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Implementation of Decision Support on the Selection of Hybrid Vehicles Using Saw Method

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ABSTRACT: Motorized vehicles in Indonesia has reached approximately 133 million units in 2019, including the growth of hybrid, that has seen a considerable increased throughout 2020. A hybrid car is a vehicle that uses two types of technology to function. Hybrid electric cars in general have a speed of 50km/h or the equivalent of 14 m/s. With this data, private users realize that hybrid vehicles can be used as an alternative choice in purchasing a car. However, the problem that often occurs is the lack of information affecting user confidence in choosing the desired car. Because of these specific problems, it is essential to create a decision support system that can be used to solve these problems. Here the authors use the Simple Additive Weighting (SAW) method, aiming to produce a decision support system in the selection of a website-based hybrid car. The research method used in this paper includes planning, analysis, design, implementation and testing. The process of making a website using a navigation structure as a website flow, display design and utilizing ML as an overview of the created system, which then was implemented in the PHP programming language with MySQL as the database manager. The final stage tested in accordance with the design based on black box trials.

KEYWORDS:SAW, Hybrid Vehicles, Support System, Hybrid Cars, PHP

I. INTRODUCTION

Transportation is a necessity in today's life, especially personal transportation which is very much needed to facilitate with daily activities. However, behind the growth of transportation, the need for fuel energy used in transportation is running low. Human dependence on these fuels has led to an energy crisis and caused problems in the form of environmental pollution. Therefore, transportation manufacturers are competing to create technology in anticipating these problems[1], by making hybrid vehicle for transportation. A hybrid or hybrid car is a vehicle that uses two types of technology for its power source (Laka, et al. 2018) whereby hybrid electric cars generally have a speed of 50 km/hour or the equivalent of 14 m/s (Nugroho and Agustina, 2015).

The Association of Indonesian Automotive Industries or GAIKINDO noted that sales of hybrid electric cars throughout 2020 jumped to 61.75. With the existing data, it can be said that private car users are aware that hybrid vehicles can be used as an alternative choice when users want to buy or change car. On the other hand, many innovations are offered from various hybrid car producers with all the advantages and disadvantages, both in terms of price, power, and other factors.

The need for a computerized system will be part of the solution to the problems experienced by users in obtaining and knowing information regarding hybrid technology and existing car specifications as well as helping users or prospective hybrid car buyers to obtain a good decision in choosing a hybrid car that suits them. With the decision support system, it is expected to be able to assist users in making choices and producing the best alternatives according to the user or decision maker.

This study uses the DSS method, one of which is the Simple Addictive Weighting (SAW) method. The SAW method is often known as the weighted addition method, where the basic concept

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of this method is to find the weighted sum of each performance rating on the alternatives in all attributes (Ismanto, Effendi. 2017). The SAW method itself has several advantages when compared to other methods. One of the advantages of the SAW method compared to other decision-making models lies in its ability to be able to make a more precise assessment because it is based on predetermined criteria and preference weights. Also, SAW is able to select the best alternative from a number of alternatives because of the ranking process (Darmastuti, 2013).

II. THEORETICAL BASIS

In the early 1970s the concept of a Decision Support System was introduced by Michael S. Scott Morton as Management Decision System. Decision support system (DSS) is a system that can be used to assist someone in making accurate decisions from various choices. Many problems can be solved by using a decision support system (Faishal and Permana, 2015). A Decision Support System is used as a computer-based system consisting of three interacting components: a language system, which is a mechanism for providing communication between users and other components of a Decision Support System, a knowledge system, which is a repository of problem domain knowledge that exists either as data or as procedures and problem processing systems, which is the relationships between other components consist of one or more general problem manipulation capabilities treated for decision making. The decision-making stages have four stages, called Intelligence, Design, Choice and Implementation (Simangunsong and Sinaga, 2019).

Simple Additive Weighting (SAW)

The simple additive weighting (SAW) method is often also known as the weighted addition method. The basic concept of the Simple Additive Weighting (SAW) method is to find the weighted sum of the performance ratings on each alternative on the attribute (Ismanto and Effendi, 2017). The Simple Additive Weighting method is used to solve the selection problem. The Simple Additive Weighting method is a method that is widely used in decision making that has many attributes. The Simple Additive Weighting method requires a process of normalizing the decision matrix (X) to a scale that is obtained compared to all existing alternative ratings (Nofriansyah, 2014).The formula to perform the normalization is as follows:

$$r_{ij} = \begin{cases} \frac{x_{ij}}{Max\, x_{ij}} & jika\ j\ adalah\ atribut\ keuntungan\ (benefit) \\ \frac{Min\, x_{ij}}{x_{ij}} & jika\ j\ adalah\ atribut\ biaya\ (cost) \end{cases}$$

Note :
Maxi : The largest value of each row and column.
Mini : The smallest value of each row and column.
rij : Normalized performance rating of the alternative.
Xij : The attribute value of each criterion.
Benefit : If the greatest value is the best.
Cost : If the smallest value is the best.

Then here is the formula for calculating the preference value for each alternative (Vi) :

$$Vi = \sum_{i=0}^{n} Wj\ rij$$

Note :
Vi : Rank for each alternative.
wj : Rank weight value
rij : Normalized performance rating value

Meanwhile, to find the weight value, first use the formula (wj) as follows:

- A large Vi value indicates that the alternative Ai is more selected.
- The advantage of the Simple Additive Weighting method compared to other decision system methods lies in its ability to make a more precise assessment based on the value of the criteria and the weight of the level of importance required.

The Hybrid Car System

A hybrid or the hybrid car is a vehicle that uses two types of technology needed for its power source (Laka, et al. 2018). The conventional car only has a gasoline engine as fuel, unlike a hybrid car which has another engine source, called the battery as a fuel source. This power source is not used directly, but the gasoline engine is used as the main power and the battery engine is used as a backup energy. Therefore, a hybrid is the combination of two different sources of engine that uses fuel oil and an electric motor to power the car. The resulting vehicle is fuel efficient and emits less carbon dioxide than conventional cars.
Hybrid car technology has two different engines, a conventional engine unit (gasoline or diesel engine) and an electric engine. The main engine uses the conventional engine, it is relatively small and has less power than a normal car engine. When a conventional engine moves with a somewhat excessive engine speed, the electric engine converts the energy from excessive engine rotation into electrical energy and then stored in a special

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battery. There are three characteristics of hybrid technology vehicles; Series Hybrid System, Parallel Hybrid System, Series-Parallel Hybrid System.

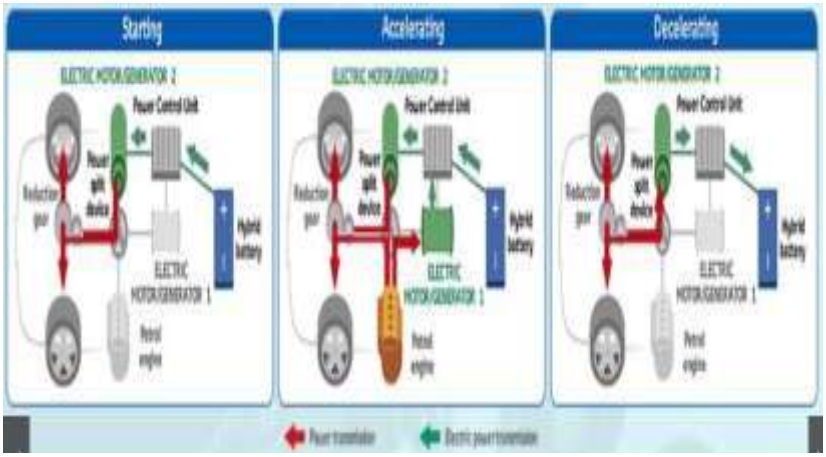


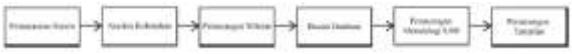
Illustration of How Hybrid Cars Function

Previous research have carried out are several studies related to decision support systems in the selection of hybrid cars, such as the research by IrwanSetiadi (2019) entitled Decision Support System for Selection of Used Cars Using the AHP and SAW methods at Nava Sukses Motor. This research uses two techniques, called AHP and SAW in determining the choice of used cars with 4 criteria, which are the year of manufacture, engine capacity, car color, and purchase price.

Another study with the same scope by HarisTrionoSigit and Dede AdhitiyaPermana (2017) LCGC Car Selection Decision Support System Using Simple Additive Weighting. This study uses the SAW method in determining the choice of an LCGC car based on 6 criteria; tank capacity, cylinder content, maximum power (Rpm), maximum power (Ps), maximum torque. The latest research conducted by Harsiti and Henri Aprianti (2017) Smartphone Selection Decision Support System By Applying the Simple Additive Weighting (SAW) Method. This study uses the analysis technique of the SAW method in determining smartphones with 5 criteria, which are price, ram, internal memory, camera, and layer.

III. ANALYSIS AND DESIGN

The stages in this research consist of six parts, they are System Design, Needs Analysis, Website Design, SAW Methodology Design, Display Design as shown in the following figure.



Research Stages

In making the website it started from system planning such as collecting the required data. The next stage is a need analysis, creating an overview of the software and hardware requirements in the website creation process. The website design stage is intended to describe the flow of the website and the flow of user and admin activities. The next stage is to design a database that goes into the design stage to store and process data on the website that we will create. The SAW design stage is the stage where the calculation process is to determine the best decision based on the results recorded by the user. The last stage is the display design which contains the design of the website that was created.

Website Design

At this stage the authors designed a website by designing a system using the Navigation Structure and Unified Modeling Language. The navigation structure is used to explain the relationship of the content on the website application with directed information. The navigation structure itself is divided into four different types of structures, which are hierarchical navigation structures, linear navigation structures, non-linear navigation structures, and mixed navigation structures. In making this research the authors used a mixed navigation structure which is a navigation structure derived from linear navigation structures, non-linear navigation structures and hierarchical navigation structures.

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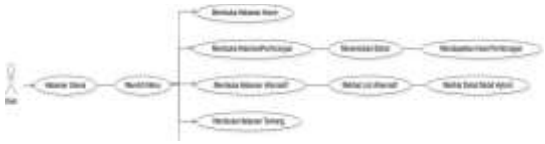
There are two mixed navigation structures used in this application; the user navigation structure and the admin navigation structure. The following is an example of a website creation navigation structure display on the user section.

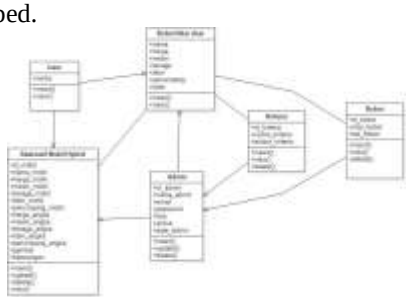
User Display

In the creation of the application a use case has been designed where there is an admin use case as the manager of this website. The roles that will be generated are like adding alternatives to smartphones, changing, deleting and managing weight value data from the criteria that the user will input. The display of the use case design can be seen in Figure 4 below.



Use Case Diagram User

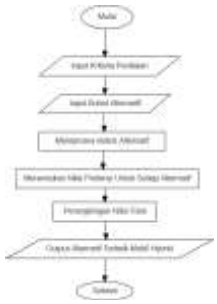
Class Diagram is also one of the elements producing the system in this study. Class diagram is used to describe the flow of the database on a system. With this class diagram, the flow of the database in the SPK application for selecting a website-based android smartphone will be described.



Class Diagram

Simple Additive Weighting Process Flowchart

The first calculation process in this system is done by entering the value of the criteria on each hybrid car and then determining the weight value of each predetermined criterion, then the system will process the input value and produce an alternative matrix normalization of each existing criterion. The results of the calculations will be displayed with the best alternative results. The following is an image of a flowchart of the calculation process of the SAW method.



SAW Calculation Process Flowchart

The decision support system website created in making hybrid car decisions uses a MySQL database and is managed using phpMyAdmin. This database is intended as a place to store all data so that it can be managed easily. Database is an indispensable item the creation of a awebsite.After determining and creating a database, the decision support system then starts determining a hybrid car using the Simple Additive Weighting (SAW) method, carrying out a calculation process that has several phases before completion. First, decide the criteria for evaluating the best hybrid car with the assessment criteria assessed in the selection of a hybrid car, with the following conditions:

1. Price (C1)
2. Engine Capacity (C2)
3. Power (C3)
4. Fuel Consumption (C5)
5. Passenger Capacity (C6)

The following is a hybrid car assessment to find the best alternative in deciding a hybrid car suitable for your needs using the Simple Additive Weighting (SAW) method which can be seen in table 1.

Table 1 Hybrid Car Rating

Name	Price	Machine (CC)	Energy	Fuel	Passenger
Corolla Cross Hybrid	Rp. 518.000.000	1800 CC	170 HP	20 KM/L	5
C-HR Hybrid	Rp. 580.040.000	1800 CC	165 HP	24 KM/L	5
Corolla Altis Hybrid	Rp. 592.500.000	1800 CC	168 HP	21 KM/L	5
Camry Hybrid	Rp. 849.500.000	2500 CC	176 HP	24 KM/L	5
Nissan Kicks	Rp. 471.000.000	1200 CC	127 HP	25 KM/L	5

The following are some of the assessment criteria that will be used in the search for the best alternative in deciding a hybrid car.

Table 2 Based on price

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PRICE	POINT
<515.000.000	1
515.000.001 - 550.000.000	2
550.000.001 - 580.000.000	3
580.000.001 - 600.000.000	4
>600.000.001	5

Table 3 Based on engine

MACHINE	POINT
>1900	5
1701-1900	4
1501-1700	3
1301-1500	2
<1300	1

Table 4 Based on power

ENERGY	POINT
>170	5
166-170	4
161-165	3
155-160	2
<155	1

Table 5 Based on fuel

FUEL	POINT
>=25	5
24	4
23	3
<=22	2
21	1

Table 6 Based on passenger capacity

PASSENGER	POINT
>5	5
4	4
3	3
2	2
2	1

After determining the criteria for each subsequent assessment, each value in the table will be made into an X matrix which is presented in the form of an alternative table that has been adjusted to the predetermined criteria assessment. The table can be seen in table 7 below.

Table 7 Table of Alternatives and Criteria

Alternatif	Kriteria				
	C1	C2	C3	C4	C5
A1	2	4	4	1	4
A2	3	4	3	4	4
A3	4	4	4	1	4
A4	5	5	5	4	4
A5	1	1	1	5	4

Where, C1: Price, C2: Engine, C3: Power, C4: Fuel, C5: Passenger

Next is to normalize the value of the X matrix in table 7 as follows:

1. C1 is the price result criteria, each value is normalized, as follows:

R1,1 = Min(2;3;4;5;1)/2 = 1/2 = 0.5
R2,1 = Min(2;3;4;5;1)/3 = 1/3 = 0.333
R3,1 = Min(2;3;4;5;1)/4 = 1/4 = 0.25
R4,1 = Min(2;3;4;5;1)/5 = 1/5 = 0.2
R5,1 = Min(2;3;4;5;1)/1 = 1/1 = 1

2. C2 is the engine result criteria, each value is normalized, as follows:

R1,2 = 4/Max(4;4;4;5;1) = 4/5 = 0.8
R2,2 = 4/Max(4;4;4;5;1) = 4/5 = 0.8
R3,2 = 4/Max(4;4;4;5;1) = 4/5 = 0.8
R4,2 = 5/Max(4;4;4;5;1) = 5/5 = 1
R5,2 = 1/Max(4;4;4;5;1) = 1/5 = 0.2

Additionally C3, C4 and C5 use the same formula as C2. Then we get the results as shown in the table below.

Table 8 Normalization Table

Alternatif	Kriteria				
	C1	C2	C3	C4	C5
A1	0.5	0.8	0.8	0.2	1
A2	0.33	0.8	0.6	0.8	1
A3	0.25	0.8	0.8	0.2	1
A4	0.2	1	1	0.8	1
A5	1	0.2	0.2	1	1

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Then if the above results have been found, calculate the weights with a formula that will give the following results.

1. W1 is the value of the price weighted results, as follows:

W1 = price alternative normalization result / alternative normalization amount = 5/18 = 0.278

2. W2 is the result value of engine weight (cc), as follows:

W2 = machine alternative normalization result / number of alternative normalization = 2/18 = 0.111

3. W3 is the value of the power weight (hp), as follows:

W3 = alternative normalization result / number of alternative normalization = 3/18 = 0.167

4. W4 is the result value of fuel weight, as follows:

W4 = alternative fuel normalization result / number of alternative normalization = 3/18 = 0.167

5. W5 is the result value of passenger weight, as follows:

W5 = passenger alternative normalization result / number of alternative normalization = 5/18 = 0.278

After calculating the weights, then calculating the preference value (Vi) or the total value of each alternative as follows.

1. Corolla Cross Hybrid: Vi,A1 = (0.5)(0.278)+(0.8)(0.111)+(0.8)(0.167)+(0.2)(0.167)+(1)(0.278)
= 0.6728
2. C-HR Hybrid: Vi,A2 = (0.3333)(0.278)+(0.8)(0.111)+(0.6)(0.167)+(0.8)(0.167)+(1)(0.278)
= 0.6933
3. Corolla Altis Hybrid: Vi,A3 = (0.25)(0.278)+(0.8)(0.111)+(0.8)(0.167)+(0.2)(0.167)+(1)(0.278)
= 0.6033
4. Camry Hybrid: Vi,A4 = (0.2)(0.278)+(1)(0.111)+(1)(0.167)+(0.8)(0.167)+(1)(0.278)
= 0.7452
5. Nissan Kicks: Vi,A5 = (1)(0.278)+(0.2)(0.111)+(0.2)(0.167)+(1)(0.167)+(1)(0.278)
= 0.7786

The last stage of the research is sorting or put into ranks the calculated preference values, by determining the alternative that has the largest total value or close to 1, that will be selected as the best alternative.

Table 9 Sorting or Ranking Table

Alternate	Total Point	Rank
Corolla Cross Hybrid	0.6728	4
C-HR Hybrid	0.6933	3
Corolla Altis Hybrid	0.6033	5
Camry Hybrid	0.7452	2
Nissan Kicks	0.7786	1

IV. IMPLEMENTATION

The interface is a means of communication between the existing system and the user in order to facilitate the user to navigate the system. The display design is made to explain the layout of the interface design used in making this website. While the actual interface will be made with a coding process, some of these display designs can be used according to the need of the system created.

Alternative Page Display Designs

An alternative page display design is made to enable users to view alternative information on hybrid cars in a website-based application. Containing pictures and detail buttons to understand the specifications of a hybrid car.

Alternative Page Designs

Calculation Page Display Design

Afterward is to make a calculation page design, as a place for the user to determine the weight value of each criterion and then processed when the user presses the button provided and results will be displayed on the results page.

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Calculation Page Design

The results page display design provides output from the input results that have been stored by the user on the calculation page displayed in the weight table. The display can be seen in the following figure.

Results Page Design

IMPLEMENTATION AND TESTING

In the implementation, the rough design that has been made in the previous section can determine whether the system or application was built according to the initial plan and can be used perfectly or not.

Calculation Page

The calculation page is the page that is used to determine the weight value inputted from each of the existing criteria then processed and the results displayed on another page, this is called the calculation results page. On this page there is also a description where the input weights have different values, there is a logo along with a navigation bar to go to other pages. The display calculation page is shown in the following image.

Calculation Display

Calculation Results Page Display

The calculation result page is the result page previously inputted by users. This page will display the logo along with the navigation bar and the results of calculations using the Simple Additive Weighting (SAW) method in the form of a ranking table, the highest value from the ranking table is the best alternative and best suits the user's needs. The calculation result page displays as shown in the image below.

Calculation Result Display

Alternative Page Display

Alternative page is a page where the results are displayed and processed in the form of alternative information on hybrid cars that are in this website-based application and logos are placed along navigation bars enabling navigation to other pages. The alternative page display is as shown in the following image.

Car Alternative Display Page

Application and System Trial

The aim of this trial stage is to find out whether the existing functions on the website application can function properly and also decide whether the application can be used according to expected purpose. In testing this hybrid car decision support system application, the Black Box trial is employed. Black box testing is a test focusing on the functional specifications of a software or system, testing is done by defining a set of input conditions and testing the program's functional specifications. The black box trial is the testing phase of the hybrid car website application. This test is carried out to discovery whether the system is running as intended. This test is carried out on the admin page, which can be seen in table 10.

Table 10 Black Box Trial

Test Cases	Expected Results	Result obtained	Remarks
Valid email and password	Displaying admin page	Admin page successfully displayed	Successful

Invalid email and password	Displaying invalid message	Invalid message successfully displayed	Successful
Change admin profile	Change admin profile can be done	Admin profile successfully changed	Successful
Delete alternative	Alternative can be deleted	Alternative successfully deleted	Successful
Change alternative data	Alternative data can be changed	Alternative data successfully changed	Successful
Add alternative	Alternative can be added	Alternative successfully added	Successful
Remove user input value weight	User input value weight removed	User input value weight successfully removed	Successful
Logout	Display login page	Login page successfully displayed	Successful

V. CONCLUSION AND SUGGESTIONS

The hybrid car selection decision support system website application has been successfully created and system testing has been carried out using the black box method. The test results established that all system functions from the Hybrid Car Selection Decision Support System Website effectively function according to the expected design. With this website user are facilitated when deciding to choose a hybrid car based on the weight of the criteria determined by the user themselves according to their desired need.

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