Integrating MLP With Algorithm with AHP Modification For Car Evaluation

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Abstract. Analytic Hierarchy Process is a well-known technique in decision making to handle the complexity of multicriteria problems based on hierarchical criteria and sub-criteria structures, evaluate alternative problems and rankings, and choose the best alternative. Decision results in the form of the best alternative are obtained based on the priority weight that each attribute has. The weight search process is carried out by forming a pairwise comparison matrix. But the problems that often occur when doing pairwise comparisons, the AHP method cannot provide a consistent comparison value, especially for problems with a large number of criteria and alternatives. Inconsistent pairwise comparisons will result in the weight of the criteria compared cannot describe the actual conditions. To avoid the problem of inconsistency in the AHP method can be done by minimizing the formation of pairwise comparison matrix. This study discusses how the search process weighted on the problem of Multiple Attribute Decision Making (MADM), especially in AHP techniques using a multilayer perceptron network in determining alternative selection. The results of the study prove that the use of multilayer perceptron can provide better results and save time because the creation of a pairwise comparison matrix is smaller.

1. Introduction
The Analytic Hierarchy Process method is a well-known and widely used method in determining the weight of the criteria as a reference in the decision making process. Various studies have been carried out with this method, as well as combinations with other methods for decision-making problems[1–5]. However, the Analytic Hierarchy Process (AHP) method also has weaknesses in handling cases with a large number of criteria and alternatives. For the decision making process using the AHP method, the problem will be decomposed into several subsystems, so that a large number of pairwise comparisons need to be made to resolve the case.

This approach has the disadvantage that the number of paired comparisons that will be made can be very large with sizes (n (n-1) / 2) so that it will take quite a long time[6]. The Analytic Hierarchy Process (AHP) method often cannot provide consistent comparison values, especially for problems with a large number of criteria and alternatives[7]. The inconsistency shown by a ratio consistency value is very important from the formation of a pairwise comparison matrix to obtain reliability[8]. Because if pairwise comparisons are inconsistent, then it can describe conditions that are not true of the weights generated from the criteria being compared. To avoid the problem of inconsistency in the AHP method, it can be done by minimizing the formation of pairwise comparison matrix. This study...
offers the integration of Multilayer Perceptron with AHP method in the process of determining weights to produce the best alternative as a result of the decision making process. So that the problem of inconsistency in pairwise comparisons when using the Analytic Hierarchy Process (AHP) method for cases with many criteria and alternatives can be overcome.

2. Study Of Literature

2.1. Multilayer perceptron

The Multilayer Perceptron (MLP) method is a method of Artificial Neural Network (ANN) which has a network architecture consisting of at least 3 layers. Multilayer perceptron is a feed-forward artificial neural network consisting of a number of neurons connected by connecting weights. These neurons are arranged in layers consisting of one input layer, one or more hidden layers, and one output layer[9],[10]. The application of this artificial neural network has been widely used in various fields of research[11]–[14].

Multilayer Perceptron is considered as a good learning algorithm, because this neural network can provide outputs that are in line with the expected target. The learning process in multilayer perceptron is a type of supervised learning. The neural network is trained with data that is known right and wrong answers. By calculating the output of the neural network and comparing this to the output for the given test data, we can identify the error and adjust the weights accordingly[15]. The training phase on the network is done by:

- Initialization and set the learning rate (α) with rate value (0< α <1)
- Calculate the output of the hidden cells (using the input cells and the weights between the hidden and input cells)

\[ Z_{inj} = V_{oj} + \Sigma_{i=1}^{n} X_{i}V_{ij} \]  

\[ Z_j = f(Z_{inj}) \text{ if we use sigmoid function } \quad Z_j = \frac{1}{1+\exp(-Z_{inj})} \]  

- Calculate the next layer up, which in this case is the output cells

\[ Y_{in k} = W_{pk} + \Sigma_{j=1}^{n} Z_{j}W_{jk} \]  

\[ Y_{k} = f(Y_{in k}) \]  

Where \( y_k, k=1,2,3 \ldots m \)

This process is commonly referred to as feeding the data forward, or more simply, feedfoward.

Fix weight and bias if an error occurs:

The error is defined as the expected result minus the actual result.

\[ e = T - y_k \]  

\[ W^{new} = W^{old} + \alpha TX_i \]  

Alpha (α) is the learning rate, T is the target (or expected) result, and X_i is the input value for current weight w_i.

2.2. AHP theory

The Analytic Hierarchy Process developed by Saaty, is a method of analysis and synthesis that can solve problems in decision making with the aim of setting priorities from various alternative choices that are complex. Complex problems mean that the criteria for the problem are numerous, have unclear problem structures, uncertainty about the opinion of decision makers, more than one decision maker, and inaccurate data.
AHP has the principle of simplifying a complex and unstructured problem into parts formed in a hierarchy[16]. The hierarchical structure can be categorized as complete and incomplete. Complete hierarchy means that all elements at a level have a relationship to all elements at the next level. While incomplete means not all elements in each level have a relationship. The arrangement of this hierarchy aims to determine the priority value or weight as the basis for decision making.

2.2.1. Weighting of criteria using AHP method

The basic concept principle of AHP includes the following procedures[17]

- Decomposition, put the problem into hierarchical form[18].
- Priority determination through pairwise comparison. Pairwise comparison judgements were performed based on predefined rating value. The scale for Pairwise comparison analysis can be seen as in Table 1.
- Priority synthesizing

\[
w = \frac{1}{n} \sum_{j=1}^{n} \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, i,j = 1,2, \ldots, n
\]  

(7)

- Evaluated consistency

The consistency of the judgements made is checked through the CR value, where CR<10% is recommended for consistent judgement decisions. First we consistency index (CI) and then Calculate consistency ratio (CR)

\[
CI = (\lambda_{max} - n)/(n - 1)
\]  

(8)

where \( n \) is the matrix size or criterion

\[
CR = CI/RI
\]  

(9)

where RI is the random consistency index of the same order matrix, can be seen as in Table 2.

**Table 1. Importance Scale for Pairwise Comparison Matrixs Analysis[19]**

| Relative Intensity | Definition                      |
|--------------------|---------------------------------|
| 1                  | Equal importance                |
| 3                  | Slightly more importance        |
| 5                  | Essential or high importance    |
| 7                  | Very high importance            |
| 9                  | Extreme importance              |
| 2,4,6,8            | Intermediate values between two adjacent judgements |

The reciprocals such as 1/3,1/5,1/7 and 1/9 obtained based on the inverse values of the scale.

**Table 2. Random index (RI)**

| N  | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|----|-----|-----|-----|-----|-----|-----|-----|-----|
| R1 | 0.58| 0.90| 1.12| 1.24| 1.32| 1.41| 1.45| 1.49|

3. Methodology

In this study the problem of determining the alternative weight in cases with many criteria, the AHP method will be integrated into the multilayer perceptron network.

3.1. Flowchart results

The Flowchart integrasi Multilayer Perceptron (MLP) with Analytic Hierarchy Process (AHP) method can be seen as in Figure 1.
3.2. Data used
The data used comes from Car Evaluation dataset for Machine Learning and Intelligent Systems. It was first presented by M. Bohanec in 1997[20]. The Car Evaluation database contains of 1728 sample data that consist of 4 class distribution such as Unacc, Acc, Good and Vgood with six input attributes: buying, maint, doors, persons, lug_boot, safety.

| Attribute  | Value |
|------------|-------|
| Buying     | Vhigh | High | Medium | Low |
| Maint      | Vhigh | High | Medium | Low |
| Doors      | 2     | 3    | 4      | 5-more |
| Persons    | 2     | 4    | More   | -   |
| Lug_boot   | Small | Medium | Big | - |
| Safety     | Low   | Medium | High | - |

3.3. Structure of hierarchy
The hierarchical structure of the car evaluation can be seen in Figure 2.
3.4. Architecture of MLP

In this study, the integration of the multilayer perceptron network to determine the alternative weight in the Car Evaluation is shown through the built network architecture can be seen in Figure 3.

![Figure 3. Architecture of Multilayer Perceptron (MLP)](image)

From the picture above, shows the number of input variables to be trained is \(x_1 \sim x_{12}\) which is the value of each attribute buying, maint, doors, persons, lug_boot and safety. \(H_1 \sim h_n\) shows the number of hidden layers in the network that was built. And the \(y_1 \sim y_2\) variable is the output target which is the result of training. The expected output target of this training is in the form of class types in Car Evaluation when its value \(y_1=0\) and \(y_2=0\) is unacc, if \(y_1=0\) and \(y_2=1\) is acc, if \(y_1=1\) and \(y_2=0\) is good then if \(y_1=1\) and \(y_2=1\) is vgood.

3.4.1. Data pre-processing

The Car Evaluation dataset contains nominal data, attribute data and class data. To perform data processing, the dataset is changed to numerical data. Conversion of nominal data to numerical data is based on the value of the dataset attribute, by transforming the attribute value data using unary encoding with a combination of numbers 0 and 1. This is done because generally the perceptron network can only process data in the form of numbers.

3.4.2. Initialization

The initialization process is carried out before the training phase. This initialization is done with the aim to determine the network parameter values that have been previously designed. The network
The values shown in Table 5 are obtained based on the results of normalization between the criteria being compared. After the normalization process is complete, the relative weight can be calculated by calculating the values of each attribute line, and then dividing it by the number of attribute elements. From the sum of the results obtained weights of each criterion are: 0.02755, 0.04515, 0.11049, 0.11301, 0.29342, 0.41038. After the relative weights are obtained, the consistency of the data will be measured based on equations 8 and 9. The results of testing data consistency, obtained the value of the consistency ratio (CR) of 0.08 which indicates that the data can be received.

4. Analysis and Result

4.1. Data testing
To find out the results of the research done, it was tested against the designed system. The testing process to determine the alternative weight in the case of evaluation of the car with the Multi Layer Perceptron network integration and AHP technique is carried out on 500 test data by limiting the epoch value starting from 100, 200, 300, 400 to 500 epochs, and adjusting the learning rate at 0.2. with 5 hidden layer Then the weighting results can be shown in table 7.

Table 6. Car Evaluation Data Real

| Number of Instances | Class (%) |
|---------------------|-----------|
| 500                 | 85.6 14.4 0 0 | 
Table 7. Integrated MLP With AHP Method Result

| Number of Sample | Epoch  | Time Process | Class (%) | Unacc | Acc | Good | Vgood |
|------------------|--------|--------------|-----------|-------|-----|------|-------|
| 500              | 100    | 0:14:41      | 0.8       | 96.8  | 2.4 | 0    |       |
|                  | 200    | 0:30:47      | 1         | 98.6  | 0.4 | 0    |       |
|                  | 300    | 0:44:22      | 0.2       | 99.4  | 0.4 | 0    |       |
|                  | 400    | 0:59:44      | 0.4       | 97.4  | 2.2 | 0    |       |
|                  | 500    | 1:14:22      | 85.4      | 14.4  | 0.2 | 0    |       |

Based on the values shown by the two tables above, it can be concluded that the integration of multilayer perceptron with the AHP method to determine the weights on the evaluation of car acceptance can provide good results because the data obtained is not much different from the actual data.

4.2. View of graphic result
Comparison of the test results on 500 test data using the perceptron method with multilayer network architecture against the actual data, more clearly displayed in graphical form in figure 4.

![Figure 4. View of Integrated MLP With AHP Method Result](image)

5. Conclusion
Based on the testing conducted on the evaluation of car acceptance, it can be concluded that the integration of multilayer perceptron networks can minimize the creation of pairwise comparison matrices in multicriteria cases, so as to avoid inconsistencies in matrix formation. The test results show that the integration of the perceptron multilayer network with the AHP method in determining the alternative weights gives significant results. But learning rate settings need to be considered for testing more data.

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