Practical and User Friendly Tool of Analytic Hierarchy Process for Decision Making

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ABSTRACT

This paper discusses on the use of analytic hierarchy process (AHP) aiming at improving and enhancing the decision making process. Currently, the decision provided by user is referring to their opinion and experience. If there is a supported tool, normally mean for expert users or researchers. By using a practical and user friendly AHP tool, many users are benefited from the tool. There are three basic features of AHP called criteria, sub-criteria and alternative. These features consist of a combination of users experience and mathematical approach. The method aim to give users a decision making process according to the given problem. The results will suggest users on what is the best decision should be made. In order to test its applicability, a real world case study at Palm Oil Mill (POM) plant is used. A satisfactory result has confirmed the practicality and user friendliness of the tool.

Keywords

Analytic Hierarchy Process (AHP), decision making, palm oil mill

1.0 INTRODUCTION

The concept of analytic hierarchy process (AHP) is a pragmatic idea of artificial intelligence (AI) that was first introduced by Saaty (1977). Since then, the vast growth interest in AHP is underscored with the numerous researchers being conducted in this area, for example in Islam (2003); Basari, Rahman, Asmai & Abas (2007). In the case of decision making according to Labib (2004) the main issues is how good the user interface when interact with the users. Researches on user interface design have been conducted by many researchers, for example in Bowen (2005); Bowen & Reeves (2007); Bowen & Reeves (2008). To date, the graphical user interface (GUI) has proved its success with the considerable number of successful systems being implemented using this kind of interface, see for example in Fernandez, Labib, Walmsley & Petty (2003); Spreitzhofer, Fierz & Lehning (2004).

The computer forms or screens and its associated keyboard are the interface elements that lets the user communicate with the computer. The computer forms are used primarily for data input, data updating, data deletion, and data inquiry. It is recognised the importance of a good screen design that reduces the interface complexity as perceived by the users. The features embodied in the form design (Shneiderman, 1998) include:

a) Meaningful title. Identifies the topic and avoid computer terminology.

b) Comprehensible instruction. Describe the user's tasks in familiar terminology. Be brief; if more information is needed, make a set of help screens available to the novice user.

c) Logical grouping and sequencing of fields. Related fields should be adjacent, and should be aligned with blank space for separation between groups. The sequencing should reflect common patterns. For example, city followed by state followed by zip code.

d) Visually appealing layout of the form. Using a uniform distribution of fields is preferable to crowding one part of the screen and leaving other parts blank. Alignment creates a feeling of order and comprehensibility. For example, the field labels name, address, and city can be right justified so that the data-entry field are vertically aligned. This layout allows the frequent user to concentrate on the entry fields only. If users are working from hard copy, the screen should match the paper form.

e) Familiar fields' level. Common terms should be used. If home address were replaced by domicile, many users would be uncertain or anxious about what to do.

f) Consistent terminology and abbreviations. Prepare a list of terms and acceptable abbreviations and use the list diligently, making additions only after careful consideration.

g) Visible space and boundaries for data-entry fields. Users should be able to see the size of the field and anticipate whether abbreviations or other trimming strategies will be needed. Underscores can indicate the number of the characters available on text-only displays, and an appropriate-sized box can show field length in GU1s.

h) Convenient cursor movement. Use a simple and visible mechanism for moving the cursor, such as TAB key or cursor movement arrows.
i) Error correction for individual characters and entire fields. Allow use of a backspace key and overtyping to enable the user to make easy repairs or changes to entire fields.
j) Error prevention. Where possible, prevent users from entering incorrect values. For example, in a field requiring a positive integer, do not allow the user to enter letters, minus signs, or decimal points.
k) Error messages for unacceptable values. If users enter unacceptable value, the error message should appear on completion of the field.
l) Optional field clearly marked whenever appropriate, the word optional or other indicators should be visible.
m) Explanatory messages for fields. If possible, explanatory information about a field or the permissible values should appear in a standard position, such as in a window on the bottom, whenever the cursor is in the field.
n) Completion signal. It should be clear to the users what they must do when they have finished filling the fields.

The main purpose of this paper is to discuss the practical and user friendly of analytic hierarchy process interface for maintenance policy decision making. The paper is organized as follows: Section 2 presents the design of AHP interface. Section 3 on the other hand, discusses the testing and the result on practicality and user friendliness of AHP interface. Finally our conclusions and future work directions are summarized in Section 5.

2.0 THE DESIGN OF AHP INTERFACE

This section discusses on the interfaces that interact with the AHP modules. In this paper, AHP is the method used for identifying the most important machines or components according to the given historical failure data (absolute data) or a subjective data based on expert judgment. This method applies the concept of matrix which called pair wise comparison matrix. The first step is obtaining the objective/goal of the analysis, for this study, identifying the most important machines in terms of maintenance priority. This objective is gained from the discussion with the organisations management and resides outside of the tools. Then identify criteria evaluation by selecting any criteria which could possibly affect the machines. This criterion refers to the information from fault mode, fault effect, fault type, fault cause and fault consequence.

This criterion could also decompose the level of criteria by adding sub criteria. The weight of this criteria/sub criterion could be calculated and shows which criteria/sub criteria is most important. Finally, the ranked machines based on various criteria from snapshot analysis will be set as an alternative for AHP method. The weight for each alternative shows which machines are most important and could be ranked based on that. This is an enhancement element that current snapshot model does not have as well as problem recognition technique.

The same method then applies to components to seek the most critical components.

The interfaces that related to decision analysis process are shown in Figure 1, Figure 2 and Figure 3. These figures came from Calculate AHP process. Based on Figure 1, the users need to follow the hierarchical order as guided by the interfaces. It means that they have to calculate the AHP weight value (see Figure 2) for each of the criteria/ sub criteria to reach the alternatives tab or to continue with the next process. Once all the process are followed properly and accepted by the system, then the rank will be displayed (see Figure 3).
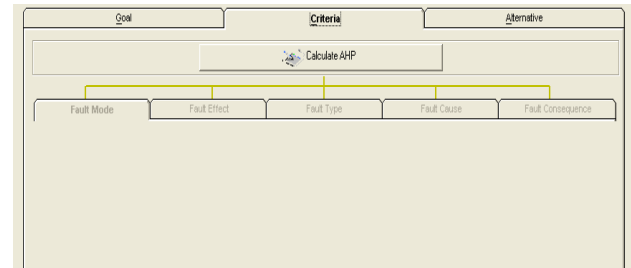

Figure 1: Interface of AHP Criteria, Sub criteria and Alternatives

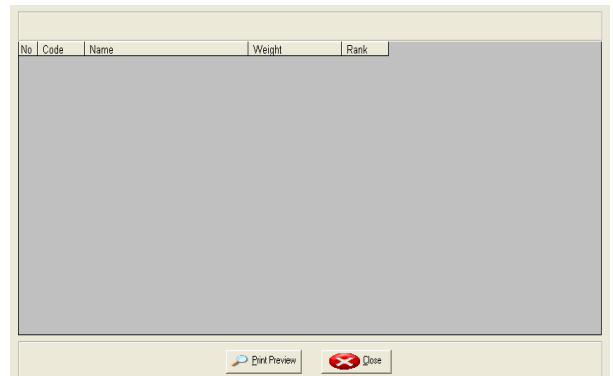*Figure 2:* Interface of AHP Calculation

Figure 3: Interface of Component Rank

3.0 TESTING OF THE AHP INTERFACE

This section aims at evaluating the AHP interface whether its main purpose to assist maintenance engineers in making decision is achieved or not. The agreement between the behaviour of the model and that of the real tools is validated. The validation of the tool is focused on two characteristics which are user interface and tool usability. The procedure to carry out the investigation is as follows:
a) Present a complete introduction of the purposes, functions and interfaces of the tool to users.
b) Demonstrate the tool to users.
c) Let the user work on the tool to solve their real-world problems.
d) Complete the evaluation questionnaires.
e) Review the suggestions and comments from the users.
f) Analyse the data to obtain the final results of the tool evaluation.

3.1 User Interface Evaluation

The user interface evaluation in Table 1 contains eleven items to evaluate level of the effectiveness and efficiency of the interfaces of the tool.

Table 1: *User Interface Evaluation Results*

Item	Description	1	2	3	4	5	6
1	This tool provides enough information for the user to learn how to use it.	0%	60%	25%	15%	0%	0%
2	The terminology in this tool is easy to understand.	5%	40%	35%	15%	5%	0%
3	This tool provides an effective means for the user to understand the problem recognition techniques.	10%	50%	30%	10%	0%	0%
4	This tool provides an effective means for the user to collect and analyse the fault data.	15%	50%	25%	10%	0%	0%
5	The "Editors" in the tool provide easy ways for the user to utilise the tool ability	10%	35%	35%	15%	5%	0%
6	The tool provides an effective means for the user to assist them in making decision	15%	15%	45%	25%	0%	0%
7	The menu and "Help" function provide enough information for the user to learn and use the tool.	15%	25%	50%	10%	0%	0%
8	The dialog function in the tool is brief and informative	0%	40%	35%	15%	10%	0%
9	The graphical input and output interfaces are user friendly.	10%	15%	45%	20%	10%	0%
10	The reports of this tool are satisfactory	15%	30%	50%	5%	0%	0%
11	The speed of processing during using the tool is satisfactory.	10%	30%	30%	15%	15%	0%

Evaluation scale level reference:

Strongly Agree	Agree	Sort of Agree	Sort of Disagree	Disagree	Strongly Disagree
1	2	3	4	5	6

Twenty theoretical engineers (lecturers) in Engineering Faculties of the Universiti Teknikal Malaysia Melaka (UTeM) and twenty experts from several POM companies participated in this survey. The results as shown in Table 1 are generally satisfactory. Most of the items received good scores except item 9 and 11 had a relatively low score due to the lack of chart and graphical output displays and the speed of processing when calling other applications respectively.

3.2 Usability Evaluation

Tool usability evaluation measures the tool functionality and users' satisfaction. In this study, a method proposed by Mitta (1991) has been used for quantifying tool usability. In this method, the tool performance variables and user perception variables need to be specified. The method is briefly described as follows:
Let S_j - user perception variable and
Q_k - tool performance variable.
Then the usability variable (U) can be expressed as

$$U = \sum_{j=1}^{m} a_j S_j + \sum_{k=1}^{n} b_k O_k \qquad (1.1)$$

Where m and a_j are the number and coefficient of user perception variables respectively, n and b_k are the number and coefficient of tool performance variables respectively, and

Evaluation scale level reference:

Excellent	Good	Acceptable	Fair	Poor
5	4	3	2	1

$$0 \le S_j, O_k \le 1,$$
$$0 \le a_j, b_k \le 1,$$
$$\sum_{j=1}^{m} a_j + \sum_{k=1}^{n} b_k = 1 \tag{1.2}$$

Three variables S_1, S_2 and S_3 regarding the user perception are defined as follows:

S_1 : Variable of user confidence,

S_2 : Variable of user perception of the tool advantage as maintenance problem recognition tool,

S_3 : Variable of user perception of ease of use of the tool.

Similarly, three variables O_1, O_2 and O_3 regarding the tool performance are defined as follows:

O_1 : Variable of accuracy of tool performance,

O_2 : Variable of completeness of the tool,

O_3 : Variable of interface performance.

Saaty & Kearns (1985) proposed a method of Analytic Hierarchy Process (AHP) which can determine the coefficients α and β of the usability function. In Saaty's method, parity checking is used to express the relative importance of the function variables. The same participants as in Section 3.1 are involved in the evaluation because of they have engineering or decision support background and experienced in using expert system. From the geometric and arithmetic mean, the coefficients of function variables are calculated and the results are as follows:

$$\begin{pmatrix} S_1 \\ S_2 \\ S_3 \\ O_1 \\ O_2 \\ O_3 \end{pmatrix} \begin{pmatrix} 0.1317 \\ 0.2370 \\ 0.1561 \\ 0.2147 \\ 0.1982 \\ 0.0932 \end{pmatrix}$$

The values of the six variables are determined by means of a questionnaire and the same participants are participated in the survey. The items and results of the survey are shown in Table 2.

Table 2: Results of Function Variables Measurements

Item	Description	Excellent	Good	Acceptable	Fair	Poor
1	User confidence	10%	60%	30%	0%	0%
2	Tool advantages	0%	65%	35%	0%	0%
3	Perception of ease of use	15%	50%	25%	10%	0%
4	Accuracy of results	15%	55%	30%	0%	0%

The usability function can be written as

$$U = \sum_{j=1}^{m} a_j S_j + \sum_{k=1}^{n} b_k O_k$$

$= 0.1317 \text{x } S_1 + 0.2370 \text{x} S_2 + 0.1561 \text{x } S_3 +$
$\quad 0.2147 \text{x } O_1 + 0.1982 \text{x} O_2 + 0.0932 \text{x} O_3$

$= 0.1317 \text{x } 0.76 + 0.2370 \text{x } 0.73 + 0.1561 \text{x } 0.74 +$
$\quad 0.2147 \text{x } 0.77 + 0.1982 \text{x } 0.74 + 0.0932 \text{x } 0.76$

$= 0.7714$

This result verifies that the tool behaviour is satisfactory to the user. But the validation result reveals that the tool contains limitations.

3.3 Statistical Test

Once the tool is validated, the next step is to determine whether the tool is capable of achieving its purpose. As AHP tool success was predefined as facilitating the maintenance policy decision making, the general hypothesis is initiated by the dependent variables of the number of the features investigated (Hypothesis One) and the time to reach a decision (Hypothesis Two). The general and test hypotheses are:

- General Hypothesis. The proposed prototype AHP tool will significantly facilitate maintenance engineers' decisions during the maintenance policy decision making.
  - Hypothesis One. AHP tool-assisted users will consider greater number of features than non AHP tool-assisted users.
  - Hypothesis Two. AHP tool-assisted users will take less time to make decision than non-AHP tool-assisted users.

The testing was conducted in Kilang Sawit United Bell (KSUB) office. The AHP tool program was installed and tested on 4 computer tools on 1st June 2007. The experiment tool setups were equipped at least with a 1.73-gigahertz *Intel's Celeron processor* with a 512-megabytes memory. An introductory session was conducted on 2nd June 2007. The testing process started with a hands-on demonstration of the tool, using a data collected from 1st August 2005 to 30th September 2005. The evaluation experiment was conducted during the same session (2nd June 2007). Sixteen participants from the department of maintenance participated in the study by completing two data collected from 1st August 2006 to 30th September 2006 (case A) and 1st November 2006 to 31st

December 2006 (case B). These participants varied from engineers to general workers who are involved in maintenance.

Although the two period of data collection selected for the experiment are equally compatible in work amount because the production operated for 24 hours daily, there might be some differences in the nature of the cases. This is due to the uncontrolled and unpredicted of the machine behaviour during the production process. The sixteen participants were randomly divided into two groups, the control and the experiment groups. Half of the participants in each group were randomly assigned to the case A-then-B experiment scheme, while the other half of each group was assigned to the case B-then-A experiment scheme in order to minimise impacts caused by differences on the case studies' nature. Due to lack of computers, the session will be divided into four sessions where each session consists of two participants for each group.

In the pre-test observation, participants in the control group had access to AHP tool, while those in the experiment group had access to the existing tools, namely Expert Choice (non-AHP tool). All participants had access to AHP tool during the post-test observation. The data set comprises eight survey responses from the control group and eight survey responses from the experiment group. The test was run to find out whether the null hypothesis ($\mu_{control} - \mu_{experiment} \geq D_0$) could be rejected. The hypothesis is

H_O: Changes in the mean number of features examined in the experiment group are not more than those in the control group.

H_A: Changes in the mean number of features examined in the experiment Group are more than those in the control group.

The null hypothesis would be rejected if the t-statistic value is equal to or smaller than the negative t-critical value of (t-statistic $\leq -t_{\alpha\,0.05}$). The result shows that the null hypothesis was rejected. This indicates a significant difference in number of features examined.

A plausible reason for the control group's decreased mean time to reach decisions in the two experiments can be explained by a maturation effect resulting from increased efficiency. For these participants, the post-test experiment was the second analysis utilising the same tool. Although the case situation was different, participants were expected to be more familiar with the AHP tool. To determine if the decrease is statistically significant, a pool t-test was conducted. The test was aimed to examine whether the null hypothesis ($\mu_{control} - \mu_{experiment} \leq D_0$) could be rejected. The null hypothesis will be rejected if the t-statistic value is equal to or higher than the t-critical value of (t-statistic $\geq t_{\alpha\,0.05}$). The hypothesis is

H_O: Changes the mean time to reach decisions in the experiment group is not more than in the control group.

H_A: Changes the mean time to reach decisions in the experiment group is more than in the control group.

The result shows that the null hypothesis was rejected. This indicates a significant difference in time to reach decisions.

The hypothesis one aims to find whether AHP tool has an impact on enhancing users' comprehensiveness of the decision context by increasing the number of features examined. According to Figure 4, the result indicates that all participants (100%) in the experiment group reported an increase in the number of features examined, as compared to a 62.5% of participants in the control group.

In other dimension, the decreases in time to reach decisions are discovered in a 100% of participants in the experiment group versus a 50% of participants in the control group. Interestingly, in the control group, both increase features and decrease time calculated about 37.5% while in the experiment group it shows 100% participants.
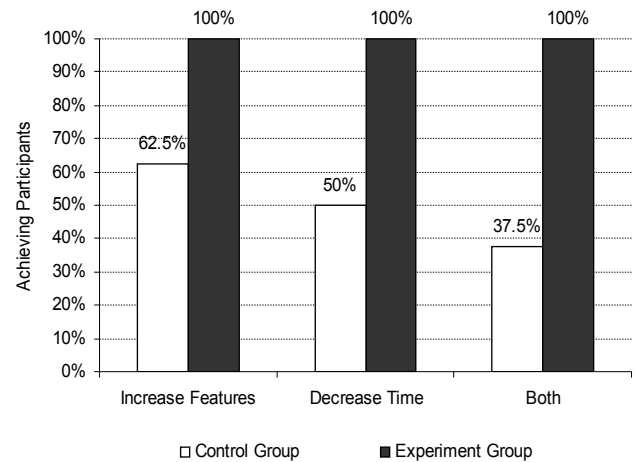

Figure 4: Result Summary – Hypothesis I and II – Graphic Comparisons

4.0 CONCLUSION AND FUTURE WORK

This paper proposed a practical and user friendly of analytic hierarchy process interface for maintenance policy decision making. According to the statistical result, the AHP tool significantly enhances comprehensiveness of decision context by increasing the number of features examined, regardless of situations' difficulty. The AHP tool also significantly contributes to the efficiency of decision-making process by reducing decision makers' time to reach decisions. However, the results also indicate that the decrease in time to reach decisions varies according to situations difficulty. A further study is needed to bridge the problems regarding to the situations difficulty. Users also indicate that the tool contains some limitations. The limitations include, the tool only offer facilitation based on one user for each analysis, while in the real world case, the decision making is made by more than one person. A group decision making interface should be considered in future works. The tool also offers only maximum ten parameters for each criteria, sub criteria and alternatives due to the computer interface problems. More extensive computer interfaces will offer better result when

more rules provided. An extensive study should be conducted to determine the suitable rules for improving its accuracy.

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