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Prediction of Dengue Hemorrhagic Fever Cases Based on Weather Parameters Using Back Propagation Neural Networks (Case Study in Pontianak City)

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ABSTRACT

Research has been conducted by predicting cases of dengue hemorrhagic fever based on weather parameters. The data used are weather parameters in the form of air temperature data, air humidity, rainfall, duration of solar radiation and wind speed as input data and data on dengue hemorrhagic fever cases as the target data. This study aims to see the confirmation of dengue hemorrhagic parameters in Pontianak. The benefit in the field of education is that students and teachers are aware of the dangers of dengue because it can cause death. The method used is back propagation neural networks with the best network architecture in predicting cases of dengue hemorrhagic fever are [50 40 30 1] and binary sigmoid activation function, bipolar sigmoid and linear function. The activation function will determine whether the signal from the neuron input will be forwarded to other neurons and is also used to determine the output of a neuron. Network training correlation value is 0.9995 (very strong correlation) with MSE 0.0001 and network testing is 0.9325 (very strong correlation) with MSE 1.61. Determination coefficient serve as accuracy with values obtained is 0.85, which means that 85% of weather parameters can be used as input in predicting the incidence of dengue hemorrhagic fever in Pontianak City.

ABSTRAK

Penelitian telah dilakukan dengan memprediksi kasus demam berdarah dengue berdasarkan parameter cuaca. Data yang digunakan adalah parameter cuaca berupa data suhu udara, kelembaban udara, curah hujan, lama penyinaran matahari dan kecepatan angin sebagai data masukan dan data kasus demam berdarah dengue sebagai data target. Penelitian ini bertujuan untuk melihat akurasi parameter cuaca dengan kejadian demam berdarah dengue di Kota Pontianak. Manfaat penelitian dalam bidang pendidikan adalah agar siswa maupun guru sadar akan bahaya nya penyakit DBD karena dapat menyebabkan kematian. Metode yang digunakan adalah jaringan syaraf tiruan propagasi balik dengan arsitektur jaringan terbaik dalam memprediksi kasus demam berdarah dengue adalah [50 40 30 1] dan fungsi aktivasi sigmoid biner, sigmoid bipolar dan fungsi linier. Fungsi aktivasi akan menentukan apakah sinyal dari input neuron akan diteruskan ke neuron lain atau tidak dan juga digunakan untuk menentukan keluaran suatu neuron. Nilai korelasi pelatihan jaringan sebesar 0,9995 (korelasi sangat kuat) dengan MSE 0,0001 dan pengujian jaringan sebesar 0,9325 (korelasi sangat kuat) dengan MSE 1,61. Hasil koefisien determinasi dijadikan sebagai akurasi dengan nilai sebesar 0,85 yang artinya 85% parameter cuaca dapat dijadikan masukan dalam memprediksi kejadian demam berdarah dengue di Kota Pontianak.

Keywords: Artificial neural network; Back propagation; Dengue hemorrhagic fever; Weather.

INTRODUCTION

Dengue hemorrhagic fever (DHF) is a disease that is transmitted through the bite of aedes mosquito infected with the dengue virus (Hastuti, 2008). DHF was first spread and found in Indonesia in 1968 in the city of Surabaya as many as 58 people were infected and 24 people died (41.3% mortality) (Pangribowo, 2010). Pontianak City is an area in the tropics, so that it becomes a spreading area as well as

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endemic areas of DHF. House can be affect for DHF, the following house condition variables were significanly related (p-value<0.05): house lighting, water usage, house wall, ventilation area, and ownership of clean water facities (Wanti, 2019). The vast majority of dengue infections are clinically inapparent. Among the approximately 25% of those infected who have clinical manifestations, symptoms are often mild, but they may be moderate or severe in a small proportion, leading to death in 0.1-2.5% of all severe depending on host factors and access to care (Simmons et al, 2012).

Weather is an atmospheric condition that lasts a short time with a narrow period of time. Weather affects the development of dengue hemorrhagic fever. Weather changes cause some viruses to be expected to increase at the turn of the season. Some weather variables can affect the transmission of dengue hemorrhagic fever including air temperature, air humidity, rainfall, and wind (Wirayoga, 2013).

Several previous studies, modeling the influence of weather on the incidence of DHF using poisson regression, generalized poisson regression and negative binomial regression. The results of the analysis show that the best model is obtained using negative binomial regression (Rahayu, 2012). In addition, the weather is also used as a parameter to estimate the chances of dengue outbreaks using the Hopfield artificial neural network method with an estimated accuracy of 72% (Renitania, 2014). Artificial neural networks have been used to solve prediction problems, one of which is using the back propagation neural network method to predict asthma (Tanjung, 2015). The back propagation artificial neural network method is also used to predict the occurrence of hotspots in Pontianak City (Hakiki, 2015).

The method used in the research is back propagation neural networks. Back propagation was chosen because this method is suitable for use in cases that use weather parameters with fluctuating conditions. In this study the accuracy value between weather parameters and DHF cases was found in Pontianak City. The purpose of this research is to see how the weather can affect the incidence of dengue and people ranging from small to mature aware of the dangers of dengue.

BackPropagation Artificial Neural Network

System design is made through several stages, the first data is grouped into 2 parts, namely training data and test data grouped into input and target data. The training data is in the form of weather data, namely air temperature, air humidity, rainfall, duration of solar radiation and wind speed. While for the target data in the form of dengue hemorrhagic fever data.

The design of artificial neural network architecture is made by determining the input layer, hidden layer and output layer used in the training. The number of hidden layers is determined by trial and error, which means the results of the fastest and best learning determine the number of hidden layers.

Training of artificial neural networks in the form of data pattern recognition process. Artificial neural network training is done by adjusting the weight values that have been set at the beginning of the training. Mean Squared Error (MSE) is the square of the error that occurs between the output and the target. The achievement of the MSE value at the end indicates that the training phase is complete. Training is stopped if the final MSE value is smaller or equal to the MSE value that was set at the beginning. But if the MSE value is greater than the initial set, the training process will continue to the back propagation stage. In the testing phase, it is done by giving input in the form of some data that is not included in the training process.

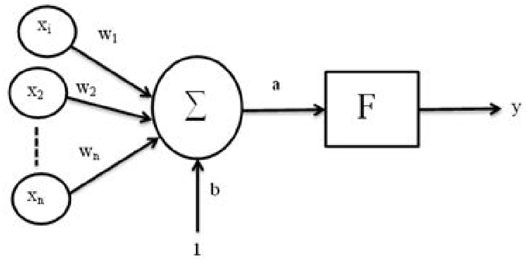

Figure 1. Activation function on simple neural networks (Kusumadewi, 2004).

In Figure 1, a neuron will process N inputs, each of which has weights w_1, w_2, ..., w_n and bias weights b with Equation (1).

$$a = \sum_{i=1}^{N} x_i w_i \qquad (1)$$

xi = input
wi = weight
Then the activation function F will activate a to be the network output y (Siang, 2005).

Back Propagation Algorithm

The back propagation algorithm is as

follows: The first step is Weight initialized with small random numbers. If the termination condition has not been fulfilled, an forward propagation phase is carried out until back propagation.

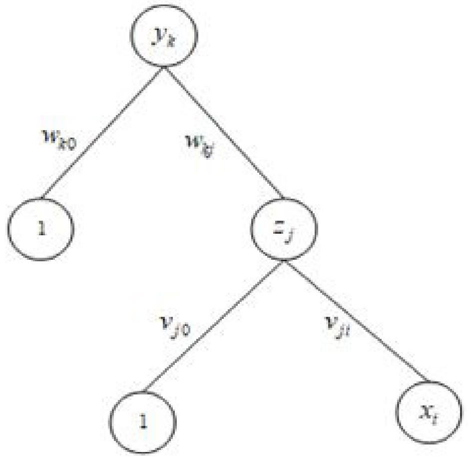

Figure 2. Network architecture

In figure 2 there are examples of input units in the form of x and a bias weight in the form of 1, a hidden screen in the form of z with a bias weight of 1, and the output unit y. In the forward propagation phase, each input unit receives a signal and is forwarded to the hidden unit above it. Next All outputs in hidden units are calculated by equation (2)

$$z\_net_j = v_{j0} + \sum_{i=1}^{n} x_i v_{ji} \tag{2}$$

The output signal is calculated (zj) in a hidden layer with an activation function, the output is passed on to the next layer.

$$z_j = f(z\_net_j) = \frac{1}{1+e^{-z\_net_j}} \tag{3}$$

Furthermore, the number of weighted signals that enter all outputs is calculated in the unit $y_k (k = 1, 2, ..., m)$

$$y\_net_k = w_{k0} + \sum_{j=1}^{p} z_j w_{kj} \tag{4}$$

The output signal result (yk) with the activation function will then be forwarded to all units in the next layer (output unit).

$$y_k = f(y\_net_k) = \frac{1}{1+e^{-y\_net_k}} \tag{5}$$

In the back propagation phase the output unit factor is calculated based on errors in each output unit $y_k (k = 1, 2, ..., m)$

$$\delta_k = (t_k - y_k) f'(y\_net_k)$$
$$\delta_k = (t_k - y_k) y_k (1 - y_k) \tag{6}$$

The weight change term is calculated by equation (10)

$$\Delta w_{kj} = \alpha \delta_k z_j \tag{7}$$

$$k = 1, 2, \ldots, m$$
$$j = 0, 1, ..., p$$

Then the hidden unit factor is calculated based on errors in each hidden unit $z_j (j = 1, 2, ...p)$

$$\delta\_net_j = \sum_{k=1}^{m} \delta_k w_{kj} \tag{8}$$

Hidden unit factor:

$$\delta_j = \delta\_net_j f'(z\_net_j)$$
$$\delta_j = \delta\_net_j z_j (1 - z_j) \tag{9}$$

The weight change term is calculated by the equation (13)

$$\Delta v_{ji} = \alpha \delta_j x_i \tag{10}$$
$$j = 0, 1, ..., p$$
$$i = 0, 1, \ldots, n$$

In the phase of weight change all weight changes are calculated Changes in line weight leading to the output unit:

$$w_{kj}(baru) = w_{kj}(lama) + \Delta w_{kj} \tag{11}$$

($k = 1, 2, \ldots, m$; $j = 0, 1, ..., p$)

Change the line weight to the hidden unit:

$$v_{ji}(baru) = v_{ji}(lama) + \Delta v_{ji} \tag{12}$$

($j = 0, 1, ..., p$; $i = 0, 1, \ldots, n$)

Test the stop condition (end of iteration) (Kusumadewi, 2004).

Results Analysis

Prediction results with artificial neural networks are considered good if they have a small MSE and a high correlation value on the results of the training and the results of the tests. The coefficient of correlation standard can be seen in Table 1.

Table 1. Relationship of Correlation Coefficients (Setiawan, 2017)

Coefficient Interval	Correlation Level
r = 0	No correlation
0 < r ≤ 0,20	Very weak
0,20 < r ≤ 0,40	weak
0,40 < r ≤ 0,70	Moderate
0,70 < r ≤ 0,90	Strong
0,90 < r ≤ 1,00	Very strong
1,00	Perfect

Then to find error values can be seen in equation (13) and training network correlation coefficients and testing in equation (14) can be determined by Equations:

$$MSE = \frac{1}{n}\sum (t-y)^2 \qquad (13)$$

$$r = \frac{n\sum ty - \sum t \sum y}{\sqrt{\left(n\sum t^2 - (t)^2\right)\left(n\sum y^2 - \left(\sum y\right)^2\right)}} \qquad (14)$$

To determine the accuracy or compatibility of the test results against the given target, the coefficient of determination is used which also serves to see the percentage of success predictions of cases of dengue hemorrhagic fever with given weather parameters. To find the coefficient of determination used the following equation (15) (Apriantoro, 2010).

$$r^2 = 1 - \left\{ \frac{\left(\sum\left((t-y)^2\right)\right)}{\left(\sum\left((t-\hat{y})^2\right)\right)} \right\} \qquad (15)$$

The final stage of this research will be obtained by a back propagation neural network system that is able to predict the number of dengue cases. So that from the training process and network testing that has been done will be obtained artificial neural network configuration that is suitable for predicting the number of dengue cases.

METHOD

The method used in this research is a back propagation artificial neural network. This method is used to predict the incidence of dengue in pontianak city in 2019.

Data

Data needed for this study include data for training, testing and prediction. Weather data was obtained from Supadio, Maritim and Siantan Meteorological Stations and data on the number of dengue cases were obtained from the Dinas Kesehatan Pontianak.

1. Training
   a. Air temperature
   b. Air humidity
   c. Rainfall
   d. Duration of solar radiation
   e. Wind speed
   f. the number of dengue cases in 2007-2017
2. Testing
   a. Air temperature
   b. Air humidity
   c. Rainfall
   d. Duration of solar radiation
   e. Wind speed
   f. The number of dengue cases in 2018
3. Data of prediction is data dengue cases in 2019

Location Research

Research did from June 2018 until February 2019 in laboratory physics computaion faculty of mathematics and sains tanjungpura university.

Diagram Work Research

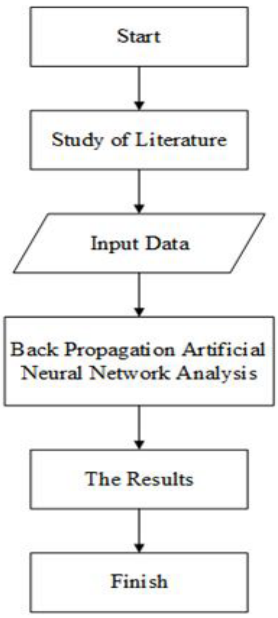

Figure 3. Diagram work research

In Figure 3, the research begins by looking for a literature study and then inputting the data to be used by analyzing the back propagation neural network method and if the results are as expected, the research is finished.

RESULTS AND DISCUSSION

Network Architecture

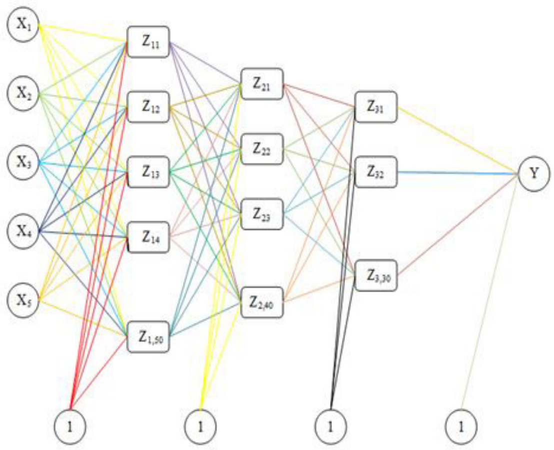

Figure 4. Artificial neural network architecture

The back propagation network architecture consists of 3 layers, namely input layer, hidden layer and output layer. Input layer consist of 5 weather parameters and dengue cases. Hidden layer look for trial and error which means the result of the fasters and best learning determine the number of layers. Output layers consist of 1 is dengue cases. The back propagation best architecture used in the study is [50 40 30 1]. As shown in Figure 6, the network consists of 5 units of neurons in the input layer, each representing data on air temperature, rainfall, air humidity, solar radiation time and wind speed, and 1 unit of neurons in the output layer. The hidden layer is designed as many as 3 layers composed of several neurons, namely 50-40-30-1. The hidden layer is designed as many as 3 layers which are composed of several neurons, namely 50-40-30. The first hidden layer in the architecture consists of 50 neurons with bipolar sigmoid activation function, the second hidden layer consists of 40 neurons with binary sigmoid activation function, and the third hidden layer consists of 30 neurons with bipolar sigmoid activation function. Whereas the output layer consists of 1 neuron with a linear function.

Training of Backpropagation Artificial Neural Networks

The purpose of network training is for the network to recognize weather parameter data patterns and dengue cases from 2007-2017. The training process is carried out by adjusting the weight values that have been set at the beginning of the training to produce a trained network. Figure 5 is a comparison of network output and the targets given in the training process using architecture and stable weights and produces network output in the form of a correlation between target and output of 0.9995. The calculation process can be seen in the attachment. Based on Table 1, the training correlation value includes the "Very Strong" category and has an MSE value of 0,0001. In figure 5 in the network training process used 572 weather parameters data and DHF case data from 2007-2017. in this figure, almost all outputs about

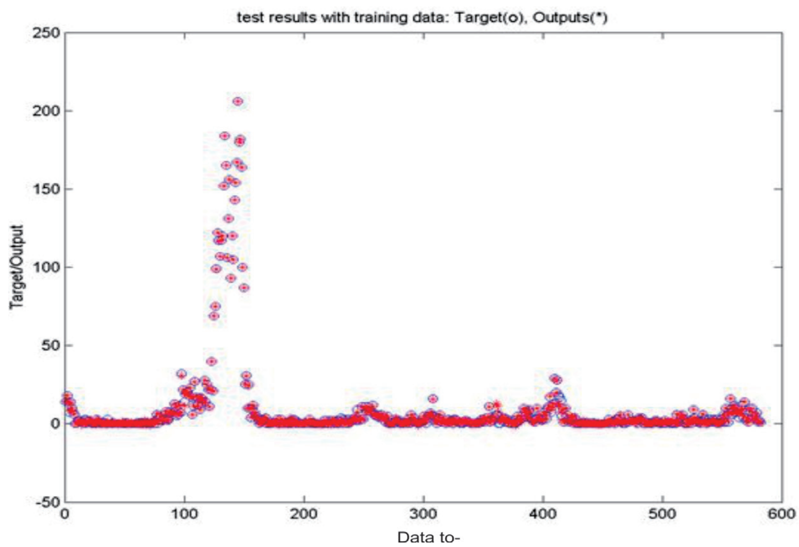

Figure 5. target and network training output

targets are very well proven by the high correlation value which is almost close to 1.

Testing of Backpropagation Artificial Neural Networks

Backpropagation Artificial Neural Network (ANN) testing is conducted to determine whether the network is able to recognize training data patterns from the input data. Data used in network testing is data that is not included in the training process, namely weather data and DHF data in 2018, each of 10 data. Figure 6 shows that the network output is nearing the target. The correlation value obtained is 0.932 and MSE is 1.61. Only a few of the outputs can hit the target precisely and it can be said that the network output pattern can recognize the target pattern.

In addition, the network testing also determines the value of determination which aims to see the strength of the relationship between the target and the output. The value of determination obtained from the calculation process is 0.85, which means that 85% of weather parameters can be used as network input data to predict the incidence of DHF. Based on the table 1, the correlation value is included in the category "Strong" category. This shows that the pattern of weekly dengue cases in Pontianak City can be identified by a backpropagation ANN using weather parameters as input. In figure 6 in the process of testing the network data used are weather parameter data and DHF case data in 2018 totaling 10 data. In this picture, not all outputs are targeted properly, but in this case it can be said that the network has been able to recognize the pattern of data provided.

Prediction of Dengue Hemorrhagic Fever

After the training and testing, prediction of dengue cases were carried out. The high correlation results from training and testing show that the network is able to recognize input data patterns. So predictions can be made. Prediction is done by using training and testing data that have produced the best correlation and only use weather parameters as input.

Figure 7 is the result of a prediction of dengue cases in 2018 in week 1-10. Prediction is done by looking at the target pattern agains the predicted output. In addition to weather factors that influence the incidence of dengue hemorrhagic fever, environmental factors are also quite influential. Another factor that influences the prediction results is that the data used for modeling comes from 3 different sta-

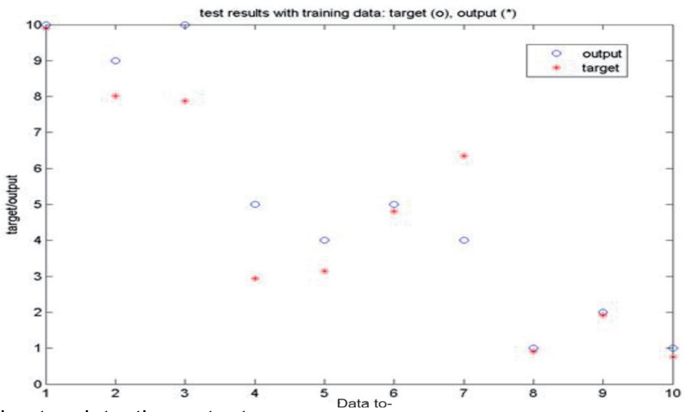

Figure 6. target and network testing output

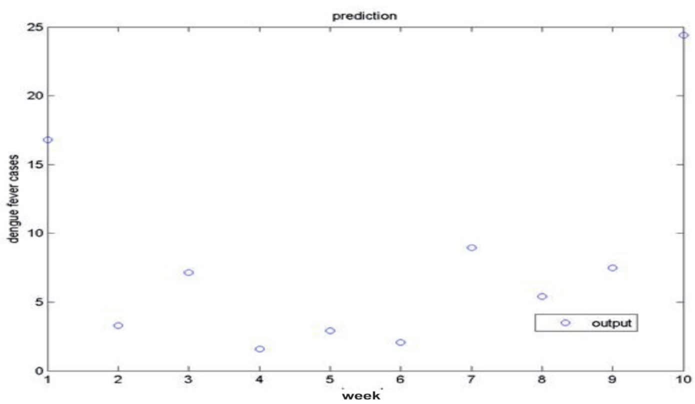

Figure 7. Predicted of dengue cases 2019

tions in the city of Pontianak. The existence of empty data for a certain period also influences the results of the prediction.

Air temperature is a measure of the average kinetic energy of the movement of molecules. The unit used in research is Celsius. For 24 hours the temperature changes. The highest case of dengue hemorrhagic fever occurred in 2009 with a correlation between temperature and the incidence of DHF was 0.30 with a weak correlation level and showed the direction of a positive relationship, which means the number of dengue events will increase if the air temperature rises. The optimum air temperature for mosquito growth is 25-30oC while the average temperature in 2009 was 27oC. Air temperature affects the development of viruses in the body of mosquitoes.

Humidity is the amount of moisture content in the air. The element of humidity used in research is relative humidity. The correlation between air humidity with the incidence of DHF is -0.44 which indicates the direction of the negative relationship, meaning that the higher the humidity, the incidence of DHF will decrease and vice versa if the humidity decreases, the incidence of DHF will increase. The average humidity in 2009 was 80-90% while the optimum humidity for mosquitoes breed was 70-80%. According to Yanti (2004) air humidity has no direct effect on the incidence of DHF, but it does affect the age of mosquitoes which are dengue vector transmitters. At air humidity below 60% evaporation of water from the mosquito's body so that it can shorten the life of mosquitoes.

Rainfall is the thickness of rainwater collected at an area of 1 m2. Rainfall is calculated in units of mm (millimeters). Rainfall is low correlated with the incidence of DHF that is equal to 0.02. There is no significant relationship between rainfall and the incidence of dengue fever because rain removes mosquito breeding places so that little by little mosquito breeding places will disappear and reduce the number of vectors.

The duration of the sun's irradiation is the length of the sun shining on the surface of the earth which is calculated from sunrise to sunset. The old solar irradiation data used is daily data in hours. The correlation between exposure time and the incidence of DHF in 2009 showed a moderate level of correlation with a value of 0.43. Mosquitoes actually tend to like dark places and protected from sunlight. Aedes aegypti mosquito habit in biting is in the morning or evening. According to Dini (2010) light influences mosquito habits to find food or a place to rest because there are species of mosquitoes that leave the resting place after 20-30 minutes of sunset.

Wind speed is the speed of air that moves horizontally above ground level. The wind speed unit used in the study is knots. The wind speed with the case of DHF in Pontianak City in 2009 has a correlation value of -0.1 which means it is negatively related. If the wind speed increases, the incidence of DHF will decrease and vice versa if the wind speed decreases, the incidence of DHF will increase. Silaban (2005) concluded that wind speed affects the spread of Aedes aegypti mosquitoes and the reachability of flying mosquitoes. The wider the range of mosquitoes, the more opportunities to contact humans, so that the age and reproduction period of mosquitoes is longer. Yanti (2004) also states that the higher the wind speed, the more difficult it is for vectors to fly. Therefore, it is difficult for mosquitoes to move long distances so that the possibility of mosquitoes to transmit DHF will be even smaller.

CONCLUSION

Artificial neural network back propagation can be used to predict dengue cases with weather parameters as network input. Correlation generated on the network testing is categorized as "very strong" and network accuracy is 85%. Weather factors can be used as initial information to predict the incidence of dengue hemorrhagic fever in Pontianak City. Research on dengue prediction can be done using other methods to see how the accuracy of the outputs with the given target. The amount of secondary data used should be expanded so that the network can better recognize input data patterns and get high correlation values.

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