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Room occupancy classification using multilayer perceptron

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ABSTRACT

A room that should be comfortable for humans can create a sense of absence and appear diseases and other health problems. These rooms can be from boarding rooms, hotels, office rooms, even hospital rooms. Room occupancy prediction is expected to help humans in choosing the right room. Occupancy prediction has been evaluted with various statistical classification models such as Linier Discriminat Analysis LDA, Classification And Regresion Trees (CART), and Random Forest (RF). This study proposed learning approach to classification of room occupancy with multi layer perceptron (MLP). The result shows that a proper MLP tuning paramaters was able estimate the occupancy with 88.2% of accuracy .

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1. INTRODUCTION

Habitability is something that must be met if someone wants to use a room to carry out activities. Rooms that should be inhabited by humans can cause discomfort and appear diseases and other health problems [1]. These rooms can be from boarding rooms, hotels, office rooms, even hospital rooms. Even though the room looks beautiful, there are other variables invisible to the human eye that can make a room uninhabitable, such as temperature and humidity. This can be caused by various things, from global warming, poor air ventilation, the lifestyle of the occupants of the room itself, and so on.

In an office or work room, work productivity can reach its maximum level if the working room conditions meet the minimum standards so that a person can work effectively and efficiently [2]. The source of danger in the workroom is a hot work climate that can cause physiological impacts in the form of an increase in body temperature, blood pressure and pulse [3]. One of the causes of hot room is global warming. The impact of global warming is felt on a regional scale [4]. External conditions in the work environment consist of the suitability of room temperature to environmental conditions, relative humidity of the air, and air flow to body temperature. Uncomfortable conditions can interfere with concentration and cause not optimal work productivity. Visual comfort such as lighting can also affect work productivity [2].

Urbanization has negative impacts such as decreasing quality, increasing environmental damage, increasing greenhouse gas emissions, and socio-economic problems [5]. As a result of the increasing number of urban residents, uninhabitable and irregular residential areas have emerged which are faced by almost all cities in Indonesia [6]. The environment as measured by the comfort of the room can affect the price of the room and in a case study of renting a boarding house around the University of Samudra, the prices given to residents sometimes do not match the environmental conditions and quality of the room [7]. The need for ventilation air lanes must meet the comfort and health of indoor temperatures as an energy conservation effort [8].

Artificial intelligence methods show advantages over nonlinear systems including neural networks and fuzzy logic. The advantages of neural networks are strong computing capabilities, adaptive, capable of parallel processing, and learning ability [9]. In general, neural networks are divided into four types, namely Single Layer Perceptron (SLP), Multilayer Perceptron (MLP), Radial Basis Networks (RBN), and Recurrent Neural Netowork (RNN) [10].

Neural networks are a field of science that produces various kinds of renewable technologies such as pattern recognition, big data classification, to cars that can drive themselves automatically [11]. Neural networks have the advantage that the solution is continuous so that it is easy to understand and process, and does not require modification methods to solve a complex problem [12].

The neural network process is divided into two, namely the training process and the network operation process [13]. In the training process, the weight of each layer will be modified according to adaptive learning. The learning is divided into two, namely directed learning and undirected learning. In the network operation process, the weights are fixed and not modified anymore and the outputs have been obtained. The neurons in the hidden layer function as processing units. The learning process in a feedforward neural network involves input-output data to determine weights and biases. The activation function in the processing unit is used as a limiter on the output of neurons in the neural network between 0 and 1, or -1 and 1. The activation function can be sigmoid, hyperbolic tangent, radial basis, and so on [14].

MLP is one of the most widely used types of artificial neural networks in various applications involving dynamic and nonlinear problems[15]. MLP has a way of working like a neural network in the human brain so that it is able to learn from experience. The first layer is connected to the input data vector, then the output is connected to the hidden layer. The output of the hidden layer is connected to the output layer and becomes the final result in the MLP. Between the two layers, there is a weight associated with each layer. These weights are multiplied by the output nodes of the layer before becoming input to the next layer [10] .MLP is often used because it has good generalization abilities and produces a high level of accuracy [12].

To determine a livable room or not, an application with artificial intelligence is needed to determine it accurately so that it is effective and efficient. Therefore, the application "Room Occupancy Classification Using Multilayer Perceptron" was made.

2. METHOD

This research was conducted in several stages: obtaining the dataset, preprocessing, model training, and evaluating the model. In the training process, the weight of each layer will be modified according to adaptive learning. Before each model training, tuning is performed on the parameters of the artificial neural network to get optimal results. The stages in this study can be seen in Figure 1.

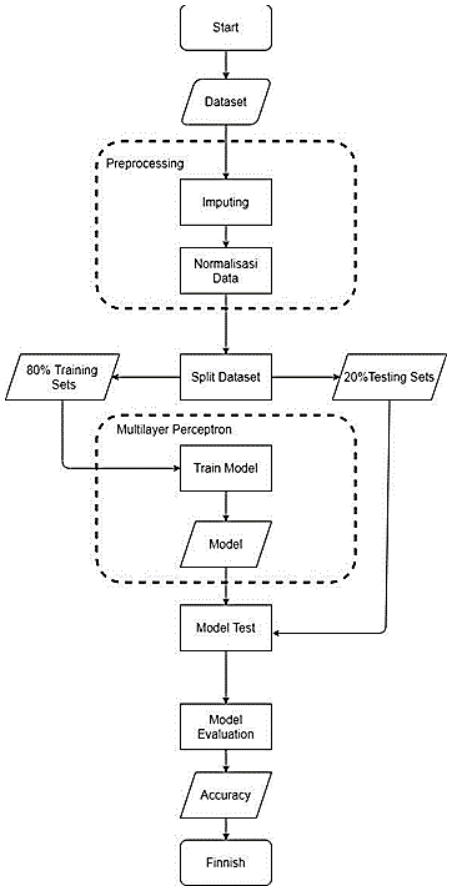

Figure 1. Multilayer perceptron artificial neural network research method

2.1 Dataset

A dataset is a collection of data that comes from past information and is managed into information to perform techniques from data mining science. In this study, the Room Occupancy dataset was used which was obtained from the kaggle.com site. This dataset has 5 features, namely temperature, humidity, light, CO2, and humidity ratio, all of which are decimal numbers and there is a target column with a value of 1 for habitable room and 0 for uninhabitable room.

2.2 Preprocessing

Preprocessing is an initial technique in data mining before the model training process is carried out to convert raw data collected from various sources into cleaner information that can be used for further processing. This process can also be called the initial step to retrieve all available information by cleaning, filtering, and combining the data. Preprocessing data is very important because errors, redundancy, missing values, and inconsistent data lead to reduced accuracy of analysis results.

In this study, preprocessing imputing missing value data and data normalization were carried out. The imputing missing value method used is the average imputation. The mean imputation replaces the missing values with the average value of the feature.

Normalize the dataset using the StandardScaler. The idea behind StandardScaler is that it will transform your data in such a way that the distribution will have a mean value of 0 and a standard deviation of 1. StandardScaler with a sample of x is calculated as

$$Z = (x - u)/s$$

where u is the mean of the training sample and s is the standard deviation of the training sample.

2.3 Model training

This study uses a multilayer perceptron artificial neural network. The calculations that occur for each neuron in the output layer and hidden layer are as follows,

$$o(x) = G(b(2) + W(2)h(x))$$

$$h(x) = \Phi(x) = s(b(1) + W(1)x)$$

Figure 2. Calculation formula for each neuron hidden layer and output multilayer perceptron

With bias vector b(1), b(2); weight matrix W(1), W(2) and activation functions G and s. The set of parameters studied is the set = {W(1), b(1), W(2), b(2)}. Common choices for s include the tanh function with tanh(a) = (ea e− a)/(ea + e− a) or the logistic sigmoid function, where sigmoid(a) = 1/(1+ e− a).

2.4 Model Evaluation

Prior to model training, the dataset was distributed. The dataset is divided into training data by 80% and test data by 20%. The model obtained from the training results was tested using test data. Tests are carried out to get the accuracy of the model

3. RESULTS AND DISCUSSIONS

Based on the data entered into the system as many as 2665 records with 5 features consisting of temperature, humidity, light, CO2, and humidity ratio, all of which are decimal numbers and there is a target column with a value of 1 for habitable room and 0 for inhabitable room. The number of data for habitable room is 1693 and unfit for habitation is 972. The top 5 datasets can be seen in Table 1.

Table 1. Five records of room occupancy dataset

No	Temperature	Humidity	Light	CO2	Humidity Ratio	Occupancy
1	23.700000	26.272000	585.200000	749.200000	0.004764	1
2	23.718000	26.290000	578.400000	760.400000	0.004773	1
3	23.730000	26.230000	572.666667	769.666667	0.004765	1
4	23.722500	26.125000	493.750000	774.750000	0.004744	1
5	23.754000	26.200000	488.600000	779.000000	0.004767	1

3.1 Preprocessing Result

In this study, preprocessing imputing missing value data and data normalization were carried out. The imputing missing value method used is the average imputation. The mean imputation replaces the missing values with the average value of that feature. Normalize the dataset using the StandardScaler. Preprocessing results can be seen in Table 2.

Table 2. Five records of room occupancy after preprocessing

No	Temperature	Humidity	Light	CO2	Humidity Ratio	Occupancy
1	0.024913	0.027616	0.615145	0.787537	0.000005	1
2	0.024809	0.027499	0.604997	0.795366	0.000005	1

3	0.024719	0.027323	0.596533	0.801743	0.000005	1
4	0.025803	0.028416	0.537043	0.842681	0.000005	1
5	0.025813	0.028471	0.530955	0.846528	0.025813	1

3.2 Model

This study used a multilayer perceptron artificial neural network. Figure 2 shows the architecture used in this study.

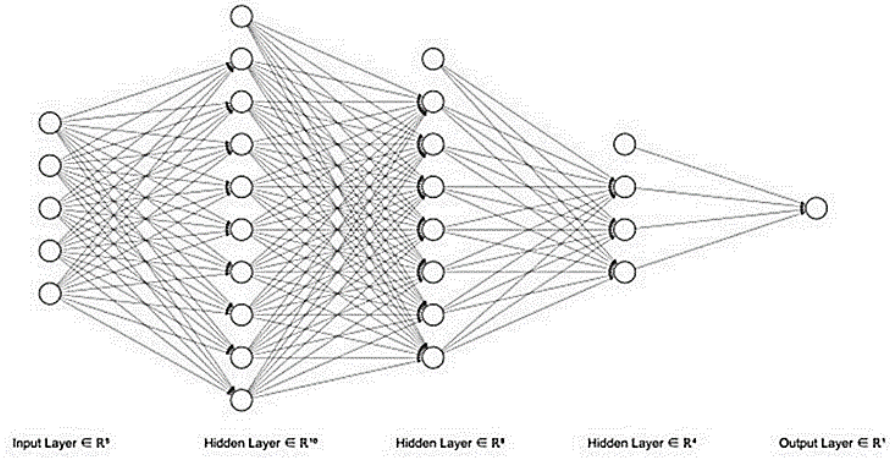

Figure 3. Multilayer perceptron neural network architecture

In the architecture there are 5 layers. The first layer is the input layer with the input data in the form of 5 features from the available dataset. There are 3 hidden layers with 10 neurons in the first hidden layer, 7 neurons in the second hidden layer, and 4 neurons in the third hidden layer. Each hidden layer has 1 bias. The output layer in the architecture used is 1 neuron because this artificial neural network model is used for classification. The activation functions used in the hidden layer are binary sigmoid and ReLU. These two activation functions are the most optimal and suitable because the target is binary. ReLU stands for rectified linear unit, and is a type of activation function. Mathematically, it is defined as:

$y = \max(0, x)$

The binary sigmoid function has values in the range 0 to 1. Therefore, this function is often used for neural networks that require output values that lie in the interval 0 to 1. The binary sigmoid function is formulated as:

$y = 1/1+e-x$

The Binary Cross Entropy function is used in this architecture. Binary Cross Entropy compares each predicted probability with the actual class output which can be either 0 or 1. Then calculates a score that penalizes the probability based on the distance from the expected value. It means how close or far from the true value. The following is the formula for the Binary Cross Entropy function.

$$H_p(q) = -\frac{1}{N}\sum_{i=1}^{N} y_i \cdot log(p(y_i)) + (1 - y_i) \cdot log(1 - p(y_i))$$

Figure 4. Formula of binary cross entropy function

3.3 Accuracy Result

The accuracy of the model obtained using test data of 533 records is 88.2%. With this accuracy result, it is good enough to detect habitable room.

4. CONCLUSION

From this study it can be concluded that the Multilayer Perceptron is suitable for use in a room with an accuracy of 88.2%. As for suggestions for further research, namely using other artificial intelligence methods or optimizing Multilayer Perceptron so that the accuracy obtained can be increased again.

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