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Algorithm Implementation *C4.5* For Classification Food Menu to Prevent Stunting in Children

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Abstract
Stunting in childhood is one of the most significant obstacles to human development and globally affects about 162 million children under five. One effort to prevent stunting is a program to increase the nutritional intake of the community, especially children under five, by providing supplementary food (PMT). Classification is one of the data processing techniques that can be used in this process. The results obtained from the study show that the designed system can input training data and data for classification so that the health centre and guardians can determine the good and bad food menus according to the existing data of toddlers. Based on the results of testing with training data and testing data with a ratio of 80:20 from a dataset of 200 data, namely 160 training data, and 40 test data using the C4.5 algorithm obtained in dataset 1 obtained an accuracy value of 82,5%, precision value of 0.96, recall value of 0,8 and F1-score of 0,87273, then in dataset 2 obtained an accuracy value of 72,5%, precision value 0,75, recall value 0,84 and F1-score value 0,79245.
Keywords: Data Mining, Classification, Algorithm C4.5, Stunting, Food Menu

INTRODUCTION

Stunting is a condition where a child is too short for his age because he experiences growth failure caused by poor nutrition and health before and after birth (UNICEF, 2024). Stunting is defined as short or very short based on length/height for an age of less than -2 standard deviations (SD) on the WHO growth curve, which occurs due to irreversible conditions due to inadequate nutritional intake and recurrent/chronic infections that occur within 1000 HPK (Ministry of Health Directorate General of Health Services, 2023).

Aceh is the province with the fifth highest prevalence of stunting in toddlers in Indonesia in 2022 based on data from the 2022 National Nutrition Status Survey (SSGI), the prevalence of stunting in Indonesia is 21.6%. This number has decreased compared to the previous year, which was 24.4%. Although decreasing, this figure is still high, considering the target prevalence of stunting in 2024 according to the WHO standard is below 20% (Ministry of Health Directorate General of Health Services, 2023) Providing an appropriate and nutritious food menu for children is very important in this context. However, providing a food menu that suits each child's needs is difficult. There are many factors to consider, such as age, weight, height, and nutritional status child.

Data analysis is required to determine the right food menu. The menu should be based on the nutritional needs of children who are vulnerable to stunting. One data processing technique that can be used in this process is classification.

Classification is a process that aims to find patterns from relatively large to extensive data. AlgorithmC4.5 is a predictive algorithm commonly used to classify segment or group data. At the same time, decision trees (*Decision Trees*) are a classical method function that transforms significant facts into decision trees representing rules (Rahmadhani & Wulan, 2020).

Using a data-driven approach and algorithms*C4.5*, recruitment classification results in the food menu will be based on learning from previously existing food menu data. This study aims to use algorithm*C4.5* to classify stunting status and food menus for stunted children. This algorithm produces rules that can determine the feasibility of a food menu to prevent stunting. The results of this study are in the form of the development of a web-based information system that can classify food menus for stunted children. With this system, parents and related parties are expected to be able to easily access relevant and practical information to ensure that children get adequate nutritional intake. This is expected to contribute to efforts to prevent stunting in children in Indonesia and other countries facing similar problems.

LITERATURE REVIEW

Data Mining

Data Mining is a process that uses statistical, mathematical, artificial intelligence, and machine learning techniques to extract and identify useful information and related knowledge from large databases. It is also known by other names: knowledge discovery (mining) in databases (KDD), knowledge extraction, data/pattern analysis, and business intelligence (Windarto et al., 2019).

Classification

Classification performs an analysis of the training data to form classification rules, commonly referred to as the learning or training process. Subsequently, classification will analyze the testing data to evaluate the classification rules obtained from the training process (Darnila et al., 2021).

Classification is a set of records that represent characteristic values in the form of a collection of attributes or specific attributes known as class labels. Classification is tasked with learning the target by mapping each attribute to one of the predefined classes (Asrianda et al., 2023) .

C4.5 Algorithm

The C4.5 algorithm is an algorithm used to form a decision tree. Decision trees are the most advanced and well-known classification and prediction method. Decision trees help find hidden relationships between several candidate input variables and a target variable. The decision tree method transforms massive facts into decision trees that represent rules. The rules can be easily understood in natural language. It can also be expressed as a database to find records in specific categories (Wijaksana et al., 2022).

According to (Ardiansyah & Walim, 2018), there are several stages in creating a decision tree in the C4.5 algorithm, namely:

1. Preparing training data. Training data is usually taken from historical data that has occurred before and has been grouped into specific classes.
2. Calculating the root of the tree. The root will be taken from the attribute to be selected by calculating the gain value of each attribute; the highest gain value will be the first root. Before calculating the gain value of the attribute, first calculate the entropy value.

To calculate the entropy value, the formula is used:

$$Entropy(S) = \sum_{i=1}^{n} -pi * Log_2\, pi \qquad (1)$$

Note:

S = case set
n = number of partitions S
pi = the proportion of Si to S

Then, after the entropy value for each attribute has been obtained, calculate the gain value using the formula:

$$Gain(S,A) = Entropy(S) - \sum_{i=1}^{n} \frac{|Si|}{|S|} * Entropy\ (Si) \qquad (2)$$

Note:

S = case set
A = feature
n = number of partition attributes A

|Si| = the proportion attributes A
|S| = number of cases in S

Stunting

ACCORDING TO WHO (2020), STUNTING IS DEFINED AS BEING SHORT OR VERY SHORT FOR AGE, WITH HEIGHT/LENGTH FOR AGE LESS THAN -2 STANDARD DEVIATIONS (SD) ON THE WHO GROWTH CURVE. IT OCCURS AS A RESULT OF IRREVERSIBLE CONDITIONS CAUSED BY INADEQUATE NUTRITION OR REPEATED/CHRONIC INFECTIONS THAT OCCUR DURING THE FIRST 1,000 DAYS OF LIFE (KEMENTERIAN KESEHATAN DIREKTORAT JENDERAL PELAYANAN KESEHATAN, 2022).

The causes of stunting include factors such as nutritional intake and health status, which encompass food security (availability, affordability, and access to nutritious food), social environment (norms, infant and child feeding practices, hygiene, education, and workplace conditions), health environment (access to and provision of preventive and curative services), and living conditions (water, sanitation, and building conditions).

Stunting Children's Food Menu

The strategies for implementing programs to address stunting include improving caregiving practices, such as Early Initiation of Breastfeeding (IMD), Early Breastfeeding (IMD), exclusive breastfeeding for the first 6 months, and continuing breastfeeding alongside complementary foods (MP-ASI) until the age of 2 years. Stunting prevention in young children can be addressed by providing age-appropriate nutrition, including both macronutrients (energy, carbohydrates, protein, and fats) and micronutrients (vitamins and minerals). Ensure a balanced diet by following the recommended intake of staple foods (3-4 servings per day), vegetables (3-4 servings), fruits (2-3 servings), and animal or plant-based protein sources (2-4 servings per day), along with increased water consumption. Additionally, it is important to limit the intake of sugar, salt, and oil (Kementerian Kesehatan Direktorat Jenderal Pelayanan Kesehatan, 2022).

MATERIALS & METHODS

The data used in this research is the Monitoring and Evaluation Data of Local Food Supplementation for Toddlers Phase. I obtained from Muara Satu Community Health Center. This data is presented in .xlsx format and consists of 200 data entries.

Table 1. Dataset 1

No	Name	Age	W/A	H/A	W/H
1	Ullfa Zaahirah	Phase 1	Underweight	Stunted	Malnutrition
2	M Kaivan A	Phase 2	Underweight	Normal	Malnutrition
3	Afifah Khairulnnisa	Phase 2	Underweight	Normal	Malnutrition
4	…	....	….	….	….
200	M.Ilham	Phase 4	Normal	Normal	Good Nutrition

Table 2. Dataset 2

No	Age	W/H	Food Menu Code	Description
1	Phase 1	Malnutrition	M2	Not Good
2	Phase 2	Malnutrition	M3	Not Good
3	Phase 2	Malnutrition	M4	Not Good
4	....	….		
200	Phase 4	Good Nutrition	M3	Good

The research method generally explains the stages that will be carried out in this research to get the desired results and solve the problem briefly. The following are the stages of research:

1. Literature Study
   In the crucial data collection phase, literature studies are drawn from a variety of sources, including journals, papers, and books, in both digital and hardcopy formats.
2. Requirement Analysis
   Requirement analysis is a comprehensive process that involves understanding the actual needs of the system to be developed and creating a system that precisely meets those needs.
3. System Design
   System design is a collection of activities that meticulously describe how the system will function in detail.
4. System Implementation
   In this phase, the design created in the previous phase is implemented using the chosen programming language.
5. System Testing
   This phase involves testing the system that was implemented in the previous stage.
6. Evaluation
   This phase involves evaluating the results of the system testing. The evaluation assesses the extent to which the research objectives have been achieved.

Algorithm Schematic

The following is the algorithm schematic for this research:

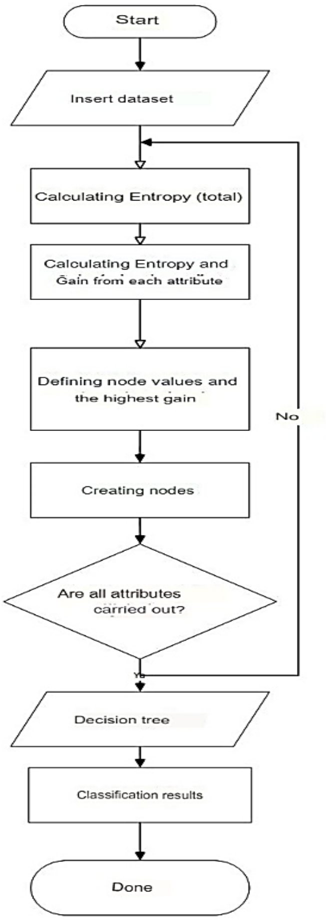

Figure 1. Algorithm Schema

System Schematics

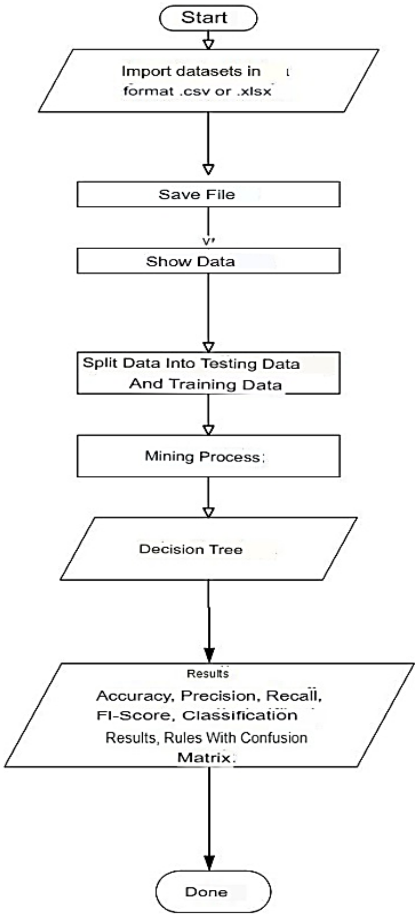

Figure 2. System Schema

Explanation

1. Start
2. Import dataset: The user uploads a dataset in .csv or .xlsx format.
3. The uploaded data is then displayed.
4. Next, the data is split into training and testing datasets.
5. Perform the mining process to generate the decision tree.
6. After obtaining the decision tree, the system will classify the dataset using the C4.5 algorithm based on the constructed decision tree.
7. The system will display the results: accuracy, precision, recall, F1-score, classification results, rules, and the confusion matrix to measure the performance of the resulting classification system.
8. Done.

RESULTS AND DISCUSSION

Below are the nutritional status tables for toddlers, the age table, and the food menu table.

1. **Toddler Status Table**

Table 3. Classes and Labels

No	Class	Labels
1	W/A	Very Underweight, Underweight, Normal Weight
2	H/A	Very Short, Short, Normal
3	W/H	Good Nutrition, Malnutrition

2. **Age Table**

The age table below shows age groups according to WHO food supplementation guidelines.

Table 4. Age Table

Code	Age (Months)
Phase 1	0-5
Phase 2	6-11
Phase 3	12-47
Phase 4	48-72

3. **Food Menu Table**
   The food menu table below is a table of food menus obtained from Muara Satu Community Health Center

Table 5. Food Menu Table

No	Food Menu Combination	Food Menu Code	Food Menu Category
1	Breast milk	M1	-
2	Vegetable omelet, whole grain bread, fruit salad + banana + grilled chicken rice, broccoli soup, fruit jelly + yogurt with fruit pieces + beef stew, potatoes, and carrots + apple slices	M2	Light food
3	Oatmeal with fruit and nuts + fruit yogurt + white rice, grilled chicken, and mixed vegetables + fruit and vegetable smoothie + peanut butter and vegetable sandwich + apple slices		
4	White rice with mixed vegetables, grilled chicken + vegetable smoothie with yogurt + white rice with vegetable soup and beef + vegetable smoothie + grilled chicken with mashed potatoes and mixed vegetables + fruit smoothie		
5	White rice with mixed vegetables + papaya + rice with meatball soup + mixed vegetables + rice with chicken meatballs + melon		
6	Green bean and banana smoothie + mixed vegetables and carrots + white rice with vegetable soup and spinach + chicken banana + boiled cassava with green beans and omelet		
7	Chicken soup + fruit slices + fried rice with spinach + whole grain bread + peanut butter and vegetable sandwich + fruit slices		
8	Mixed vegetables and whole grain bread + banana + rice with omelet and shrimp + green bean smoothie + fried rice with chicken and soup + papaya and salad	M3	Medium Food
9	Mixed vegetables and whole grain bread + papaya and avocado + rice with meatball soup + boiled cassava + rice with chicken meatballs and greens + fruit salad		
10	Papaya and whole grain bread + banana + grilled rice with fish + mixed vegetables and cassava + rice with chicken and soup + fried potatoes		
11	Chicken rice with boiled potatoes and carrots + papaya + fried rice with spinach + whole grain bread + rice with fish noodle soup + papaya and salad	M4	Heavy Food
12	Mixed vegetables and whole grain bread + papaya and avocado + rice with meatball soup + boiled cassava and papaya + rice with chicken meatballs and greens + fruit salad and salad		

Manual Calculation of the C4.5 Algorithm

The table below contains a dataset from Muara Satu Community Health Center for 2023/2024. The dataset is divided into two parts, 80:20, where 80% is for training data and 20% is for testing data.

The following are the steps for manually constructing the decision tree:

1. **Preparing the Dataset**

Table 6. Dataset 1

No	Name	Age	W/A	H/A	W/H
1	Ullfa Zaahirah	Phase 1	Underweight	Stunted	Malnutrition
2	M Kaivan A	Phase 2	Underweight	Normal	Malnutrition
3	Afifah Khairulnnisa	Phase 2	Underweight	Normal	Malnutrition
4	…	….	….	….	….
200	M.Ilham	Phase 4	Normal	Normal	Good Nutrition

Table 7. Dataset 2

No	Age	W/H	Food Menu Code	Description
1	Phase 1	Malnutrition	M2	Not Good
2	Phase 2	Malnutrition	M3	Not Good

3	Phase 2	Malnutrition	M4	Not Good
4	....	….		
200	Phase 4	Good Nutrition	M3	Good

2. **Splitting the Dataset Into Training Data and Testing Data.**
The next step is to separate the dataset into training and testing data. The comparison for splitting the dataset is 80% training and 20% testing data. The training data can be found in Table 7 below:

Table 8. Training Data 1

No	Name	Age	W/A	H/A	W/H
1	Ullfa Zaahirah	Phase 1	Underweight	Stunted	Malnutrition
2	M Kaivan A	Phase 2	Underweight	Normal	Malnutrition
3	Afifah Khairulnnisa	Phase 2	Underweight	Normal	Malnutrition
4	…	....	….	….	….
160	Mikhayla Jasmine	Phasel 4	Normal	Normal	Good Nutrition

Table 9. Training Data 2

No	Age	W/H	Food Menu Code	Description
1	Phase 1	Malnutrition	M2	Not Good
2	Phase 2	Malnutrition	M3	Not Good
3	Phase 2	Malnutrition	M4	Not Good
4	....	….		
160	Phase 4	Good Nutrition	M3	Not Good

Next, the testing data can be seen in Tables 8 and 9 below:

Table 10. Testing Data 1

No	Name	Age	W/A	H/A	W/H
1	Muhammad Habib Zayyan	Phase 4	Normal	Normal	Good Nutrition
2	Adam Nur Wahid	Phase 4	Normal	Normal	Good Nutrition
3	AISYAH APRINIA ASZAHRA	Phase 3	Normal	Normal	Good Nutrition
4	…	....	….	….	….
40	M.Ilham	Phase 4	Normal	Normal	Good Nutrition

Table 11. Testing Data 2

No	Age	W/H	Food Menu Code	Description
1	Phase 1	Good Nutrition	M1	Good
2	Phase 4	Good Nutrition	M4	Good
3	Phase 4	Good Nutrition	M2	Not Good
4	....	….		
40	Phase 4	Good Nutrition	M3	Good

3. **Calculate Entropy, Information Gain and Gain Ratio**
A. Data 1

Table 12. Results of the Entropy Calculation for Data 1

NODE		Description	Amount	Good Nutrition	Malnutrition	eIntropy	Gain
0	**Total**		160	70	90	0,9886994	
							0,94144
	W/A	Underweight	70	1	69	0,1080232	
		Very Underweight	21	0	21	0	
		Normal weight	69	69	0	0	
							0,24675
	H/A	Short	34	1	33	0,1914333	
		Normal	111	68	43	0,9630928	
		Very Short	15	1	14	0,3533593	

	Age	Phase 1	1	0	1	0	0,59138
		Phase 2	4	0	4	0	
		Phase 3	82	5	77	0,3313056	
		Phase 4	73	65	8	0,4986751	

Table 13. Results of the Calculation Node Level 1.2 for Data 1

NODE 1		Description	Amount	Good Nutrition	Malnutrition	elntropy	Gain
1.2	Amount		70	1	69	0,108023195	
	W/A	Underweight	70	1	69	0,108023195	**0**
	H/A						**0,079451767**
		Short	25	0	25	0	
		Normal	43	0	43	0	
		Very Short	2	1	1	1	
	Age						0,045901545
		Phase 1	1	0	1	0	
		Phase 2	3	0	3	0	
		Phase 3	58	0	58	0	
		Phase 4	8	1	7	0,543564443	

Table 14. Results of the Calculation Node Level 1.2.3 for Data 1

NODE 1		Description	Amount	Good Nutrition	Malnutrition	elntropy	Gain
1.2.3	Amount		4	1	1	1	
	W/A	Underweight	2	1	1	1	0,5
	H/A	Very Stunted	2	1	1	1	0,5
	Age						**1**
		Phase 1	0	0	0	0	
		Phase 2	0	0	0	0	
		Phase 3	1	0	1	0	
		Phase 4	1	1	0	0	

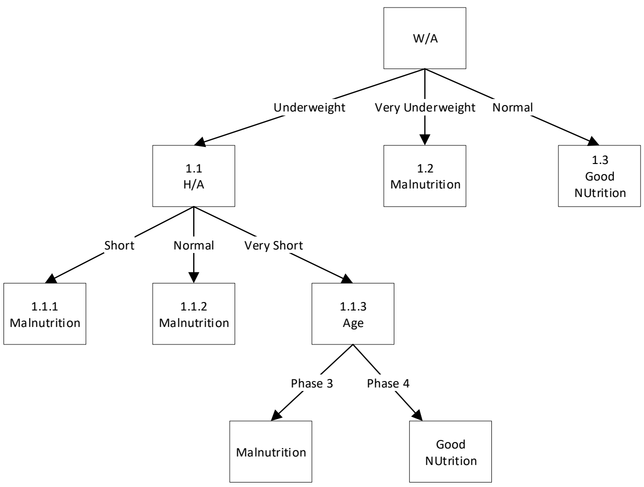

Figure 3 Decesion Tree Node Level 1 Data 1

B. Data 2

Table 15. Results of the Entropy Calculation for Data 2

NODE 1		Description	Amount	Good Nutrition	Malnutrition	elntropy	Gain
1	Amount		160	60	100	0,954434	
							0,0002746
	W/H	Good Nutrition	70	27	43	0,961978	

		Malnutrition	90	33	57	0,948078	
							0,0122115
	Age	Phase 1	6	2	4	0,918296	
		Phase 2	8	1	7	0,543564	
		Phase 3	79	31	48	0,966334	
		Phase 4	67	26	41	0,963536	
							0,1615318
	Food Menu Code	M2	32	1	31	0,200622	
		M3	58	31	27	0,996566	
		M4	54	26	28	0,99901	
		M1	16	2	14	0,543564	

Table 16. Results of the Entropy Calculation Node Level 1.2 for Data 2

NODE 1		Description	Amount	Good Nutrition	Malnutrition	eIntropy	Gain
1.1	Amount		32	1	31	0,200622	
	Food Menu Code	M2	32	1	31	0,200622	0
							0,031977291
	W/H	Good Nutrition	16	0	16	0	
		Malnutrition	16	1	15	0,33729	
	Age	Phase 1	1	0	1	0	**0,200622324**
		Phase 2	1	1	0	0	
		Phase 3	14	0	14	0	
		Phase 4	16	0	16	0	

Table 17. Results of the Entropy Calculation Node Level 1.3 for Data 2

NODE 1		Description	Amount	Good Nutrition	Malnutrition	eIntropy	Gain
1.2	Amount		58	31	27	0,996566	
	Food Menu Code	M3	58	31	27	0,996566	0
							0,428688081
	W/H	Good Nutrition	23	2	21	0,426229	
		Malnutrition	35	29	6	0,660962	
	Age	Phase 1	2	0	2	0	**0,996566371**
		Phase 2	3	0	3	0	
		Phase 3	31	31	0	0	
		Phase 4	22	0	22	0	

Table 18. Results of the Entropy Calculation Node Level 1.4 for Data 2

NODE 1		Description	Amount	Good Nutrition	Malnutrition	eIntropy	Gain
1.3	Amount		54	26	28	0,99901	
	Food Menu Code	M4	54	26	28	0,99901	0
							0,618142904
	W/H	Good Nutrition	26	24	2	0,391244	
		Malnutrition	28	2	26	0,371232	
	Age	Phase 1	1	0	1	0	**0,999010271**
		Phase 2	2	0	2	0	
		Phase 3	25	0	25	0	
		Phase 4	26	26	0	0	

Table 19. Results of the Entropy Calculation for Node Level 1.1 Data 2

NODE 1		Description	Amount	Good Nutrition	Malnutrition	elntropy	Gain
1.4	Amount		16	2	14	0,543564	
	Food Menu Code	M1	16	2	14	0,543564	0
	W/H						0,015807735
		Good Nutrition	5	1	4	0,721928	
		Malnutrition	11	1	10	0,439497	
	Age						**0,543564443**
		Phase 1	2	2	0	0	
		Phase 2	2	0	2	0	
		Phase 3	9	0	9	0	
		Phase 4	3	0	3	0	

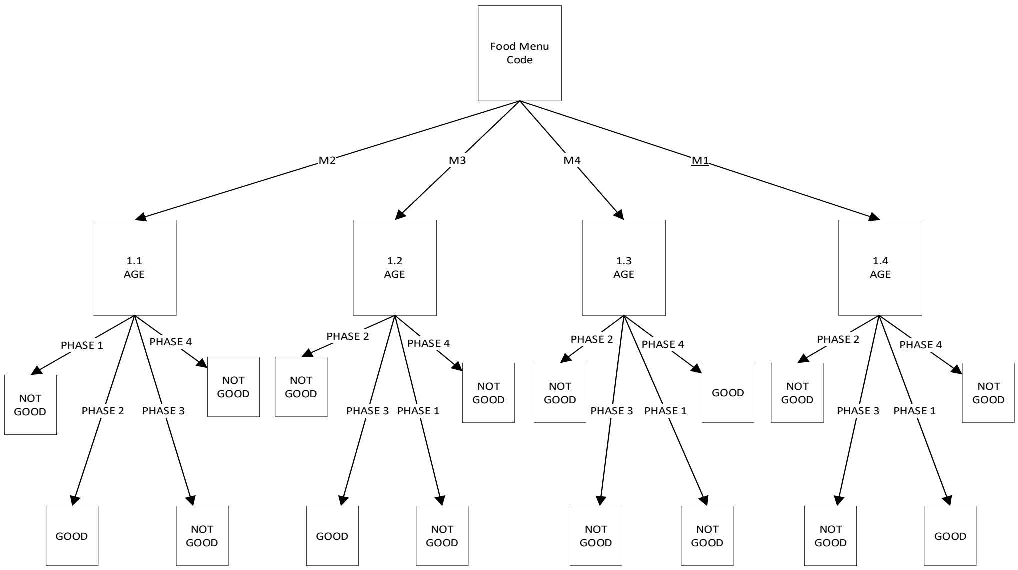

Figure 4. Decision Tree Node Level 0 Data 2

Table 20. Results of Classification Prediction for Data 1

No	Name	Age	W/A	H/A	W/H	Prediciion
1	Muhammad Habib Zayyan	Phase 4	Normal	Normal	Good Nutrition	Good Nutrition
2	Adam Nur Wahid	Phase 4	Normal	Normal	Good Nutrition	Good Nutrition
3	AISYAH APRINIA ASZAHRA	Phase 3	Normal	Normal	Good Nutrition	Good Nutrition
4	…	....	….	….	….	….
40	M.Ilham	Phase 4	Normal	Normal	Good Nutrition	Good Nutrition

Table 21. Results of Classification Prediction for Data 2

No	Age	W/H	Food Menu Code	Description	Prediction
1	Phase 1	Good Nutrition	M1	Good	Good
2	Phase 4	Good Nutrition	M4	Good	Good
3	Phase 4	Good Nutrition	M2	Not Good	Good
4	....	….			
40	Phase 4	Good Nutrition	M3	Good	Not Good

Table 22. Confusion Matrix Data Testing 1

Actual	Prediction	
	Good Nutrition	Malnutrition

Good Nutrition	24	6
Malnutrition	1	9

Table 23. Confusion Matrix Data Testing 2

Actual	Prediction	
	Good	Not Good
Good	21	4
Not Good	7	8

4. **Calculate Accuracy, Precision, Recall, and F1-Score**

A. Accuracy Data Testing 1

$$Accuracy = \frac{(24+9)}{(24+9+1+6)} \times 100\% = 82{,}5\%$$

B. Accuracy Data Testing 2

$$Accuracy = \frac{(21+8)}{(21+8+7+4)} \times 100\% = 72{,}5\%$$

C. Precision Data Testing 1

$$\text{Precision} = \frac{(24)}{(24+1)} \times 100\% = 0{,}96$$

D. Precision Data Testing 2

$$\text{Precision} = \frac{(21)}{(21+7)} \times 100\% = 0{,}75$$

E. Recall Data Testing 1

$$\text{Recall} = \frac{(24)}{(24+6)} \times 100\% = 0{,}8$$

F. Recall Data Testing 2

$$\text{Recall} = \frac{(21)}{(21+4)} \times 100\% = 0{,}84$$

G. F1-score Data Testing 1

$$\text{F1-score} = 2 \times \frac{0{,}96 \times 0{,}8}{0{,}96 + 0{,}8} = 0{,}87273$$

H. F1-score Data Testing 2

$$\text{F1-score} = 2 \times \frac{0{,}75 \times 0{,}84}{0{,}75 + 0{,}84} = 0{,}79245$$

CONCLUSIONS

1. The C4.5 classification algorithm can classify the nutritional status of toddlers and food menus effectively.
2. This study utilized a dataset consisting of 200 data points.
3. In this research, training and testing data were used with a ratio of 80:20 from the dataset of 200 data points, with 160 data points for training and 40 data points for testing.
4. The C4.5 algorithm has proven to be effective in classifying food menus for stunted children, yielding a reasonably good performance. In dataset 1, the accuracy was 82,5%, precision value of 0.96, recall value of 0,8 and F1-score of 0,87273, then in dataset 2 obtained an accuracy value of 72,5%, precision value 0,75, recall value 0,84 and F1-score value 0,79245.

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