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Implementation of Simple Additive Weighting Method for Biomass Selection in IoT-Based Smart Stove

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Abstract

Technology is now needed most in everyday society. Many things have changed to become modern and sophisticated because of the role of technology. It helps with cooking food or drinks at home. The stove is one of the most critical components in the kitchen. A furnace can help cook food or beverages. The use of gas stoves is cost-intensive. Liquid petroleum gas (LPG) is a stove fuel often used by people for cooking. As cooking demands increase, gas consumption increases, causing gas expenses to become more and more costly. We make an intelligent or innovative stove with advantages. This smart stove is medium and portable so that it can be taken anywhere; besides that, this tool uses a supercapacitor to store the electric voltage generated in the heat of biomass combustion; this tool can generate electricity from biomass and solar cells. The selection of biomass types using the Simple Additive Weighting (SAW) method, namely wood or waste. The Internet of Things (IoT) is an information medium for the innovative stove process. In addition to cooking, this tool can turn on 1 LED lamp measuring 5-10 watts as a cellphone charger with as much as 5 volts or 60 minutes of charge time. The advantages of this intelligent stove are that it is beneficial to the community to reduce gas prices.

Keywords: Smart stove, internet of things, simple additive weighting, biomass.

1. Introduction

Society now needs technology in various fields, including biomass. Biomass, organic material produced from plants, is commonly used as energy in substantial quantities. Biomass is common in everyday life, such as grass, trees, etc. Biomass is also called bioresource, which means living resources that humans can use. Wood, water hyacinth, palm oil, sugar cane, kitchen waste, straw, sawdust, seaweed, and even livestock manure are all included in biomass. Biomass can be used as a fuel power source and as building materials, animal feed, and others [1], [2], [3]. In addition, biomass materials can also be sold and exported as a source of income. The use of biomass has recently become an option. Biomass energy is sustainable (renewable) so that it will not run out for a long time and remain sustainable. Biomass does not contain CO2, so it does not support the increase in greenhouse gas emissions. It makes biomass more environmentally friendly [4].

The collaboration of technology and biomass is something new in this research. Biomass from kitchen waste can be an efficient fuel medium for innovative stoves. A stove is a cooking hearth that uses kerosene, gas, or electricity as fuel. The furnace has a closed/ isolated space from the outside, where fuel is processed to heat items placed on it [5]. One of the activities related to using LPG gas stoves is cooking. There are several types of cooking, one of which is boiling water. Boiling water is something that someone involved in cooking activities often does [6].

Previous research entitled Design of Automatic Electrical Control System for Halogen

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Electric Stove Based on Microcontroller. A microcontroller is used as a control medium to turn off the fire on the stove. This research does not use IoT as operational information but uses a buzzer [7]. Another study entitled Design of an Automatic Control System for Conventional LPG Gas Stoves in the Arduino Uno-Based Water Boiling Process. This research is about the hot temperature of the water in the stove. Automatic heat temperature control using a microcontroller as an on-off stove [6].

The stove is one of the essential components in the kitchen. Stoves can help cook food or drinks. The use of stoves with gas is very cost-intensive. LPG gas is a stove fuel often used by people for cooking. The price of stoves and LPG gas is now increasing. While cooking needs are also many, this will make the use of gas more and more expensive.

Considering this problem, the author makes an intelligent or innovative stove with advantages. This smart stove is medium and portable so that it can be taken anywhere; besides that, this tool uses a supercapacitor to store the electric voltage generated in the heat of biomass combustion; this tool can generate electricity from biomass and solar cells. The selection of biomass types using the SAW method, namely wood or garbage. The Internet of Things (IoT) is an information medium for the innovative stove process [8]. In addition to cooking, this tool can turn on 1 LED lamp measuring 5-10 watts and be used as a cellphone charger for as much as 5 volts or 60 minutes of charge time. The advantage of this intelligent stove is that it is beneficial to the community in reducing the cost of gas.

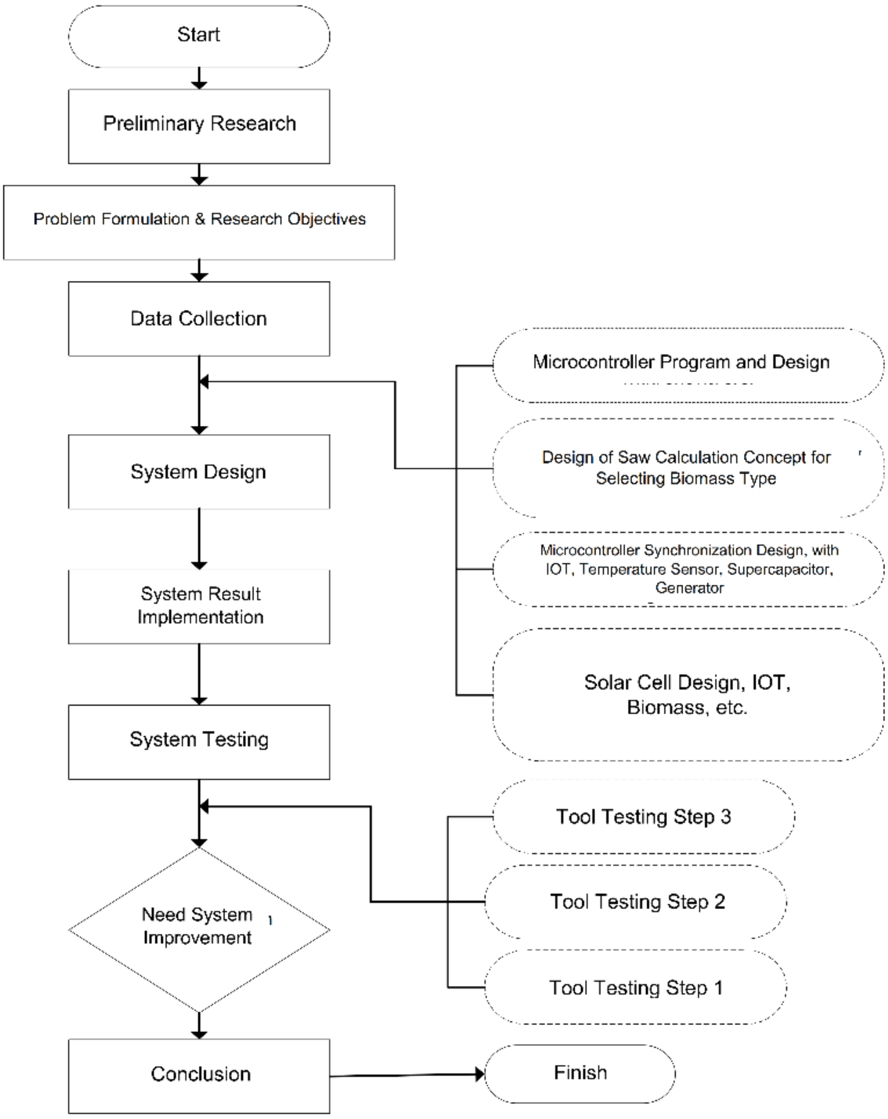
The SAW method is one of the methods used in the decision-making process [9], [10]. The basic concept of the SAW method is to find the weighted sum of the performance ratings on each alternative on all attributes [11]. The SAW method is used to select the types of biomass in this study: wood, kitchen waste, water hyacinth, and oil palm. The criteria that include a decision support system are dry conditions, the level of wetness of goods, the size of goods, and flammability.

This research has a location that is Karanganyar Paiton Village, East Java Province, Indonesia. The trial was carried out based on the collaboration between the electrical engineering study program of Nurul Jadid University and Karanganyar Paiton village. The following is a link to the location map, which is the place of this research: https://maps.app.goo.gl/5GGpM8F6hkTD66mq8.

2. Method

The research method visually breaks down the process from preliminary research to the final testing and implementation of the smart stove's biomass selection feature, as shown in Figure 1. The flowchart, as seen in Figure 1, highlights the integration of various components such as microcontrollers, IoT, sensors, and renewable energy sources like solar cells. The process reflects a structured methodology, ensuring that all stages—research, data collection, system design, implementation, and testing—are thoroughly addressed. This clear representation aligns with the article's aim, showcasing how the Simple Additive Weighting (SAW) method is applied for optimal biomass selection and improving the smart stove's overall efficiency.

Figure 1.
Research Steps



a. Initial Research

The initial step in this research is to visit one of the residents of Karanganyar Paiton village. The initial observation stage of the research location for innovative stoves using biomass based on microcontrollers and photovoltaic. The chief researcher conducted initial research. This initial stage was carried out for 1-10 days.

b. Problem Formulation and Research Objectives

The head and members of the research team carried out this stage. This stage involves interviewing and observing the location to get information on the community's response to this research and formulating problems with one of the residents about using biomass in this portable stove. In addition, it also estimates the size of the solar panel and portable stove holder. This stage was carried out for 1-15 days.

c. Data Collection

The chairman and members of the research team carried out this data collection stage. Data collection includes interviews and observations in the initial research, supported by literature studies. In this study, the research team applies the SAW method to select biomass types [12], including wood, kitchen waste, water hyacinth, and oil palm. They evaluate the biomass options based on specific criteria such as dry conditions, moisture levels, size, and flammability. The decision support system is used to rank the alternatives effectively. This selection process is conducted for 1 to 2 months to ensure accurate results.

d. System Design

The chief researcher, research members, chief technicians, and technicians carry out the system design stage. They are designing microcontrollers, Thermoelectric Generators that function as generators to convert heat energy into electrical energy, Supercapacitors as voltage storage, Protection to protect supercapacitors from excessive voltage, determining data that becomes research material, and 5V DC-DC Step-Up USB Converter to increase voltage. This stage is carried out for 1-2 months.

e. Design Implementation

Design implementation is carried out by the chief researcher, programmer, and chief technician. This stage is the preparation of system implementation at the research location. Previously, the research team provided system training to farmers about the operation of the control system and other electronic components. As the research team explains, this training can be done twice if the Karanganyar villagers have difficulty understanding the system's performance. This stage can also be used as the first program evaluation before farmers operate the tool directly. This stage is carried out for 1-20 days.

f. System Testing

The chief researcher, programmer, and technician perform the System Testing stage. Test the application by testing the system. If appropriate, then continue. If not, then return to system design. The trial and error experiment stage was carried out three times. The first stage is a trial of synchronizing data from the sensor to the microcontroller. The second stage tests the Arduino cloud application with a microcontroller, and the third stage tests the system as a whole. This stage is carried out for 1-3 months.

g. Drawing Conclusions

This stage concludes with the chairman and members of the researcher. Conclusions obtained from the control system and the research process carried out and not further from the research will be suggestions that the following research will further develop. Stages carried out for 1-10 days.

Multi-attribute decision-making (MADM) is evaluating m alternatives A_i (i=1, 2, ..., m) against a set of attributes or criteria C_j (j=1, 2, ..., n), where each attribute is independent of the other [13], [14]. The decision matrix of each alternative against each attribute, *x*, is given as.

$$r_{ij} = \begin{cases} \dfrac{x_{ij}}{\max\limits_{i} x_{ij}} & \text{If j is the profit attribute} \\ \dfrac{\min\limits_{i} x_{ij}}{x_{ij}} & \text{If j is the cost attribute} \end{cases} \quad (1)$$

$$x = \begin{pmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{pmatrix}$$

x_{ij} is the performance rating of the i-th alternative to the j-th attribute; the weight value that shows the relative importance of each attribute is given as w: w = {w_1, w_2,...., wn}[15].

Fishburn states that the SAW method's basic concept, the Weighted Sum Model (WSM), is to find the weighted sum of the performance ratings on each alternative on all attributes [16]. The SAW method requires a normalization process of the decision matrix (x) to a scale that can be compared with all existing alternative ratings [15].

r_{ij} is the normalized performance rating of alternative Ai on attribute C_j where i=1, 2, ..., m and j=1, 2, ..., n. A more excellent value of Vi indicates that alternative A_i is more chosen. The preference value for each alternative (V_i) is as: [15].

3. Result and Analysis

This section presents the results of this research: the tool trial results and the SAW method calculation results. The supercapacitor trial results if it produces a voltage above 6 volts. It is a good trial because it can turn on one 5-watt LED lamp and cellphone charger for 30 minutes with an estimated voltage of 20 volts. An estimated voltage of 10 Volts is equal to 6.5 Amperes. The test results of supercapacitors that store electrical power are in Table 1.

Table 1.
Supercapacitor Test Results

Test run	Date	Biomass Type	Supercapacitor Voltage	Biomass Burning Time	Description		
					Good	Not Good	Biomass Condition
1	August 23, 2023	wood	3.2 volt	2 hours		✓	wet wood
2	August 24, 2023	wood	4 volt	3 hours		✓	wet wood
3	August 25, 2023	wood	4 volt	3 hours		✓	wet wood
4	August 27, 2023	wood	4 volt	3 hours		✓	wet wood
5	August 28, 2023	wood	40 volt	4 hours	✓		dry wood

Test run	Date	Biomass Type	Supercapacitor Voltage	Biomass Burning Time	Description		
					Good	Not Good	Biomass Condition
6	August 29, 2023	leaf	25 volt	3 hours	✓		dry leaf
7	August 30, 2023	leaf	25 volt	3 hours	✓		dry leaf
8	September 01, 2023	leaf	22,6 volt	3 hours	✓		dry leaf
9	September 02, 2023	leaf	23 volt	3 hours	✓		dry leaf
10	September 03, 2023	plastic	20 volt	3 hours	✓		dry plastic
11	September 04, 2023	plastic	10 volt	3 hours		✓	wet plastic

The following test results show the solar cell's voltage power without burning biomass on the portable stove. Solar panel specifications are panel size 354 x 251 x 18mm, maximum power generated 17.5 Volts, visero brand, as shown in Table 2.

Table 2.
Solar cell test results without biomass combustion

Test run	Date	Electrical Power	Solar Panel Drying Time	Description		
				Good	Not Good	Weather Condition
1	September 01, 2023	5 volt	3 hours		✓	cloudy
2	September 02, 2023	7 volt	3 hours		✓	cloudy
3	September 03, 2023	10 volt	4 hours		✓	cloudy
4	September 04, 2023	8 volt	3 hours		✓	cloudy
5	September 05, 2023	14 volt	4 hours	✓		sunny / daytime
6	September 06, 2023	13 volt	3 hours	✓		sunny / daytime
7	September 07, 2023	15,5 volt	4 hours	✓		sunny / daytime
8	September 08, 2023	9 volt	2 hours		✓	cloudy
9	September 09, 2023	9,2 volt	2 hours		✓	cloudy

10	September 10, 2023	6 volt	3 hours		✓	cloudy
11	September 11, 2023	14 volt	4 hours	✓		sunny / daytime

The research results are presented in this section. Research results can be in the form of narrative descriptions, tables, graphs, and other forms that show the presentation of research results, as shown in Table 3.

Table 3.
Tool Operational Test Results

Test run	Time	Tool Component	Description		
			Good	Not Good	Tool Condition
1	September 08, 2023	solar panel	✓		normal
1	September 08, 2023	supercapacitor	✓		normal
1	September 08, 2023	usb converter	✓		normal
1	September 08, 2023	kdh transistor	✓		normal
1	September 08, 2023	dc fan	✓		normal
1	September 08, 2023	2 ampere diode	✓		normal
1	September 08, 2023	heat sink	✓		normal
1	September 08, 2023	led light	✓		normal
1	September 08, 2023	indicator light	✓		normal
1	September 08, 2023	on/off switch	✓		normal
1	September 08, 2023	thermometer	✓		normal

This section contains the test results of calculating the SAW method for selecting the type of biomass in portable stoves and starting from determining the alternative, namely the type of biomass, as shown in Table 4.

Table 4.
Alternative Calculation

Number	Alternative Name	Alternative Code
1	Wood	A1
2	Leaf	A2
3	Trash	A3

As shown in Table 5, the SAW method has five criteria: dry condition, wetness of goods, size, and flammability.

Table 5.
Calculation Criteria

No	Criteria Name	Criteria Code
1	Dry	K1
2	Wetness Level	K2
3	Item Size	K3
4	Flammability	K4
5	Item Weight	K5

Table 6 shows the weight value of each criterion on each alternative. This biomass selection calculation also uses weight values. The value of was a preference value is w = {5,3,4,4,2}.

Table 6.
Loyal weight value criteria on each alternative

Criteria/Alternative	K1	K2	K3	K4	K5
A1	4	4	5	3	3
A2	3	3	4	2	3
A3	5	4	2	2	2

Next is the normalized matrix from Table 6 as follows.

$$x = \begin{bmatrix} 4 & 4 & 5 & 3 & 3 \\ 3 & 3 & 4 & 2 & 3 \\ 5 & 4 & 2 & 2 & 2 \end{bmatrix}$$

Next, the X matrix will be normalized as follows:

$$r11 = \frac{4}{Max\,\{4;3;5\}} = \frac{4}{5} = 0{,}8$$

$$r21 = \frac{3}{Max\,\{4;3;5\}} = \frac{3}{5} = 0{,}6$$

$$r31 = \frac{5}{Max\,\{4;3;5\}} = \frac{5}{5} = 1$$

$$r21 = \frac{4}{Max\,\{4;3;5\}} = \frac{4}{4} = 1$$

$$r22 = \frac{3}{Max\,\{4;3;5\}} = \frac{3}{4} = 0{,}75$$

$$r32 = \frac{4}{Max\,\{4;3;5\}} = \frac{4}{4} = 1$$

Next is the normalized matrix R as follows.

$$R = \begin{bmatrix} 0{,}8 & 1 & 1 & 1 & 1 \\ 0{,}6 & 0{,}75 & 0{,}8 & 0{,}6 & 1 \\ 1 & 1 & 0{,}4 & 0{,}6 & 0{,}6 \end{bmatrix}$$

Next is the ranking process for each alternative and criterion. This step is the last in the SAW method calculation if the highest alternative value is the best choice.

$$A1 = (5)(0{,}8) + (3)(1) + (4)(1) + (4)(1) + (2)(1) = 17$$

$$A2 = (5)(0{,}6) + (3)(0{,}75) + (4)(0{,}8) + (4)(0{,}6) + (2)(1) = 13{,}11$$

$$A3 = (5)(1) + (3)(1) + (4)(0{,}4) + (4)(0{,}6) + (2)(0{,}6) = 13{,}6$$

From the results of this ranking, it is clear that the highest value is alternative 1 = Wood, with a value of 17—drought level 5 (very good).

This section is the result of tool assembly. We starting from the overall tool design in Figure 2 as follows. The following is the result of the tool design. Figure 3 - 5 Smart stove based on Simple Additive Weighting (SAW) method and photovoltaic.

Figure 2.
Smart Stove Design.

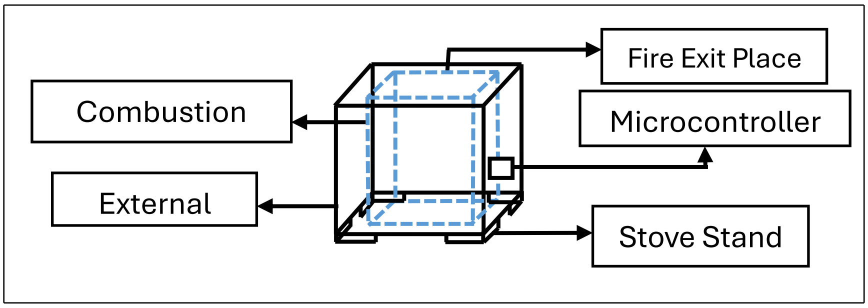


Figure 2 illustrates the design components of a smart stove, highlighting the integration of various elements necessary for its functionality within an IoT-based system. The smart stove design features external components such as combustion and structural elements, along with internal components including microcontroller-based controls, essential for managing the stove's performance. The design is focused on selecting biomass for fuel using the Simple Additive Weighting (SAW) method [17], [18], optimizing the stove's efficiency through automated control.

Figure 3.
Smart stove.

Two primary components—Combustion and External—are listed, indicating the core areas where the combustion process occurs. The combustion zone is essential for the heat generation process, while the external design refers to the stove's structural parts that provide support and house the internal systems. The center of the image features a dashed cube, symbolizing the stove's main body, where internal components are housed. This cube represents the framework holding the smart stove's essential control mechanisms and the compartment where the biomass combustion occurs. It provides a central reference point around which the other components are arranged.

Figure 4.
Smart stove test run

Figure 5.
Smart stove test run

Three other elements are labeled—Fire Exit Place, Microcontroller, and Stove Stand. The fire exit place likely refers to the exhaust system where combustion gases are released. The microcontroller is a key element, responsible for regulating the stove's operations and monitoring its efficiency, making real-time adjustments as necessary based on the IoT system [19]. The stove stand provides stability and support, ensuring the structure is safely elevated and functional.

Overall, the figure demonstrates the interconnectedness of the stove's physical and technological aspects. By integrating IoT technology, the smart stove can optimize fuel selection, combustion efficiency, and overall energy management, making it a modern solution for biomass-based cooking systems.

4. Conclusion

This study has a conclusion that the operation of the tool usually runs, the supercapacitor test that deviates the voltage was not successful in the first trial, the second trial was successful, and the voltage generated by the solar panel was above 10 volts, meaning that the voltage obtained from the solar panel and supercapacitor successfully turned on the 5watt LED lamp and cellphone charger for 60 minutes.

According to the Simple Additive Weighting (SAW) method calculation results, it is alternative = wood. Alternative one has the highest rank value of 17. This rank value is the highest compared to the rank values of alternative two and alternative 3. Wood is a type of biomass chosen for this smart stove because of its dry condition, low wetness level, and small size.

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