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Prediction of Indonesia School Enrollment Rate by Using Adaptive Neuro Fuzzy Inference System

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ABSTRACT
The study aimed to predict the school enrollment rate in Indonesia using the Adaptive Neuro Fuzzy Inference System (ANFIS). ANFIS is a combination of fuzzy inference system and artificial neural networks. The study used the Gaussian and Gbell membership functions to make the predictions. The results were evaluated using the R square score (coefficient of determination) and Mean Square Error methods. The results showed that the model performed well in predicting the school enrollment rate, particularly in the age categories of 7-12 years and 13-15 years. The R square score for these categories was 0.981 and 0.989, respectively, while the Mean Square Error was 0.023 and 0.367, respectively. The performance of the model in the age categories of 16-18 years and 19-24 years was also good, but with a slightly lower R square score and Mean Square Error compared to the younger age categories. When using the Gaussian membership function, the model performed even better, particularly in the age categories of 13-15 years and 19-24 years. The R square score for these categories was 0.990 and 0.988, respectively, while the Mean Square Error was 0.329 and 0.315, respectively. Overall, the study demonstrated that ANFIS is a suitable method for predicting school enrollment rate in Indonesia. The results from this study can provide useful information for decision makers in the education sector, who can use the model to make informed decisions about future educational policies and programs..
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1. INTRODUCTION

Education is a process of preparing students for development so that they will gain knowledge and skills needed for the future. Education is an important role in providing skills to achieve its potential optimally [1]. Education was enshrined as a human right in the United Nations Universal Declaration of Human Rights in 1948 [2]. Education participation can be influenced by several factors, among which are the level of poverty and employment. The higher the level of education, of course, the more costs are needed, therefore the higher the level of education, the lower the level of participation.

In recent years, artificial intelligence (AI) systems are in great demand, especially in neural-fuzzy technology. The Artificial Neural Network (ANN) modeling method with fast calculation and high precision is a very valuable method for determining the relationship of variables in complex structures. ANN has many advantages over mathematical methods, among them the ability to determine patterns of interdependence in

biological systems without any awareness of the kinetic and metabolic processes of previous systems. The existence of back-propagation learning rules in its application in artificial neural networks leads to learning for fine parameterization models, one of which is about fuzzy inference systems (fuzzy models). As a result, the fuzzy inference system that used to be only for retrieving linguistic information from human experts, is now able to adapt to using numerical data, namely the presence of input/output pairs. This gives fuzzy inference systems an advantage over neural networks, so there is a combined model between the Fuzzy Inference System and the Artificial Neural Network, namely the Adaptive Neuro Fuzzy Inference System (ANFIS). ANFIS is considered better for predicting variables in complex structures. Anfis digunakan dalam berbagai prediksi predict the %oil yield from grape peels, wind power forecasting, prediction of biogas production from palm oil mill effluent (POME), and predictive total petroleum hydrocarbon (TPH) [3]–[6], however, the use of ANFIS for school enrolment rate prediction does not yet exist so it is necessary to conduct a study on the use of anfis in school enrolment rate prediction.

Against this background, we predict the level of education participation in Indonesia by using the Adaptive Neuro Fuzzy Inference System (ANFIS). The purpose of this study is to create a good model for predicting school enrollment rates in Indonesia. Predicting the enrollment rate can provide important information for policymakers and educational institutions in planning and making decisions regarding the allocation of resources and improving the quality of education in the future. By predicting the enrollment rate, governments and educational institutions can find out how many students are expected to enter the education system at a given time period, so that they can organize and adjust the educational resources and policies needed to meet those needs. In addition, the predicted enrollment rate can also help the government and educational institutions to estimate the needs of teaching staff, books and teaching materials, as well as other supporting facilities needed to support the teaching and learning process. This can help improve the efficiency and effectiveness of the education system as a whole.

2. LITERATURE REVIEW

2.1. Adaptive Neuro Fuzzy Inference System

Adaptive Neuro Fuzzy Inference System is a combination of Fuzzy Inference System and Artificial Neural Network. The Adaptive Neuro Fuzzy Inference System (ANFIS) is a hybrid neuro-fuzzy system [7]. ANFIS is enabled through the presentation of a specific function called the Membership Function and is enhanced through the ability of the Artificial Neural Network and fuzzy if-then rules under the Fuzzy Inference System (FIS). A fuzzy set is a set without firm boundaries. In a paper entitled "Fuzzy Set" by Zadeh in 1965, fuzzy set is defined as a set that is defined incorrectly in playing human thinking, especially in the domains of pattern recognition, information communication and abstraction [8]. The characteristic of fuzzy sets is in their membership function, because most of the fuzzy sets used have a universe of X conversations consisting of real lines R [9]. The concepts of fuzzy set theory, fuzzy reasoning, and if-then rules are the basis for the principles of fuzzy systems [10].

Layer 1 **: Input Layer-** Two inputs $a1$ and $a2$ are fed into the input layer of the ANFIS network and then processed to the fuzzification layer.

Layer 2 **: Fuzzification layer-** This layer fuzzifies the inputs with a fuzzy membership function. The layer output at each node is characterized by the fuzzy membership grade of the input, which is expressed as follows:

$$O_{2,i} = \mu_{G_i}(a_i) \tag{1}$$

Where $i = 1, 2$, a_i denotes the input to the node i, and G_i represents the linguistic labels corresponding to the ith node. The membership function $\mu_{G_i}(a_i)$ can be of different types, for example, Gaussian, bell-shaped, etc. The Gaussian membership function (MF) can be expressed as

$$\mu_{A_1}(a) = exp[-\frac{1}{2}\left(\frac{a-b_3}{\sigma}\right)^2 \tag{2}$$

and the bell-shaped MF can be expressed as

$$\mu_{A_1}(a) = \frac{1}{1+\left|\frac{a-b_3}{b_1}\right|^{2b_2}} \tag{3}$$

Where b_1, b_2 and b_3 denote the width of the bell-like curve, positive integer, and center of the curvature, respectively. Here, b_1, b_2 and b_3 are the premise parameters of ANFIS.

Layer 3 **: Product layer-** The product layer uses AND operator for fuzzification of inputs. This layer is labeled as Π, which indicates a simple multiplication operation. The outputs of this layer can be expressed as:

$$O_{3,i} = w_i = \mu_{G_i}(a_1) \times \mu_{H_i}(a_2) \text{ (where } i = 1, 2) \quad (4)$$

Layer 4 **: Normalization layer-** In the normalization layer, the nodes (labeled as N) are used to compute normalized weights of rules. The output from the ith node (known as normalized firing strengths, $\overline{w_i}$) can be expressed as:

$$O_{4,i} = \overline{w_i} = \frac{w_i}{\sum_{i=1}^{2} w_i} \quad (5)$$

Layer 5 **: Defuzzification layer-** Each node in the defuzzification layer is adaptive in nature. Defuzzification of normalized firing strengths is done by multiplying the normalized firing strength ($\overline{w_i}$) with a first-order polynomial (f_i). The output of ith node in this layer can be expressed as the following Eq. Where $\{\mu_i^1,\ \mu_i^2, \mu_i^3\}$ are the consequent parameters of the network.

$$O_{5,i} = \overline{w_i} f_i = \overline{w_i}(\mu_i^1 a_1 + \ \mu_i^2 a_2 + \mu_i^3 \quad (6)$$

Layer 6 **: Output layer-** In the output layer, there is only one fixed node labeled as Σ . It sums all incoming signals coming from the previous layer. The output of this layer can be expressed as:

$$O_{6,i} = \sum_{i=1}^{2} \overline{w_i} f_i = \frac{\sum_{i=1}^{2} w_i f_i}{\sum_{i=1}^{2} w_i} \quad (7)$$

2.2. School Enrollment Rate

Education is one of the most important aspects of social and economic development, human rights, and is a tool that can develop human qualities that will support economic growth [11]. Through education, students will go through a process of self-development in reasoning and skills that are needed for the next life.

Education in Indonesia has an education system consisting of basic education, secondary education, and higher education [12]. Basic education is the initial education that underlies secondary education and higher education, consisting of elementary school or other equivalent forms and junior high school or other equivalent forms. Secondary education is a continuation of basic education, consisting of high school and vocational high school or other equivalent forms. Higher education is the level of education after secondary education organized by universities. Elementary school education consists of grades 1-6 which must be followed by children aged 7 years or at least 6 years starting from the start of the new school year. It takes six years to complete elementary school education (grades 1-6), three years to complete junior high school education (grades 7-9), and three years to complete high school education (grades 10-12).

International policy makers and governments widely believe that poverty and education have a significant two-way correlation, where poverty leads to low education, and vice versa [13]. The Indonesian Education Statistics 2021 shows that there is a disparity in the value of the Net Enrollment Rate for upper secondary education levels which is disaggregated based on regional type, disability status, and household economic status. The economic status of the household is divided into 5 quintiles, where the lower the economic quintile, the lower the net enrollment rate [14]. The level of education also affects the value of the Net Enrollment Rate, where the higher the level of education. the smaller the value of the Pure Participation Rate. Researchers speculate that this is because the cost of education is directly proportional to the level or level of education. The higher the level of education, the greater the costs incurred. Difficult socioeconomic conditions (low quintile economic status) will also increase the chance of dropping out of school. The model produced in this study is used to predict the number of school admissions in Indonesia which can be used as a reference for planning and determining policies in order to improve the quality of education in Indonesia.

2.3. Evaluation Method

The prediction results are then measured accuracy and error, MSE and MAPE methods is used to meassure error, and R^2 is used to meassure accuracy. Where the three methods are formulated as follows.

MSE formula:

$$MSE = \frac{\sum_{i=1}^{n} (y_i - y_i')^2}{n} \quad (8)$$

MAPE formula:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - y_i'}{y_i}\right| \quad (9)$$

R^2 formula:

$$R^2 = 1 - \frac{\sum(y_i - y_i')^2}{\sum(y_i - \overline{y_i})^2} \quad (10)$$

With n = numbers of data, y = real data, and y' = prediction.

3. RESEARCH METHOD

In this study, the data used is Indonesian school enrollment rate data which consists of 4 categories, namely 7-12 years (y1), 13-15 years (y2), 16-18 years (y3), and 19-24 years (y4), as well as poverty rate (x1) and unemployment rate (%) (x2) from 2000 to 2020. This data is taken from the World Bank Data and the Central Bureau of Statistics.In this research, 10 epochs were used and two membership functions, Gaussian and Gbell, were used to create the model. Grid partition was used to divide the data into several parts. The number of memberships used is 4 and 3, and linear type is used as the MF type. With this method, it is expected to create a good model to predict Indonesian school enrollment rates and determine what factors affect school enrollment rates. The results of this study will be analyzed and discussed to provide conclusions about the effectiveness of the ANFIS method in predicting Indonesian school enrollment rates.

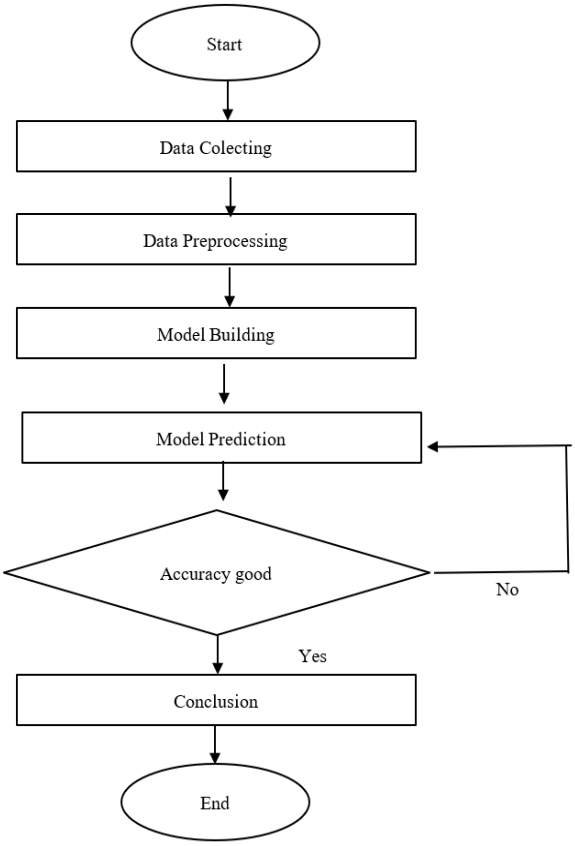

Figure 1. Research Flowchart

4. RESULTS AND ANALYSIS

The results from the study show that the prediction model using the Adaptive Neuro Fuzzy Inference System and computed by using Matlab was able to predict the school enrollment rate accurately. In the study, there were four graphs, each graph depicting the prediction results using the Gaussian and Gbell membership functions along with the actual data. Figure 1(a) for category 7-12 years, Figure.1(b) for category 13-15 years, Figure.1(e) for category 16-18 years, Figure.1(d) for category 19-24 years.

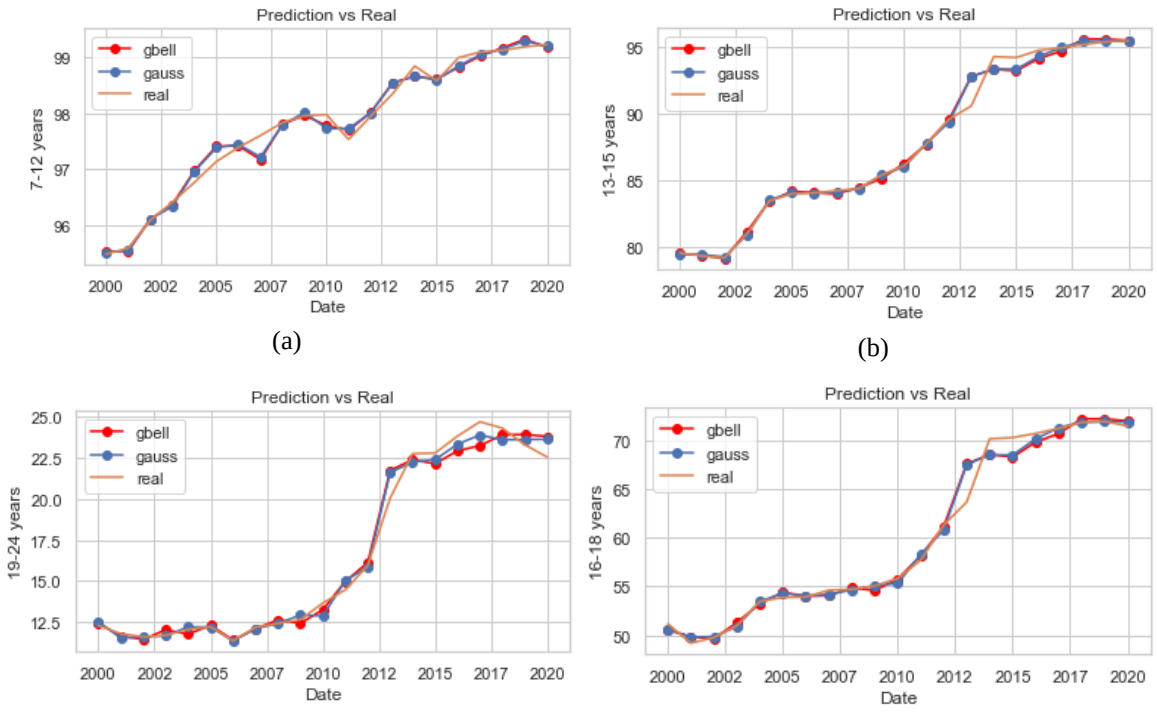

Figure 2. (a) category 7-12 years, (b) category 13-15 years
(c) category 16-18 years, (d) category 19-24 years

Here is a table of accuracy calculation results using all three methods (MSE, MAPE, R^2):

Table 1. Evaluation Score

No.	Category	Membership function	MSE	MAPE	R^2
1	7-12 years	Gbell	0.023	0.001	0.981
2	13-15 years		0.367	0.003	0.989
3	16-18 years		1.217	0.011	0.982
4	19-24 years		0.438	0.025	0.983
5	7-12 years	Gaussian	0.022	0.001	0.982
6	13-15 years		0.329	0.003	0.990
7	16-18 years		1.098	0.009	0.984
8	19-24 years		0.315	0.021	0.988

The results showed that the Adaptive Neuro Fuzzy Inference System (ANFIS) model performed well in predicting the school enrollment rate in Indonesia. It was observed that the model performed particularly well in the age categories of 7-12 years and 13-15 years. The R square score for these categories was 0.981 and 0.989, respectively, which indicates a high level of accuracy in the predictions. This can be attributed to the high correlation between the input variables and the output variable in these age categories.

The Mean Square Error (MSE) was also relatively low in these age categories, with a value of 0.023 and 0.367, respectively. This suggests that the model's predictions were very close to the actual values, thus leading to a high level of accuracy in the predictions. This finding confirms that the Adaptive Neuro Fuzzy Inference System (ANFIS) is a suitable model for predicting the school enrollment rate in Indonesia.

In the age categories of 16-18 years and 19-24 years, the model also performed well, but with a slightly lower R square score and Mean Square Error compared to the younger age categories. The R square score for these categories was 0.982 and 0.9837385, respectively, which indicates a good level of accuracy in the predictions. The MSE was also relatively low, with a value of 1.217 and 0.438, respectively. This indicates that the model's predictions were close to the actual values in these age categories.

However, when using the Gaussian membership function, the model performed even better in certain age categories, particularly in the age categories of 13-15 years and 19-24 years. The R square score for these categories was 0.990 and 0.988, respectively, which shows a high level of accuracy in the predictions. The MSE was also relatively low, with a value of 0.329 and 0.315, respectively. This suggests that the Gaussian membership function improved the accuracy of the model's predictions in these age categories.

5. CONCLUSION

Based on the results of the analysis carried out, it can be concluded that the Adaptive Neuro Fuzzy Inference System (ANFIS) model has a good performance in predicting school acceptance rates in Indonesia. Especially in the age category of 7-12 years and 13-15 years, the ANFIS model has an R square score of 0.981 and 0.989, as well as a Mean Square Error of 0.023 and 0.367. In the age category of 16-18 years and 19-24 years, the ANFIS model also performed well although with a slightly lower R square and Mean Square Error scores compared to the younger age category. However, when using the Gaussian membership function, the ANFIS model performs better, especially in the age categories of 13-15 years and 19-24 years. The R square scores for this category are 0.990 and 0.988, as well as the Mean Square Error of 0.329 and 0.315. Overall, it can be concluded that the ANFIS model is a good choice for predicting school acceptance rates in Indonesia, especially when using the Gaussian membership function.

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