# Design of Single User Decision Support System

# Model Based on Fuzzy Simple Additive Weighting

# Algorithm to Reduce Consumer Confusion

# Problems in Smartphone Purchases

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**Abstract**

Nowadays, choosing the most suitable smartphone product is not an easy matter. A large number of product brands, technology features are offered, and unobjective product recommendation from others could make customers more difficult to choose. Therefore, this study proposed a single-user model of Decision Support System application based on Fuzzy Simple Additive Weighting algorithm. It is purposed to facilitate customers to narrow down the set of smartphone product alternatives into several recommendations.

**Keywords**: Single-User Decision Support System, Fuzzy Simple Additive Weighting, consumer confusion, smartphone selection problem

## Introduction

In every aspect when people should purchase something like products or services, people definitely face various confusion problems to consider what is the most suitable product or service for them, before deciding to buy it. Those feelings are such as: feeling of regrets or disapointment may come if people fail to address what they need or what they expect. Scientifically, in this case experts from many disciplines mapped those confusion problems as consumer confusion [8, 9, 12, 13].
        Naturally to avoid or to reduce the confusion, people may have strategies to deal with it. The strategy may be vary, like the traditional method oftenly used by people to reduce the confusion, such as: doing the several product/service check by seeking additional information on the internet, discussing about products' after sales services with close relatives (family, friends, colleagues, etc), or asking to the salesperson to help consider what is the most worth product to be purchased. Experts name those strategies as confusion reduction strategy (abbreviated as CRS) [8, 9, 12, 13].

In some traditional CRS methods, those methods may cause inaccurate decision making process, because there were many assumptions from many sources. In order to reach more accurate, more effective and more objective decision results, several characteristics of Multi Criteria Decision Making (MCDM) could be considered as another alternative of traditional or conventional CRS method. As a subset of Decision Support Systems (DSS), there were several reliable MCDM algorithms could fit to solve consumer confusion problems, such as: Analytical Hierarchy Process (AHP), ELECTRE (Elimination and Choice Expressing Reality), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), Simple Addition Weighting (SAW), PROMETHEE and so on.

This study was trying to reduce consumer confusion problem in smartphone product purchases using single user DSS approach. Researchers proposed a single user model of DSS using Fuzzy SAW algorithm because of its simplicity to develop and implement in computer program. The confusion problem in smartphone product purchases is an interesting issue to investigate, because of the proliferation of smartphone brands, the more advanced smartphone technology offered, further the more competitive smartphone prices with a huge amount of its attractive features and many other aspects which are definitely causing a confusion for its potential consumer to choose the right one.

The main focus of this study is to propose a single user DSS application model based on Fuzzy SAW algorithm, using a computer program to reduce the confusion issues specifically in consumer confusion problem. This static desktop application was built using Microsoft Visual Basic .NET SDK without database management system capability. The software development in this study refers to linear sequential model developed by Pressman [6].

## Related Works

The use of DSS application to solve several decision making problems has many success records on its best practices. Most of scholars or practitioners employs powerful charecteristic of MCDM algorithms to simplify several complex input criteria into one, two, or three important recommendation(s) that could affect to expected decision results. Previous study by Nativade-Jesus, Coutinho-Rodrigues, & Antunes [1] tells about the important contribution of DSS application to solve the housing selection problem in Portugal. The development of DSS application in their study has several purposes, such as: (1) the assessment of property value, (2) the evaluation of property quality, and (3) for supporting consumer needs about the "for sale" property. The combination of three MCDM algorithms, consisting of: SAW, TOPSIS, and ELECTRE in tandem with Geographic Information System (GIS) tool was used in Nativade-Jesus, Coutinho-Rodrigues, & Antunes [1] study. Another important contribution of DSS application study by Coutinho-Rodrigues, Simao, & Antunes [3] which was still located in Portugal, has several strategic impacts for the urban infrastructure investment problem. Coutinho-Rodrigues, Simao, & Antunes [3] named their GIS-Based DSS application as MCPUIS (Multi Criteria Planning of Urban Infrastructure Systems) which has capability to evaluate and compare four investment options on water supply network project in Coimbra city. Their MCPUIS was employed together with three MCDM algorithms, consisting of: SAW, TOPSIS, and ELECTRE I; used for evaluate and compare the alternative of course actions. In this study the development of DSS application aimed to reduce the confusion problem in smartphone product selection. Fuzzy SAW algorithm was used because of its simplicity to develop and implement.

## Method

The design of DSS application software in this study used Pressman sequential linear model on software development and the decision weighting process of the DSS was based on Fuzzy SAW algorithm. The illustration of Pressman framework could be seen in **Figure 1**.



**Figure 1.** Sequential linear model of Pressman framework [6]
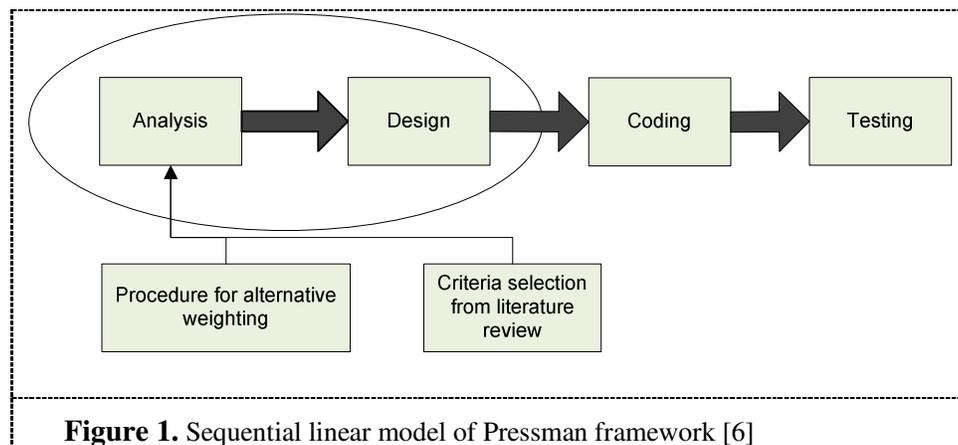
The sequential linear model of Pressman framework [6] consists of four phases. Those phases are: (1) Analysis phase, (2) Design phase, (3) Coding phase, and (4) Testing phase

## Result

Below is brief explanation of several implementation processes on **Figure 1**.

**Phase one: the analysis steps (A)**

*First step*
Using linguistic variable (LV) groupping for fuzzy numbers as used in previous study by Aghajani, Sedaghat, Dargahi, & Pourhossein [2]. The scale of fuzzy numbers in LV was ranging from "very low" to "very high" (see **Table 1**). Then the scale of fuzzy numbers was converted into crisp numbers using the representation of linear triangulation [7] (see **Figure 2**).
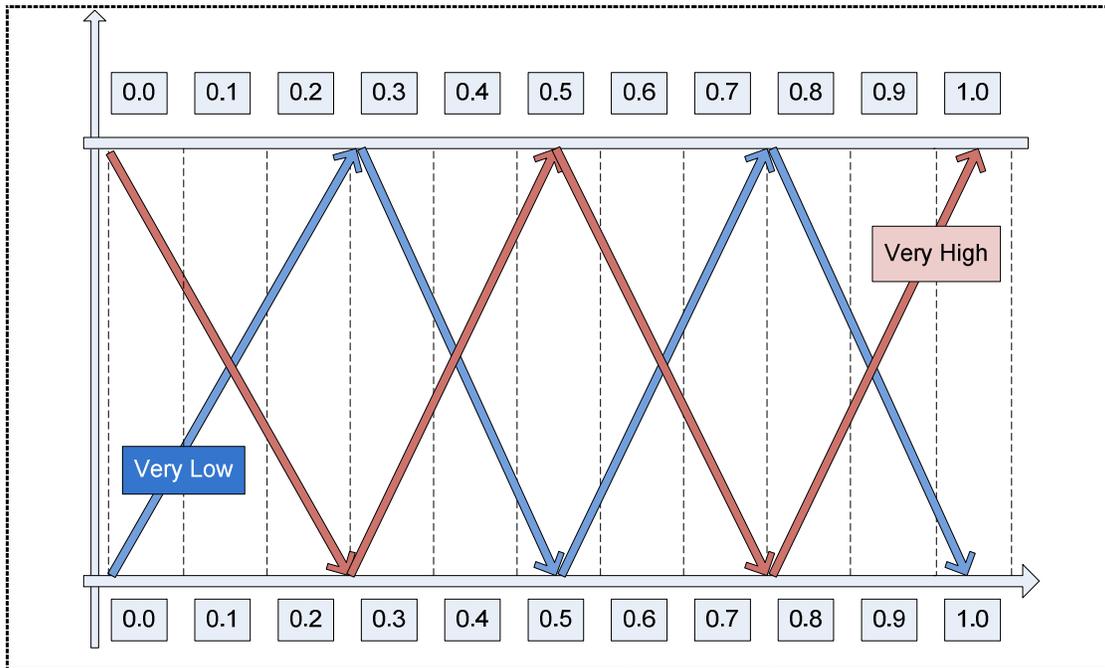
**Figure 2.** Linear triangulation representation model by Kusumadewi [7]

**Table 1.** The linguistic variable for alternative and criteria weighting of Fuzzy SAW algorithm (adapted from Aghajani, Sedaghat, Dargahi, & Pourhossein [2])

| Fuzzy linguistic variable | Conversion from fuzzy linguistic variable into crisp numbers |
|---|---|
| Very Low (VL) | {(0.01), (0.01), (0.25)} |
| Low (L) | {(0.01), (0.25), (0.50)} |
| Normal (N) | {(0.25), (0.50), (0.75)} |
| High (H) | {(0.50), (0.75), (1.00)} |
| Very High (VH) | {(0.75), (1.00), (1.00)} |

**Figure 2.** Linear triangulation representation model by Kusumadewi [7]

*Second step*
After getting the total sum of alternative and criteria weighting values, the second step was creating a comparison matrix between alternative towards the criteria. For example, the data results from smartphone experienced user, gathered four main criteria about smartphone product valuation. The criteria are: (1) product price, (2) battery lifetime, (3) processor speed, and (4) screen size. After all alternative weighting values were gathered, the sample values can be written like in **Table 2**.

**Table 2.** Comparison matrix between alternative towards criteria

| Criteria/Alternative | Criteria | | | |
|---|---|---|---|---|
| | **product price** | **battery lifetime** | **processor speed** | **screen size** |
| **BlackBerry 9330 CDMA** | 0.9 | 0.3 | 0.2 | 0.3 |
| **Samsung Galaxy S4** | 0.3 | 0.4 | 0.9 | 1.00 |
| **LG L9** | 0.5 | 0.7 | 0.7 | 0.7 |
| **HTC One** | 0.4 | 0.6 | 0.8 | 0.8 |

Then, the comparison matrix between alternative towards the criteria can be written as in matrix **M1**:

$$M1 = \begin{bmatrix} 0.9 & 0.3 & 0.2 & 0.3 \\ 0.3 & 0.4 & 0.9 & 1.00 \\ 0.5 & 0.7 & 0.7 & 0.7 \\ 0.4 & 0.6 & 0.8 & 0.8 \end{bmatrix}$$

After the **M1** values were obtained, the next step was consumers turn to do the criteria weighting process using the scale range like in **Table 1**, the scale starts from 0.01 to 1.00**.** The reason of using 0.01 as the smallest value in the scale range is to avoid division by zero which may cause the calculation error.

In example: The consumer wants a smartphone which has several criteria of weighting values like in **Table 3**.

**Table 3.** Matrix with criteria weighting

| Criteria | Weight |
|---|---|
| Product price (-) | 0.60 |
| Battery lifetime (+) | 0.75 |
| Processor speed (+) | 0.82 |
| Screen size (+) | 0.47 |
| | |

**\*Legend**
Negative (-) = i.e. cheaper **product price** is better
Positive (+) = i.e. bigger **screen size** is better

Then, from **Table 3** it can be formed a matrix called as **(N1)** which consists of:

$$N1 = \begin{bmatrix} 0.60 \\ 0.75 \\ 0.82 \\ 0.47 \end{bmatrix}$$

*Third step*

Do the normalization for matrix **M1**, with the following rules (**Theorem 1** & **Theorem 2**):

*For the criteria which have negative weight*

$$n_{ij} = \frac{r_j^{MIN}}{r_{ij}}$$

**Theorem 1.** The normalization formula for negative criteria

*For the criteria which have positive weight*

$$n_{ij} = \frac{r_{ij}}{r_j^{MAX}}$$

**Theorem 2.** The normalization formula for positive criteria

The results should be:

*Row* 1.1 (Product price) = $\frac{Min\{0.9;0.3;0.5;0.4\}}{0.9} = \frac{0.3}{0.9} = 0.33$

*Row* 1.2 (Battery lifetime) = $\frac{0.3}{Max\{0.3;0.4;0.7;0.6\}} = \frac{0.3}{0.7} = 0.43$

*Row* 1.3 (Processor speed) = $\frac{0.2}{Max\{0.2;0.9;0.7;0.8\}} = \frac{0.2}{0.9} = 0.22$

*Row* 1.4 (Screen size) = $\frac{0.3}{Max\{0.3;1.00;0.7;0.8\}} = \frac{0.3}{1.00} = 0.30$

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*Row* 2.1 (Product price) = $\frac{Min\{0.9;0.3;0.5;0.4\}}{0.3} = \frac{0.3}{0.3} = 1.00$

*Row* 2.2 (Battery lifetime) = $\frac{0.4}{Max\{0.3;0.4;0.7;0.6\}} = \frac{0.4}{0.7} = 0.57$

*Row* 2.3 (Processor speed) = $\frac{0.9}{Max\{0.2;0.9;0.7;0.8\}} = \frac{0.9}{0.9} = 1.00$

*Row* 2.4 (Screen size) = $\frac{1.00}{Max\{0.3;1.00;0.7;0.8\}} = \frac{1.00}{1.00} = 1.00$

------------------------------------------------------------------------

*Row* 3.1 (Product price) = $\frac{Min\{0.9;0.3;0.5;0.4\}}{0.5} = \frac{0.3}{0.5} = 0.60$

*Row* 3.2 (Battery lifetime) = $\frac{0.7}{Max\{0.3;0.4;0.7;0.6\}} = \frac{0.7}{0.7} = 1.00$

*Row* 3.3 (Processor speed) = $\frac{0.7}{Max\{0.2;0.9;0.7;0.8\}} = \frac{0.7}{0.9} = 0.77$

*Row* 3.4 (Screen size) = $\frac{0.7}{Max\{0.3;1.00;0.7;0.8\}} = \frac{0.7}{1.00} = 0.70$

------------------------------------------------------------------------

*Row* 4.1 (Product price) = $\frac{Min\{0.9;0.3;0.5;0.4\}}{0.4} = \frac{0.3}{0.4} = 0.75$

*Row* 4.2 (Battery lifetime) = $\frac{0.6}{Max\{0.3;0.4;0.7;0.6\}} = \frac{0.6}{0.7} = 0.85$

*Row* 4.3 (Processor speed) = $\frac{0.8}{Max\{0.2;0.9;0.7;0.8\}} = \frac{0.8}{0.9} = 0.88$

*Row* 4.4 (Screen size) = $\frac{0.8}{Max\{0.3;1.00;0.7;0.8\}} = \frac{0.8}{1.00} = 0.80$

Then, the normalization results from matrix **M1** can be written as in matrix **MN**

$$\mathbf{MN} = \begin{bmatrix} 0.33 & 0.43 & 0.22 & 0.30 \\ 1.00 & 0.57 & 1.00 & 1.00 \\ 0.60 & 1.00 & 0.77 & 0.70 \\ 0.75 & 0.85 & 0.88 & 0.80 \end{bmatrix}$$

*Fourth step:*
Do the calculation for **MN** and **N1** using SAW algorithm (**Theorem 3**)

$$A_i = \sum N1.MN$$

**Theorem 3.** The SAW algorithm

$$N1 = \begin{bmatrix} x1 & \cdots & (x1,n) \\ \vdots & \ddots & \vdots \\ (x3,1) & \cdots & (x3,n) \end{bmatrix}; MN = \begin{bmatrix} y1 & \cdots & y1,\,n \\ \vdots & \ddots & \vdots \\ (y3,1) & \cdots & (y3,n) \end{bmatrix}$$

$$N1MN = \begin{bmatrix} x1y1 & +\cdots+ & (x1,n)(y3,1) \\ \vdots & \ddots & \vdots \\ (x3,1)y1 & +\cdots+ & (x3,n)(y3,n) \end{bmatrix}$$

$A_1 = \{(0.60 \text{ x } 0.33) + (0.75 \text{ x } 0.43) + (0.82 \text{ x } 0.22) + (0.47 \text{ x } 0.30)\} = \mathbf{0.84}$
$A_2 = \{(0.60 \text{ x } 1.00) + (0.75 \text{ x } 0.57) + (0.82 \text{ x } 1.00) + (0.47 \text{ x } 1.00)\} = \mathbf{2.32}$
$A_3 = \{(0.60 \text{ x } 0.60) + (0.75 \text{ x } 1.00) + (0.82 \text{ x } 0.77) + (0.47 \text{ x } 0.70)\} = \mathbf{2.07}$
$A_4 = \{(0.60 \text{ x } 0.75) + (0.75 \text{ x } 0.85) + (0.82 \text{ x } 0.88) + (0.47 \text{ x } 0.80)\} = \mathbf{2.18}$

Finally, the ranking of smartphone recommendations based on Fuzzy SAW algorithm will be (**Table 4**):

**Table 4.** The smartphone ranking based on Fuzzy SAW algorithm

| $A_i$ | *Ranking* | Alternatives |
|-------|-----------|--------------|
| $A_2$ | 1 (2.32) | Samsung Galaxy S4 |
| $A_4$ | 2 (2.18) | HTC One |
| $A_3$ | 3 (2.07) | LG L9 |
| $A_1$ | 4 (0.84) | BlackBerry 9330 CDMA |

**Phase one: the analysis steps (B)**

In the smartphone selection criteria, there were many aspects can be considered as a measurement indicator on criteria weighting process. The aspects are such as: inovative feature, brand image, product price, product recommendation among consumers (like product review), durability, and product portability [11]; advertising and after sales service [10]; product design (quality aspect) [4]. In This study choose ten criteria as a fundamental weighting process; those criteria are based on the combination of literature review and direct interview (survey) from ten   smartphone experienced users. From direct interview, the data which were generated qualitatively can be deducted that inovative features, product price, battery lifetime, and camera quality were most choosen criteria by the consumer. Meanwhile from literature review the other six criteria were display/resolution, weight, dimension, processor speed, built in memory, and built in storage Mokhlis & Yaakop [11], Mokhlis [10].

**Phase two: design of DSS application workflows**
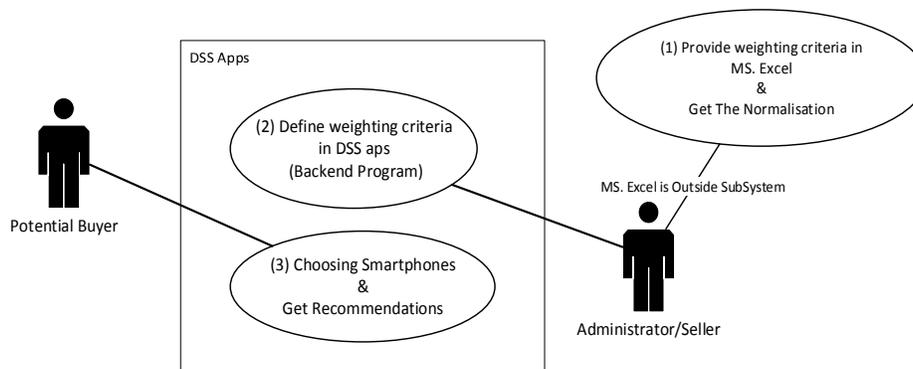
A.   Use-Case Diagram:



**Figure 3.** Use Case Diagram

Explanation of **Figure 3**: (1) Administrator performs weighting criteria using a spreadsheet application like MS. Excel and get the normalized result. (2) Administrator define the normalized results into the application program backend (3) Potential buyers choose smartphones based on the criteria that they need and the FSAW algorithm provide the recommendations. The description of DSS application workflow is more fully described in two section, such as:   *Sequence Diagram – Buyer Perspective* and *Sequence Diagram – Administrator Perspective.*

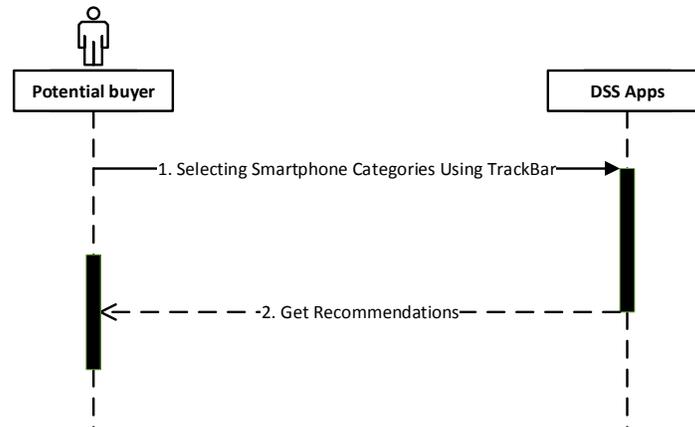B.    Sequence Diagram – Buyer Perspective:



**Figure 4.** Sequence Diagram – Buyer Perspective

Explanation of **Figure 4**: The DSS application workflow is reviewed from the perspective of a potential buyer, then the phase is: (1) using the trackbar slider in the application interface, potential buyers can choose the smartphone category based on the most criteria they need. (2) After a potential buyer gives the weighting criteria by sliding the trackbar function and clicking the recommendations button, then it will display a series of recommendations that fit the potential buyer needs. The recommendation results were based on fuzzy SAW weighting algorithm as written in **Theorem 3**.

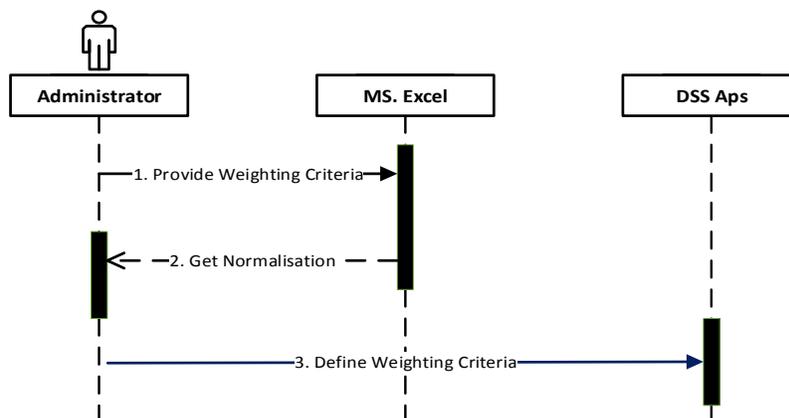C.    Sequence Diagram – Administrator/Seller Perspective



**Figure 5.** *Sequence Diagram - Administrator/Seller Perspective*

Explanation of **Figure 5**: The DSS application workflow is reviewed from the perspective of an administrator, then the phase is: (1) the administrator has had a comparative values between smartphones. The values obtained were from the benchmark results of various technical reports from GSMArena as well as HWM Singapore magazine as in **Table 2**. Then the value obtained, normalized in MS. Excel uses **Theorem 1** and **Theorem 2**. (2) In this step, the value obtained by administrator has been normalized. (3) Furthermore, the normalized values were defined in the DSS application back-end program as the indicator of criteria weighting.

**Phase two: design of DSS application interface**

To implement a computation algorithm (e.g. FSAW, AHP, etc.) actually can use spreadsheet applications such as MS. Excel, as done by Bonometti [5] when he made an application of DSS / ES (Expert System) Shell to help students learn to manage a project. However, in order to attract more attention and facilitate respondents to select the appropriate smartphone products, the prototype of DSS application interface which is simple and easy to use, needs to be developed [1].
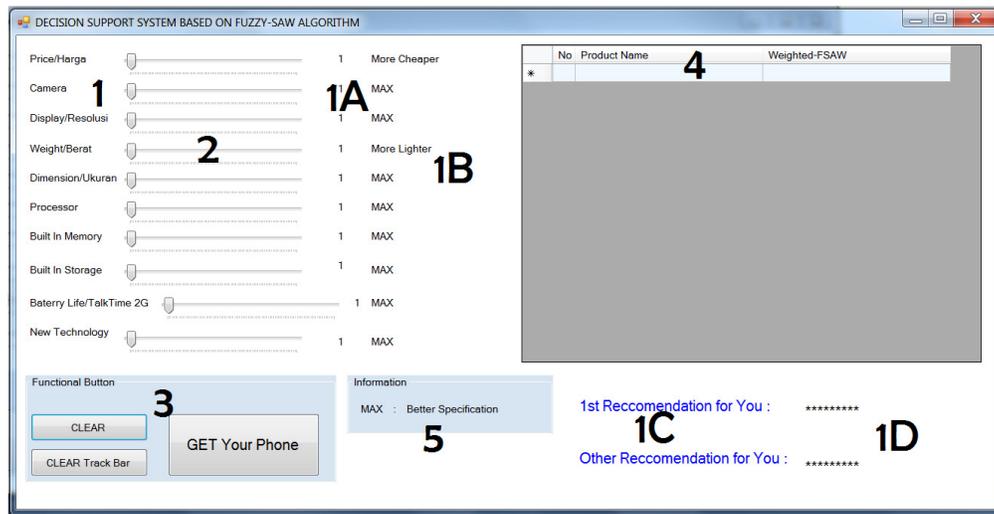


**Figure 6**. DSS application interface (A)

Explanation of **Figure 6** : the property type of point (1) is text label, which serves as a marker of the weighting criteria; the property type of point (1A) is text label, which serves as a number counter whose value can be increased or decreased in accordance with the trackbar movement (point 2); the property type of point (1B) is text label which serves as measurement indicator, for example: when the indicator marked as "cheaper" means the potential buyer expects the smartphone category that have less cost than the others. Likewise, the indicator marked as

"Lighter" is when the potential buyer expects the smartphone has lighter weight than the others; the property type of point (1C) is text label which serves as a pointer of first and second recommendation options; point (1D) is a text label which has the function to showing the calculation results (recommendation options). In point (2) the "trackbar" serves as a slider to increase or decrease the value of weighting criteria. Point (3) contains three buttons, such as: (a) "CLEAR" button is used to reset the weighting result in DataGridView property (point 4), (b) "Clear Track Bar" is used to reset the trackbar position and value counter into initial value (the initial value is 0), (c) "GET Your Phone" button is used to execute the FSAW algorithm and then the calculation result will be shown in the DataGridView property (point 4) and in the text label property (1D). Point (5) is text label which has the function as a information "billboard" only.

**Phase three: the DSS application backend coding**

When running the DSS application program, a potential buyer is conditioned to choose a smartphone which is cheap and has long-life battery endurance characteristics, then after moving the TrackBar slider and clicking the "GET Your Phone" button the potential buyer will get the result as shown in **Figure 7.**
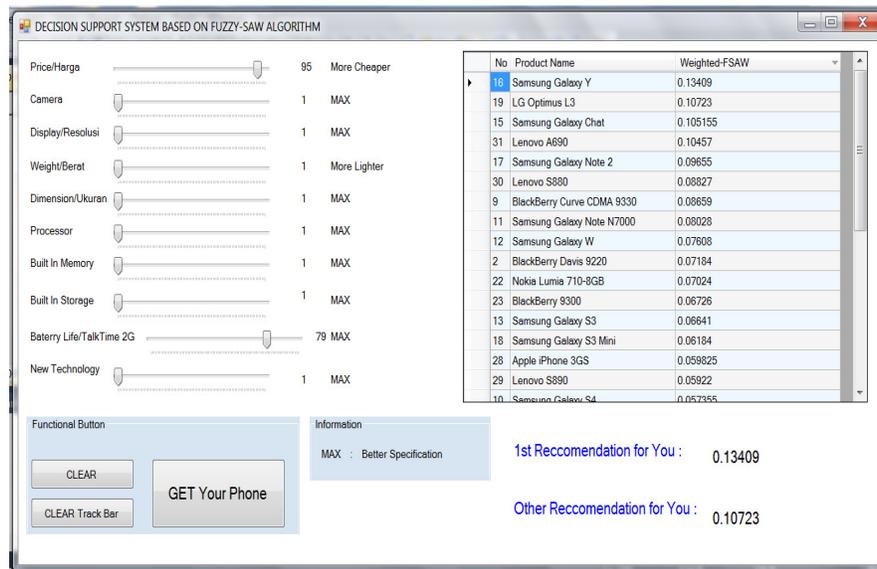


**Figure 7.** DSS application interface (B)

Explanation of **Figure 7**:

(a) TrackBar: if the trackbar slider is moved, then it will be an increase or a decrease value of the counter. The pseudocode to move the counter value is described in **Conceptual 1.**

```
Var min, max: double
 Begin
      TrackBarN setVal min=1, max=100
      TrackBarN setSliderChange=1
      LabelN.Text = TrackBarN.Value
 End
```
**Conceptual 1.** The TrackBar slider pseudocode

(b) "GET Your Phone" button: if this button is clicked, then the calculation of **Theorem 3** will be processed. The code of **Theorem 3** and the function to find the biggest value in calculation result is described in **Conceptual 2.**

**Pseudocode:**
!-- *for Theorem 3*
```
MultiplyMatriks(X1, Y2): double
Var SigmaSum: double
Begin
For   loop Xrow and Ycolumn
          Begin
                SigmaSum += (Xrow*Ycolumn)
End
Return SigmaSum
End
```

!-- *biggest number*
```
Arr(n): double
Var Max = Arr(0)
Var Max2 = Arr(n)
Begin
For loop counter to Arr(n)-1
Begin
                If (Arr(counter) > Max) Then
                            Max = Arr(counter)
                    Else If Max2 < Arr(counter) Then
                            Max2 = Arr(counter)
                    End If
            End
```
**Conceptual 2.** Pseudocode of **Theorem 3** and the function to find the biggest number in calculation result

(c) "CLEAR" button: if the button is clicked, then the weighting result of smartphone on DataGridView (point 4) and the recommendation result on point (1D) will be reset. The pseudocode is described in **Conceptual 3.**

```
Begin
    DataGridViewPoin4.Rows.Clear()
    Label1D.Text = "******" (CharType: String)
End
```
**Conceptual 3.** Pseudocode to reset the recommendation result

(d) "Clear Track Bar" button: if the button is clicked, then the TrackBar slider with its counter will be reset into initial value (intial value is 1/100). The pseudocode is described in **Conceptual 4**.

```
Var reset=1
Begin
    TrackBarN.Value = reset
    Label1A.Text = "1" (CharType: String)
End
```
**Conceptual 4.** Pseudocode to reset the TrackBar and its counter value

**Phase four: testing of DSS application**

In this study the phase of laboratory testing application program such as alpha-beta testing was not done, the application was tested directly to the DSS research object (potential buyers). However, there are no specific rules stating that every application program must go through a series of prototype tests before testing it directly to the sample. This method refers to the previous studies of DSS application development conducted by Bonometti [5] and Coutinho-Rodrigues, Simao, & Antunes [3] which did not specifically discuss about software pre-test in their research article.

## Conclusion

The result of DSS application test displayed in a separate report proves that two of 27 smartphone purchases were initiated by the DSS. The small number of purchases may be caused due to the aesthetic aspects of the Human Computer Interaction which are ignored in the user interface design phase. As well as, the criteria and alternative weighting in this DSS application are static. However, in further development, DSS application can be used as an effective marketing tool. For example, there is a DSS application for restaurant selection problems built on mobile application. Using a DSS, consumers can simplify the confusing aspects like choosing a food menu, find out the availability of food menu, or table reservations only with their "touches". In addition, in a few seconds the DSS gives them a several recommendations of the "their choice" restaurant. The limitation in this study is the accuracy analysis of fuzzy SAW algorithm which

was not conducted. Imprecision of weighting process may cause imbalance of calculati on result. Therefore, the weighting process in spreadsheet application should not have any mistakes.

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