An Interactive Analytic Hierarchy Process for Product Recommendation: A Case Study in Studio Recording

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Abstract

The Analytic Hierarchy Process (AHP) is a powerful tool for decision making. In this paper, we present an application of AHP used for product recommendation to assist customers in selecting power equipment for studio recording. The application is implemented in Microsoft Excel in an interactive manner where customers are asked to answer questions related to product requirements and customer preferences. The customer information is combined with the predefined judgments from the experts according to a given set of criteria for product selection. The score for each product is then calculated according to the AHP, and the top three products with the highest score are recommended for the customer. The proposed method is tested by the customers and the results are discussed.

Keywords

Analytic Hierarchy Process, Interactive Method, Decision Making, Recommendation Technique.

1. Introduction

In studio recording, the power unit plays an essential role in proper operations of recording equipment and in recording high-quality audio. Many electrical issues could significantly affect the recording sound quality, interrupt the recording process, or even damage the recording equipment. For examples, switching on or off an electrical equipment could generate electrical noise interfering audio recording, lightning strike could cause voltage surges in the power lines which could potentially damage the studio equipment, power outage from short circuit could interrupt the recording process, etc. Therefore, a power unit with exclusive features such as noise filtering and surge protection is very crucial for studio recording.

Selecting a right power unit is not an easy task. Product selection is often a time consuming process which may require buyer to read many reviews of the related products. Furthermore, some reviews may involve technical knowledge which is hard to understand especially for customers who do not have strong background. This happens for choosing many technical products not only for finding a suitable power unit for studio recording.

Due to the needs for exclusive features, there are many decision criteria involved in selecting a power unit that is best suit for user requirements. These features include noise filtering, surge protection, voltage regulation, energy storage capability, etc. The combination of numerous features often makes user confuse when selecting a potential product. To assist customer selecting the right product, product recommendation techniques are often used in today's rapidly growing e-commerce market. Despite to many techniques used in this area, the Analytic Hierarchy Process (AHP) is one of the well-known decision making tools which is used around the world in a wide variety of applications.

This paper addresses the issues of selecting a power unit for studio recording as a multi criteria decision making problem by applying the AHP in an interactive way. The AHP provides a systematic procedure in evaluating the alternatives for a given set of criteria regarding to the usage in studio recording. The interactive approach allows customer to adjust his/her requirements accordingly based on the set of available products. By using the information from customer inputs and the predefined judgments from the experts, products are ranked to identify the alternative that best suits the customer requirements.

The remaining of this paper is organized as follows. In Section 2, we discuss background and related work. The decision model for product recommendation is proposed in Section 3. Result and discussion are given in Section 4, followed by conclusion in Section 5.

2. Background and Related Work

The Analytic Hierarchy Process (AHP) is a tool for decision making developed by Saaty in the 1970s (Saaty, 1977). It has been extensively used in many areas. Examples in manufacturing and industrial applications include product designs (Rao, 2007a), material selection (Rao, 2007b), robot selection (Rao, 2007c), software selection (Rao, 2007f), equipment selection (Dağdeviren, 2008; Rao, 2007e), etc. In the product selection problem, the fuzzy AHP is used for decision making in fuzzy environments. Examples include product selection service in e-commerce (Chen, Tseng, & Lin, 2011), selection of identity management product in security system (Noradachanon & Senivongse, 2017), and passenger aircraft type selection (Dožić, Lutovac, & Kalić, 2018). For product recommendation, a number of examples for online product recommendation are given by Kumar (2018). Liu & Shih (2005) propose an integration of AHP and data mining for product recommendation based on customer lifetime value. A work similar to this study is the AHP-Based recommendation system for exclusive or specialty stores by Nguyen, Lo, & Sheu (2011). They combine the product knowledge and AHP to recommend an appropriate item for customers.

3. Decision Model for Product Recommendation

The concept of the decision model is depicted in Figure 1. The customer preferences are inputted to the decision model, and based on the predefined expert opinions, the model computes the score for each alternative and provides recommendation of the products that best suit the customer requirements.

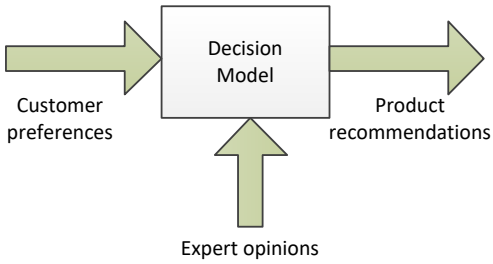

Figure 1: The concept of the decision model

We use the AHP for the decision model with the basic hierarchical structure depicted in Figure 2. The AHP model consists of three levels: the first level is the goal of recommending the right product for the customer, the second level is the criteria with respect to the goal, and the last level is the alternatives with respect to the criteria.

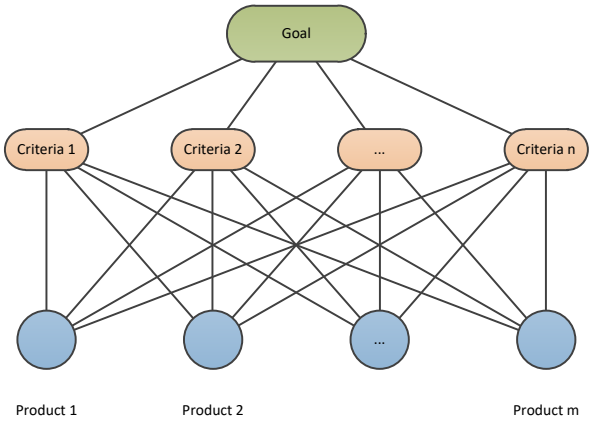

Figure 2: The hierarchical structure of the decision model for product recommendation

The steps of the AHP can be described as follows:

Step 1: Determine the goal and the evaluation criteria
Step 2: Determine the relative importance of different criteria with respect to the goal (Based on customer preferences)
Step 3: Compare the alternatives pairwise with respect to each of the criteria (Based on experts' opinions)
Step 4: Compute the overall scores for each alternative

In order to provide instant feedback to the customer, an interactive method is used for the model implementation. The model is constantly adjusted based on customer inputs. As getting more information, unqualified products are removed from the list of alternatives. A pairwise comparison matrix of the criteria is then generated automatically based on customer preferences, and the pairwise comparison matrices of the remaining alternatives are reconstructed. Finally, the score for each alternative is computed, and the top three products with the highest scores are recommended to the customer. Figure 3 shows the flow of this interactive process.

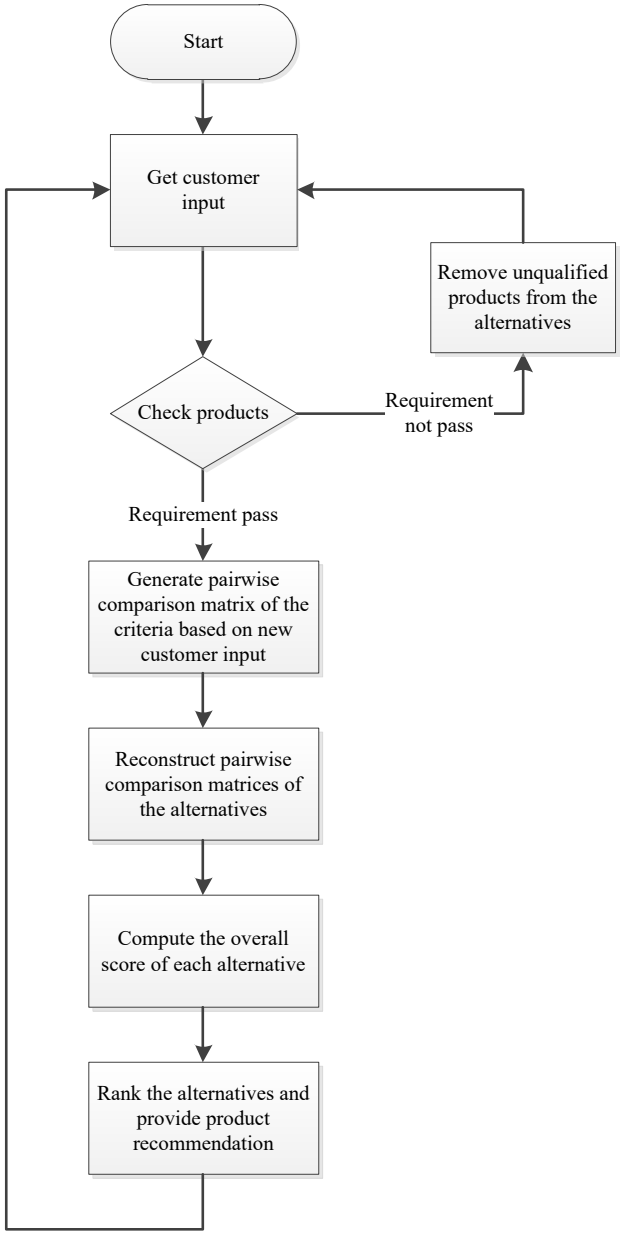

Figure 3: The flow chart of the interactive method

3.1 Goal and Criteria

The goal of this study is to provide recommendation of power equipment for customers in studio recording. As shown in Table 1, fifteen products with fourteen specific features are considered. The description of each feature is given in Table 2.

Table 1: Features of the products

Product/Feature	Price	Amp	Outlets	Surge Protection	Noise Filtering	Over-voltage Protection	Voltage Regulation	Power Boost	Power Sequencing	UPS	Isolation	Indicator	USB Charger	Software Control
M-10X E	3,780	10	11	Standard	RFI/EMI	-	-	-	-	-	-	Yes	-	-
PL-8C E	11,000	10	11	SMP	LiFT	EVS	-	-	-	-	Yes	Yes	-	-
PL-PLUS C E	14,000	10	11	SMP	LiFT	EVS	-	-	-	-	Yes	Yes	-	-
PL-PRO DMC E	22,500	10	11	SMP	LiFT	EVS	-	-	-	-	Yes	Yes	Yes	-
PS-8RE III	14,000	10	9	SMP	LiFT	EVS	-	-	Yes	-	Yes	Yes	-	-
CN-3600 SE	22,500	16	9	SMP	LiFT	EVS	-	-	Yes	-	Yes	Yes	-	Yes
P-2300 IT E	108,000	10	14	SMP	LiFT+BP	EVS	-	-	-	-	Yes	Yes	Yes	-
P-1400 AR E	44,100	6	11	SMP	LiFT	EVS	True RMS	-	-	-	Yes	Yes	Yes	-
P-6900 AR E	126,000	30	11	SMP	LiFT	EVS	True RMS	-	-	-	Yes	Yes	Yes	-
F1500-UPS E	54,000	7	10	SMP	LiFT	EVS	AVR	-	-	Yes	Yes	Yes	-	Yes
IT-REF 16EI	146,200	16	12	SMP	LiFT+BP	EVS	-	Yes	-	-	Yes	-	-	-
ELITE-16 PFE I	43,000	16	12	SMP	LiFT	EVS	-	Yes	-	-	Yes	Yes	-	-
SPR-16E I	94,600	16	12	SMP	LiFT	EVS	AVR	-	-	-	Yes	Yes	-	-
ELITE-10E I	28,337	10	8	SMP	LiFT	EVS	-	-	-	-	-	Yes	-	-
AC-210A E	6,300	10	2	SMP	LiFT	EVS	-	-	-	-	-	Yes	-	-

Table 2: Description of the product features

No.	Features	Description
1	Price	The price of the product
2	Amp	The current rating of the product
3	Outlets	The number of outlets
4	Surge protection	The type of surge protection
5	Noise filtering	The type(s) of noise filtering technology
6	Over-voltage protection	The type of over-voltage protection
7	Voltage regulation	The type of voltage regulation technology
8	Power boost	Whether the product provides power boost feature
9	Power sequencing	Whether the product provides power sequencing feature
10	UPS	Whether the product provides energy storage (UPS)
11	Isolation	Whether the product provides isolation circuits for different equipment
12	Indicator	Whether the product provides system monitoring indicator
13	USB charger	Whether the product provides built-in USB charger
14	Software control	Whether the product can be controlled by software

From Table 1, some features are considered as product requirement rather than decision criteria in the AHP. For example, the recommended product must provide enough current (AMP) and has enough outlets for the customer's equipment. Customer may look for a particular feature or otherwise the product will not be considered. Therefore, we divide the features into two categories: product requirements and decision criteria. The first category is used to filter out the alternatives that could not meet the customer requirements, while the second category is used to construct the pairwise comparison matrix for the AHP. As a result, the remaining features for the decision criteria are price, surge protection, noise filtering, and voltage regulation.

To obtain all product requirements and decision criteria, we propose a list of questions for the customer survey. The questions are compiled from product guides and reviewed by the experts in the field. The feedback is used to adjust the questions accordingly. The types of question include Yes/No answers and multiple choice answers. An example of the questions is given in Figure 4.

Customer Survey		
Please answer the following questions: (select from drop-down list)	**Needs**	
What is your budget?	<= 50,000	Baht
What is your equipment current rating?	< 16	amp
What is your maximum numbers of equipment	<=10	
What level of equipment protection is required? (i.e. surge and over-voltage protections)	medium	
What level of sound quality (protection from noise) do you prefer?	high	
How often do you require for power boost?	very low	
Do you need power sequencing?	No	
Do you need energy storage? (UPS)	Not required	
How important is power isolation to your equipment?	low	
Do you care about the status of the power system?	Don't know	
Do you need built-in USB charger?	Doesn't matter	
Do you need software control for the power unit?	No	

Figure 4: Example of customer survey

3.2 Pairwise Comparison

In constructing the pairwise comparison matrix for the decision criteria, it is difficult for customers to understand how the AHP works and enter the relative importance of each pair of product features accordingly, and it is also a matter of convenience for the customers. Instead, we take an alternative approach to generate the pairwise comparison matrix automatically based on the answers from the customer survey as discussed in Section 3.1. The steps of generating the pairwise comparison matrix are described as follows:

Step 1: Translate customer ratings to scores with integer value ranks from 0-9
Step 2: Rescale each criterion's score to 1-9 according to the relative weights provided by the expert
Step 3: Compute the ratio of the scores for each pair of criteria to obtain the pairwise comparison matrix
Step 4: Normalize the matrix

On the other hand, the comparison matrices for the alternatives with respect to the criteria are provided by the experts. This involves providing the relative scores for each pair of alternatives according to the four decision criteria, i.e., price, surge protection, noise filtering, and voltage regulation. For price comparison, products are divided into five groups according to their price. Products within the same group will be equally important. This approach simplifies the rating process for the experts and also increases the consistency of the ratting. For the other pairwise comparisons which involve product features, the ratting is provided according to what feature of that product had compared to the other. If two products have the same feature, then the relative score will be equal to 1. Tables 3 to 6 show the pairwise comparison matrices of the alternatives with respect to price, surge protection, noise filtering, and voltage regulation respectively.

Table 3: Pairwise comparison matrix of the alternatives with respect to price

Price		**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**
P1	**(M-10X E)**	1	2	2	4	2	4	8	6	8	6	8	6	8	4	1
P2	**(PL-8C E)**	0.5	1	1	2	1	2	6	2	6	2	6	2	6	2	0.5
P3	**(PL-PLUS C E)**	0.5	1	1	2	1	2	6	2	6	2	6	2	6	2	0.5
P4	**(PL-PRO DMC E)**	0.25	0.5	0.5	1	0.5	1	4	2	4	2	4	2	4	1	0.25
P5	**(PS-8RE III)**	0.5	1	1	2	1	2	6	2	6	2	6	2	6	2	0.5
P6	**(CN-3600 SE)**	0.25	0.5	0.5	1	0.5	1	4	2	4	2	4	2	4	1	0.25
P7	**(P-2300 IT E)**	0.13	0.17	0.17	0.25	0.17	0.25	1	0.5	1	0.5	1	0.5	1	0.25	0.13
P8	**(P-1400 AR E)**	0.17	0.5	0.5	0.5	0.5	0.5	2	1	2	1	2	1	2	0.5	0.17
P9	**(P-6900 AR E)**	0.13	0.17	0.17	0.25	0.17	0.25	1	0.5	1	0.5	1	0.5	1	0.25	0.13
P10	**(F1500-UPS E)**	0.17	0.5	0.5	0.5	0.5	0.5	2	1	2	1	2	1	2	0.5	0.17
P11	**(IT-REF 16EI)**	0.13	0.17	0.17	0.25	0.17	0.25	1	0.5	1	0.5	1	0.5	1	0.25	0.13
P12	**(ELITE-16 PFE I)**	0.17	0.5	0.5	0.5	0.5	0.5	2	1	2	1	2	1	2	0.5	0.17
P13	**(SPR-16E I)**	0.13	0.17	0.17	0.25	0.17	0.25	1	0.5	1	0.5	1	0.5	1	0.25	0.13
P14	**(ELITE-10E I)**	0.25	0.5	0.5	1	0.5	1	4	2	4	2	4	2	4	1	0.25
P15	**(AC-210A E)**	1	2	2	4	2	4	8	6	8	6	8	6	8	4	1

Table 4: Pairwise comparison matrix of the alternatives with respect to surge protection

Surge protection		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
P1	(M-10X E)	1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
P2	(PL-8C E)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P3	(PL-PLUS C E)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P4	(PL-PRO DMC E)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P5	(PS-8RE III)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P6	(CN-3600 SE)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P7	(P-2300 IT E)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P8	(P-1400 AR E)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P9	(P-6900 AR E)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P10	(F1500-UPS E)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P11	(IT-REF 16EI)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P12	(ELITE-16 PFE I)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P13	(SPR-16E I)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P14	(ELITE-10E I)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P15	(AC-210A E)	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 5: Pairwise comparison matrix of the alternatives with respect to noise filtering

Noise filtering		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
P1	(M-10X E)	1	0.33	0.33	0.33	0.33	0.33	0.11	0.33	0.33	0.33	0.11	0.33	0.33	0.33	0.33
P2	(PL-8C E)	3	1	1	1	1	1	0.33	1	1	1	0.33	1	1	1	1
P3	(PL-PLUS C E)	3	1	1	1	1	1	0.33	1	1	1	0.33	1	1	1	1
P4	(PL-PRO DMC E)	3	1	1	1	1	1	0.33	1	1	1	0.33	1	1	1	1
P5	(PS-8RE III)	3	1	1	1	1	1	0.33	1	1	1	0.33	1	1	1	1
P6	(CN-3600 SE)	3	1	1	1	1	1	0.33	1	1	1	0.33	1	1	1	1
P7	(P-2300 IT E)	9	3	3	3	3	3	1	1	1	1	1	1	1	1	1
P8	(P-1400 AR E)	3	1	1	1	1	1	1	1	1	1	0.33	1	1	1	1
P9	(P-6900 AR E)	3	1	1	1	1	1	1	1	1	1	0.33	1	1	1	1
P10	(F1500-UPS E)	3	1	1	1	1	1	1	1	1	1	0.33	1	1	1	1
P11	(IT-REF 16EI)	9	3	3	3	3	3	1	3	3	3	1	1	1	1	1
P12	(ELITE-16 PFE I)	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P13	(SPR-16E I)	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P14	(ELITE-10E I)	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P15	(AC-210A E)	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 6: Pairwise comparison matrix of the alternatives with respect to voltage regulation

Voltage Regulation		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
P1	(M-10X E)	1	1	1	1	1	1	1	0.2	0.2	0.5	1	1	0.5	1	1
P2	(PL-8C E)	1	1	1	1	1	1	1	0.2	0.2	0.5	1	1	0.5	1	1
P3	(PL-PLUS C E)	1	1	1	1	1	1	1	0.2	0.2	0.5	1	1	0.5	1	1
P4	(PL-PRO DMC E)	1	1	1	1	1	1	1	0.2	0.2	0.5	1	1	0.5	1	1
P5	(PS-8RE III)	1	1	1	1	1	1	1	0.2	0.2	0.5	1	1	0.5	1	1
P6	(CN-3600 SE)	1	1	1	1	1	1	1	0.2	0.2	0.5	1	1	0.5	1	1

P7	**(P-2300 IT E)**	1	1	1	1	1	1	1	0.2	0.2	0.5	1	1	0.5	1	1
P8	**(P-1400 AR E)**	5	5	5	5	5	5	5	1	1	2	1	1	2	1	1
P9	**(P-6900 AR E)**	5	5	5	5	5	5	5	1	1	2	1	1	2	1	1
P10	**(F1500-UPS E)**	2	2	2	2	2	2	2	0.5	0.5	1	1	1	0.5	1	1
P11	**(IT-REF 16EI)**	1	1	1	1	1	1	1	1	1	1	1	1	0.5	1	1
P12	**(ELITE-16 PFE I)**	1	1	1	1	1	1	1	1	1	1	1	1	0.5	1	1
P13	**(SPR-16E I)**	2	2	2	2	2	2	2	0.5	0.5	2	2	2	1	1	1
P14	**(ELITE-10E I)**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P15	**(AC-210A E)**	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

3.3 Consistency Measure

In applying AHP, the scores of the preference ratings given in the pairwise comparison matrix should be consistent. Therefore, a consistency check should be performed to test if the preference ratings provided from the experts are consistent. In the proposed approach, since the pairwise comparison matrix of the criteria for the customer inputs is generated automatically, the result is always consistent. Therefore, consistency check is discarded. On the other hand, consistency measures are required for the pairwise comparison matrices of the alternatives which are based on expert opinions. Consistency check can be measured from the consistency ratio (CR) which is computed by$CR = CI/RI$, where CI is the consistency index given by

$$CI = \frac{\lambda_{max} - n}{n-1},$$

RI is the average Random Index of a matrix size n, and λ_{max} is the maximum eigenvalue of the measured matrix. Table 7 shows the results of the consistency measure for the pairwise comparison matrices in Tables 3 to 6 which pass the consistency test for a typical CR value of less than 0.1.

Table 7: Consistency test of the pairwise comparison matrices with respect to decision criteria

Criterion	Consistency index	Consistency ratio
Price	0.019	0.011
Surge protection	0.000	0.000
Noise filtering	0.035	0.020
Voltage regulation	0.070	0.041

3.4 Normalizing the Comparison

As mentioned in Section 3, unqualified products will be discarded from the list of alternatives, and the pairwise comparison matrices need to be reconstructed by removing the rows and columns associated with the discarded products. Once the new matrices are reconstructed, the weights of alternatives need to be derived from the matrices. This is made by normalizing the column sum of the matrix and the weights of alternatives can be computed from the row average.

3.5 Computing Overall Score of the Alternatives

The weights from the comparison matrices in each level are used to compute the score for the element in the next level. In our model, the weight from each criterion is used to compute the score of the alternatives, and the overall score for each alternative is obtained by summing the associated scores from the criteria.

4. Results and Discussion

To evaluate the proposed model, three experts from recording studio are asked to review the questions and provide pairwise comparison of the alternatives for each decision criteria. The feedback from the experts is used to adjust the model accordingly to obtain a reasonable model. Consistency test is also performed for each pairwise comparison matrix to ensure that there is no conflict among the alternatives. Then, the performance of the model is tested by comparing the results from the model to the recommendations from the experts. Eight customers are asked to take the surveys and the results are given in Table 8.

Table 8: Results from customer surveys and expert recommendations

Question	Result from customers							
	1	2	3	4	5	6	7	8
1. What is your budget?	<= 50,000	> 100,000	Not specified	Not specified	Not specified	Not specified	Not specified	<= 20,000
2. What is your equipment current rating?	< 10	< 30	Don't know	< 16	< 30	< 30	< 16	< 6
3. What is your maximum number of equipment	<= 9	<= 11	<= 2	<= 8	<= 14	<= 12	<=10	<= 2
4. What level of equipment protection is required? (i.e. surge and over-voltage protections)	medium	very high	medium	very high	high	very high	very high	high
5. What level of sound quality (protection from noise) do you prefer?	very high	very high	very high	very high	very high	very high	high	high
6. How often do you require for power boost?	very high	medium	medium	very high	medium	high	medium	medium
7. Do you need power sequencing?	No	No	No	No	Yes	Yes	Yes	No
8. Do you need energy storage? (UPS)	Not required	Not required	Required	Required	Required	Required	Required	Not required
9. How important is power isolation to your equipment?	very low	very high	medium	medium	very high	very high	high	medium
10. Do you care about the status of the power system?	No	Yes	Don't know	Yes	Yes	Yes	Doesn't matter	Don't know
11. Do you need built-in USB charger?	No	No	No	No	Doesn't matter	Doesn't matter	Doesn't matter	Doesn't matter
12. Do you need software control for the power unit?	No	No	No	No	No	Yes	Yes	No
Recommendation from proposed model	PL-8C E PS-8RE III PL-PLUS C E	P-6900 AR E - -	F1500-UPS E - -	- - -	- - -	- - -	- - -	PL-8C E PS-8RE III PL-PLUS C E
Recommendation from expert	PL-PRO DMC E - -	P-6900 AR E - -	F1500-UPS E - -	F1500-UPS E / PL-PRO DMC E - -	F1500-UPS E/ P-6900 ARE / PS-8RE III - -	P-6900 AR E / F1500-UPS E - -	F1500-UPS E / PL-PRO DMC E - -	PL-8C E PL-PLUS C E -

From Table 8, we observed that the results can be divided into three different cases. Case 1, results from customer number 2, 3, and 8, the recommendations from the model agree with those from the expert. Case 2, result from customer number 1, the model and expert give different product recommendation. Case 3, results from customer number 4, 5, 6, and 7, the model cannot find any qualified product for the customer where the expert suggests a combination of products to the customer.

In case 1, the recommended products for customers number 2 and 3 match exactly with the recommendations from the experts. For customer number 8, the model suggests one additional product for the customer in addition to the recommendations of the expert. This is simply because the model is assigned to provide three suggestions and there are more than two products that qualified for this customer.

In case 2, the model recommends three products that are in a lower price range to customer number 1, while the expert suggest PL-PRO DMC E which has a higher price. This is because the expert try to suggest a high-end product to the customer that may over qualified for his requirements but still within his budget constraint. Further investigation shows that the PL-PRO DMC E is ranked fourth in the alternatives. If the customer would lower his budget, than the recommendation of the expert will definitely be any of the three alternatives in the list.

The results in the third case reveal the limitation of our model where the model is only capable of recommending a single product but not the combination of the products. To address this issue, the set of alternative can be extended to include the combination of products and the Analytic Network Process (ANP) can be used for our model improvement. Similar to the AHP, the ANP uses a network to represent the structure of the decision making process and allows interdependence among the decision criteria and the alternatives.

Another shortcoming of the model is that some features are used for filtering the requirements of the products but not considered in the decision criteria. As a result, the product with additional features that are not required by the customer will not preferable over the products that do not have such features. We can further improve the model by taking into account these additional features in the decision criteria.

5. Conclusion

In this paper, we propose an interactive AHP decision model for recommending power unit used in studio recording. Questionnaire is used to gather customer requirements for the product. This information is coupled with the predefined judgments from the experts to justify the products that best suit for the customer requirements. The evaluation result shows that the recommendation from the model is reasonable in circumstances where a single product is recommended. Model improvement can be focus on how to handle recommendation for product combinations as well as extend the functional requirements of the decision criteria.

References

Chen, D., Tseng, C., & Lin, C. (2011). Applying Fuzzy AHP on Product Selection Service in e-Commerce. In *2011 International Joint Conference on Service Sciences* (pp. 198–202). https://doi.org/10.1109/IJCSS.2011.46

Dağdeviren, M. (2008). Decision making in equipment selection: an integrated approach with AHP and PROMETHEE. *Journal of Intelligent Manufacturing*, *19*(4), 397–406. https://doi.org/10.1007/s10845-008-0091-7

Dožić, S., Lutovac, T., & Kalić, M. (2018). Fuzzy AHP approach to passenger aircraft type selection. *Journal of Air Transport Management*, *68*, 165–175. https://doi.org/10.1016/j.jairtraman.2017.08.003

Gremyr, I., Hildenbrand, J., Sarasini, S., & Raharjo, H. (2014). A Framework for Developing and Assessing Eco-innovations. In S. G. Azevedo, M. Brandenburg, H. Carvalho, & V. Cruz-Machado (Eds.), *Eco-Innovation and the Development of Business Models: Lessons from Experience and New Frontiers in Theory and Practice* (pp. 55–79). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-05077-5_4

Kumar, G. (2018). A multi-criteria decision making approach for recommending a product using sentiment analysis (Vol. 2018-May, pp. 1–6). Presented at the Proceedings - International Conference on Research Challenges in Information Science. https://doi.org/10.1109/RCIS.2018.8406679

Liu, D.-R., & Shih, Y.-Y. (2005). Integrating AHP and data mining for product recommendation based on customer lifetime value. *Information & Management*, *42*(3), 387–400. https://doi.org/10.1016/j.im.2004.01.008

Nguyen, H. D., Lo, W., & Sheu, R. (2011). An AHP-Based Recommendation System for Exclusive or Specialty Stores. In *2011 International Conference on Cyber-Enabled Distributed Computing and Knowledge Discovery* (pp. 16–23). https://doi.org/10.1109/CyberC.2011.13

Noradachanon, N., & Senivongse, T. (2017). Decision model for identity management product selection using fuzzy AHP. In *2017 18th IEEE/ACIS International Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD)* (pp. 269–275). https://doi.org/10.1109/SNPD.2017.8022732

Rao, R. V. (Ed.). (2007a). Evaluation of Product Designs. In *Decision Making in the Manufacturing Environment: Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods* (pp. 71–80). London: Springer London. https://doi.org/10.1007/978-1-84628-819-7_6

Rao, R. V. (Ed.). (2007b). Material Selection for a Given Engineering Application. In *Decision Making in the Manufacturing Environment: Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods* (pp. 53–69). London: Springer London. https://doi.org/10.1007/978-1-84628-819-7_5

Rao, R. V. (Ed.). (2007c). Robot Selection for a Given Industrial Application. In *Decision Making in the Manufacturing Environment: Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods* (pp. 169–179). London: Springer London. https://doi.org/10.1007/978-1-84628-819-7_13

Rao, R. V. (Ed.). (2007d). Selection of Best Product End-of-Life Scenario. In *Decision Making in the Manufacturing Environment: Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods* (pp. 285–293). London: Springer London. https://doi.org/10.1007/978-1-84628-819-7_25

Rao, R. V. (Ed.). (2007e). Selection of Material Handling Equipment. In *Decision Making in the Manufacturing Environment: Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods* (pp. 187–195). London: Springer London. https://doi.org/10.1007/978-1-84628-819-7_15

Rao, R. V. (Ed.). (2007f). Selection of Software in Manufacturing Industries. In *Decision Making in the Manufacturing Environment: Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods* (pp. 209–214). London: Springer London. https://doi.org/10.1007/978-1-84628-819-7_17

Saaty, T. L. (1977). A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology*, *15*(3), 234–281. https://doi.org/10.1016/0022-2496(77)90033-5

Xu, Z. (2014). Interactive Intuitionistic Fuzzy Multi-Attribute Decision Making. In Z. Xu (Ed.), *Intuitionistic Preference Modeling and Interactive Decision Making* (pp. 195–223). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-28403-8_2

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