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Mobile Decision Support System to Determine Toddler's Nutrition using Fuzzy Sugeno

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ABSTRACT

Determination of nutritional status is closely related to the determination of dietary patterns should be given to infants. Nutrition is very important role in mental, physical development, and human productivity. In this study, the system based on android is developed to determine the nutritional status of infants by using Fuzzy Sugeno. Indicator variables are age, height, circle head, and body weight according to the male or female. In this study, the results of measurements of nutritional status of children with Fuzzy Sugenoare tested by comparing the nutritional quality of the data Posyandu toddler by using anthropometric tables. The results of the evaluation measurement accuracy in this application are compared with the results of manual calculation based infant growth charts according to WHO standards. Therefore, these applications can be used to help the community in monitoring the nutritional status of children so that the growth of children is more appropriate in line with expectations.

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1. INTRODUCTION

The growth technology forces the human resource adapting this growth smartly as well. The alignment of growing technology in information industry, especially *cloud computing*, where the system created to be able access wherever and whenever needed with integration application by using internet. One of the application is to determine the toddler's nutrition status which uses the android system. This application is created for parents and doctors to check on toddler's nutrition and provide the nutrient needed. The food menu is chosen by the need by the toddler and the nutrients in the food. Choosing the right food makes the nutrition status normal, where there's balancing between food consumption and nutrient. Fulfillment of nutrient takes an important role for mental and physical growth, and productivity. So the nutrition fulfillment must be controlled to maintain the health of growing period toddlers

Method used to support the nutrition system on toddler is logic *Fuzzy* and Sugenomethod. By using this method is to simplify the information of toddler's nutrition so that the parents or doctors can make the right decision. This research is to determine the toddler's nutrition according to height, weight, and age. But this system has not applied to an application based on computerization [1]. Author will develop tis toddler's nutrition application by using logic *Fuzzy Sugeno*. *Fuzzy Sugeno* method is the inference Fuzzy method to be represent in a form of "IF-THEN", where the output (consequence) system not a *Fuzzy* compilation, but a constant or linear [2]. Indicator used in this research is an age variable, height, and weight accordingly to the gender; boy or girl. Software used to create this application is *Java* using *Basic4Android* and *database SQL Lite Manager* based on *Android.*

2. RELATED WORKS

Fidiantoro and Setiadi [3] uuses the weight according to the age, height according to the age and weight according to height. The Method for evaluate the toddler's nutrition usesfuzzy logic. *Fuzzy*is able to solve the complex nonlinear in order to able to view the nutrition status with member degree. Jean Christophe Buission [4] (2008) did a research called "Nutri-Educ, a nutrition software application forbalancing meals, using fuzzy arithmetic andheuristic search algorithms". This research used a daily input meal breakdown and meal description with output balance assesment and fix or improve the meal. Programming language called combining Java and Flash/ Action Script (Buisson, 2008).

Josua M. Krebez and Adnan Saout[5] conducted a research call "*Fuzzy Nutrition System*". The research mentionedthe Fuzzy diet analysis system with food recommendations. The proposed system is described and implemented as follows. Two methods for nutritional feedback, one fuzzy and the other crisp, are compared. A comparison is made between the usefulness of fuzzy and crisp diet data from a user's perspective. Similarity with this research is using the same method but the difference is discussed topic, where on this system explain about Fuzzy diet analysis, but on our research explain toddler's nutrition status and the program used is *SQL Queries for database USDA SR23*, but this research using *Java* based on *Android*. Petri Haimonen's research [6] with entitled "Development of a Fuzzy Expert for Nutritional Guidance Application" discussed theNutritional Guidance with fuzzy mandani method. This application is designed using Matlab. (Heinonen, Mannelin, Iskala, Sorsa & Junso, 2009).

Research that done by Sudirman [7] called "Classification Nutrition Analysis with *Fuzzy* Method *C-means* using application based on *Android*". This application used height input, weight and gender as the research indicator with an output of toddler's nutrition status. Programming language that used is *Java* based on *Android.* Tomy Prasetio's research with entitled [8] "Application to diagnose Nutrition on Toddler with the Calories needed using Fuzzy Sugeno method". On this research system, the input used such as Height/Age, Weight/Age and Height/Weight with output toddler's nutrition status. Programming language used is Visual C++. (Prasetion, Martiana & Mubtada'i, 2011)

3. RESEARCH METHOD

Flowchart determine toddler's nutrition system uses Fuzzy Sugeno method as shown Figure 1

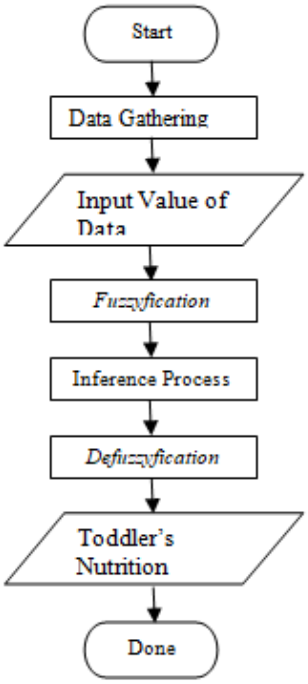

Figure 1. Flowchart of Toddler's Nutrition Status Valuation

3.1. Gathering Data

Data in this research uses the data gathered from Clinic Silalas, West Medan 2014. Toddler's data needed for this research include height, weight, age accordingly to the gender, either boy or girl. Toddler's Nutrition status is specified by Minister of Health No.1995/MENKES/SK/XII/2010 about Anthropometry standard. Valuation divided into 4 category, such as; extra nutrition, good nutrition, less nutrition and poor nutrition (Dr. LannyLestiani S., Sp.GK as Nutrition Specialist at Medistra Hospital Medan).

3.2. Fuzzy Sugeno Method

Fuzzy Sugeno method used for the assessment of nutritional status can be done in three stages:

1. Fuzzyfication is a process where input data tend to be certain (crips input) into the Fuzzy input. On this research, used Fuzzy variable include age, weight, height and head diameter and body mass index and also gender. Age variable divided into 5 types such as; Phase1, Phase2, Phase3, Phase4, and Phase5. Weight variable according to gender divided into 3 such as; Light, Medium and Heavy. But height variable according to gender divided into 3 such as; Short, Medium and Tall. And body mass index divided into 3 types such as; Skinny, Medium and Fat (Dr.LannyLestiani S., Sp.GK as Nutrition Specialist at Medistra Hospital Medan).
2. Inference Process
   Next, based on Fuzzy resulted on toddler's nutrition status, the total indicator used on this method total 145 rules. The result of this Fuzzy rule been consulted with Dr.LannyLestiani S., Sp.GK as Nutrition Specialist at Medistra Hospital Medan.
   But nutrition status for toddler can be determined according to nutrition status such as;
   a. Bad nutrition, if nutrition less than 49 (<49).
   b. Less nutrition, if nutrition less than 53 and bigger than 49 (49<nutrition value<60).
   c. Good nutrition, if nutrition less than 70 and bigger than 60 (60<nutrition value<70).
   d. Excellent nutrition, if nutrition more than 70 (nutrition value>70).
   e. (Dr.LannyLestiani S., Sp.GK as Nutrition Specialist at Medistra Hospital Medan).
3. Defuzzyfication using Sugeno can be converted into Fuzzy output to crips with calculation of weighted average with formula as shown Eq. (1);

$$\text{Output(Crips)} = \frac{\sum(\text{Alpha})X(\text{Consequent})}{\sum\text{Consequent}} \quad (1)$$

Where:
Alpha : output parameter of degree member
Consequent: Number of Consequent

4. RESULTS AND ANALYSIS

The following will be made comparison testing between Sugeno method and the results obtained by anthropometric table.

4.1. Manual Testing Sugeno Method

In this stage, the variable input test such as:

Age	:	32
Height	:	88
Weight	:	13
Head Diameter	:	48
Gender	:	Girl
Body Mass Index	:	16,7872

Before inference needs to be found, the member value degree on each fuzzy variable, such as age as shown Figure 2, body mass index as Figure 3, head diameter as Figure 4, and nutrion as shown Figure 5.

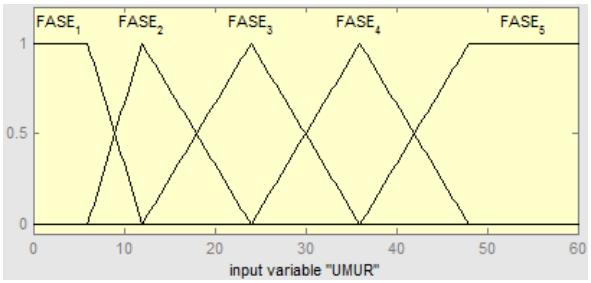

Figure 2. Variable Fuzzy Age

Age

$\mu PHASE_1(32) = 0$

$\mu PHASE_2(32) = 0$

$\mu PHASE_3(32) = (36 - 32) / (36 - 24) = 0{,}3333$

$\mu PHASE_4(32) = (32 - 24) / (36 - 24) = 0{,}6667$

$\mu PHASE_5(32) = 0$

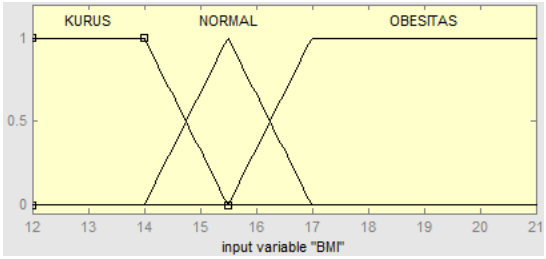

Figure 3. Variable Fuzzy Body Mass Index

Body Mass Index

BMI = BB / ((TB / 100) * (TB / 100))
= 13 / ((88 / 100) * (88 / 100))
= 16,7872

$\mu_{SKINNY}(16{,}7872) = 0$

$\mu_{OVERWEIGHT}(16{,}7872) = (17 - 16{,}7872) / (17 - 15.5)$
= 0,1419

$\mu_{NORMAL}(16{,}7872) = (16{,}7872 - 15{,}5) / (17 - 15{,}5)$
= 0,8581

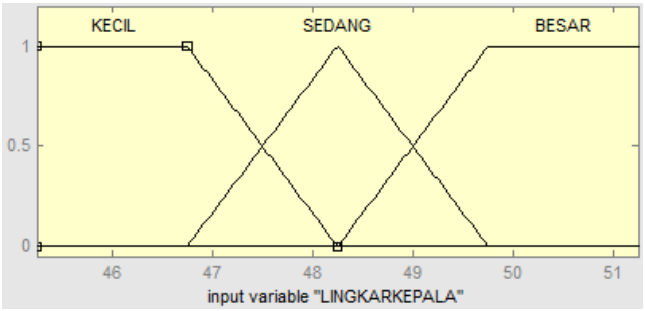

Figure 4. Variable Fuzzy Head Diameter

Head Diameter

$\mu_{SMALL}(48)$ = (48,25 - 48) / (48,25 - 46,75)
= 0,1667
$\mu_{MEDIUM}(48)$ = (48 - 46,75) / (48,25 - 46,75)
= 0,8333
$\mu_{BIG}(48)$ = 0

After get a function on each member variable then the next step is to form the rule and weight by using defuzzification using Sugeno method.

Connected Rule

[R1] **IF**Age=PHASE3 **AND**HeadDiameter= SMALL**AND**BMI=NORMAL**THEN**Nutrition=MEDIUM
α-predicate = $\min(\mu_{PHASE3}(32); \mu_{SMALL}(48); \mu_{NORMAL}(16,7872)$
= min(0, 3333; 0,1667; 0,1419)
= 0,1419

[R2] **IF**Age=PHASE3 **AND**HeadDiameter= SMALL**AND**BMI=OVERWEIGHT**THEN**Nutrition=EXTRA
α-predicate = $\min(\mu_{PHASE3}(32); \mu_{SMALL}(48); \mu_{OVERWEIGHT}(16,7872)$
= min(0, 3333; 0,1667; 0,8581)
= 0,1667

[R3] **IF**Age=PHASE3 **AND**HeadDiameter=MEDIUM**AND**BMI=NORMAL**THEN**Nutrition=GOOD
α-predicate = $\min(\mu_{PHASE3}(32); \mu_{MEDIUM}(48); \mu_{NORMAL}(16,7872)$
= min(0, 3333; 0,8333; 0,0.1419)
= 0,1419

[R4] **IF**Age=PHASE3 **AND**HeadDiameter=MEDIUM**AND**BMI=OVERWEIGHT**THEN**Nutrition=GOOD
α-predicate = $\min(\mu_{PHASE3}(32); \mu_{MEDIUM}(48); \mu_{OVERWEIGHT}(16,7872)$
= min(0, 3333; 0,8333; 0,8581)
= 0,3333

[R5] **IF**Age=PHASE4 **AND**HeadDiameter= SMALL**AND**BMI=NORMAL**THEN**Nutrition=MEDIUM
α-predicate = $\min(\mu_{PHASE4}(32); \mu_{SMALL}(48); \mu_{NORMAL}(16,7872)$
= min(0, 6667; 0,1667; 0,1419)
= 0,1419

[R6] **IF**Age=PHASE4 **AND**HeadDiameter= SMALL**AND**BMI=OVERWEIGHT**THEN**Nutrition=EXTRA
α-predicate = $\min(\mu_{PHASE4}(32); \mu_{SMALL}(48); \mu_{OVERWEIGHT}(16,7872)$
= min(0, 6667; 0,1667; 0,8581)
= 0,1667

[R7] **IF**Age=PHASE4 **AND**HeadDiameter=MEDIUM**AND**BMI=NORMAL**THEN**Nutrition=GOOD
α-predicate = $\min(\mu_{PHASE4}(32); \mu_{MEDIUM}(48); \mu_{NORMAL}(16,7872)$
= min(0, 6667; 0,8333; 0,1419)
= 0,1419

[R8] **IF**Age=PHASE4 **AND**HeadDiameter=MEDIUM**AND**BMI=OVERWEIGHT**THEN**Nutrition=GOOD
α-predicate = $\min(\mu_{PHASE4}(32); \mu_{MEDIUM}(48); \mu_{OVERWEIGHT}(16,7872)$
= min(0, 6667; 0,8333; 0,8581)
= 0,6667

Determine maximum value on nutrition

Worst = 0
Less = 0
Medium = max(0,1419; 0,1419)
= 0, 1419
Good = max(0,1419; 0,3333; 0,1419; 0,6667)
= 0, 6667
More = max(0,1667; 0,1667)
= 0,1667

$$Z = \frac{(0 \times 43) + (0 \times 49) + (0{,}1419 \times 53) + (0{,}6667 \times 60) + (0{,}1667 \times 70)}{0 + 0 + 0{,}3333 + 0{,}6667 + 0{,}1667}$$

$$= \frac{59{,}1917}{0{,}9753}$$

= **60,6907**

From the calculation above, 32 mounths toddler with height 88cm, weight 13kg and Head Diameter 48cm has a good nutrition. The nutrition value 60,6907.

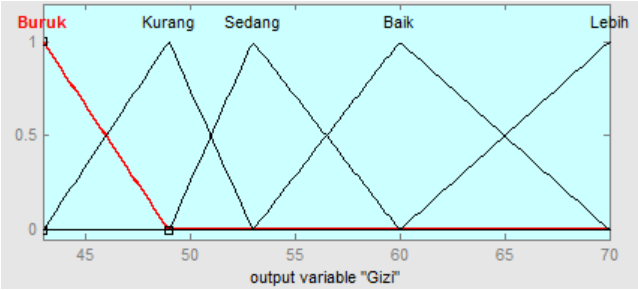

Figure 5. Variable Fuzzy Nutrition

From the Figures 2-5, the fuzzy sugeno can be determined to be 60,6907, which is on a GOOD value.

4.2. Test Based on Anthropometry

In this stage, variable test input such as:

Age	:	32
Height	:	88
Weight	:	13
Head Diameter	:	48
Gender	:	Girl

Weight / Age

Z_1 = (13 - 13,1) / (13,1 - 11,6)
= - 0,1 / 1,5
= - 0,06667

Weight / Height

Z_2 = (13 - 12,1) / (13,3 - 12,1)
= 0,9 / 1,2
= 0,75

Height Diameter / Age

Z_3 = (48 - 48,25) / (48,25 - 46,75)
= - 0,25 / 1,5
= - 0,16667

$$Z = \frac{(Z_1 + Z_2 + Z_3)}{3} = \frac{- 0,06667 + 0,75 - 0,16667}{3} = 0,172222$$

From the calculation above, test based on anthropometry resulted 0,172222. This value is a GOOD value which between -1 and 1 according to anthropometry.

4.3. Evaluation System Result

Parameter will be filled with manual calculation such as;

Age	: 8
Height	: 65
Weight	: 9
Head Diameter	: 45

Filling on the nutrition status such as;

Worst : 43
Less : 49
Medium : 53
Good : 60
More : 70

Table 1. Category Toddler's Nutrition

No.	Evaluation Result	Result
1	43 – 48	WORST
2	49 – 52	LESS
3	53 – 58	MEDIUM
4	60 – 69	GOOD
5	70 above	MORE

Table 1 is toddler's nutrition category table, which shows the range evaluation result to determine the nutrition status. For example; Evaluation between 43-48 has a worst nutrition status, 49-52 has a less nutrition status, 53-58 has a medium nutrition status, 60-69 has a good nutrition status and evaluation more than 69 has an excellent or great nutrition status.
Input onto the system:

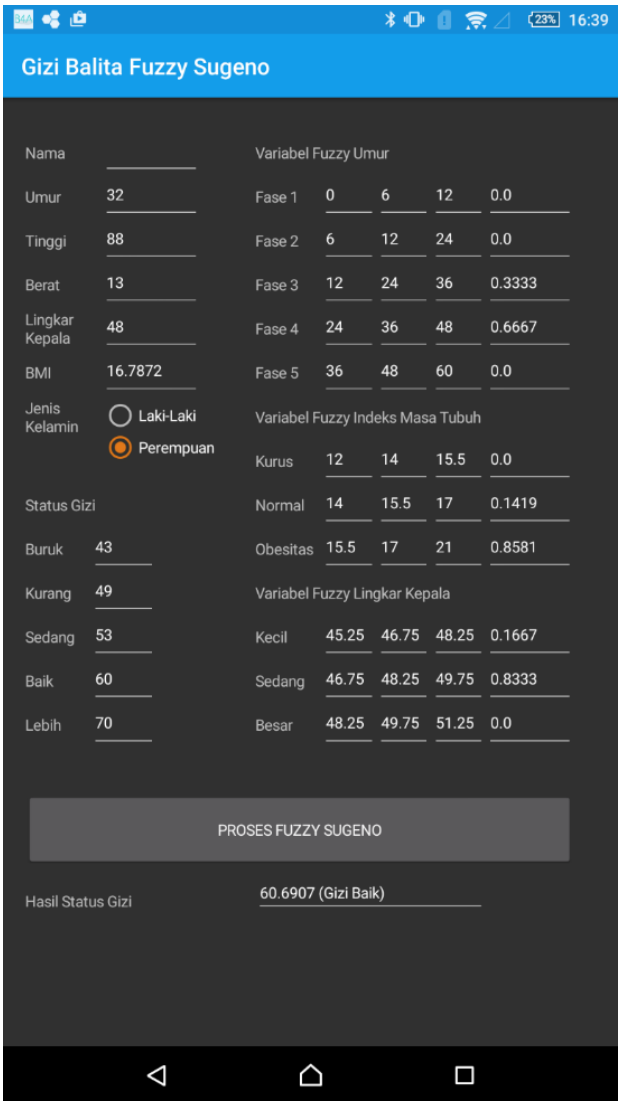

Figure 6. Calculation from Fuzzy Sugeno

After test on this system, the result shows the same as manual calculation. So this system program can prove the accuracy between system calculation and manual. The result can be seen on figure 6, the result from fuzzy sugeno method on toddler's nutrition is 60,6907 (Good Nutrition).

4.4. Comparison Result between Clinic (Manual) with Sugeno Application

Table 2 shows the comparison evaluation result between data from clinic and fuzzy calculation using fuzzy sugeno method.

Table 2. Comparison Result between Clinic and Sugeno Application

No	Toddler Name	Age	Date of Birth	Weight	Height	Head Diameter	Anthropometry Result	Nutrition Status	Sugeno Result	Nutrition Status
1	Marisa	36	29/03/2013	13	94	48	- 0,47	Good	53,1751	Medium
2	Ting - ting	24	18/03/2014	12	87	47	0,15	Good	63,3333	Good
3	Kalista	30	29/09/2013	13	88	48	0,31	Good	60,833	Good
4	Rachael kusuma	26	23/01/2014	13	87	48	0,70	Good	63.3333	Good
5	Alfinriski	28	10/12/2013	12	89	48	- 0,70	Good	55,4344	Medium
6	Federick	7	23/08/2015	10	68	45	1,85	Medium	61,3761	Good
7	Cyntia	20	08/08/2014	12	86	48	0,80	Good	64,8332	Good
8	Filbert hosea	2	23/01/2016	5.5	61	42	0,42	Good	56,6445	Medium
9	Wilbert bernardi	49	26/03/2012	18	112	51	0,09	Good	54,631	Medium
10	Cindy	54	15/10/2011	14	97	49	- 0,74	Good	54,0054	Medium
11	Kent	49	12/01/2012	18	95	49	0,99	Good	65,6051	Good
12	Sese	49	27/02/2012	14	95	48	- 0,70	Good	53,1413	Medium
13	Aurel	44	18/08/2012	12	96	48	- 1,44	Medium	50,3333	Less
14	Cesilia	42	11/10/2012	15	99	50	0,29	Good	58,553	Medium
15	Vorencia	35	16/05/2013	15	97	50	0,77	Good	62,9479	Good
16	Hubert	44	24/10/2012	14	93	48	- 0,62	Good	60,7842	Good
17	Gerrison	50	27/04/2012	13	97	50	- 0,93	Good	53,0	Medium
18	Chelsea	56	30/10/2011	14	109	49	- 1,55	Medium	53,0	Medium
19	Rihanna	43	23/01/2014	13	94	48	- 1,53	Medium	50,9001	Less
20	Andre	57	30/09/2011	18	110	52	0,25	Good	57,0882	Medium
21	Michael andrian	38	22/04/2013	12	91	48	- 1,30	Medium	50,3093	Less
22	Chirstine	42	23/12/2012	13	93	48	- 0,69	Good	51,4603	medium
23	Agung	44	24/10/2012	13	95	49	- 1,03	Medium	52,7206	Less
24	Muhammad	47	26/07/2012	13	91	50	- 0,65	Good	60,8144	Good
25	Agus salim	36	21/06/2013	14	97	49	- 0,34	Good	54,0054	Medium
26	Farel	54	29/12/2012	14	102	48	- 1,61	Medium	49,0	Less
27	Steveny	49	27/05/2012	14	95	50	- 0,17	Good	60,0892	Good
28	Junita	37	22/05/2013	12	96	48	- 1,14	Medium	50,3333	Medium
29	Darliana	59	01/08/2011	19	114	51	0,17	Good	55,8928	Medium
30	Ferdinan	52	27/02/2012	16	100	50	- 0,12	Good	60,0694	Good

4.5. Comparison Evaluation Result

Evaluation result gathered from clinic uses the anthropometry table to get deviation standard value of toddler's nutrition quality. In this evaluation, the clinic uses 3 variables such as; weight, height and head diameter. Each variable connect to each other to get a comparison result of toddler's nutrition quality based

on the variable used. Result on -1 and 1 deviation standard is Good to Medium according to fuzzy sugeno method calculation. This happen because the parameter variable is the input of fuzzy sugeno. To be more detail e, 30 samples are tested to prove the toddler's nutrition. According to the evaluation, there're 12 toddlers have a same result, Good Nutrition. From the 30 data, there's 40% toddler's data has a same output, and the other data result resemble to each other. As an example according to anthropometry, calculation resulted -1,61 where the category near less and according to sugeno calculation resulted 49 where this value number resulted worst.

Gathered outcome has each criteria based on calculation input. This calculation proves that parameter has a different calculation, eventhough different, nutrition status resemble to each other.

5. CONCLUSION

The evaluation application and comparing toddler's nutrition survey at clinic and manual calculation with growth graphic involve 30 toddlers are conducted in this research. The category group toddler's nutrition uses 4 categories; worst, less, medium, good. Sugeno uses 5 categories; worst, less, medium, good and excellent so Fuzzy Sugeno method has a high accuracy to determine the calculation of Age, Body Mass Index and Head Diameter. The result value of Fuzzy Sugeno isnear to ideal value and same as manual method.

Calculation result does not always shows the same result because of the different method used. Even though different method used, the result value almost the same. So, fuzzy sugeno method can be an alternative method to increase the nutrition needed or the check the result on which part need to be improve for toddler's nutrition. The result can be used to decide the daily food consumption for toddler so that the nutrition value is excellent. This method can be used to check on toddler's growth on weight, height and head diameter.

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