Interdisciplinary Journal of Global and Multidisciplinary
IJGAM
+62852-3430-9925 https://jurnal-ijgam.or.id/ admin@jurnal-ijgam.or.id
Vol. 2, No. 3 July 2026 | Page. 729 - 737

PREDICTING EMPLOYEE PRODUCTIVITY AT BHAYANGKARA HOSPITAL LAMPUNG USING ARTIFICIAL NEURAL NETWORKS

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Keywords:

Artificial Neural Network, Employee Productivity, Lampung Hospital,

Abstrak

In recent decades, computer-based applications have been developed to assist in predicting problems by representing them as mathematical models and solving them through iterations that leverage computational speed. To ensure the resulting predictions are precise and accurate, these applications must incorporate intelligent systems—such as Artificial Neural Networks—capable of modeling complex problems by learning data relationship patterns.An Artificial Neural Network is an information processing paradigm inspired by biological neural systems—much like the way the human brain processes information. The fundamental element of this paradigm is a novel information processing system structure. Like humans, artificial neural networks learn from examples. They are designed to solve specific problems, such as pattern recognition or classification, through the learning process.

INTRODUCTION

In recent decades, computer-based applications have been developed to assist in predicting problems by representing them as mathematical models and solving them through iterations that leverage computational speed. To ensure the resulting predictions are precise and accurate, these applications must incorporate intelligent systems—such as Artificial Neural Networks—capable of modeling complex problems by learning data relationship patterns.

An Artificial Neural Network is an information processing paradigm inspired by biological neural systems—much like the way the human brain processes information. The fundamental element of this paradigm is a novel information processing system structure. Like humans, artificial neural networks learn from examples. They are designed to solve specific problems, such as pattern recognition or classification, through the learning process.

Increasingly fierce competition among employees requires each individual to perform at their best and strive for maximum productivity. However, a subsequent challenge arises regarding how an institution or organization measures or predicts employee productivity levels to serve as a basis for determining whether an employee merits retention or promotion.

In general, there are two factors that influence the assessment of an employee's productivity: academic factors and non-academic factors. Academic factors relate to an employee's capabilities associated with intelligence, or IQ. These factors are typically quantitative in nature, meaning they can be measured numerically—examples include TOEFL scores, IQ test results, and the like. Conversely, non-academic factors relate to capabilities associated with emotional intelligence, or EQ. These factors are primarily qualitative, meaning they cannot be directly measured with numbers; examples include teamwork skills, responsibility, honesty, diligence, attention to detail, discipline, attitude, decision-making style, and so forth.

LITERATURE REVIEW

An Artificial Neural Network (ANN) is defined as an information processing system with characteristics resembling biological neural networks (Fausett, 1994, cited in Anita Desiani and Muhammad Arhami, 2006). ANNs were developed as a mathematical generalization of human cognition, based on the following assumptions (Arief Hermawan, 2006):

a. Information processing occurs within simple elements called neurons.

b. Signals flow between nerve cells (neurons) via connecting links.

c. Each connecting link has an associated weight; this weight is used to multiply the signal transmitted through it.

d. Each neuron applies an activation function to the weighted sum of incoming signals to determine its output signal.

An Artificial Neural Network (ANN) is composed of a large number of elements that perform activities analogous to the most basic biological functions of neurons. These elements are organized in a manner resembling the anatomy of the brain, though not exactly. ANNs can learn from experience, generalize from the examples they receive, and abstract the essential characteristics of inputs—even amidst irrelevant data (Arief Hermawan, 2006).

A neuron is the smallest processing unit in the brain; a simplified representation of this processing unit, as viewed by experts, is illustrated in Figure 1.

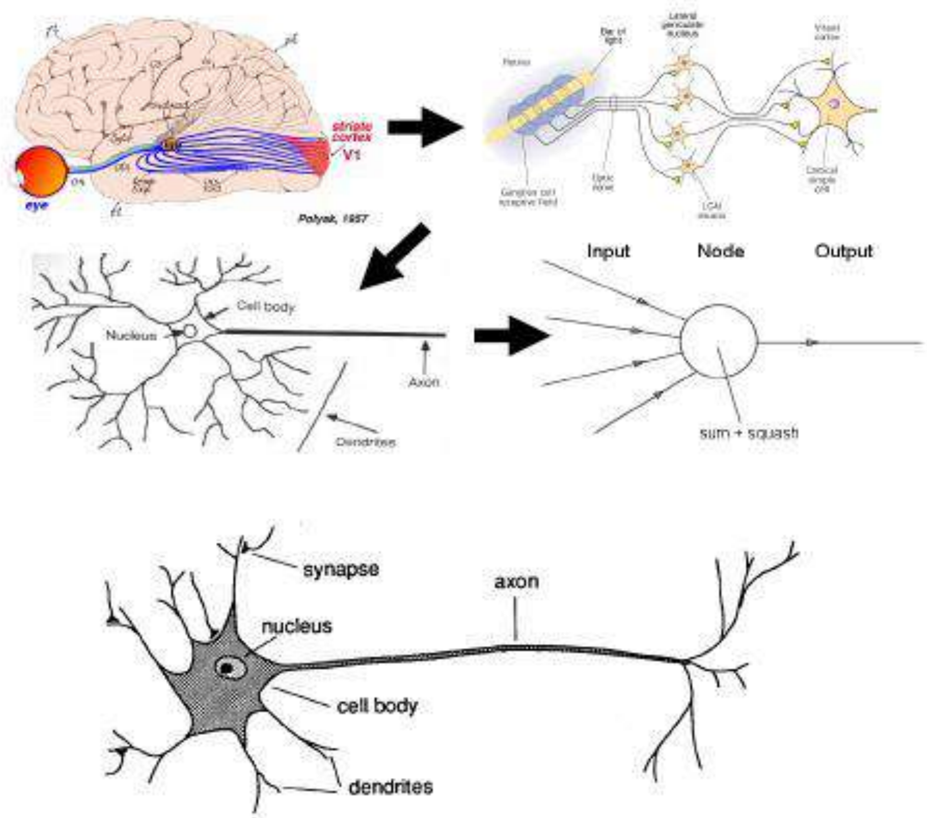

Figure. 1

Figure 1. Basic Structure of an Artificial Neural Network and the Simple Structure of a Neuron

The structure shown in Figure 1 represents a simplified, standard model of a human brain processing unit. The human brain network consists of no fewer than 10^{13} neurons, each connected by approximately 10^{15} dendrites. Dendrites function to transmit signals between a neuron and the other neurons connected to it. Each neuron possesses an axon for output, while the signal-receiving component is known as a synapse.

In general, a neural network is formed from millions (or more) of these basic neuronal structures, interconnected and integrated with one another, enabling them to perform activities in an orderly and continuous manner as required.

RESEARCH METHODS

The framework employed in this study involves the following steps:

a. Defining the Problem Scope

The scope of the problem under investigation must be determined first; understanding and defining this scope provides a broad overview of the issue, thereby facilitating the establishment of boundaries aligned with research objectives and enabling the determination of the best solution to the problem at hand.

b. Problem Analysis

This step is undertaken to gain a thorough understanding of the problem—along with its boundaries—that was identified and defined in the previous step. This ensures a comprehensive understanding of the issue.

c. Determining Objectives

Based on the understanding of the problem, the research objectives are established. These objectives define the specific targets to be achieved in relation to the previously identified problems.

d. Literature Review

To achieve the research objectives, it is necessary to search for and study literature relevant to the problem that can support or assist in resolving the issue under investigation. The gathered literature is then screened to select the specific materials to be utilized.

e. Data Collection

Several supporting methods are used for data collection, including:

1. Observation: Data collection conducted through direct observation at the research site (in this case, Bhayangkara Hospital Bengkulu) to clearly identify existing problems.
2. Interviews: Gathering data and information through inquiries, questionnaires, and interviews with parties or individuals knowledgeable about the problem under investigation.
3. Literature Study: Collecting data and information by reading and studying relevant books and research journals that support both the analysis of data and information and the overall resolution of the problem.

f. System Analysis

System analysis is conducted to identify problems and necessary variables, as well as to establish the boundaries for the model to be developed.

g. System Design

System design is conducted to outline the solution to be produced. The design is based on the results of data processing and the components to be utilized.

h. System Testing

System testing is performed to determine whether the developed system meets the requirements prior to its implementation.

i. System Implementation

This stage involves the implementation of the developed system.

j. System Evaluation

This stage entails comparing the results obtained during the system implementation phase with the previous system.

RESULTS AND DISCUSSION

Implementation of Artificial Neural Networks using MATLAB

The implementation of the artificial neural network to predict employee productivity was carried out using the MATLAB programming language on a computer with the following hardware and software specifications:

a. Processor : Intel Centrino Duo 1.73 GHz (2 CPUs)
b. Memory : DDR2 1 GB
c. VGA : Mobile Intel(R) 945GM Express Chipset Family 256 MB
d. Hard Drive : 120 GB

The software used included the following:

a. Operating System : Microsoft Windows XP Professional
b. Application : MATLAB 6.1

5.3. Testing with the 5-4-1 Architecture

Testing in this study utilized a 5-4-1 network architecture, consisting of 5 input units, 4 hidden layer units, and 1 output unit.

The objective of this testing was to demonstrate that the constructed network architecture—specifically for the case of employee productivity prediction—could be successfully implemented using the selected software, MATLAB.

Testing of the artificial neural network application with the 5-4-1 architecture (facilitated by MATLAB) was conducted to compare the desired targets with the network's learning results. Prior to testing, the input and output variables were categorized; the input variables consisted of factors influencing employee productivity forecasting. Table 5.1 below displays the network's input variables and targets.

Table 1. Network input and target variables for training data

No.	Training Input Data					Target
	X1	X2	X3	X4	X5	
1	7.4	7.2	6.8	5.8	7.9	1
2	7.6	6.3	8.7	7.1	7.5	1
3	8.3	8.2	8.5	6.5	7.2	1
4	8.5	7.1	9.8	7.4	6.5	1
5	6.1	7.1	8.6	7.3	7.3	1
6	7.3	6.5	9	6.5	6.3	1
7	6.3	6	9.1	6	6	1
8	8.9	7.5	6.9	7	7	1
9	8.5	7.8	6.8	6.5	7.4	1
10	9.1	8.1	8.7	7.4	8.2	1
11	6.7	6.9	8.9	8	6.9	1
12	8.4	5	8.5	7.2	7.7	1
13	6.9	7.9	9.4	6.1	7.8	1
14	7.2	7.1	9.1	5.8	7.1	1
15	7.9	7.5	8	6.7	5.3	1
16	8.5	8.2	7	7.6	7.5	0
17	7.5	7.4	8.9	8.7	6.7	0
18	6	7	8.1	7	4.2	0
19	7.8	5.9	7.5	6.5	8.2	0
20	8.1	7.9	7.6	6	8.5	0
21	8.5	5.9	6.5	8	7.1	0
22	6.5	7.4	5.5	7.2	8.2	0
23	6	7.8	5.7	8.6	7.3	0
24	7.5	7.8	7.9	7	8	0
25	8.7	7.3	7.4	8.9	7.3	0
26	8	7.6	7.4	6.5	7.6	0
27	7.2	7.4	7.5	5.9	8.6	0
28	9.2	9.4	9.3	7.6	7.5	0

29	9.3	7.8	6	7.5	8	0
30	9	9.3	7.2	8.8	6	0

Table 2. Network input and target variables for testing data

No.	Testing Input Data			Target		
X1	X2	X3	X4	X5		
1 7.3	7.6	6.9	5.9	8.1	1	
2 6.3	8.9	8.7	5.5	7.4	1	
3 6.8	9.1	7.4	6	6.7	1	
4 8.3	7.8	7.5	6.8	6.4	1	
5 9.2	7.1	7.1	7.2	6.2	1	
6 9	8.5	7.8	8	6.5	1	
7 6.7	8.7	6.9	7.1	8.9	1	
8 8.4	6.9	8.9	6.9	7.1	1	
9 7.6	8.3	7.6	6.8	6	1	
10	8.1	6	7.1	6.1	5.2	1
11	6.9	6.9	6.5	6	5	1
12	5.5	7.1	8.8	9.1	7.9	1
13	7.5	6.2	8.7	8	6.8	1
14	6.2	8	7.8	8.6	6.2	1
15	8.4	7.3	8.7	9.1	6.3	0
16	6.5	7.8	9.1	8.2	7.2	0
17	9.1	6	7.1	8	6.5	0
18	7.7	7.3	9.2	7.9	8.5	0
19	7.3	5.6	7.1	8.7 8.5 0		
20	9.3	7.5	6.2	9	8	0
21	8	7	6	8.9	8	0
22	8.5	7.7	9.3	6.5	8.5	0
23	8.7	7.6	8.5	7.8	6.9	0
24	8.9	6.7	9.1	8.2	9.1	0
25	5.5	6.5	9.5	8.7	7.4	0

Before the network is constructed, preprocessing is performed to normalize the data using the mean and standard deviation. If the input data is stored in matrix p and the target data is stored in matrix t, then:

[pn,meanp,stdp,tn,meant,stdt] = prestd(p,t)

Then, a neural network is constructed using the gradient descent with momentum (traingdm) learning method:

Net = newff(minmax(pn),[4 1],{'tansig','purelin'},'traingdm');

a. Input and Target Data

Defining the matrices for input and target data. >>Data=[...

7.4 7.2 6.8 5.8 7.9 1
7.6 6.3 8.7 7.1 7.5 1
8.3 8.2 8.5 6.5 7.2 1
8.5 7.1 9.8 7.4 6.5 1
6.1 7.1 8.6 7.3 7.3 1
7.3 6.5 9 6.5 6.3 1

```
6.3 6 9.1 6 6 1
8.9 7.5 6.9 7 7 1
8.5 7.8 6.8 6.5 7.4 1
9.1 8.1 8.7 7.4 8.2 1
6.7 6.9 8.9 8 6.9 1
8.4 5 8.5 7.2 7.7 1
6.9 7.9 9.4 6.1 7.8 1
7.2 7.1 9.1 5.8 7.1 1
7.9 7.5 8 6.7 5.3 1
8.5 8.2 7 7.6 7.5 0
7.5 7.4 8.9 8.7 6.7 0
6 7 8.1 7 4.2 0
7.8 5.9 7.5 6.5 8.2 0
8.1 7.9 7.6 6 8.5 0
8.5 5.9 6.5 8 7.1 0
6.5 7.4 5.5 7.2 8.2 0
6 7.8 5.7 8.6  7.3  0
7.5  7.8  7.9  7    8    0
8.7  7.3  7.4  8.9  7.3  0
8    7.6  7.4  6.5  7.6  0
7.2  7.4  7.5  5.9  8.6  0
9.2  9.4  9.3  7.6  7.5  0
9.3  7.8  6    7.5  8    0
9    9.3  7.2  8.8  6    0];
>>P=Data(:,1:5)';
>>T=Data(:,6)';
```

b. Performing Preprocessing

```
>>[pn,meanp,stdp,tn,meant,stdt]=prestd(P,T)
```

c. Constructing the Backpropagation Neural Network

Creating the desired network using MATLAB:

```
>>net=newff(minmax(pn),[4 1],{'tansig','purelin'},'traingdm');
```

This results in the formation of a 5-4-1 network architecture.

d. Setting Initial Weights

The initial weights from the input layer to the first hidden layer are as follows:

```
>>net.IW{1,1}
ans =
-0.4286   -0.3067    0.5514    0.0351   -0.5009
-0.5013   -0.5696   -0.0501   -0.4785    0.2182
0.3304    0.5548   -0.2294    0.5299   -0.2775
-0.4017   -0.0684    0.5406    0.576
```

Conclusions from the test results based on Table 2.:

1. Network Architecture 5-4-1

The learning result for the 11th data point (from the 11th employee) matched the desired target of 1.00, with no error (0.00). Figure 5.4 shows that for the 11th data point, the star is positioned exactly in the center of the circle, indicating that the

ANN result aligns with the desired target. Regarding ANN accuracy, there were 17 correct data points (56.7%) and 13 incorrect data points (43.3%).

2. Network Architecture 5-2-1

The learning results for data points 1, 7, 18, and 23 matched the desired targets (1.00, 1.00, -0.00, and -0.00, respectively), with no error (0.00). Regarding ANN accuracy, there were 22 correct data points (73.3%) and 8 incorrect data points (26.7%).

3. Network Architecture 5-3-1

The learning results for data points 1, 12, 27, and 28 matched the desired targets (1.00, 1.00, -0.00, and -0.00, respectively), with no error (0.00). Regarding ANN accuracy, there were 20 correct data points (66.7%) and 10 incorrect data points (33.3%).

4. Network Architecture 5-5-1

The learning results for data points 12, 16, 17, and 30 matched the desired targets (1.00, 0.00, -0.00, and 0.00, respectively), with no error (0.00). Regarding ANN accuracy, there were 21 correct data points (70%) and 9 incorrect data points (30%). 5. 5-6-1 Network Architecture

The learning results for data points 2, 11, 20, 21, and 30 matched the desired targets—specifically 1.00, 1.00, -0.00, 0.00, and -0.00—with no error (0.00). Regarding ANN accuracy, there were 21 correct data points (70%) and 9 incorrect data points (30%).

CONCLUSION

Based on the implementation and testing conducted using the MATLAB programming language, the following conclusions can be drawn:

1.Artificial neural networks can be used to predict the productivity of Bhayangkara Hospital Bengkulu employees based on knowledge, expertise, ability, attitude, and behavior.

2. The most suitable network architecture for predicting employee productivity using an artificial neural network with the backpropagation algorithm (incorporating momentum) is the 5-2-1 configuration.

3. Research results derived from the training and testing data indicate that good knowledge, expertise, ability, attitude, and behavior do not always result in high productivity. This is due to various other influencing factors, such as amenities (housing, vehicles, income, social security/Jamsostek), workspace comfort, family circumstances, age, psychological state, and other factors affecting the employee's lifestyle.

4. Workplace discipline and regulations influence only specific factors related to work motivation assessment and do not affect overall employee productivity.

5. Regarding the ability to predict employee productivity within an organization or field, a larger training dataset improves the artificial neural network's predictive capability, although it also results in a slower training process.

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