AI APPLICATION IN MCDM: A REVIEW

Mohamad Ashari Alias
Faculty of Computer Science and Information Systems,
University Teknologi Malaysia,
Malaysia
607-5532458
ashari@utm.my

Siti Zaiton Mohd Hashim
Faculty of Computer Science and Information Systems,
University Teknologi Malaysia,
Malaysia
607-5532458
sitizaiton@utm.my

Supiah Samsudin
Faculty of Civil Engineering,
University Teknologi Malaysia,
Malaysia
607-5531581
supiah@utm.my

ABSTRACT

This paper presents the application of artificial intelligence (AI) techniques in multi criteria decision making (MCDM). MCDM is a systems analysis tool to find the best opinion from all of the feasible alternatives in the present of multiple, usually conflicting, decision criteria. We present answers to three questions: 1) What is the most common AI technique used in MCDM? 2) What is the nature of problems which AI techniques are used in MCDM? 3) What is the most common AI technique integrated with analytic hierarchy process (AHP)? AHP is a famous MCDM tool that has been used extensively. Future work to solve MCDM problem is also presented.

Categories and Subject Descriptors

General Terms
Algorithms

Keywords
AI, MCDM, AHP, fuzzy logic, Fuzzy AHP

1. INTRODUCTION

MCDM is considered a complex decision-making involving both quantitative and qualitative factors. MCDM getting even more complex when confronted with real world uncertain, random, imprecise, lost or fuzzy data. Problems such as ranking, evaluation and comparing river basin to find the most reasonable and efficient use of water is considered as multiple criteria decision making. The task involves evaluation of quantitative and qualitative aspects including water quantity, water quality, land use, economy and etc. [14]. Researches have been continuing to make MCDM more accurate and applicable to various applications from numerous fields or sectors. To name a few, planning [1], [15], finance [2] and economics [15]. Others are management, education, social, government, sports, industry, manufacturing, personal, political, and engineering [3], aquaculture [19], and the water resource planning [15]. There are various applications of MCDM in management [12], [13], [14], [17]. Selection of MCDM methods is crucial since different methods may give significantly different results [1]. The tools and methodologies provided by MCDM are not just some mathematical model aggregating criteria, points of view, attributes, but also they are decision-support oriented. The key concept in MCDM is support [15], implying that there iterative process where decision makers (DM) present and their role are needed. This iterative and interactive preference modelling procedure constitutes the underlying basis of decision support orientation of MCDM and it is one of the basic distinguishing features of MCDM as opposed to statistical and optimisation decision-making approaches [15].

AI is a field in computer science that lend its advantages to improve MCDM performance. Researches to integrate AI and MCDM have long been done, for example Mezher et al. [1], who had embedded critics to reduce judgemental human errors, Marks et al. [3] addressed the conventional MCDM problem using Fuzzy logic and MCDM, Zhou and Malakooti [10] developed fuzzy artificial neural network (FANN) that assess the parameters and change its topology as needed, and Perny and Pomerol [18] who incorporated soft computing into interactive MCDM methods. Fuzzy logic has been found to be the most common AI technique that has been integrated to MCDM methods. Fuzzy logic has been found to be the most common AI technique that has been integrated to MCDM [3], [4], [5], [6], [7], [10], and [19]. Other AI techniques are (not limited to); genetic algorithm (GA) [22], [23], [24], [25] and [26], neural network (NN) [9], [10] and [27], knowledge [28] and [29], and particle swarm optimization (PSO) [30].

One of the most famous conventional techniques in MCDM is analytic hierarchy process (AHP). AHP is a multiple criteria decision making tool that has been applied to almost all applications related with MCDM [15]. AHP was developed by Saaty (1980), has been
studied extensively and used in almost all the applications related to MCDM in the last 20 years [2]. For example, AHP has been used to rank 5 rivers in southern Johor, Malaysia [14]. The use of AHP will keep increasing because of the AHP’s advantages such as ease of use, great flexibility, and wide applicability [2]. Benefits of using AHP [21] are: 1) It helps to capture both objective and subjective evaluation measures; and 2) It allows organization to minimized common pitfalls of decision-making process. Therefore, a special attention is given in this paper on integration of AI techniques with AHP.

Next section presents and analyses applications of AI techniques in MCDM highlighting the most common AI techniques used in MCDM. The result from this chapter is presented in Table 1. Third section presents analysis and discussion on AI integration with AHP. Last section is the conclusion and suggestion for future works.

2. AI TECHNIQUES IN MCDM

AI techniques are currently applied in many areas of MCDM. They are either applied as a stand alone or integrated with other MCDM techniques. This review is based on recent researches focusing on MCDM related works which exploiting AI techniques.

Among AI technique used in MCDM is a work by Mehzer, et al [1], Ho [2] who presented 8 meta-heuristics (GA, ANN) application integrated with AHP, whereas Vaidya and Kumar [16] presented 6 articles combining AI with AHP together with their applications. Yan and Li-li [7] developed Fuzzy MCDM to incorporate DM’s perception and feelings towards each of the evaluated criterion. They claimed that this model is feasible and practical decision support model, which analyses both qualitative and quantitative factors. Yager [8] had shown how prioritisation on criteria can be modelled by using important weights by which the weight of lower priority criteria are related to the higher priority criteria. Li-li and Yan [9] developed integrated MCDM based on feedforward artificial neural network (FANN) to solve nonlinear function structure and multiple attributes to reduce the very difficult, time consuming and confusing job in MCDM. This technique is applied to evaluate the location of logistic centers. Zhou and Malakooti [10] developed FANN that assess the parameters and change its topology as needed. In the article, they present adaptive strategy algorithm, approaches to solve MCDM problems via FANN and showed the result from computational experiments.

The work by Marks et al. [3] addressed the conventional MCDM problem using Fuzzy logic and MCDM. Three problems that they addressed are: 1) treatment of noncomensurate units, 2) ranking procedure for a solution, 3) the degree of discrimination between attribute values (alternatives). Chu and Shyu [4] had used fuzzy MCDM to identify and evaluate index priority and to measure benefits preferences on communities of practice. Vasant, et al. [5] had proposed modified smooth s-curve MF approach to Guide DM in finding out the best candidate-alternative with higher degree of satisfaction with lesser degree of vagueness under tripartite fuzzy environment. The proposed methodology is claimed to be qualified as a logistic function and is said to be flexible that enable the analyst, in tripartite fuzzy environment, to tackle the problem of fuzziness in various parameters of MCDM problems. More detailed conclusion and discussion can be found in [5]. Scope of future works on the methodology [5] is immense including possibility to design self-organizing fuzzy system for MCDM and extends to group decision support systems. Chu and Lai [6] have proposed a new improved fuzzy MCDM approach to resolved limitation and enhance the applicability to the DC location problem previously proposed by Li-li and Yan [9].


Table 1. AI Techniques in MCDM

<table>
<thead>
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<th>No.</th>
<th>Technique</th>
<th>No. of articles</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>AI + AHP</td>
<td>81</td>
<td>64%</td>
</tr>
<tr>
<td>2.</td>
<td>AI MCDM</td>
<td>47</td>
<td>36%</td>
</tr>
</tbody>
</table>

Table 1 shows AI techniques used in MCDM. From our literature survey, we found that 81 out of 128 (63%) articles integrate AI with AHP including fuzzy logic, neural networks, and genetic algorithm. The other 47 articles presented MCDM techniques without integrated with AHP (AI MCDM) including fuzzy MCDM, fuzzy quality function deployment (QFD), and fuzzy analytic network process (ANP).

3. INTEGRATED AI TECHNIQUES WITH AHP

AI has been proved more efficient in solving hard optimisation problems than the exact algorithm. Combination of Fuzzy-AHP, AHP-GA, AHP-ANN, AHP-SA (simulated annealing) and AHP-TS (tabu search) can also solve combinatorial optimization problems. Unlike traditional cost-based optimisation techniques, those combinations consider both quantitative and qualitative values [2].
Table 2 shows that there are 68 out of 81 (84%) articles combined Fuzzy-AHP including 7 articles on combination of fuzzy-AHP-TOPSIS and one fuzzy-AHP-SWOT. There are 5 articles combining GA and AHP, 2 articles combining AHP with knowledge, 3 articles combining AHP with self organizing map (SOM), 2 articles combining AHP and neural network and 1 article for each combination of AHP and PSO, SWOT and Dempster–Shafer. All combination of fuzzy logic and AHP addressed problem involving vagueness, ambiguity, qualitative, and quantitative factors. Combination of AHP-GA and AHP-PSO were used to get optimised results. Combination of AHP and SOM has been used to classify input automatically. AHP and neural network was combined to evaluate selections from multiple criteria alternatives. Integration of AHP and knowledge, addressed problems such as difficulties to collect information from DMs, therefore knowledge acquisition algorithm was developed, and utilized expert’s knowledge to better the decision-making’s results. Integration of fuzzy-AHP and SWOT had help to select choice based on traditional SWOT analysis. Integration of AHP and Dempster-Shafer addressed selection with incomplete information.

Table 2. AI Techniques with AHP

<table>
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<th>No.</th>
<th>Technique</th>
<th>No. of articles</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fuzzy-AHP</td>
<td>67</td>
<td>82%</td>
</tr>
<tr>
<td>2</td>
<td>AHP-GA</td>
<td>5</td>
<td>6%</td>
</tr>
<tr>
<td>3</td>
<td>AHP-SOM</td>
<td>3</td>
<td>3.6%</td>
</tr>
<tr>
<td>4</td>
<td>AHP-knowledge</td>
<td>2</td>
<td>2.48%</td>
</tr>
<tr>
<td>5</td>
<td>AHP-Neural network</td>
<td>2</td>
<td>2.4%</td>
</tr>
<tr>
<td>6</td>
<td>AHP-PSO</td>
<td>1</td>
<td>1.2%</td>
</tr>
<tr>
<td>7</td>
<td>FAHP-SWOT</td>
<td>1</td>
<td>1.2%</td>
</tr>
<tr>
<td>8</td>
<td>AHP-Dempster-Shafer</td>
<td>1</td>
<td>1.2%</td>
</tr>
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4. CONCLUSIONS AND FUTURE WORK

Based on the number of articles produced recently, it is shown that integrated AI and AHP are more commonly used than AI MCDM. Fuzzy logic is observed to be the most common AI technique combined with AHP used in MCDM. It is also observed that combination of AHP and fuzzy logic has been used to solve problem involving fuzzy aspects in decision making successfully. For our future work, we will focus on application of integrated AI-AHP approach to solve multi criteria river-ranking problem involving optimisation, missing information and fuzzy aspects.

REFERENCES


