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Improved Hamming Distance Method for Measuring Staff Performance Evaluation

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ABSTRACT

Performance evaluation is the annual assessment about the overall works and responsibilities for every staff in an organization or institution. It needs to be measured correctly and fairly in order to pay what the staffs have done in a particular year. In this process, the staffs in the particular organization are evaluated with respect to specific criteria by the assigned decision makers based on their performance in a particular year. Based on the existing literature, the decision makers always overlook the sub-criteria weights in the evaluation process and only focus for main criteria. Hence, this study presents an approach of integrating the subjective and objective weights incorporated with Hamming distance method dealing with main and sub-criteria. A case study at an institute of local university in Malaysia is provided to demonstrate the advantages of the proposed method. Based on the results, the proposed method can determine the most important criteria and the best staff in that institute.

Keywords: Performance Evaluation, Decision Makers, Sub-Criteria Weights, Hamming Distance Method.

1. INTRODUCTION

Performance evaluation can be defined as formal management system which is used to approximate the employee achievement of organization goals, behavior and results in a given time [1]. It has been considered as an indicator for determine the quality of Human Resource Management (HRM) in an organization [2]. By having a good performance evaluation, it will provide the useful and accurate results for the organization. Meanwhile, failing in executing the performance evaluation process will deteriorate the work productivity and job satisfaction. It is agreed that to enhance the quality of work, it is needed for the organization to maximize the employee satisfaction.

However, it is arduous and difficult to determine the staff performance perfectly since it is dealt with human judgments. There are many problems existed in current performance evaluation process which are numerous qualitative indicators, insufficiency of quantitative assessment, unfair and many subjective evaluations [3]. Thus, the evaluation process needs to be performed precisely and accurately to avoid the dissatisfaction among the employees. Regarding to this matter, the HRM is required to develop a reasonable decision making process in order to measure the employees' performance perfectly.

Multi-criteria decision making (MCDM) method is one of the methods that is persistently utilized in decision making area. MCDM methods were presented by many researchers in order to help the decision makers to analyze and construct complex decision models [4]. Some of the

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methods that were used are Analytic Hierarchy Process (AHP) which is initially introduced by Saaty (1980) [5] and the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) introduced by Chen and Hwang (1992) [6] for operations research application. The other methods that frequently used are linear programming technique [7], Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) [8], Simple Additive Weighting (SAW) [9] and Elimination and Choice Expressing Reality (ELECTRE) [10].

In the existing literature, one of the MCDM approaches that can be used in performing decision making process is by applying distance measure methods. This approach plays an important role in solving various social, biological, scientific and technological issues as it can build equality and closeness measurements in a particular problem [11]. In recent years, the enhancement of distance measurement method has been done due to the rapid growth and knowledge development. The examples of the methods are Hamming, Euclidean, Manhattan, Hausdorff and Minkowski distances.

One of the distance measure method which Hamming distance would be emphasized in this paper. Hamming distance method is firstly proposed by Hamming (1950) to detect and correct the errors in telecommunication [12]. It also has been used by many researchers in various field such as bioinformatics [13], communications [14] and iris recognition [15]. Md Saad, Ahmad, Abu and Jusoh (2014) had proposed a mathematical model by using Hamming distance method for personnel selection problem [16]. However, this mathematical model only focused on the evaluation of main criteria weights. Hence, in this paper, we will improve the existing Hamming distance method by introducing the sub-criteria weight in the evaluation process that are assessed by a group of decision makers. Before performing the Hamming distance method, the weights of the sub-criteria are determined first by using integrated approach of subjective and objective weights. Both types of weights are well known in dealing with qualitative and quantitative information.

The remainder of this paper is organized as follows. Some preliminaries for Hamming distances are introduced in Section 2. In Section 3, a new approach of Hamming distance method is presented by introducing the objective and subjective weights for main and sub-criteria. A real application of academic staff performance evaluation in one of the local universities in Malaysia is provided in Section 4 to demonstrate computational procedure of the proposed method. Based on the results obtained, the discussion and analyzation are executed in Section 5. Some conclusions and future direction are provided in last section.

2. PRELIMINARIES

Hamming distance method is defined as the least distance between two different sets or elements. There are three conditions that must be satisfied in a metric which are [12]:

1) $d(x,y)=0$ if and only if $x=y$. (1)

2) $d(x,y)=d(y,x)>0$ if $x\neq y$. (2)

3) $d(x,y)+d(y,z)\geq d(x,z)$ (triangle inequality). (3)

In this paper, Hamming distance that will be used is as follows.

2.1 Definition 1 [17]

Given two subsets, namely $A=\{a_1,a_2,\ldots,a_n\}$ and $B=\{b_1,b_2,\ldots,b_n\}$ where a_j and b_j are the crisp values in real numbers. Then, the Hamming distance is defined as:

$$d(A,B)=\sum_{j=1}^{n}\left|a_j-b_j\right| . \tag{4}$$

2.2 Definition 2 [18]

The weighted Hamming distance of dimension n is a mapping $d_{WHD}:[0,1]^n \text{ x } [0,1]^n \rightarrow [0,1]$ that associated weighting vector W of dimension n with $W=\sum_{j=1}^{n} w_j = 1$, and $w_j \in [0,1]$. Then, the weighted Hamming distance is defined as:

$$d_{WHD}(A,B)=\sum_{j=1}^{n} w_j\left|a_j-b_j\right|. \tag{5}$$

3. A NEW APPROACH OF HAMMING DISTANCE METHOD

In this section, the algorithm and description for a new approach of Hamming distance method are provided. This approach is enhanced by including the sub-criteria into the process. This method is very useful since the performance evaluation deals with various types of criteria that need to be accessed. The algorithms for determining the ranking of staff are given as follows:

Step 1: Define criteria, sub-criteria, alternatives and decision makers for decision making problem.

Assume there are m possible alternatives, $A=\{A_1,A_2,\ldots,A_m\}$ to be evaluated against n main criteria, $C=\{C_1,C_2,\ldots,C_n\}$ and sub-criteria $S=\{S_{11},S_{12},\ldots,S_{1a},S_{21},S_{22},\ldots,S_{2b},\ldots,S_{nl}\}$ where a ,b and l are the number of sub-criteria in main criteria 1, main criteria 2 and main criteria n respectively. The weight of the main criteria and the sub-criteria are denoted by $\Omega_j\left(j=1,2,\ldots n\right)$ and $w_{jk}\left(j=1,2,\ldots,n\,;k=1,2,\ldots,l\right)$ respectively. These evaluations are to be made by a set of t decision makers, $D=\{D_1,D_2,\ldots,D_t\}$ by using crisp number.

Step 2: Construct a decision matrix for ideal alternative.

The decision matrix for ideal alternative is given as follows:

$I=\left[v_{1k},v_{2k},\ldots,v_{nk}\right]$ for $k=1,2,...,l$,

Where v_{jk} is the optimum value of alternative performance rating against the given sub-criteria that are set up by decision makers.

Step 3: Construct the decision matrices for alternatives performance and weighting matrix for weight of sub-criteria.

The decision matrixes of performance rating for each alternative based on each sub-criterion are given as follows:

$$X = \begin{matrix} & \begin{matrix} C_1 & & & C_2 & & & \dots & C_n & & \\ S_{11} & S_{12} & \dots & S_{1a} & S_{21} & S_{22} & \dots & S_{2b} & \dots & S_{n1} & S_{n2} & \dots & S_{nl} \end{matrix} \\ \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} & \begin{pmatrix} x_{111}^{(u)} & x_{112}^{(u)} & \cdots & x_{11a}^{(u)} & x_{121}^{(u)} & x_{122}^{(u)} & \cdots & x_{12b}^{(u)} & \cdots & x_{1n1}^{(u)} & x_{1n2}^{(u)} & \cdots & x_{1nl}^{(u)} \\ x_{211}^{(u)} & x_{212}^{(u)} & \cdots & x_{21a}^{(u)} & x_{221}^{(u)} & x_{222}^{(u)} & \cdots & x_{22b}^{(u)} & \cdots & x_{2n1}^{(u)} & x_{2n2}^{(u)} & \cdots & x_{2nl}^{(u)} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ x_{m11}^{(u)} & x_{m12}^{(u)} & \cdots & x_{m1a}^{(u)} & x_{m21}^{(u)} & x_{m22}^{(u)} & \cdots & x_{m2b}^{(u)} & \cdots & x_{mn1}^{(u)} & x_{mn2}^{(u)} & \cdots & x_{mnl}^{(u)} \end{pmatrix} \end{matrix}$$

For $u = 1, 2, \dots, t$,

Where x_{ijk} represents the crisp assessment on the performance rating of alternative, $A = \{A_1, A_2, \dots, A_m\}$ with respect to each sub-criteria, $S = \{S_{11}, S_{12}, \dots, S_{1a}, S_{21}, S_{22}, \dots, S_{2b}, \dots, S_{nl}\}$ evaluated by decision makers, D_u $(u = 1, 2, \dots, t)$.

The weighting matrix for criteria weights, $w_{jk}^{(u)}$ that are evaluated by decision makers, D_u is given as follows:

$$W = \begin{matrix} & \begin{matrix} C_1 & & & C_2 & & & \dots & C_n & & \\ S_{11} & S_{12} & \dots & S_{1a} & S_{21} & S_{22} & \dots & S_{2b} & \dots & S_{n1} & S_{n2} & \dots & S_{nl} \end{matrix} \\ \begin{matrix} D_1 \\ D_2 \\ \vdots \\ D_t \end{matrix} & \begin{pmatrix} w_{11}^{(1)} & w_{12}^{(1)} & \cdots & w_{1a}^{(1)} & w_{21}^{(1)} & w_{22}^{(1)} & \cdots & w_{2b}^{(1)} & \cdots & w_{n1}^{(1)} & w_{n2}^{(1)} & \cdots & w_{nl}^{(1)} \\ w_{11}^{(2)} & w_{12}^{(2)} & \cdots & w_{1a}^{(2)} & w_{21}^{(2)} & w_{22}^{(2)} & \cdots & w_{2b}^{(2)} & \cdots & w_{n1}^{(2)} & w_{n2}^{(2)} & \cdots & w_{nl}^{(2)} \\ \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots & \vdots & \ddots & \vdots \\ w_{11}^{(t)} & w_{12}^{(t)} & \cdots & w_{1a}^{(t)} & w_{21}^{(t)} & w_{22}^{(t)} & \cdots & w_{2b}^{(t)} & \cdots & w_{n1}^{(t)} & w_{n2}^{(t)} & \cdots & w_{nl}^{(t)} \end{pmatrix} \end{matrix}$$

where $w_{jk}^{(u)}$ represents the crisp number of relative importance of given sub-criteria, $S = \{S_{11}, S_{12}, \dots, S_{1a}, S_{21}, S_{22}, \dots, S_{2b}, \dots, S_{nl}\}$ evaluated by the decision makers D_u $(u = 1, 2, \dots, t)$.

Step 4: Aggregate the performance ratings for each alternative and weights for each sub-criterion.

The aggregated crisp ratings of performance for each alternative and the weight of each sub-criterion is calculated by using the following equations:

$$x_{ijk} = \frac{1}{t}\left[x_{ijk}^{(1)} + x_{ijk}^{(2)} + \cdots + x_{ijk}^{(t)}\right] \tag{6}$$

$$w_{jk} = \frac{1}{t}\left[w_{jk}^{(1)} + w_{jk}^{(2)} + \cdots + w_{jk}^{(t)}\right]. \tag{7}$$

In this case, equal preference for each decision maker is assumed.

Step 5: Construct the normalized decision matrix of alternatives performance.

The decision matrix need to be normalized in order to make the assessment value in each criterion is comparable where its value is between 0 and 1 [19]. The element of normalized matrix is given by [20]:

$$x^*_{ijk} = \frac{x_{ijk}}{x^{\max}_{jk}},\ i=1,2,\ldots,m\ ;\ j=1,2,\ldots,n\ ;k=1,2,\ldots,l \text{ for benefit criteria,} \tag{8a}$$

and $$x^*_{ijk} = \frac{x^{\min}_{jk}}{x_{ijk}},\ i=1,2,\ldots,m\ ;\ j=1,2,\ldots,n\ ;k=1,2,\ldots,l \text{ for cost criteria,} \tag{8b}$$

Where, $x^{\max}_{jk} = \max\{x_{1jk}, x_{2jk}, \ldots, x_{mjk}\}$ and $x^{\min}_{jk} = \min\{x_{1jk}, x_{2jk}, \ldots, x_{mjk}\}$.

Step 6: Evaluate the criteria weight.

As for this paper, we assumed that the weights of main criteria are prepared by administration of the university based on its policy. The weight that needs to be evaluated are for the sub-criteria. In this paper, the weights of sub-criteria are calculated by using integrated approach of subjective and objective weights of criteria. In order to make the evaluation is standardized, the sum of the weights in the same class must be equal to one [18].

Step 6.1: Determine the subjective weight of sub-criteria.

The subjective weights of the sub-criteria are evaluated based on the decision maker's preference against the sub-criteria for this application. Ma et al. (1999) had proposed the least square method to determine the subjective weight of the criteria [21]. In this paper, this approach is applied to determine the subjective weight of sub-criteria in each main criterion. Suppose the decision maker gives his/her pairwise comparison matrix, $D = [d^{(j)}_{pq}]_{lxl}$ on the sub-criteria.

The elements of matrix D satisfy $d^{(j)}_{pq} > 0$, $d^{(j)}_{pq} = \frac{1}{d^{(j)}_{qp}}$, $d^{(j)}_{pp} = 1$ for $j = 1,2,..,n$ and $p,q = 1,2,..,l$ where $d^{(j)}_{pq}$ represents the relative weight of sub-criteria $S_{jp}(w_{jp})$ against sub-criteria $S_{jq}(w_{jq})$ in main criteria C_j such that

$$d^{(j)}_{pq} = \frac{w_{jp}}{w_{jq}}. \tag{9}$$

Suppose the matrix $F = [f^{(j)}_{pq}]_{lxl}$ such that

$$f^{(j)}_{pp} = l - 2 + \sum_{k=1}^{l} d^{2(j)}_{kp} \text{ for } p = 1,2,\ldots,l\ ;\ j = 1,2,\ldots,n \text{ and} \tag{10}$$

$$f^{(j)}_{pq} = -(d^{(j)}_{pq} + d^{(j)}_{qp}) \text{ for } p,q = 1,2,...,l;\ j = 1,2,\ldots,n;\ p \neq q\,. \tag{11}$$

It can be seen that F is an l-by-l square matrix and $\det(F) \neq 0$, then there exists an inverse matrix, F^{-1} such that:

$$FF^{-1} = F^{-1}F = \mathrm{I}_{lxl}$$

Thus, the subjective weight of sub-criteria can be determined by using

$$\vec{w}^{\,j} = \frac{F^{-1}e}{e^T F^{-1} e} \tag{12}$$

where $\vec{w}^{j} = (w^{s}_{j1}, w^{s}_{j2}, \ldots, w^{s}_{jl})^{T}$ and $e = (1,1,\ldots,1)^{T}$.

Step 6.2: Determine the objective weight of sub-criteria.

In this study, statistical variance is used to evaluate the objective weight of sub-criteria [22]. It is a measure of the dispersion of a set of data points around their mean value. It is also a mathematical expectation of the average squared deviations from the mean. Firstly, we have to obtain the projection value of each sub-criterion and its formula is as follows:

$$p_{ijk} = \frac{x_{ijk}}{\sum_{i=1}^{m} x_{ijk}}, \tag{13}$$

Where p_{ijk} is the projection value of x_{ijk} and $\sum_{i=1}^{m} x_{ijk}$ is the total of values of alternatives against the sub-criteria, $S_{jk}\left(j = 1,2,\ldots,n\,; k = 1,2,\ldots,a,1,2,\ldots,b,\ldots l\right)$.
The formula for statistical variance is

$$v_{jk} = \frac{1}{m}\sum_{i=1}^{m}\left(p_{ijk} - (p_{ijk})_{mean}\right)^{2}, \tag{14}$$

Where v_{jk} is the statistical variance of the data corresponding to k-th sub-criteria of j-th main criteria and $(p_{ijk})_{mean}$ is the average value of p_{ijk}.

Thus, the objective weight of sub-criteria can be evaluated by the following equation:

$$w^{o}_{jk} = \frac{v_{jk}}{\sum_{k=1}^{l} v_{jk}}. \tag{15}$$

The method of statistical variance to determine the objective weight of criteria is approximately simpler than entropy method presented by Shannon and Weaver (1947) [23].

Step 6.3: Integrated approach of subjective and objective weights of sub-criteria.

This approach is used to merge the subjective and objective weights of sub-criteria described in steps 6.1 and 6.2. Knowing that the both type of weights are essential to determine the importance of sub-criteria, then the decision makers may use the integrated approach defined by the following equation:

$$w_{jk} = \alpha w^{s}_{jk} + \beta w^{o}_{jk}, \tag{16}$$

Where w_{jk} are the integrated weights of sub-criteria k corresponding to main criteria j, α and β represent the relative important of the subjective and the objective weight to decision maker respectively where $\alpha + \beta = 1$. By Eq. (16), the decision maker can desire how much important of each type of weight that needs to be assigned.

Step 7: Calculate the distance value.

The weighted Hamming distance (WHD) was presented by Md Saad et al. (2014) [16]. In this paper, the method has been improved by considering the sub-criteria weight in the algorithm that involving the crisp numbers. The improved WHD method is:

$$d_{WHD}(X^{*},I)=\Omega_1\sum_{k=1}^{a}w_{1k}\left|v_{1k}-x_{i1k}^{*}\right|+\Omega_2\sum_{k=1}^{b}w_{2k}\left|v_{2k}-x_{i2k}^{*}\right|+\ldots+\Omega_n\sum_{k=1}^{l}w_{nk}\left|v_{nk}-x_{ink}^{*}\right| \quad \text{for } i=1,2,..,m \tag{17}$$

where $\sum_{j=1}^{n}\Omega_j=1$, $\sum_{k=1}^{a}w_{1k}=1$, $\sum_{k=1}^{b}w_{2k}=1$,... , $\sum_{k=1}^{l}w_{nk}=1$.

Step 8: Rank the candidate.

Based on the distance values, the alternatives are ranked in ascending order. The shorter the distance between alternative and the ideal alternative, the better the performance of that alternative.

4. NUMERICAL APPLICATION

Step 1: In this application, there are 10 academic staff, $A=\{A_1,A_2,\ldots,A_{10}\}$ to be evaluated against 14 sub-criteria, $S=\{S_{11},S_{12},,\ldots,S_{41}\}$. These sub-criteria are assembled into four main criteria, $C=\{C_1,C_2,C_3,C_4\}$. These main criteria and sub-criteria are shown Figure FIGURE **1**.

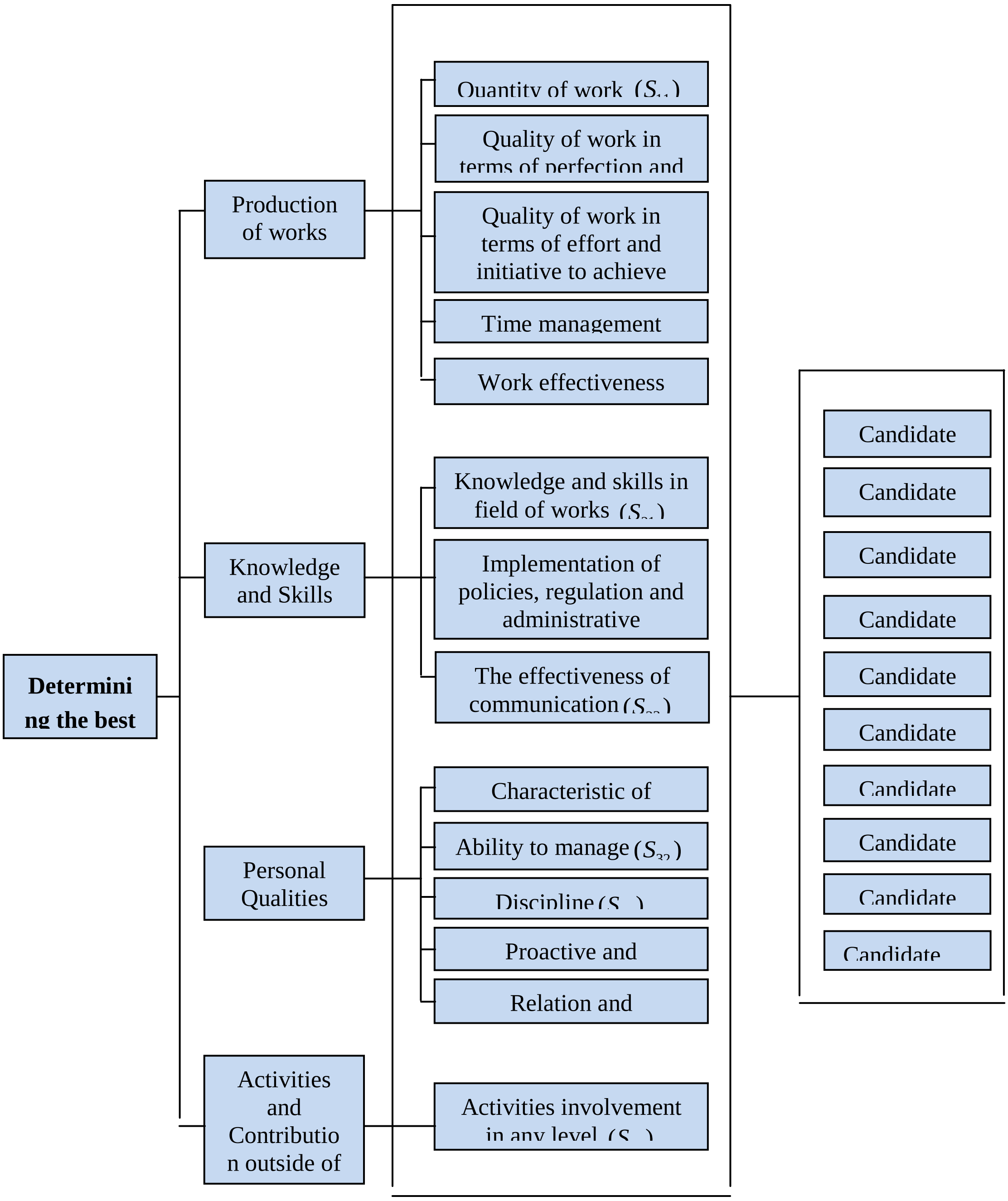

Figure 1. The hierarchy structure for staff performance evaluation.

Step 2: The decision matrix for ideal candidate is constructed as follows:

$I = [1,1,\ldots,1]$,

where its value is the optimum value of candidate's performance rating that are agreed by the decision maker for each sub-criterion.

Step 3: The decision matrix of performance rating, for each candidate based on each sub-criterion is constructed by each decision maker. The evaluation score for each candidate by the two decision makers are obtained from the human resource department of the university. The weighting matrixes for each sub-criterion assessed by two decision makers are shown as follows:

$$
\begin{array}{cc}
 & \begin{array}{cccccccccccccc} & & C_1 & & & & C_2 & & & & C_3 & & & C_4 \\ S_{11} & S_{12} & S_{13} & S_{14} & S_{15} & S_{21} & S_{22} & S_{23} & S_{31} & S_{32} & S_{33} & S_{34} & S_{35} & S_{41} \end{array} \\
W = \begin{array}{c} D_1 \\ D_2 \end{array} & \begin{pmatrix} 0.65 & 0.80 & 0.80 & 0.80 & 0.80 & 0.90 & 0.80 & 0.65 & 0.65 & 0.80 & 0.90 & 0.90 & 0.80 & 0.80 \\ 0.80 & 0.65 & 0.90 & 0.80 & 0.80 & 0.80 & 0.65 & 0.65 & 0.65 & 0.65 & 0.90 & 0.80 & 0.65 & 0.50 \end{pmatrix}
\end{array}
$$

Step 4: The performance rating for each candidate and the weights for each sub-criterion are aggregated by using Eqs. (6) and (7) respectively. The results of aggregated values for weights of sub-criteria and the candidates' performance are given as follows:

$$
\begin{array}{cc}
 & \begin{array}{cccccccccccccc} & & C_1 & & & & C_2 & & & & C_3 & & & C_4 \\ S_{11} & S_{12} & S_{13} & S_{14} & S_{15} & S_{21} & S_{22} & S_{23} & S_{31} & S_{32} & S_{33} & S_{34} & S_{35} & S_{41} \end{array} \\
X = \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \\ A_8 \\ A_9 \\ A_{10} \end{array} & \begin{pmatrix}
10 & 9 & 8.5 & 8.5 & 8 & 9 & 8.5 & 8.5 & 8.5 & 9 & 10 & 8.5 & 9 & 9 \\
9 & 8.5 & 8.5 & 8.5 & 9 & 8.5 & 9 & 9 & 8.5 & 8.5 & 10 & 8.5 & 9 & 8 \\
9 & 8 & 9 & 9 & 8.5 & 8.5 & 9 & 9 & 8.5 & 9 & 10 & 9 & 8 & 8 \\
10 & 8.5 & 8.5 & 8.5 & 8.5 & 9 & 9 & 9 & 8.5 & 8 & 10 & 8.5 & 9 & 8 \\
10 & 10 & 10 & 9.5 & 9.5 & 9.25 & 9.5 & 9.5 & 10 & 10 & 10 & 10 & 9.75 & 8.5 \\
10 & 8.5 & 8.5 & 8 & 8.25 & 9 & 8.5 & 8 & 8 & 8 & 10 & 8 & 8.5 & 8 \\
10 & 9 & 9 & 9 & 8 & 8.5 & 9 & 9 & 9.5 & 9 & 10 & 9 & 9 & 9 \\
9.5 & 9 & 9 & 9 & 8.5 & 8.5 & 9 & 9 & 9.5 & 9 & 10 & 9 & 9.5 & 9 \\
9 & 8.5 & 8.5 & 8.5 & 9 & 8.5 & 9 & 9 & 8.5 & 9 & 10 & 9 & 9 & 8.5 \\
10 & 8 & 8.5 & 8.5 & 8.5 & 8.5 & 9 & 9 & 8.5 & 9 & 10 & 9 & 9 & 8.5
\end{pmatrix}
\end{array}
$$

$$
\begin{array}{cc}
 & \begin{array}{cccccccccccccc} & & C_1 & & & & C_2 & & & & C_3 & & & C_4 \\ S_{11} & S_{12} & S_{13} & S_{14} & S_{15} & S_{21} & S_{22} & S_{23} & S_{31} & S_{32} & S_{33} & S_{34} & S_{35} & S_{41} \end{array} \\
W = & \begin{pmatrix} 0.725 & 0.725 & 0.85 & 0.80 & 0.80 & 0.85 & 0.725 & 0.65 & 0.65 & 0.725 & 0.90 & 0.85 & 0.725 & 0.65 \end{pmatrix}
\end{array}
$$

Step 5: The normalized decision matrix of candidates' performance is constructed by using Eqs. (8a) and (8b).

Step 6: The weights of main criteria are given by the administrative of university in Table 1. The subjective and objective weights of the sub-criteria are identified. The aggregated weights assessed by decision makers are used to evaluate the subjective weight based on Eqs. (9)-(12) while for objective weight, statistical variance method is used based on Eqs. (13)-(15). The integration of subjective and objective weights can be evaluated by using Eq. (16) based on preference of decision makers. The results of subjective, objective and integrated weights for $\alpha = 0.5$ and $\beta = 0.5$ are shown in Table 2.

Table 1 Weights of main criteria

Main criteria	Weight
Production of works (C_1)	0.50
Knowledge and skills (C_2)	0.25
Personal qualities (C_3)	0.20
Activities and contributions outside of official duties (C_4)	0.05

Table 2 Weights of sub-criteria by using integrated weight approach

Main Criteria	Sub-criteria	Subjective weight	Objective weight	Integrated weight
C_1	S_{11}	0.1858974	0.1572992	0.1715983
	S_{12}	0.1858974	0.2962642	0.2410808
	S_{13}	0.2179487	0.1961598	0.2070543
	S_{14}	0.2051282	0.1529106	0.1790194
	S_{15}	0.2051282	0.1973662	0.2012472
C_2	S_{21}	0.3820225	0.2838168	0.3329196
	S_{22}	0.3258427	0.2425444	0.2841935
	S_{23}	0.2921348	0.4736388	0.3828868
C_3	S_{31}	0.1688312	0.3253705	0.2471008
	S_{32}	0.1883117	0.2703211	0.2293164
	S_{33}	0.2337662	0.0000000	0.1168831
	S_{34}	0.2207792	0.2256399	0.2232096
	S_{35}	0.1883117	0.1786685	0.1834901
C_4	S_{41}	1.0000000	1.0000000	1.0000000

Step 7: The distance values are evaluated between the candidates and the ideal candidate by using Eq. (17). The distance values present how much is the similarity between the candidates and the ideal candidate.

Step 8: Based on the distance values, the candidates are ranked in ascending order. The results of Hamming distance method and the ranking of candidates are given in Table 3. The best candidate is the candidate that has the least distance value among the other candidates.

Table 3 Ranking of candidates

Candidate	Distance value	Ranking
A_1	0.094248	4
A_2	0.101790	8
A_3	0.102475	9
A_4	0.096322	6
A_5	0.002780	1
A_6	0.124054	10
A_7	0.072949	3
A_8	0.071908	2
A_9	0.094487	5
A_{10}	0.097272	7

5. DISCUSSION

Based on the results acquired, the ranking order among those candidates is $A_5 \succ A_8 \succ A_7 \succ A_1 \succ A_9 \succ A_4 \succ A_{10} \succ A_2 \succ A_3 \succ A_6$. The best candidate is A_5 since it has the minimum distance among others while the worst candidate is A_6 as it has the maximum distance. The most important main criterion is production of works (C_1) based on the weights provided by administration of the university. Meanwhile, the most important sub-criterion in each main criterion are S_{12}, S_{23}, S_{31} and S_{41} based on the numerical calculation by using integrated approach of subjective and objective weights. In addition, the sub-criteria weights obtained are affected by assigned values of α and β by the decision makers. For instance, if the decision makers scrutinize that subjective weight is more preferable, then the value of α will be increases and vice versa. In this paper, equal value for α and β is agreed since the decision makers considered that subjective and objective weights have the same of value importance. The comparison of results between Hamming distance method and actual results provided by the university is shown in Table 4. There are some differences of ranking between these two methods since the Hamming distance method considers the inclusion of sub-criteria weights in the decision making process. For instance, candidates A_2 and A_3 share the ranking with reference to actual results, now by using the proposed method, the ranking of these two candidates can be distinguished based on their performances.

Table 4 Comparison of Hamming distance method and the actual results

Candidate	Distance value	Ranking	Actual Results (Percentage, %)	Ranking
A_1	0.094248	4	88.17	4
A_2	0.101790	8	87.38	8
A_3	0.102475	9	87.38	8

A_4	0.096322	6	88.10	5
A_5	0.002780	1	96.69	1
A_6	0.124054	10	85.50	10
A_7	0.072949	3	90.18	3
A_8	0.071908	2	90.38	2
A_9	0.094487	5	88.03	6
A_{10}	0.097272	7	88.03	6

6. CONCLUSIONS

In this paper, we have proposed an approach to solve staff performance evaluation by using improved Hamming distance method. Realizing that the significance of weighting the criteria in the decision process, two types of weights is appertained in the algorithm which is subjective and objective weights. The subjective weight is determined based on decision makers' preferences by using the least square method and the objective weight is gained by the method of statistical variance. These two types of weights obtained are then combined by using the integrated approach of subjective and objective weights. By having these weights, the distance values between the candidates the ideal candidate are identified and sorted into a ranking.

The final results showed that main criterion C_1 is considered as the most important criterion and candidate A_5 is considered as the best candidate based on the staff performance. To verify the proposed method, we also made the comparison with the actual results obtained from the university and we can justify that the results are almost similar for both methods. With an emphasis on finding distance between the candidates and the ideal candidates suited to the use of subjective and objective weights, the proposed method provides a productive way to be used. For further research, we would like to apply fuzzy concept in determining the criteria weights and candidates' performances.

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