SEMARAK ILMU PUBLISHING

Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Forecasting Occupancy Rate using Neural Network and Decision Tree at Hotel X

Mohamad Yusak Anshori[1], Teguh Herlambang[2], Vaizal Asy'ari[3], Puspandam Katias[1], Aji Akbar Firdaus[4,*], Hamzah Arof[5]

1 Department of Management, Faculty of Business Economics and Digital Technology, Universitas Nahdlatul Ulama Surabaya, 60237, Surabaya, Indonesia
2 Department of Information Systems, Faculty of Business Economics and Digital Technology, Universitas Nahdlatul Ulama Surabaya, 60237, Surabaya, Indonesia
3 Postgraduate of Department of Information Technology, Faculty of Computer Science, Universitas Pembangunan Nasional "Veteran" Jawa Timur, 60294, Surabaya, Indonesia
4 Department of Engineering, Faculty of Vocational, Universitas Airlangga, Surabaya, Jawa Timur 60115, Indonesia
5 Department of Electrical Engineering, Universiti Malaya, 50603 Kuala Lumpur, Malaysia

ABSTRACT

Occupancy rate is a critical factor in a hotel because it is used to measure the operational success of a hotel. The higher the hotel occupancy rate, the more successful the hotel business is in generating revenue. In the hospitality business, occupancy rates are very important to monitor and analyse as marketing strategies and pricing policies. This study compares the forecasting of occupancy rates at Hotel X using neural network method and decision tree method. The dataset used in this study is room available, room sold, and available occupancy percentage data at Hotel X from April 2018 to June 2023. The simulation was carried out by dividing the data into training data and testing data with a percentage ratio of 70:30, 75:25, 80:20, 85:15, and 90:10. The forecasting results that have been carried out using a neural network with one hidden layer have an optimal RSME result of 0.010 for split data of 70%:30% and 80%:20% while using a neural network with two hidden layers the optimal result of RSME is 0.013 for split data of 75%:25%. Forecasting results using decision tree RSME optimal results of 0.022 for split data 85%:15% and 90%:10%. From this forecasting, the most optimal results use a neural network with one hidden layer for data splits of 70%:30% and 80%:20% with RSME results of 0.010. The results of the research can be used by Hotel X as a policy determination in the next hotel management.

Keywords:
Occupancy; forecasting; neural network; decision tree

1. Introduction

Tourism development is proven to have advantages and disadvantages [1]. All stakeholders in the tourism sector must collaborate to make the tourism industry run well [2]. Stakeholder's roles, interests, and their power of influence can be determined for better management of the stakeholders [3]. Hotels are one of the biggest stakeholders in tourism and have an important role in tourism

* *Corresponding author.*
E-mail address: aa.firdaus@vokasi.unair.ac.id

https://doi.org/10.37934/araset.58.1.4962

industry. The hotel performance is mostly determined by two indicators occupancy and Average Room Rate (ARR). Some hotels prefer to use its occupancy as performance indicator, while some other hotels prefer to use its ARR as its performance indicator. However, most of the people believe that when the hotel occupancy is higher than others, people tend to see that its performance better than others. The hotel business is one of the industries that is growing amid today's business competition, as evidenced by the increasing number of rooms in accommodation businesses before and after the coronavirus disease 2019 (Covid-19) outbreak. The number of rooms in the accommodation business in Indonesia from 2018 to 2020 continued to increase from 712,202 rooms in 2018 to 870,783 rooms in 2020, then decreased the number of rooms in 2021 due to the Covid-19 outbreak to 718,898 rooms (a decrease of 17.42% from 2020). And the number of rooms in the accommodation business again increased by 9.75% in 2022 recorded at 788,982 rooms [4]. Based on the Data Center and Information System, Kemenparekraf/Baparekraf (Kementerian Pariwisata dan Ekonomi Kreatif / Badan Pariwisata dan Ekonomi Kreatif Republik Indonesia) the occupancy rate of star classification hotel rooms in June 2023 reached an average of 53.67% (up 3.39%) compared to June 2022 which was 50.28% [5] and non-star classification hotels in June 2023 reached an average of 24.58% (up 0.66%) compared to June 2022 which was 23.92% [6].

With the increasingly high competition in the hotel business, the hotel must be able to make a good strategy in its hotel management, by knowing the factors that affect the success of hotel operations. One of the factors used to measure the operational success of a hotel is to know the occupancy rate of hotel rooms. Occupancy rate of hotel room is the number of rooms in a hotel that have been rented out as compared to the total of rooms available in the hotel [7]. This ratio can fluctuate every day, the ratio in one month or one year is the average percentage of room occupancy sold, with high room sales, it is expected that sales at other outlets will also increase [8]. The higher the hotel occupancy rate, the more successful the hotel business is in generating revenue. In the hospitality business, occupancy rates are very important to monitor and analyse as marketing strategies and pricing policies. Based on this, this study will forecast occupancy rate using neural network and decision tree at Hotel X.

Neural networks have been around since 1943 when Warren McCulloch and Walter Pitts introduced the first neural network model calculations. This model describes the way artificial neurons can be used to process information binary. In 1950, Frank Ronseblatt continued his research by discovering a two-layer network called a perceptron. Neural network is a model with a flexible function structure, so the neural network model is rapidly developing and has been widely applied in various fields. Neural networks can be used to find solutions to problems when classical methods prove difficult or fail frequently [9].

A decision tree is a type of algorithm with a tree-like structure with acres, branches, and leaves. The root node represents the characteristics of the dataset, the canbang node represents the decision rules, and each leaf node represents the result. The purpose of using decision trees is to create a training model that can be used to predict the class or value of target variables by examining simple decision rules derived from previous information [10]. A decision tree is a useful tool for decision analysis because it may graphically and clearly reflect choices and the decision-making process.

In previous studies, several forecasting methods were used for forecasting average room rate using k-nearest neighbour [11], estimation of closed hotels and restaurants in Jakarta as impact of corona virus disease spread using adaptive neuro fuzzy inference system [12], neural network algorithm for breast cancer diagnosis [13], forecasting occupancy rate using neural network [14], comparison between neural network and adaptive neuro guzzi inference system on sunlight intensity prediction [15], forecasting the number of demam berdarah dengue (DBD) patients using the fuzzy logic [16], prediction of bubble point pressure for Sudan crude oil using artificial neural network [17], profitability estimation using H-Infinity and Ensemble Kalman Filter (EnKF) [18], stock price estimation using Unscented Kalman Filter [19] and Ensemble Kalman Filter Square Root (EnKF-SR) [20], prediction of student graduation on time using decision tree [10], estimation of magnetorheological elastomer carbonyl iron particle concentration using artificial neural network [21], uses decision tree in datamining for new zeotropic refrigerant [22]. In this study, neural network and decision tree methods were used to forecast occupancy rates at Hotel X, so that it can be used as the next policy determinant in the next hotel management.

From the use of the neural network method with one hidden layer, optimal RSME results were obtained of 0.010 for split data training 70% and data testing 30%, the same results RSME of 0.010 for split data training 80% and data testing 20%. From the use of the neural network method with two hidden layers, the optimal RSME result was obtained at 0.013 for split data training 75% and data testing 25%. From the use of the decision tree method, the optimal result of RSME 0.022 for split data training 85% and data testing 15%, the same result RSME of 0.022 for split data 90% and data testing 10%. The results of the research can be used by Hotel X as a policy determination in the next hotel management.

2. Methodology

2.1 Neural Network

The basics of neural networks consist of inputs, weights, processing units, and outputs. Neural networks can be applied to classifying patterns, mapping patterns obtained from inputs into new patterns in outputs, storing patterns to be recalled, mapping similar patterns, optimizing problems, and also predicting. Neural Network terms to perform typical tasks that would be performed by the brain [23]. Neural networks start from preparing data for training and learning, discovering neural network architecture, training and learning processes, and testing processes [24].

Neural networks can be divided into three parts called layers as shown in Figure 1.

i. Input layer, responsible for receiving information, signals, features, or measurements from the external environment.
ii. Hidden layers, responsible for extracting patterns related to the process or system being analysed.
iii. The output layer, responsible for producing and presenting the final network, results from processing by neurons in the previous layer.

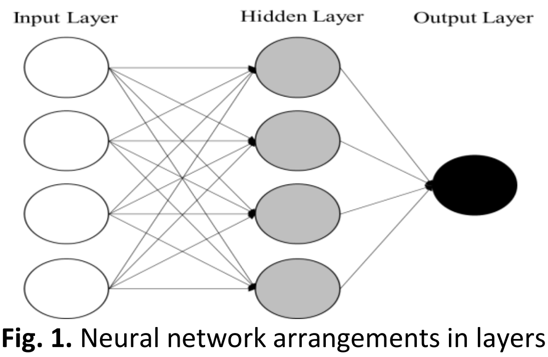


Fig. 1. Neural network arrangements in layers

Neural networks can change structures to solve problems based on internal and external information flowing through the network. Neural networks can be used to model the relationship between input and output to find patterns of data. Neurons are a basic part of the processing of a neural network. The basic shape of a neuron can be seen in Figure 2 below.

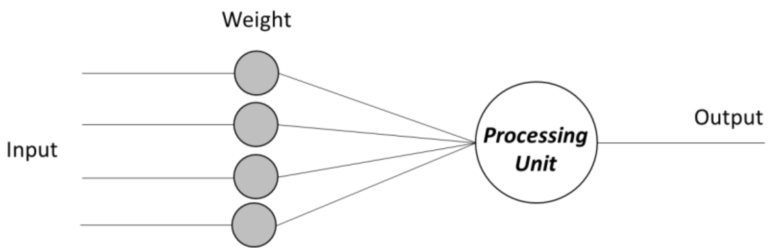


Fig. 2. Basic from of neurons

The weight vector (w) contains weights that connect the various parts of the network. The term "w" is used in the terminology of neural networks and is a suggestion of the expression of connections between two neurons, that is, the weight of information flowing from one neuron to another neuron in a neural network. The first stage is the process of summing the inputs x_1, x_2 ,… x_n which is multiplied by its weight w_1, w_2 ,… w_n expressed in Eq. (1) as Figure 3.

$$Net = (w_1.x_1 + w_2.x_2 + w_3.x_3 + \ldots + w_n.x_n) \quad (1)$$

This concept can be written in vector notation as follows:

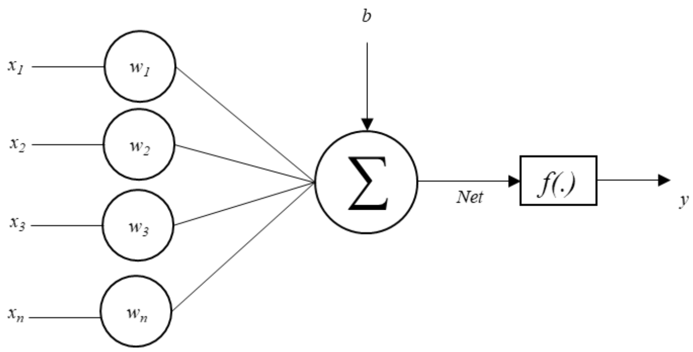


Fig. 3. Perceptron model

A threshold value of b is called a bias, which plays an important role for some neuron models and needs to be referred to as a separate neuron model parameter. Various input conditions and influences on output are required to include a nonlinear activation function f(.) in the arrangement of neurons [25]. This aims to achieve an adequate level if the input signal is small and avoid the risk of output going to inappropriate limits. Like the perceptron model in Figure 3 the output of the neuron can be expressed in terms of Eq. (2):

$$y = f(net) \quad (2)$$

2.2 Decision Tree

Decision trees use data tree structures as models in the process of determining the class of data. There are three types of nodes in the decision tree [26]:

i. Root node, is a node that has no input edge and has a value of 0 or more output edges.
ii. Internal node, has exactly one input edge and has two or more output edges.
iii. The output layer, responsible for producing and presenting the final network, results from processing by neurons in the previous layer.

The main benefit of using decision trees is their ability to describe complex decision-making processes more simply so that decision makers will better interpret the solution of problems. Decision trees are also useful for exploring data, finding hidden relationships between a number of prospective input variables and a target variable [27].

The working step of the decision tree algorithm begins with calculating entropy. Entropy (S) is used to determine the number of bits in the process of class + and – extraction from a random amount of data in the sample space S. Entropy is also used as a bit requirement to express a class. The entropy value in the sample space S is defined in Eq. (3).

$$Entropy(S) = -p+\ log2\,p+\ -p-\ log2\,p- \tag{3}$$

S = Data or sample collection for training
P+ = Number of positive solutions on sample data for specific criteria
P- = Number of negative solutions on sample data for specific criteria

The next step is the calculation of gain. Gain serves as a measure of how well an attribute separates the training example into target classes. The attribute with the highest gain information value will be selected. Then the calculation of gain information is carried out. To calculate the gain information used Eq. (4).

$$Gain(S,A) = Entropy\ (S) - \sum_{Values\ (A)}^{n} \frac{|S_v|}{|S|}\ Entropy\ (S_v) \tag{4}$$

S = data Samples used for training
A = attribute
V = an attribute value A
Values(A) = possible sets for attribute A
$|S_v|$ = number of samples for values *V*
|S| = sum of all sample data
Entropy (S)= entropy for Samples that have value *V*

3. Results

The dataset used in this study is room available, room sold out, and available occupancy percentage data at Hotel X. The dataset used is data from April 2018 to June 2023 (63 months). Furthermore, the data is split into training data and testing data. Then a test analysis was carried out with the neural network algorithm with one hidden layer, neural network with two hidden layers, and decision tree. After that, a comparison of RSME results from several tests of the algorithm was carried out.

3.1 Analysis of Neural Network Algorithm Testing with One Hidden Layer

At this stage, a model is made using a neural network algorithm with one hidden layer. Training data and testing data use percentage comparisons of 70:30, 75:25, 80:20, 85:15, and 90:10. The design model used can be seen in Figure 4.

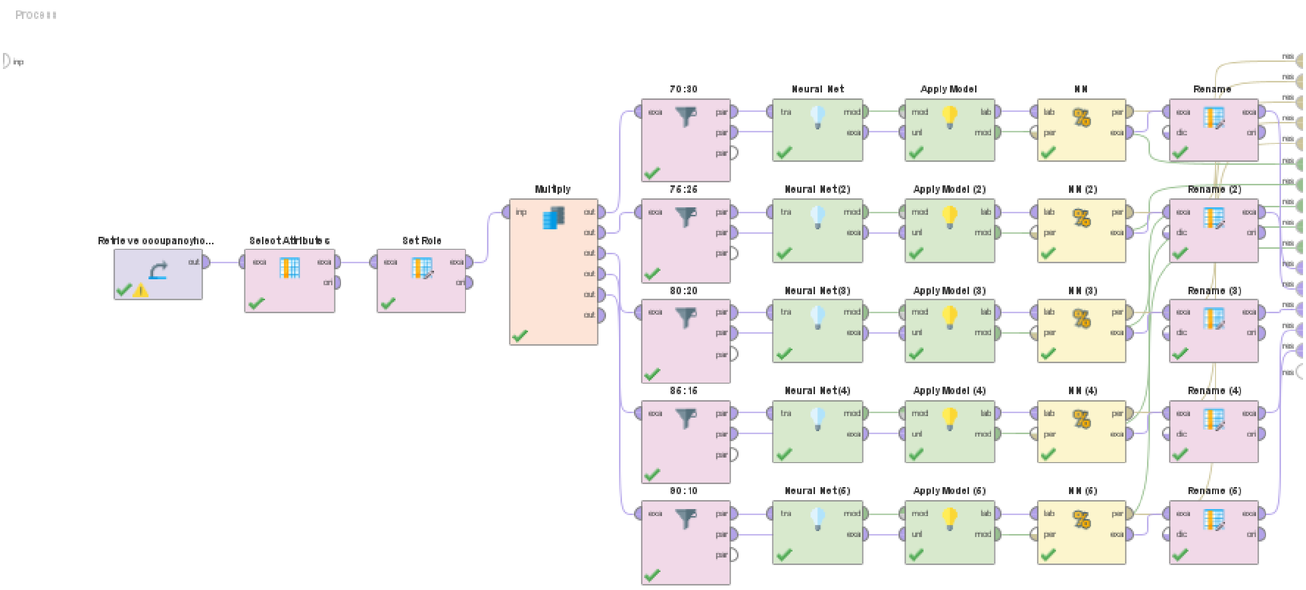


Fig. 4. Design a neural network model with one hidden layer

From the design of the neural network model with one hidden layer that has been created, then apply the model to determine the performance of each split data. The results of these tests can be seen in Table 1.

Table 1
Test result using neural network with one hidden layer

Training data	Testing data	RSME
70%	30%	0.010
75%	25%	0.013
80%	20%	0.010
85%	15%	0.014
90%	10%	0.012

From forecasting done using a neural network with one hidden layer is known that RSME is best found in split data 70%: 30% and split data 80%: 20% with RSME of 0.010. The test result model using a neural network with one hidden layer for split data of 70%:30% can be seen in Figure 5(a). The test result model using a neural network with one hidden layer for split data of 80%:20% can be seen in Figure 5(b).

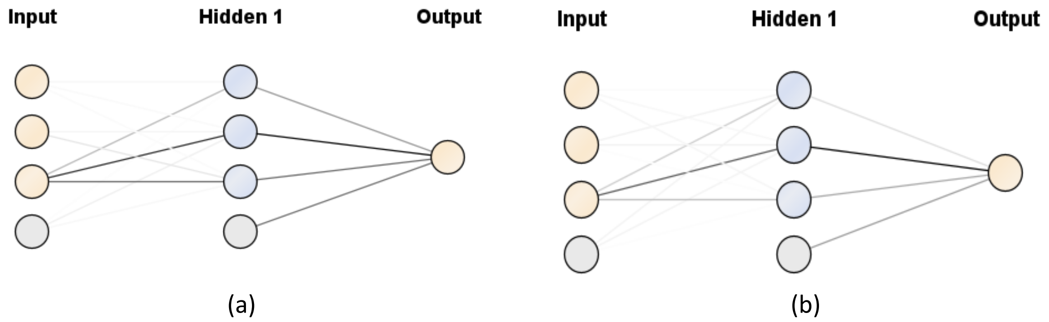


Fig. 5. Neural network model with one hidden layer (a) split data 70%:30% (b) split data 80%:20%

Figure 6 shows a comparison of real occupancy percentage data and occupancy rate prediction in 70%:30% split data using neural network algorithm with one hidden layer. In the graph, the black line shows real occupancy data and the red line shows the predicted occupancy rate data. There was a significant decrease in April 2020 with an occupancy of 15.30% in real data and an occupancy of 17.14% in forecasting data. There was an increase in the occupancy rate in December 2020 with an occupancy of 83.24% in real data and an occupancy of 82.19% in forecasting data.

Fig. 6. Occupancy prediction using neural network with one hidden layer (split data 70%:30%)

Figure 7 shows a comparison of real occupancy percentage data and occupancy rate prediction in 80%:20% split data using neural network algorithm with one hidden layer. In the graph, the black line shows real occupancy data and the red line shows the predicted occupancy rate data. The lowest occupancy rate in April 2023 with an occupancy of 29.75% in real data and an occupancy of 38.83% in forecasting data. There was an increase in December 2020 with 83% occupancy in real data and 82% occupancy in forecasting data.

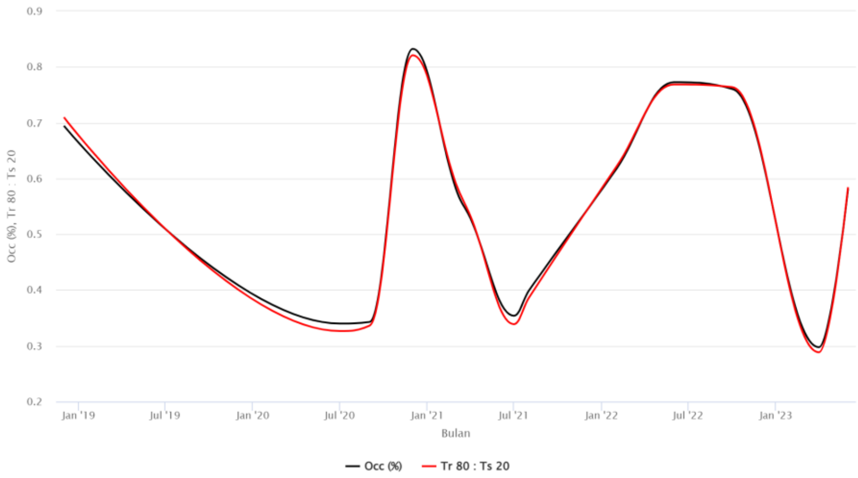


Fig. 7. Occupancy prediction using neural network with one hidden layer (split data 80%:20%)

3.2 Analysis of Neural Network Algorithm Testing with Two Hidden Layer

At this stage, a model is made using a neural network algorithm with two hidden layers. Training data and testing data use percentage comparisons of 70:30, 75:25, 80:20, 85:15, and 90:10. The design model used can be seen in Figure 8.

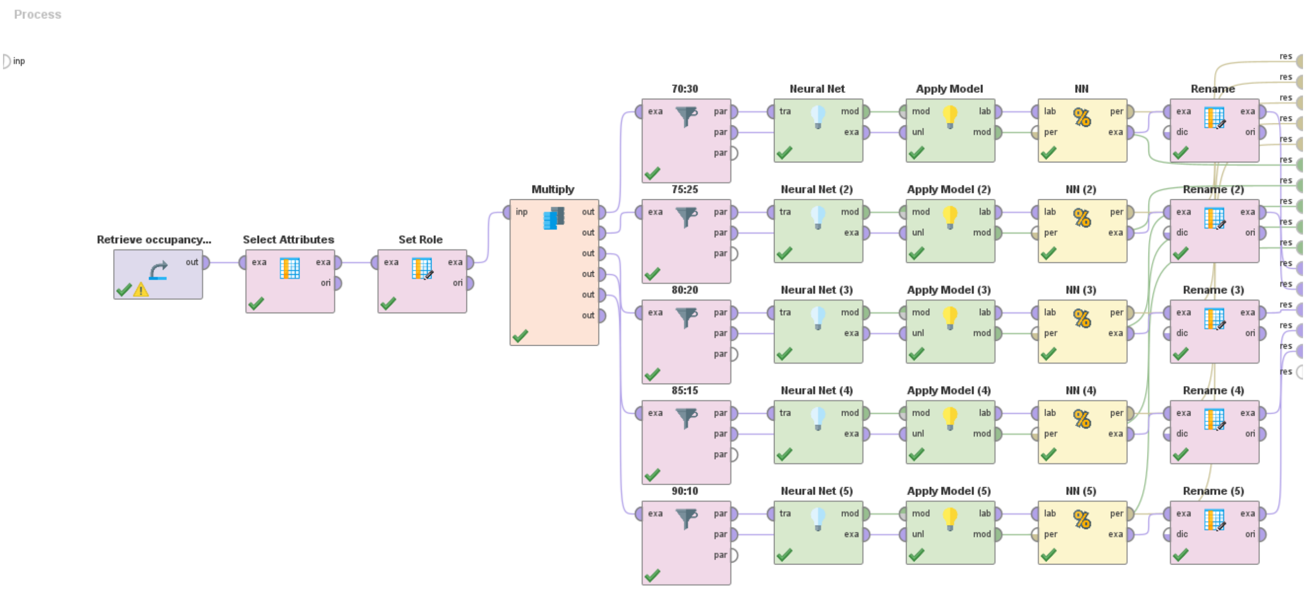


Fig. 8. Design a neural network model with two hidden layers

From neural network model design with two hidden layers that have been created are then applied model to find out the performance of each split data. The results of these tests can be seen in Table 2.

Table 2
Test result using neural network with two hidden layers

Training Data	Testing Data	RSME
70%	30%	0.036
75%	25%	0.013
80%	20%	0.020
85%	15%	0.023
90%	10%	0.016

From forecasting carried out using neural networks with two hidden layers is known that RSME is best found in split data 75%: 25% with RSME of 0.013. The test result model using a neural network with two hidden layers for split data of 75%:25% can be seen in Figure 9.

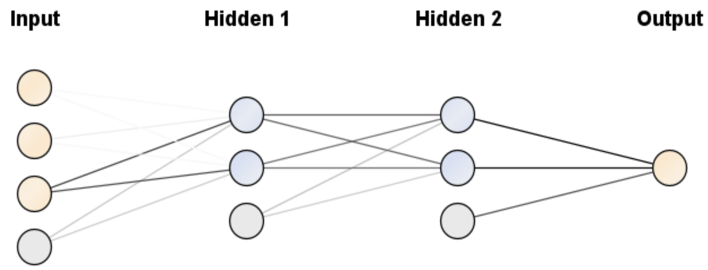


Fig. 9. Neural network model with two hidden layers (75%:25% split data)

Figure 10 shows comparison of real occupancy percentage data and occupancy rate prediction in 75%:25% split data using neural network algorithm with two hidden layers. In the graph, the black line shows real occupancy data and the blue line shows the predicted occupancy rate data. The highest occupancy rate was in November 2018 with 79.27% occupancy in real data and 78.23% occupancy in forecasting data. The lowest occupancy rate was in August 2020 with an occupancy of 35.25% in real data and an occupancy of 33.56% in forecasting data.

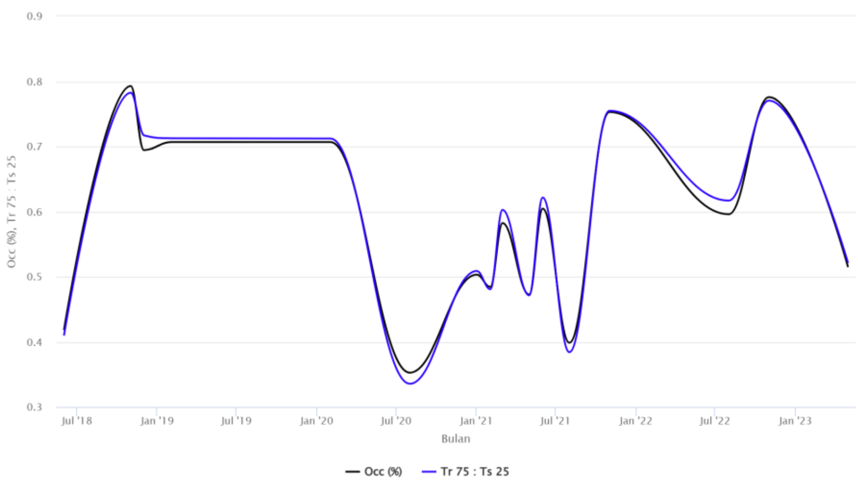


Fig. 10. Occupancy prediction using neural network with two hidden layers (split data 75%:25%)

3.3 Decision Tree Algorithm Testing Analysis

At this stage, model creation is carried out using the decision tree algorithm. Training data and testing data use percentage comparisons of 70:30, 75:25, 80:20, 85:15, and 90:10. The design model used can be seen in Figure 11.

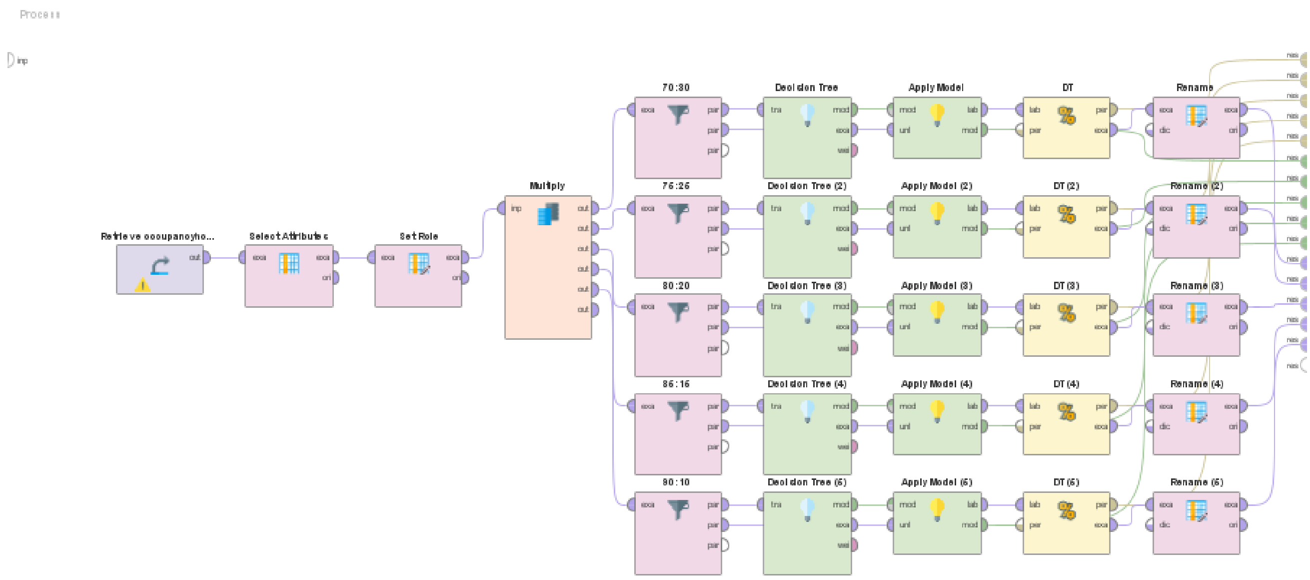


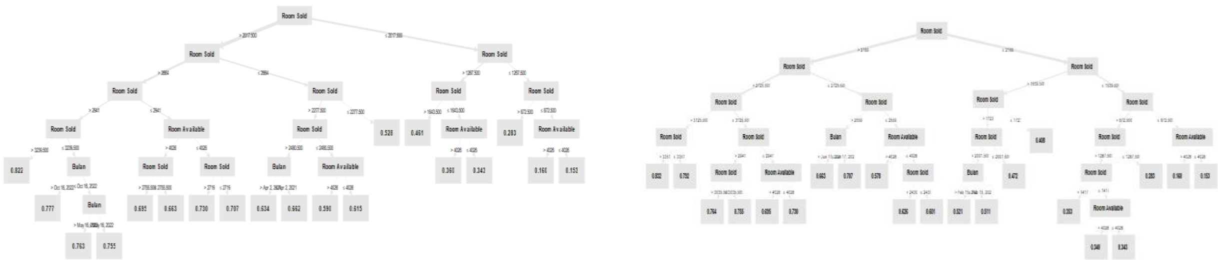
Fig. 11. Design a decision tree model

From the decision tree design model that has been created is then applied model to determine the performance of each split data. The results of these tests can be seen in Table 3.

Table 3
Test result using neural decision tree

Training data	Testing data	RSME
70%	30%	0.023
75%	25%	0.033
80%	20%	0.097
85%	15%	0.022
90%	10%	0.022

From forecasting carried out using a neural network with one hidden layer, it is known that RSME is best found in split data 85%: 15% and split data 90%: 10% with RSME of 0.022. The test result model using a decision tree for split data of 85%:15% can be seen in Figure 12(a). The test result model using a decision tree for split data of 90%:10% can be seen in Figure 12(b).



(a) (b)

Fig. 12. Decision tree model (a) split data 85%:15% (b) split data 90%:10%

Figure 13 shows a comparison of real occupancy percentage data and occupancy rate prediction in 85%:15% split data using decision tree algorithm. In the graph, the black line shows real occupancy data and the green line shows the predicted occupancy rate data. The highest occupancy rate was in December 2020 with an occupancy of 83.23% in real data and an occupancy of 82.16% in forecasting data. The lowest occupancy rate was in July 2019 with an occupancy of 33.99% in real data and an occupancy of 35.95% in forecasting data.

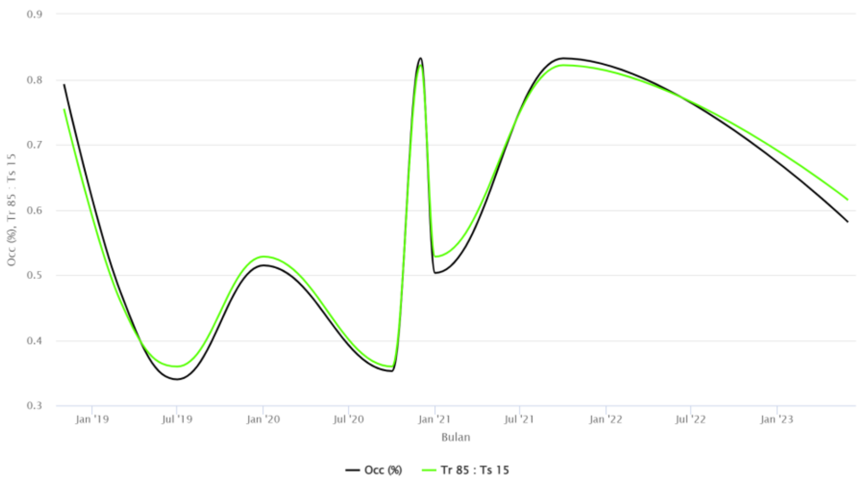


Fig. 13. Occupancy prediction using decision tree (split data 85%:15%)

Figure 14 shows a comparison of real occupancy percentage data and occupancy rate prediction in 90%:10% split data using decision tree algorithm. In the graph, the black line shows real occupancy data and the green line shows the predicted occupancy rate data. The highest occupancy rate was in October 2018 with an occupancy of 82.69% in real data and an occupancy of 83.22% in forecasting data. The lowest occupancy rate in January 2023 with 59.21% occupancy in real data and 57.77% occupancy in forecasted data.

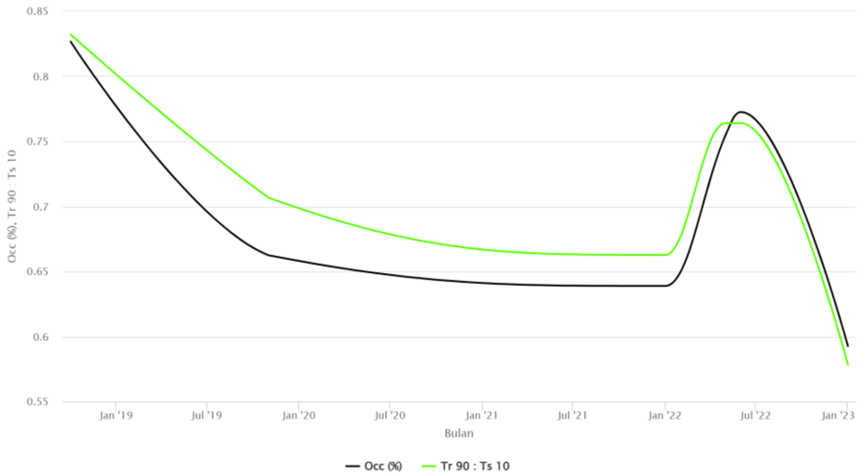


Fig. 14. Occupancy prediction using decision tree (split data 90%:10%)

3.4 Algorithm Testing Comparison

At this stage, a comparison of neural network algorithms with one hidden layer, neural network with two hidden layers, and decision tree is carried out. The results of the comparison of these algorithm tests are shown in Table 4.

Table 4
Comparison of algorithm testing

Algorithm	RSME with split data				
	70:30	75:25	80:20	85:15	90:30
Neural network with one hidden layer	0.010	0.013	0.010	0.014	0.012
Neural network with two hidden layers	0.036	0.013	0.020	0.023	0.016
Decision tree	0.023	0.033	0.097	0.022	0.022

The most optimal RSME result in split data with a percentage ratio of 70:30, 80:20, 85:15, 90:30 is to use a neural network with one hidden layer. Meanwhile, in split data with a percentage ratio of 75:25, the most optimal RSME of 0.013 was obtained using a neural network with one hidden layer or using a neural network with two hidden layers.

The most optimal RSME results for neural networks with one hidden layer with an RSME of 0.010 are in data splits of 70%:30% and 80%20%. The most optimal RSME result for neural networks with two hidden layers with an RSME of 0.013 is in a data split of 75%:25%. The most optimal RSME result for decision trees with RSME of 0.022 is in split data of 70%:30% and 80%:20%. The most optimal RSME result from the algorithm comparison is to use RSME neural network with one hidden layer with RSME of 0.010 in the data split of 70%:30% and 80%:20.

4. Conclusions

Based on research that has been conducted on the Hotel X dataset using a neural network with one hidden layer, a neural network with two hidden layers, and a decision tree, the most optimal RSME results are obtained using a neural network with one hidden layer with an RSME of 0.010 in a data split of 70%:30% and 80%:20%. So, it can be concluded that Hotel X can use a neural network with one hidden layer as a prediction of occupancy rate to determine policies in the next hotel management.

Acknowledgement
High appreciation to the Kemdikbudristek for the very fund support for the research conducted in the year of 2023 with contract number 183/E5/PG.02.00.PL/2023, 049/SP2H/PT/LL7/2023 and 1287/UNUSA-LPPM/Adm-I/VII/2023.

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