF PSO IN MUSA METHOD

The MUO-PSO is a MUlti -Objective Particle Swarm optimization technique that combines or incorporates the concept of pare to-dominance into a PSO algorithm to make it capable of handling multiple objective functions. While incorporating PSO in multi-objective optimization, the algorithm has to keep track of the local best for every solution (particle) with time. To find the g best for each particle an external archive is used to store all non-dominated particles [9-10]. A particular particle would be selected from the archive for the gest depending upon the density of the area surrounding the particle. The size of the archive is controlled using the grid technique and is updated continuously.

Algorithm: Pseudo-Code for a MUO-PSO
Begin
Initializes warm, velocities and best positions
Initialize external archive (initially empty)
While (stopping criterion not satisfied)
do
for each particle
Select a member of external archive Update velocity and position
Evaluate new position
Update best position and external archive
End for
End While
End

Though PSO has been widely accepted as an efficient optimization technique in engineering domains, its application and consequent effectiveness is still undermined in the field of management. But of late several implementations have proved the efficiency of this technique in solving management problems specifically multi-objective optimization problems. A few but exemplary research has be end one on the applications of PSO specifically MUO-PSO in the field of competency mapping in Human Resource management.

Optimization problems using Multi-Objective Particle Swarm Optimization Algorithm approach for optimal human resource allocation using the competency model theory can be considered. In the engineering faculty performance measurement, the objective was "to seek an optimal allocation of a limited amount of resources to a number of tasks for optimizing their objectives subject to the given resource constraint. Resource may be a class, time, fields or lecture which can be used to accomplish a goal. The best or optimal solution included objectives of maximizing profits, minimizing costs, or achieving the best possible product and process quality [11, 18-20].

The process of MUO-PSO for human resource allocation as follows:

Step1: Initialize PSO, including population size N, the location of particles x_i, speed v_i;
Step2: calculate the fitness value of each objective function
Step3: back up fitness value;
Step4: get the initiall Best and gBest using weight;
Step5: update particles in accordance with standard PSO algorithm;
Step6: divide the group into four sub-groups according to definition;
Step7: according to definition find the global optimum region, and get a new individual extreme value and the global extreme value, and then update the entire inferior sub-groups;
Step8: update the speed v_i and position x_i of every particle with the gBest and lBest in Step7;
Step9: If meet the suspension conditions, the circle stop; else return to Step6.

The above procedure applied on the competency model and position assessment and engineering faculty's expectation to determine the credit of al locating some staff to some lecture. The method uses the principles of staffs' competency matching with position request and faculty's expectations matching with position, which is considered to increase faculty motivation and productivity in actual situations.

III. PERFORMANCE EVALUATION OF ENGINEERING FACULTY BY IMPLEMENTING PSO ON MUSA

To explain a typical scenario, the requirement of even semester for the year 2020-21 is considered for the Department of Computer Science and Engineering. There are about 64 faculties excluding 8 were on study leave and the required faculties to be assigned were 76 [21-23].

Table 1 shows the parameters considered for simulation of MUOPSO. To satisfy the constraints, the maximization functions are added with negative penalty and the minimization functions are added with positive penalty.

Table 1: Parameters considered for Simulation of MUOPSO

Parameters	Values
Population Size	250
Maximum Iterations	1000
Inertia Weight	0.72977
Cognitive Parameter	1.4945
Social Parameter	1.4994

The types of penalties used are presented in Table 2.

Table 2: Types of penalty used for Simulation of MUOPSO

Penalty type	Values
Small	10
Medium	20
Large	30
Very large	40
Extremely large	50

Table 3 shows the constraints considered and the type and units of penalty applied on it. The penalty applied on the evaluated value of the objective functions are unit times the respective penalty value. The category of constraints relating to leaves and relaxation are not considered

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directly. Only the database of faculties under study leave is restricted from access during simulation.

Table 3: Types and Quantum of Penalty applied for Simulation of MUOPSO

Constraint type	Units	Penalty Type
Allotment without preference	1	Very large
No subject allotment	1	Extremely large
Papers allotted differ allotment limit	Abs (Papers allotted – allotment limit)	Small
Hours allotted differ hour limit	Abs (Hours allotted- hour limit)	Small
More sections allotted than required sections per subject	Number of sections allotted- required sections	Small
Less sections allotted than required sections per subject	Required sections- number of sections allotted	Large

The level of satisfaction to different objectives, have been discussed here.

One of the acceptable solutions is presented below in the graph. Figure 1 shows the number of subjects allocated with different preference levels of the faculty as per the questionnaire results (a primary data source for analysis) which is the benchmark for the performance outcome. The 10 point priority is satisfied for maximum subjects, next highest is 9 point and so on. Priority level of 1 to 4 is not assigned for any subject. However, two subjects are assigned for 0 priority level. Analysis of the preference given by different faculties revealed that for these two subjects, no options were obtained [24]. Considering depth of knowledge, these two subjects are assigned.

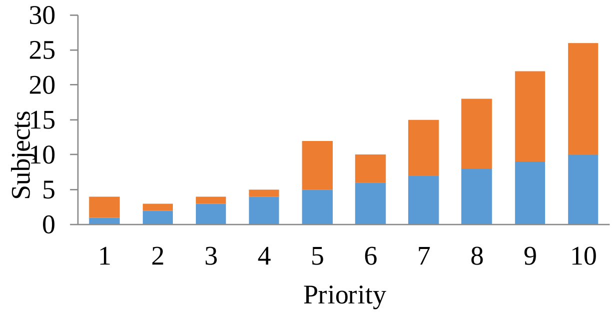

Fig.1: Allocation of subjects allotted for priority level

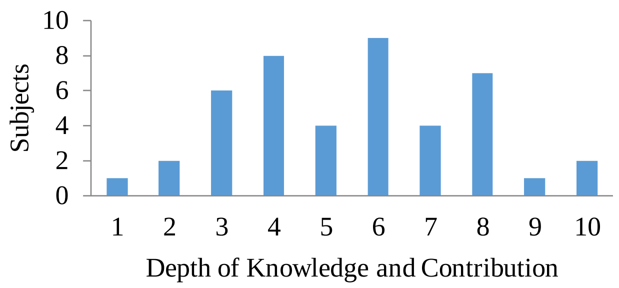

Fig.2: Number of subjects allotted for different levels of the depth of knowledge and contribution.

Figure2 shows the number of subjects allotted for different level of depth of knowledge and contribution considered together as one of the functions for optimization. At the current occurrence only one member having Ph.D. degree followed by continuous research publications and publication of books is assigned with depth of knowledge and contribution as 10, and has been assigned with two subjects. Other Ph.D. holders, not having subjects relating to their research in the current semester are allotted papers having less depth of knowledge and contribution. Faculties not having Ph.D, assigned with depth of knowledge ranging from 3 to5depending on their years of experience and expertise, are allocated subjects where there has zero contribution level. Around 50% of the allocations satisfy rating of 4, 6 and 8 in depth of knowledge and contribution to research [12-13].

Similarly, Figure3shows the number of subjects allotted optimizing the sincerity and class management levels by the MUOPSO. This is also quite impressive, where about 64% of subjects get allocated to sincerity and class management level of 9 and above and only 9% get allocation below level 7, whereas levels below 4 does not get any allocation. The faculty analysis statistics highlight the positive and negative aspects of the satisfaction of engineering faculty and outline the necessary improvement initiatives. By combining the weights of the satisfaction criterion with the average satisfaction indicators, MUOMUSA results for the basic criteria can also aid in the creation shown in histogram. As a result, it is possible to identify the positive and negative aspects of faculty satisfaction in terms of sincerity and class management levels as well as the different level of preferences.

Fig.3: Number of subjects allotted for different sincerity and class management levels

We have analyzed the results from subject allotment point of view. Now, considering the analysis from faculty point of view. Figure 4 shows to what extent the preferences of the faculties are satisfied by assigning subjects. From the figure, it can be seen that 61% of faculty get their allotment with preference level of 8 and above and 92 % of the faculties get allotment of subjects with preference level 8 and above. However, very less faculty is considered for allotment of subject's withpreferencelevels1to5 except 3.Here more priority value implies higher preference for the subject.

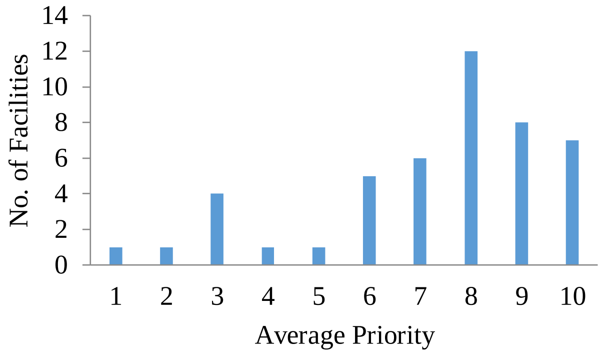

Fig.4: Number of faculties satisfied with different level of preferences

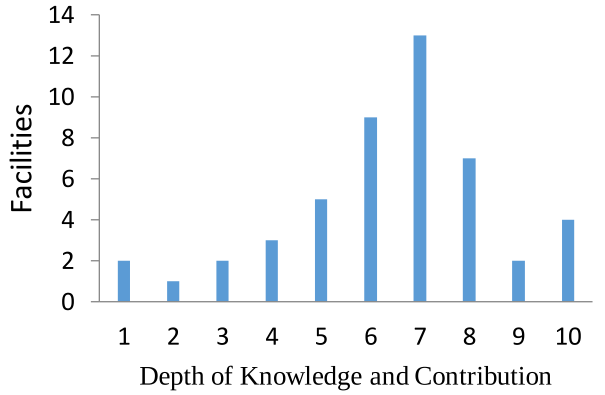

Fig.5: Allotment of papers satisfying different depth of knowledge and contribution levels

Figure5 shows the number of faculties allotted with subjects reside in which depth of knowledge and contribution level. Hardly 8.33% of the faculties get subject allotment where depth of knowledge and contribution level is 8 or more. In fact, many faculties in this category do not exist; hence MUOPSO has performed the best possible mapping. There is no mapping for level1 or2, though many faculties exist at this level for some of the subjects. About 80.56% faculties mapped with subjects with depth of knowledge and contribution level5 and above. However due to lack of alternatives, only 2.78% of the faculties are assigned with papers where they have depth of knowledge and contribution level at 3.

IV. CONCLUSIONS

Two aspects regarding model building and using the faculty evaluation model deserve special attention. Firstly, the proposed algorithm was tested for two types of redundancies within criteria and across criteria redundancies. There might be cases that require special analysis. In order to avoid within criteria redundancies, using the model should account for potential overlaps between quantitative and qualitative performance. A faculty member is the author of a research study that has been cited extensively, contributing significantly to the author's quantitative performance. As an overall result, the MUOMUSA method is typically used to indicate particular improvement actions for an educational organization or an education sector so that faculty performance satisfaction could be improved. The criteria action can be used to indicate the strong and the weak points of faculty satisfaction and suggest the necessary improvements. The satisfaction evaluation problems may refer to educational systems, expectations and needs of a specific point and benchmarking of educational institutions. As a conclusion, the MUOMUSA method is employed here to portray a clear picture of the faculty performance satisfaction.

Future research regarding the MUSA method is mainly focused on comparison analysis with other alternative satisfaction measurement approaches like statistical models, data analysis techniques, fuzzy sets, and other advanced prediction methods (e.g. neural networks). Also, the implementation of the MUSA method requires completely and correctly answered questionnaires as input data, which cannot always be achieved. The missing data analysis and data mining techniques is used to overcome this problem by filling in the empty cells in the data table.

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