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Application of min-max normalization in backpropagation to detect early malnutrition

Rudi Setiawan[*], Faculty of Technology Information, Universitas Budi Luhur, South Jakarta, Jakarta, Indonesia
Imelda, Faculty of Technology Information, Universitas Budi Luhur, South Jakarta, Jakarta, Indonesia

[*]Email for Correspondence: 1911600110@student.budiluhur.ac.id* imelda@budiluhur.ac.id

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ABSTRACT

Malnutrition is the nutritional condition of toddlers which is characterized by a very thin condition, along with or without edema on the backs of both legs, weight according to body length or weight compared to height less than -3 standard deviations and/or upper arm circumference less than 11.5 cm in children aged 0-59 months. The contribution of this study is to apply min-max normalization to detect malnutrition using the Backpropagation method. This study uses the Backpropagation method with CRISP-DM, the input value of the artificial neural network is in an infinite range to a finite output value, which is in a range of 0 to 1. In order for this value to be met, a min-max normalization is carried out on the input value. The test results on this prototype achieved a maximum accuracy value of k= 1 with an accuracy value of 69%, Precision of 94% and Sensitivity of 69%. The results of the recommendation of the condition of children who are detected with malnutrition are very useful as an initial preventive measure in order to improve the nutritional condition of children with the right special treatment early and comprehensively.

INTRODUCTION

Nutritional needs between individuals differ depending on age, activities, and gender. The fulfillment of these nutrients must be fulfilled in every growth period so that they become physically and mentally healthy. The lack of nutritional fulfillment in children can cause children to experience malnutrition conditions (Dipasquale et al., 2020; Ghosh, 2020; Hulst et al., 2022; Katoch, 2022; Vassilakou, 2021). Malnutrition is the nutritional condition of toddlers which is characterized by a very thin condition (Alaaraj et al., 2021; El-Shafie et al., 2020; Medialdea et al., 2021; Scheffler et al., 2020; Scrinis, 2020), along with or without edema on the backs of both legs, weight according to body length or weight compared to height less than -3 standard deviations and/or upper arm circumference less than 11.5 cm in children aged 0-59 months (Peraturan Menteri Kesehatan Republik Indonesia Nomor 29 Tahun 2019 Tentang Penanggulangan Masalah Gizi Bagi Anak Akibat Penyakit, 2019).

The Ministry of Health stated that the short-term impact of malnutrition is disruption of brain development, decreased intelligence and disorders in the body's metabolism. Meanwhile, in the long term, a child who experiences malnutrition is a decrease in cognitive ability, learning achievement, decreased immunity which causes diseases and an increased risk of diabetes, obesity, heart disease, cancer, stroke and disability in old age. In addition, it can also create uncompetitive work quality which results in low economic productivity (Hossain et al., 2021; Hutabarat, 2023; Morris et al., 2008).

Ciangsana Health Center is a health center located in Ciangsana Village, Gunung Putri District, Bogor Regency, West Java Province. For Human Resources (HR) at the Ciangsana Health Center, there are 28 people, namely 2 general practitioners, 1 dentist, 2 dental nurses, 3 nurses, 9 midwives, 2 Health Promotion, 1 Environmental Health, 1 Nutritionist, 1 pharmacist assistant, 1 Financial Manager, 1 medical record, 3 Hygiene and 1 Security. There are 74 posyandu in the working area of the Ciangsana Health Center, namely Nagrak Village, Ciangsana Village and Bojong Kulur Village. In 2021, the number of children in the working area of the health center was 6728 children with a classification of nutritional status: 72 malnourished children, 321 malnourished children, 5209 well-nourished children, 687 over-nourished children, 240 over-nourished children, 173 obese children.

The classification of nutritional status at the health center is carried out by a nutritionist at the health center. For the classification data of the results of measuring weight, height, age and body mass index (BMI) is carried out by village midwives or volunteers at the Ciangsana Health Center. The classification process is slow because the personnel who carry out the classification are only 1 person. Based on this, a model is needed that can classify nutritional status.

Research on malnutrition has been carried out with various methods such as in the study by Purwati et al. (2017) comparing the C.45 algorithm and Backpropagation for the classification of nutritional status in variable toddlers used in Weight/Age and Weight/Height with the results obtained by Backpropagation with an accuracy of 96.08%. The input value of the artificial neural network is in an infinite range to a finite output value, which is in a range of 0 to 1. In order for this value to be met, a min-max normalization is carried out on the input value. After it is known that children who are malnourished, they can determine the first handling action to be taken for children who are indicated to be malnourished and changes in nutritional parenting can be made.

The research attempted to build a nutritional status classification model using Artificial Neural Network (JST, *Jaringan Syaraf Tiruan*). The contribution of this study is to apply min-max normalization to detect malnutrition using the Backpropagation method. The results of this study's recommendations are used for stakeholders in making decisions so that they can provide policies in determining early preventive actions for children who are detected as malnourished. Proper treatment is very useful as an initial preventive measure in order to improve the nutritional condition of children with special treatment early and comprehensively.

METHOD

The following are the 6-stage Cross-Industry Standard Process for Data Mining or CRISP-DM and can be shown in Figure 1.

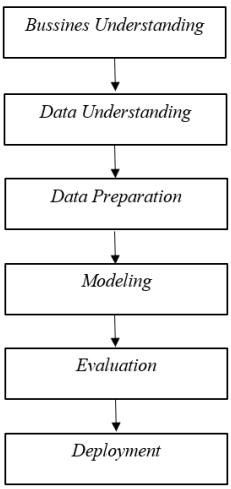

Figure 1. Cross-Industry Standard Process for Data Mining atau CRISP-DM

Business Understanding

The Business Understanding stage requires knowledge of business objects, how to build or obtain data, and how to match modeling goals with business goals. The objectives of this stage are obtained from the initial plan to achieve the business objectives (Brown, 2014). This study uses data from the Ciangsana Health Center, Bogor Regency. The Ciangsana Health Center is located at Cikeas Hilit Village, RT 5 RW 3, Ciangsana Village, Gunung Putri, Bogor. The health center also provides health services directly to the community through posyandu spread across Ciangsana village with a total of 113 posyandu. One of the services carried out at the posyandu is to identify the nutrition of toddlers by weighing the child. After the results of the child's scale, including Weight, Height and Age.

Data Understanding

The purpose of the Data Understanding stage is to identify problems with the data that has been obtained. This stage provides the basis for analysis of the research by collecting data, describing the data, exploring the data and verifying the quality of the data (Brown, 2014). The data was obtained from the results of measuring the weight (BB, *Berat Badan*) and height (TB, *Tinggi Badan*) of children at the posyandu in the Ciangsana Health Center area. The period used in data collection is from January to December 2021. The data obtained are as follows: NIK (ID number), Name, Gender, Date of Birth, Birth Weight, Birth Height, Parent's Name,

Province, Regency/City, District, Health Center, Village/Village, Posyandu, RT, RW, Address, Age, Weight, Height, Body Mass Index (BMI).

Data Preparation

The steps of the Data Preparation stage include: selecting data, cleaning data, building data, integrating data and formatting data. The details of the Data Preparation steps are described as follows:

a. Data collection was carried out from the results of age, weight (BB, *Berat Badan*) and height measurements in children aged 0-59 months by village midwives / volunteers at posyandu in the working area of the Ciangsana Health Center in a span of 1 year from January to December 2021. But in this study, the data provided by the health center was only 400 data.
b. The next step is to carry out the Data Cleaning process. The Data Cleaning process cleans data that has columns/rows with imperfect fillings.
c. The next step is to carry out the Data Selection process. This process sorts the data according to the needs and focus of this research.
d. The data used was only name, gender, date of birth, age (months), weight, height and body mass index in children.

Modeling

The modeling stage is carried out after the existing data has been in accordance with the needs. The next step is modeling on the data by selecting modeling techniques, designing tests, building models and assessing models (Brown, 2014). The next step is to determine the model of the artificial neural network.

Evaluation

The evaluation stage is carried out after digging up the data and determining the pattern on the model. The next step is to evaluate the model that has been determined. The model is then trained using training data and evaluated for quality and accuracy with data testing (Brown, 2014). The division of training data and testing data uses the Cross Validation method. After that, the evaluation and validation of accuracy, precision and sensitivity were carried out using the Confusion Matrix method.

Deployment

No matter how good the model has been determined, it will not be known if it does not obtain the expected results (Brown, 2014). Deployment is carried out by applying a model on a prototype that has been known to be accurate, precise, and sensitive to detect malnutrition early in children, then a system functionality test using the Black-box method is carried out by nutritionists at the Ciangsana Health Center.

RESULTS AND DISCUSSION

Business Understanding

The first step in Cross-Industry Standard Process Data Mining (CRISP-DM) is Business Understanding. Business understanding refers to this study refers to the condition of maternal and child health services at the Ciangsana Health Center. One of the services carried out is to identify the nutritional status of children carried out at the posyandu at the Ciangsana Health Center work unit. The identification was obtained by looking at the results of measuring age, weight (BB, *Berat Badan*), height (TB, *Tinggi Badan*) and Body Mass Index (BMI) in the child. The results of the measurement were used for data processing by the nutrition staff of the Ciangsana Health Center.

Data Understanding

In this step, data on the results of child scales in the Ciangsana Health Center area was collected from the working area of the health center, the number of Posyandu was 113. The data obtained was in the form of a file in excel format containing NIK, Name, Gender, Date of Birth, Birth Weight, Birth Height, Parents' Name, Province, Regency/City, District, Health Center, Village/Kelurahan, Posyandu, RT, RW, Address, Age, Weight, Height, Body Mass Index (BMI).

Data Preparation

Data preparation is the step used to create a dataset that will be used in data mining to be classified. In addition, in this step, data cleaning and data selection are carried out. The next step is to carry out the Data Selection process, which is to sort out which data will be calculated on the artificial neural network.

The data used in the study amounted to 400 in accordance with the provisions of Cross Validation data, as many as 75% of the data was used as Training Data, which was 300 data. Meanwhile, as much as 25% of the data is used as Data Testing, which is 100 data. Before calculating the data, data normalization was carried out with the aim that the data was only on a scale of 0-1.

In the data of the scale results, the maximum value of each category is known according to table 1.

Table 1. Maximum and Minimum Values According to Categories

Information	Age	Weight	Height	IMT
Max	59	32.1	198	30.9
Min	0	1.62	39	4.1

For the calculation process, an example was taken for the age category of 3 months, weight 5.9 Kg, height 59.3 cm and Body Mass Index (BMI) 16.8 Kg/M2. The age category is shown in Equation 10.

$$x_{age} = \frac{0{,}8\,(3-0)}{(-0)} + 0{,}1 \qquad (4.1)$$

$$= \frac{2.4}{59}$$

$$= 0.141$$

For the weight category is shown in Equation 11.

$$= \frac{3.424}{30.48} \qquad (10)$$

$$= 0.212$$

For the height category, it can be shown in Equation 12.

$$= \frac{28.1}{159} \qquad (4.3)$$

$$= 0.202$$

For the category Body Mass Index (BMI) can be shown in Equation 13

$$= \frac{13.52}{26.8} \qquad (4.2)$$

$$= 0.479$$

From the equation above, the normalization value for the age category is 0.141, weight 0.212, height 0.202 and Body Mass Index (BMI) 0.479. This data normalization process is also carried out on the test data in order to make the data results from the test data in accordance with the process carried out by the training data.

Modeling

At this stage, the classification process is carried out using the artificial neural network method on each data. As for the application of classification on the prototype using the web with the php programming language and mysql database. Because the method used is an artificial neural network, the process by data consists of an Input Layer, a Hidden Layer and an Output Layer. For each criterion, a weight value has been given, namely the weight value on the criteria of age, weight, height and Body Mass Index (BMI).

Evaluation

The next step is to find out the compatibility of the prototype with the needs of the Ciangsana Health Center environment, Bogor Regency. The conformity carried out is by calculating the values of Accuracy, Precision, Recall in accordance with the provisions of the confusion matrix.

From the existing data to determine the accuracy of this model, it was measured by the Confusion Matrix method for data set division using Cross Validation with a value of k = 3 with a total of 100 data. The following Cross Validation values k = 1 according to the category are found in Table 2.

Table 2. Cross Validation value k = 1

No	Information	Actual Positive	Actual Negative
1	Positive Predictions	TP = 61	FP = 4
2	Negative Predictions	FN= 27	TN = 8
	Total	25	18

Accuracy = (TP + TN) / (TP + TN + FP + FN)) * 100%
(61+8)/ (61+8+4+27)* 100 %
69 %

Precision = (TP) / (TP + FP) * 100%
(61)/ (61+4)* 100 %
94 %

Sensitivity = (TP) / (TP + FN)) * 100%

(61)/ (61+8)* 100 %
69 %

The following Cross Validation value k = 2 is found in Table 3.

Table 3. Cross Validation Value k = 2

No	Information	Actual Positive	Actual Negative
1	Positive Predictions	TP = 7	FP = 40
2	Negative Predictions	FN= 33	TN = 20
	Total	40	60

Accuracy = (TP + TN) / (TP + TN + FP + FN)) * 100%
(7+20)/ (7+20+48+52)* 100 %
21 %

Precision = (TP) / (TP + FP) * 100%
(7)/ (7+48)* 100 %
13 %

Sensitivity = (TP) / (TP + FN)) * 100%
(7)/ (7+52)* 100 %
12 %

The following Cross Validation value k = 3 is found in Table 4.

Table 4. Cross Validation Value k = 3

No	Information	Actual Positive	Actual Negative
1	Positive Predictions	TP = 6	FP = 24
2	Negative Predictions	FN= 62	TN = 8
	Total	68	32

Accuracy = (TP + TN) / (TP + TN + FP + FN)) * 100%
(61+8)/ (61+8+4+27)* 100 %
69 %

Precision = (TP) / (TP+FP)*100%
(61)/ (61+4)* 100 %
94 %

Sensitivity = (TP)/(TP+FN))*100%
(61)/ (61+8)* 100 %
69 %

The conclusion from the results of the Cross Validation assessment from k=1, k=2 and k=3 the maximum accuracy value was obtained at the first accuracy, namely accuracy of 69%, precision of 94% and sensitivity of 69%.

Deployment

The next stage is to make a prototype model for the classification of malnutrition using the artificial neural network method. This model is made according to the calculation process at the modeling stage. In this prototype, there are two menus, namely Nutrition Data Input and Check Nutrition Status. the unit is Centimeter (cm) and the Body Life Index (BMI) unit is kilogram/m2 (Kg/M2). The display of the Nutrition Data input menu is shown in Figure 2.

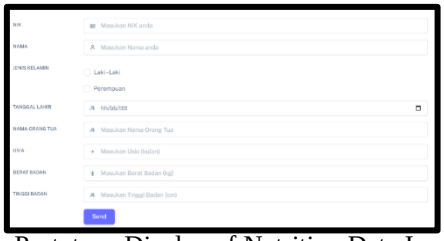

Figure 2. Prototype Display of Nutrition Data Input Menu

The Nutrition Data Input menu is used to store child data according to their nutritional status. This data is used as a report to the Health Office regarding the condition of children in the work area of the Ciangsana health center. In addition to being a report, this data is used by the health center to carry out first treatment for children who are malnourished.

In addition to the Nutrition Data Input menu, there is also a Check Nutrition Status menu to check the nutritional condition of children at the age of 0-59 months according to the criteria of Weight (Kg), Height (cm). As shown in Figure 3 below.

Figure 3. Prototype Display of the Check Nutrition Status Menu

To determine the functionality of the application, tests were carried out by nutritionists at the Ciangsana Health Center using the Black-Box method. Functional on the Nutrition Data Input Menu and Check Nutrition Status in table 5 below.

Table 5. Black-Box Testing

Modules Tested	Charging Procedure	Input	Expected Output	Results	Conclusion
Enter the name of the child who has been measured Age, Weight, Height and BMI	● Open Prototype ● Click the Nutrition Data Input menu	Data on the results of Age, Weight, Height and BMI measurements	Data on children who have been entered appear along with their nutritional status	Data on children who have been entered appear along with their nutritional status	Succeed
Check Nutritional Status	● Open Prototype ● Click the Check Nutrition Status menu	Data on the results of Age, Weight, Height and BMI measurements	Children's Nutritional Status According to the provisions of the interval whether malnutrition, undernutrition, good nutrition, risk of overnutrition, overnutrition or obesity	Children's Nutritional Status According to the provisions of the interval whether malnutrition, undernutrition, good nutrition, risk of overnutrition, overnutrition or obesity	Succeed
Search for data on children that have been entered into the database	● Open Prototype ● Click the Nutrition Data Input menu	Type a name in the seacrh field	Display the child's name that has been input into the system	Display the child's name that has been input into the system	Succeed

CONCLUSION

The Backpropagation artificial neural network has been used to detect malnutrition in web-based children, achieving a maximum accuracy of 69%, precision of 94%, and sensitivity of 69%. This prototype can assist nutrition workers in classifying nutritional status and malnutrition. However, it has some shortcomings and needs further development and improvement. Additional variables like economic conditions and parenting styles should be considered when determining children's nutrition classification. The study's results were used by the health office to determine malnutrition policies in Bogor Regency.

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