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Research paper



Towards Academic Successor Selection Modelling with Genetic Algorithm in Multi-Criteria Problems

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Abstract

Succession planning is a subset of talent management that deals with multi-criteria and uncertainties which are quite complicated, ambiguous, fuzzy and troublesome. Besides that, the successor selection involves the process of searching the best candidate for a successor for an optimal selection decision. In an academic scenario, the quality of academic staff contributes to achieving goals and improving the performance of the university at the international level. The process of selecting appropriate academic staff requires good criteria in decision-making. The best candidate's position and criteria for the selection of academic staff is the responsibility of the Human Resource Management (HRM) to select the most suitable candidate for the required position. The various criteria that are involved in selecting academic staff includes research publication, teaching skills, personality, reputation and financial performance. Previously, most studies on multi-criteria decision-making adopt Fuzzy Analytical Hierarchy Process (FAHP). However, this method is more complex because it involved many steps and formula and may not produce the optimum results. Therefore, Genetic Algorithm (GA) is proposed in this research to address this problem in which a fitness function for the successor selection is based on the highest fitness value of each chromosome.

Keywords: *Genetic Algorithm; Multi-criteria; Successor planning; Talent management.*

1. Introduction

Succession planning is a process to recruit and select the new workers for replacing the retire leaders. In the context of university, the achievement of succession planning depends highly on the combination between good management initiatives and experienced employees who have a good track records [1]. Indeed, the existing selection approach focuses on work and job analysis defined through specific tasks and tasks based on their static assets. Jobs cannot be easily described especially for work at the top level. In this high-tech era, it is now possible to see the economic growth and progress in various fields. It also has a high impact on higher education in Malaysia. This is because every university in Malaysia is seen to have a high level of competitiveness to maintain the best quality in line with the latest technological advances. In a successful institution, a strong position from the top level among academic staff also plays an important role. By enhancing the quality of higher education will be achieved with emphasis on human resources. The good leadership has a direct impact on university performance with regards to succession planning [1].

It is a very important role of Human Resource Management (HRM) in the implementation of succession planning as well as for developing and implementing the overall work efficiency [2]. HRM should also evaluate the suitability of candidates for the academic staff according to the positions required to be able to select the most suitable candidate [3]. In the academic area, among the key components to be evaluated in the selection of the best academic staff are that the candidate must excellent in three main components, which are teaching, research and services [4]. Academic staff assessments can also be seen through research articles, learning methods and involvement in activities organized by the university or outside communities [5].

This paper discusses the use of GA in selecting the best candidate for academic staff as successors. Section two shows some of the literature reviews about GA. The previous of related work of application by GA is discussed in section three. Then, implementation methods of GA are discussed in section four. Lastly, the final section concludes on how the study was carried out.

2. Genetic Algorithm

Genetic Algorithm (GA) which was introduced by John Holland in 1975, is a search algorithm based on the mechanisms of natural selection and natural genetics. It is used to search large, non-linear search spaces where expert knowledge is lacking or difficult to encode, and where traditional optimization techniques fall short [6]. GA works with each individual chromosome population, each representing a possible solution for a particular problem. The basic concept of this algorithm is based on the concept of 'survival of the fittest'. It resembles a process observed in a natural system that if it is strong then it is more likely to adapt and survive while the weak will perish. GA is a population-based approach where members of the population are based on their completion. The new GA population is formed using certain genetic controllers such as crossover, reproduction, and mutation, just like the natural process of reforming the life of the organism. Chromosomes in the form of a set of strings represent the population.

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In each generation, new chromosomes in population members are created using the information obtained from the most accurate chromosomes in the previous population. GA generates qualified beginners and recruits them by guiding their search towards a better search space. Each good solution is encoded as a chromosome, also referred to as a genotype, and each of these chromosomes will gain vitality through fitness functions. The GA fitness function is used to evaluate the quality of newly generated solutions. Fitness value chromosome function determines its ability to survive and produce children. The higher the value of the fitness, the higher the probability of the parent to be selected. Higher fitness values show better solutions to maximize the problem while minimum fitness values show better solutions to minimize problems.

The base GA has five main components: initializing population, calculate fitness function, selection, crossover and mutation. In initializing population, a set of population are created. Population size is very important for all variations in evolutionary algorithm because limited population size can produce low quality solutions [7]. The fitness function is a mathematical formula used for calculating the fitness of the chromosome. In the selection process, two chromosomes will be selected denoted as parents. Next after the parents have been selected, the parents will undergo crossover. Crossover is a reproduction operator that create new chromosome by exchanging two existing chromosomes. Method of crossover includes one-point crossover, two-point crossover, universal crossover, just to name a few. Mutation is a genetic operator that randomly changes the gene value in chromosome.

GA has several advantages and, this makes the search algorithm using GA is one of the most preferred and widely used in Artificial Intelligence [8]. GA is a popular solution method and is often used to optimize solutions to solve problems in many fields such engineering, computer sciences, economic management and supply chain management [9]. GA's advantages over other algorithms is that GA solves problems by utilizing optimum solution clustering so algorithm is less opportunity to be trapped in local optimum [10]. Other than that, compare to other algorithm, GA is more simple and very direct in providing the solutions [8]. Nevertheless, GA has also some limitations. This is because the complex part of GA is on the calculation of its fitness function where it requires a large number of fitness functions for assessment [11].

3. Related Work

In this section, some of the related work on the selection method are cited. Firstly, a study on vendor selection using Genetic Algorithm (GA) with discussions on how GA works in selecting the best vendor; where GA based solution is used using fitness function [12]. Their work is an extended work on vendor selection using fuzzy integration [13]. 16 criteria are used which are price, quality, lead time, quantity, technical support, market share, past performance, delivery performance, quality of raw material, quality of storage, quality of technology, quality of equipment, certification, defect rate, the degree of burn, and hydration. The weightage of all these criteria have been calculated using fuzzy integration in the previous work. Then, they calculate the fitness function using GA to test the potential vendors. The higher the value of the vendor, the higher the chances to be selected as a parent for crossover and mutation. The final results that done by GA show that the best vendor is has been selected rightly and it is done faster than previous work. Next is based on previous work on a decision on green supplier selection using Analytical Hierarchy Process (AHP) and multi-objective genetic algorithm optimization. Their work focused on the green aspects in supplier selection. They created a two-stage model where the first stage involves using AHP tool as a multi-criteria decision making that performs the pair-wise comparison in a hierarchical way to generate weight as the output. The generated output then will be used in the second stage using a genetic algorithm. The genetic algorithm will maximize the total value of purchasing, minimize total cost of purchasing and minimize the total number of rejected items.

Next, the previous research study discusses important criteria for promoting academic staff in higher education institutions. Their study has focused on four important components in the selection criteria of academic staff. The four criteria involved are research and publication, teaching, service and personality. They have used AHP techniques in selecting the weighting priorities of the four components. In their studies, it has been found that the highest weightage in the selection criteria of staff is research and publication.

Another study on speech-based emotion recognition (ER) that employed GA was performed by [14]. This classification problem was solved by various methods based on supervised learning approach. Some method produces product results in trade-off between time-consuming and the accuracy of the model. However, some features can be very correlative, or their level of variability can be very low, so some properties cannot bring a good impact to the system or even lower their performance. That is why an effective feature for ER tasks should be representative and compact. So, they come out with a suggestion to use multi-objective genetic algorithm (MOGA) which can optimize the ER accuracy and the number of the item in feature sets simultaneously. The results turn out that the MOGA can improve the percentage of the accuracy of the ER procedure.

University's academic schedule is complicated problem because it has many limitations since many factors which is lecturer activities, rooms and times must be considered. Therefore, the university needs a tool to determine an academic schedule. The study in [10] aims to design an academic scheduling system which is developed using Genetic Algorithm (GA) to solve the academic schedule. Their finding shows that GA can perform with the fitness value 0.952 in the training phase, and 0.927 in the testing phase.

4. Genetic Algorithm Modelling

This section discusses on how genetic algorithm is used to select the best candidate among academic staff using five criteria and the 25 sub-criteria. The conceptual framework, the structure of GA, fitness function, crossover and mutation that involved in this study is also discussed.

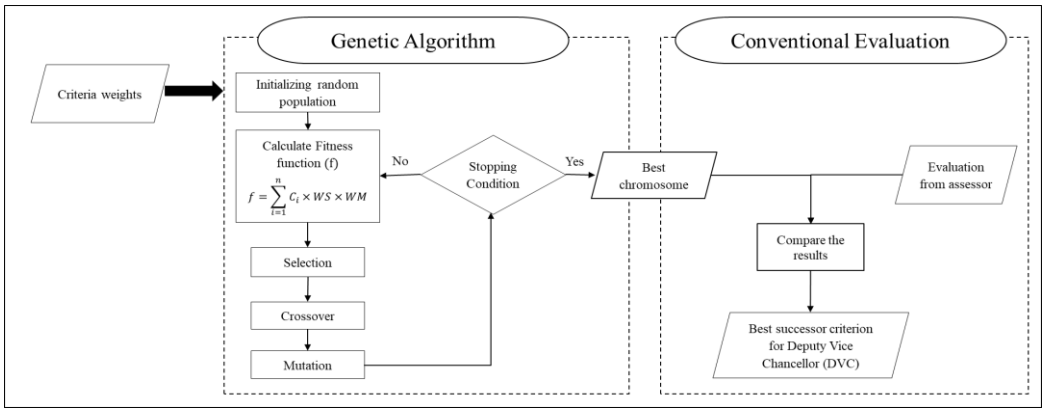


Fig. 1: Conceptual Framework of GA Modelling for multi-criteria problems

4.1. Criterion and Research Framework

In this study, effective parameters in the selection of academic staff are evaluated based on five main criteria. These main criteria are Effective Implementation (A1), Learning and Teaching Outcomes (A2), Personal and Interpersonal Incomes (A3), Recognition and Reputation (A4) and Financial Performance (A5). All the main criteria and sub-criteria are shown in Table 1. The list of the main criteria and sub-criteria for the academic staff position was taken from the University Transformation Programme (UniTP) - Orange Book [15].

Table 1: The list of main criteria and sub-criteria

Main Criteria (Leadership Criteria)	Label	Sub-Criteria
A1: Effective implementation	(A1,1)	Bringing innovative policies and practices into action
	(A1,2)	Delivering agreed tasks or projects on time and to specification
	(A1,3)	Delivering successful team projects in learning and teaching
	(A1,4)	Producing successful learning systems or infrastructures
	(A1,5)	Successful implementation of new initiatives
A2: Learning and Teaching Outcomes	(A2,1)	Achieving high-quality graduate outcomes
	(A2,2)	Enhanced representation of equity groups
	(A2,3)	Improving student satisfaction ratings for learning and teaching
	(A2,4)	Increased student retention rates
	(A2,5)	Producing significant improvements in learning and teaching quality
	(A2,6)	Winning learning and teaching awards and prizes
A3: Personal and Interpersonal Incomes	(A3,1)	Achieving goals set for your own professional development
	(A3,2)	Establishing a collegial working environment
	(A3,3)	Formative involvement of external stakeholders in your work
	(A3,4)	Having high levels of staff support
	(A3,5)	Producing future learning and teaching leaders
A4: Recognition and Reputation	(A4,1)	Achieving a high profile for your area of responsibility
	(A4,2)	Achieving positive outcomes from external reviews of the area
	(A4,3)	Being invited to present to key groups on learning and teaching
	(A4,4)	Publishing refereed papers and reports on learning and teaching
	(A4,5)	Receiving positive user feedback for your area of responsibility
A5: Financial Performance	(A5,1)	Achieving a positive financial outcome for your area of responsibility
	(A5,2)	Meeting student load targets
	(A5,3)	Securing competitive funds related to learning and teaching
	(A5,4)	Winning resources for your area of responsibility

This study is more focused on the selection of a replacement candidate for the Deputy Vice Chancellor (DVC) position. First, it is important to identify the criteria and sub-criteria for the selection of candidates for the position. In addition, selection of the criteria is also through the experience of the former dean, and the highest ranking of the university. Once the criteria and sub-criteria have been set, a questionnaire was being made and given to the four top member of the faculty to evaluate. In the questionnaire, the evaluator needs to evaluate each candidate with a value of 1 to 5, where the value of 1 indicates strongly disagree while 5 indicates strongly agree. These questionnaires will be used as the indicator to compare with the final results that produced by GA modelling.

Figure 1 above shows the conceptual framework of this study. In the first process of the framework, all the weights from the main criteria and sub-criteria will be extracted. Then all the weights will be used in the GA modelling process that includes initializing population, calculating fitness function, selection, crossover and mutation. This GA modelling will produce the best chromosome that will be used to compare with the results from accessor evaluations (conventional evaluation). The main criteria and sub-criteria weight were based on the research work in [16]. The weight for the criteria shown in Table 2.

Table 2: Weight of the main criteria and sub-criteria

Main Criteria	Weight	Sub-Criteria	Weight
A1	0.5027	(A1,1)	0.299
		(A1,2)	0.299
		(A1,3)	0.0515
		(A1,4)	0.0515
		(A1,5)	0.299
A2	0.1514	(A2,1)	0.5382
		(A2,2)	0.1114
		(A2,3)	0.1114
		(A2,4)	0.0688
		(A2,5)	0.1114
		(A2,6)	0.0589
A3	0.2097	(A3,1)	0.1422
		(A3,2)	0.3928
		(A3,3)	0.0360
		(A3,4)	0.3928
		(A3,5)	0.0361
A4	0.0497	(A4,1)	0.1028
		(A4,2)	0.5271
		(A4,3)	0.1028
		(A4,4)	0.0364
		(A4,5)	0.2309
A5	0.0865	(A5,1)	0.3759
		(A5,2)	0.3759
		(A5,3)	0.1241
		(A5,4)	0.1241

4.2. Structure of genetic algorithm

A genetic algorithm (GA) contains a lot of parameters, operators and processes which determine its ability to an excellent solution. As illustrated in Figure 1, the structure of GA begins by generating a random population. Next, the selection process in GA is used to choose the best solution by using the defined fitness function. In addition, the crossover processes in GA is switched between the selected parents to produce offspring. After the crossover is done, then the mutation process will change some random bits of the chromosome. Finally, the process end when they meet the stopping condition.

4.3. Initialize population

Initializing population is the first step in GA process. The quality in selecting the best population is very important in order to solve the problem by using GA [17]. In this study, the population size is 100, 300 and 1000 population. These populations are selected randomly.

4.4. Fitness function

The main part for this model is the fitness function. This fitness function will help in calculating the fitness value for each sub-criterion. The higher the value of the fitness function, the higher the chances of the sub-criteria chosen. So, the parent for the next crossover will be chosen from the highest value of the fitness function of the sub-criteria. The fitness function for the proposed model is defined below:

$$f = \sum_{i=1}^{n} C_i \times WS_i \times WM_i \quad (1)$$

where

f = Fitness function
WS_i = Sub-criteria weight
WM_i = Main criteria weight

When $\boldsymbol{f}$ is the value of the fitness function for each offspring, C_i is an integer value of the i^{th} selection criterion ($1 \leq C_i \leq 5$). $\boldsymbol{WS_i}$ represents the weight of sub-criteria and $\boldsymbol{WM_i}$ represents the main criteria ($\boldsymbol{0 \leq W_i \leq 1}$) as listed in Table 2. Both $\sum_{i=1}^{n} \boldsymbol{WS_i} = \boldsymbol{1}$ and $\sum_{i=1}^{n} \boldsymbol{WM_i} = \boldsymbol{1}$, while n denotes the total number of criteria. Then, every total value of fitness function will be added until the fitness value reaches the stopping condition. The stopping condition of this GA modelling is either the maximum iteration or reaches a certain threshold value ($\boldsymbol{\varepsilon}$).

4.5. Selection

The chromosome will be ranked based on the fitness value according in (1). The chromosomes having the highest fitness value will be selected as parents. This selection method will be based on rank type of selection in which the parents are selected based on the highest fitness value. The higher the fitness value, the higher the tendency that the chromosome will be chosen as parents.

4.6. Crossover and mutation

All the selected parents will undergo the random crossover by changing the gene to produce new offspring for the next level. The crossover will be changing the gene between the parents using crossover rate. Different crossover rate which is 10%, 30%, 50%, 70% and 90% will be used. Then, the crossover will continue until it reaches the maximum iteration which stops at the respective fitness value. The mutation for this research is rare or may not happen because the sub criteria lies in different main criteria.

5. Conclusion

In this study, the conceptual framework of GA modelling was proposed for assessing the multi-criteria selection problem of academic staff. The process of successor selection in academic field is complex as it involved multi-criteria components. The proposed GA modelling with the formulated fitness function is expected to provide an optimum solution for the successor selection planning.

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