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Artificial Neural Network for Predicting Abscess Disease Based on Patient Data Using the Backpropagation Method

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Abstract

The development of information technology, particularly Artificial Intelligence (AI), has had a significant impact on the healthcare sector, including its application in supporting disease diagnosis. One of the common diseases encountered is abscess, a pyogenic bacterial infection characterized by the accumulation of pus in body tissues. At Bidadari General Hospital Binjai, abscess cases have shown fluctuations from 2023 to 2025, highlighting the need for faster, more accurate, and more efficient prediction methods to assist medical personnel in decision-making. This study aims to develop an abscess disease prediction model using an Artificial Neural Network (ANN) with the backpropagation algorithm based on patient data, analyze the model's accuracy, and provide an alternative decision-support system for early diagnosis. The research method applied is quantitative-experimental, involving several stages: problem identification, collection of patient clinical data, data normalization, ANN architecture design, model training using backpropagation, and evaluation using accuracy metrics, Mean Squared Error (MSE), and Confusion Matrix. The prediction results indicate that the average number of abscess patients per month is projected to increase by 14.33% from historical records to the next 12 months. The historical monthly average was 14.9 patients, while the predicted average for the following year reached 17.0%. The model demonstrated good performance with a Mean Absolute Percentage Error (MAPE) of 244.25%. Therefore, the application of backpropagation-based ANN has the potential to serve as an effective solution in assisting medical personnel to perform early diagnosis of abscess disease in a faster, more accurate, and efficient manner.

Keywords: *abscess, artificial neural network, backpropagation, health information system, patient prediction*

1. Introduction

Health is one of the most essential aspects of human life as it greatly influences the quality and continuity of daily activities. One disease that can disrupt health conditions is abscess, which is the accumulation of pus caused by infection, often accompanied by pain, swelling, and inflammation. If not detected and treated early, an abscess may lead to more serious complications and reduce the patient's quality of life. Therefore, predicting the likelihood of abscess occurrence in the future is important as a preventive measure in healthcare services.

The advancement of computer technology and Artificial Intelligence (AI) has created significant opportunities in the medical field, particularly in disease prediction [1]. One widely used method for prediction tasks is the Artificial Neural Network (ANN), which mimics the way the human brain processes information. With its ability to recognize patterns and learn from historical data, ANN can be utilized to predict the potential occurrence of diseases based on patients' medical history [2]. The backpropagation algorithm, as one of the supervised learning methods in ANN, has proven effective in training networks to generate predictions with smaller errors [3]. This process is carried out by iteratively adjusting the network's weights until the model can optimally recognize data patterns [4].

By applying backpropagation to patients' historical data, a predictive model can be developed to estimate the likelihood of abscess disease within a specific time frame. This study aims to build and evaluate an artificial neural network model with the backpropagation algorithm to predict the possibility of abscess disease based on patient data for the upcoming year. The results of this research are expected to provide a prediction system that can serve as a decision-support tool for medical professionals, as well as contribute to early prevention and treatment of abscess disease.

2. Theoretical Foundation

2.1. Prediction

Prediction is a systematic process of estimating future events by utilizing historical data and current conditions. Its primary goal is to minimize the gap between actual outcomes and estimated results. Prediction does not provide absolute certainty but rather seeks to generate the most plausible approximation of what may occur. In the context of research in Indonesia, prediction is understood as the application of statistical analysis or machine learning methods to produce more accurate and reliable estimations [5].

2.2. Abscess

An abscess is a localized infection characterized by the accumulation of pus as the body's immune response to bacterial invasion, most commonly caused by Staphylococcus aureus and Streptococcus pyogenes [6]. In Indonesia, abscesses are frequently observed in the skin, oral cavity, and submandibular region. A study at RSUD Cut Meutia, North Aceh (2022), reported that the empirical use of ceftriaxone for submandibular abscesses was deemed inappropriate according to Gyssens category IVA, highlighting the need for revised therapeutic strategies [7]. Another study in Bali found a 12.4% prevalence of periapical abscesses, with higher cases among females and the 46–50 age group. Common clinical manifestations include pain, swelling, redness, and pus discharge, often influenced by oral health behavior and treatment choices. These findings underline the importance of culture- and sensitivity-based management. Supporting this, Indonesia's 2018 Basic Health Research (Riskesdas) reported that dental abscesses ranked among the three most frequent dental health problems, with a prevalence of 14% [8].

2.3. Patient

According to research conducted at Poltekkes Kemenkes Semarang, a patient is an individual who receives health services due to physical, mental, or social conditions requiring medical or nursing care [9]. Similarly, a study published in the Soedirman Nursing Journal emphasizes that patients are the central subjects in healthcare services who must be treated with dignity, humanity, and in accordance with ethical and legal standards. Furthermore, the Indonesian Hospital Administration Journal (JARSI) highlights that a patient refers to any person who registers and receives services in a hospital or other healthcare facility, whether as an outpatient or inpatient. Taken together, these perspectives suggest that a patient is an individual in need of medical intervention—either due to illness, health disorders, or routine examinations—who is entitled to professional care delivered with respect and guided by medical ethics[10].

2.4. Artifical Neural Network

Artificial Neural Networks (ANN) are computational models inspired by the structure and function of the human brain. [8]. JST consists of simple processing units called neurons, arranged in layers (input, hidden, output). Each neuron receives an input signal, multiplies it by a weight, sums it, and passes it through an activation function such as sigmoid, ReLU, or others to produce an output. The learning process is carried out by adjusting the weights through algorithms such as backpropagation, so that the network can map patterns in the data without being explicitly programmed[8].

2.5. Backpropagation

Backpropagation is a learning algorithm in artificial neural networks (ANN) used to train the weights of connections between neurons by propagating errors from the output to the input in stages. This process begins after the network performs a feedforward process, which is when input data is fed into the network to produce an output. After the output is obtained, the algorithm calculates the difference between the actual output and the expected output using an error function such as Mean Squared Error (MSE). This difference or error is then used to calculate the partial derivatives with respect to the weights in the network, and these derivative values are used to update the weights to minimize the error in the next iteration. This error propagation process proceeds backward from the output layer through the hidden layers and ends at the input layer, hence the term backpropagation. The main advantage of this algorithm is its ability to efficiently handle multilayer networks and non-linear activation functions, making it highly useful for solving prediction, classification, and pattern recognition problems in complex data. This algorithm forms a crucial foundation in the development of modern artificial neural networks and is widely used across various fields such as image processing, speech recognition, recommendation systems, and medical diagnostics[11].

Backpropagation is a supervised learning algorithm in artificial neural networks designed to minimize the error between predicted output and target values. The process is iterative and consists of two main stages: feedforward and backward (error backpropagation).
1. Weight Initialization
The weights and biases are initialized with small random values (e.g., between –1 and 1) to avoid saturation in the activation function.
2. Feedforward Process
Input signals are propagated through the hidden layer up to the output layer.
Each neuron computes:

$$\boldsymbol{z} = \sum(\boldsymbol{xi} \cdot \boldsymbol{wi}) + \boldsymbol{b} \quad (1)$$

The neuron's output is obtained using the sigmoid activation function:

$$\boldsymbol{f}(\boldsymbol{z}) = \frac{1}{1+e^{-z}} \quad (2)$$

3. Error Calculation
The error is determined as the difference between the target t_k and the predicted output y_k

$$\boldsymbol{E} = (\boldsymbol{t_k} - \boldsymbol{y_k}) \quad (3)$$

4. Error Backpropagation
Delta for the output layer:

$$\boldsymbol{\delta_k} = (\boldsymbol{t_k} - \boldsymbol{y_k}) . \boldsymbol{f'}(\boldsymbol{z_k}) \quad (4)$$

Delta for the hidden layer:

$$\boldsymbol{\delta_j} = \boldsymbol{f'}(\boldsymbol{z_j}) . \Sigma(\boldsymbol{\delta_k} . \boldsymbol{w_{jk}}) \quad (5)$$

5. Weight Update
The weight adjustment is computed and added to the previous weight:

$$\boldsymbol{\Delta w_{jk}} = \boldsymbol{a} . \boldsymbol{\delta_k} . \boldsymbol{z_j} \quad (6)$$

$$\boldsymbol{w_{new}} = \boldsymbol{w_{old}} + \boldsymbol{\Delta w} \quad (7)$$

2.6. Python

Python is an open-source programming language that can be freely used and distributed without restrictions. It provides comprehensive support including source code, a debugger, a profiler, and interfaces for systems, graphical user interfaces (GUI), databases, and interactive services. Python was first developed in 1990 by Guido van Rossum at CWI in Amsterdam as a successor to the ABC programming language. Its development later continued through various institutions such as CNRI, BeOpen.com, and DigitalCreations, before being formally managed by the Python Software Foundation, which ensures its non-commercial status. Over time, Python has evolved into both the 2.x and 3.x versions with continuous contributions from a global community. The name "Python" was chosen by Guido as a tribute to the television show Monty Python's Flying Circus, which has since influenced the culture and terminology within the Python community [12].

3. Analysis and Design

3.1. Analysis of The Backpropagation Method Process

The data used is historical data on abscess patients from Bidadari Binjai General Hospital. The dataset contains several relevant patient medical parameters as input for the network training process. A total of 342 data points have been collected, with 125 data points in 2023, 186 data points in 2024, and 31 data points in 2025. The data is divided into two parts, namely the training set and the testing set.

Table 1: Abscess Patient Dataset

Month	2023	2024	2025
January		25	16
February		23	3
Maret	4	12	3
April	25	8	
Mei	7	3	
Juni	10	17	
Juli	3	14	
Agustus	6	0	
September	10	0	
Oktober	13	7	
November	22	22	
Desember	15	7	

3.2. Pre-Processing

Data normalization using the Min-Max Normalization method so that all data is within the range of 0 to 1. Change all data value ranges to the range 0-25 so that all features have a balanced contribution when entering the Artificial Neural Network model.

$Xnorm = \frac{X - Xmin}{Xmax - Xmin}$
Xmin = 0
Xmax = 25
Xnorm = $\frac{X}{25}$
Normalize all training values on a scale of 0-1

Table 2: Training Data

T-2	T-1	T	T+1 (target)
`0.16	1.00	0.28	0.40
1.00	0.28	0.40	0.12
0.28	0.40	0.12	0.24
0.40	0.12	0.24	0.40
0.12	0.24	0.40	0.52
0.24	0.40	0.52	0.88
0.40	0.52	0.88	0.60
0.52	0.88	0.60	1.00
0.88	0.60	1.00	0.92
0.60	1.00	0.92	0.48
1.00	0.92	0.48	0.32
0.92	0.48	0.32	0.12

Normalize all testing data using the min-max of the training data.

Table 3: Testing Data

T-2	T-1	T	T+1 (target)
0.56	0	0	0.28
0	0	0.28	0.88
0	0.28	0.88	0.28

3.3. Designing Artificial Neural Network Models

Data normalization using the Min-Max Normalization method so that all data is within the range of 0 to 1. Change all data value ranges to the range 0-25 so that all features have a balanced contribution when entering the Artificial Neural Network model.
Input layer = 3 neuron
Hidden layer = 4 neuron
Output layer = 1 neuron Designing Artificial Neural Network Models

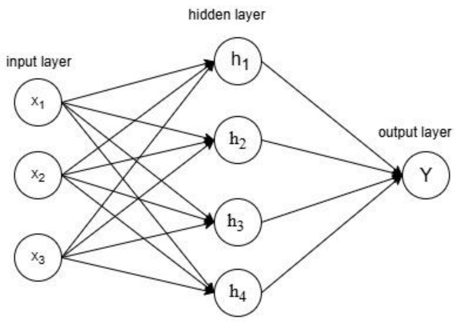

Fig. 1: Architecture ANN

Initialize weights randomly with a small range of values from -0.5 to 0.5
W_{ih} = 0.2, -0.1, 0.3, 0.0, 0.1, 0.2, -0.2, 0.3, -0.1, 0.3, 0.1, -0.2
Bobot *hidden* to *output layer*
W_{ih} = 0.2, -0.1, 0.3, 0.1
Tentukan bias
b_h = [0.1, 0.1, 0.1, 0.1] 1 neuron *hidden*
b_o = 1 bias *output*

3.4. Forward Propagation

Take the first 3 values from the normalized training data.
Neth = WTih · bh

Neth1 = (0.2)(0.16)+(0.1)(1.00)+(−0.1)(0.28)+0.1=0.032+0.1−0.028+0.1=0.204
Out h1 = $\sigma(0.204) = \frac{1}{1+e}$-0.204 = $\frac{1}{1+0.815} = \frac{1}{1.815} \approx 0.551$

Neuron h2 = (−0.1)(0.16)+(0.2)(1.00)+(0.3)(0.28)+0.1=−0.016+0.2+0.084+0.1= 0.368
Outh2 = σ(0.368) = $\frac{1}{1+e}$-0.368 = $\frac{1}{1+0.692}$ = $\frac{1}{1.692}$ ≈0.591

Neth3 = (0.3)(0.16)+(−0.2)(1.00)+(0.1)(0.28)+0.1=0.048−0.2+ 0.028+0.1=−0.024
Outh3 = σ(−0.024) = $\frac{1}{1+e}$-0.024 = $\frac{1}{1+0.24}$ = $\frac{1}{2.024}$ ≈0.494

Net¬h4 = (0.0)(0.16)+(0.3)(1.00)+(−0.2)(0.28)+0.1=0+0.3−0.056+0.1=0.344
Outh4 = σ(0.344) = $\frac{1}{1+e}$-0.0344 = $\frac{1}{1+0.709}$ = $\frac{1}{1.709}$ ≈0.585

Output Hidden :
Outhh = [0.551,0.591,0.494,0.585]
Hitung output layer
Neto = WTho · outh + bo
Neto = (0.2)(0.551)+(−0.1)(0.591)+(0.3)(0.494)+(0.1)(0.585)+0.1
=0.1102−0.0591+0.1482+0.0585+0.1=0.3578

Outo = σ(0.3578) = $\frac{1}{1+e}$-0.3578 = $\frac{1}{1+0.699}$ = $\frac{1}{1.699}$ ≈0.588
error MSE

$E = \frac{1}{2}(target - out_o) = \frac{1}{2}(0.40 - 0.588) = \frac{1}{2}(-0.188)^2 = \frac{1}{2}(0.035344) = 0.01767$

3.5. Backpropagation

Use the previous forward data to calculate the output delta, hidden delta, hidden weights to output, input weights to hidden update bias.
Input: [4, 25, 7] → normalisasi: [0.16, 1.00, 0.28]
Target: 10 → normalisasi: 0.40
Output aktual (out_o): 0.588
Error (MSE): 0.01767

Bobot and output hidden layer:
W_{ho} = [0.2,−0.1,0.3,0.1]
Out_h = [0.551,0.591,0.494,0.585]
b_o = 0.1
b_h = [0.1,0.1,0.1,0.1]
η=0.1 (learning rate)
delta output
$\delta_o = (target - out_o) \cdot out_o \cdot (1 - out_o)$
δ_o = (0.40−0.588)·0.588·(1−0.588)=(−0.188)·0.588·0.412
=−0.188·0.242=−0.0455
delta hidden
$\delta_h = out_h \cdot (1 - out_h) \cdot (W_{ho} \cdot \delta_o)$

neuron h_1
out_{h1} = 0.551
out_{h1} (1−out $_{h1)=}$0.551·(1−0.551)=0.551·0.449=0.247
$W_{ho} \cdot \delta_o$ = 0.2·(−0.0455)=−0.0091)
δ_{h1} = 0.247·(−0.0091)=−0.00225

$Neuron_{h2}$
out_{h1} = 0.591
0.591·(1−0.591)=0.591·0.409=0.242
$W_{ho} \cdot \delta_o$ = −0.1·(−0.0455)=0.00455)
δ_{h2} = 0.242·0.00455=0.00110

$Neuron_{h3}$
out_{h1} = 0.494
0.494·(1−0.494)=0.494·0.506=0.250
$W_{ho} \cdot \delta_o$ = 0.3·(−0.0455)=−0.01365
δ_{h3} = 0.250·(−0.01365)=−0.00341

$Neuron_{h4}$
out_{h1} = 0.585
0.585·(1−0.585)=0.585·0.415=0.243
$W_{ho} \cdot \delta_o$ = 0.1·(−0.0455)=−0.00455

$\delta_{h4} = 0.243 \cdot (-0.00455) = -0.00111$
$\delta_h = [-0.00225, 0.00110, -0.00341, -0.00111]$

update bobot hidden to output W_2
$W_{ho\ new} = W_{ho\ old} + \eta \cdot \delta_o \cdot out_h$
$\Delta W_{ho} = \eta \cdot \delta_o \cdot out_{h2} = 0.1 \cdot (-0.0455) \cdot [0.551, 0.591, 0.494, 0.585]$
$= -0.00455 \cdot [0.551, 0.591, 0.494, 0.585] = [-0.00251, -0.00269, -0.00225, -0.00266]$

3.6. System Design

The flowchart is constructed based on the process of Artificial Neural Networks using the Backpropagation algorithm, starting from data collection, model architecture design, and continuing through the training phase.

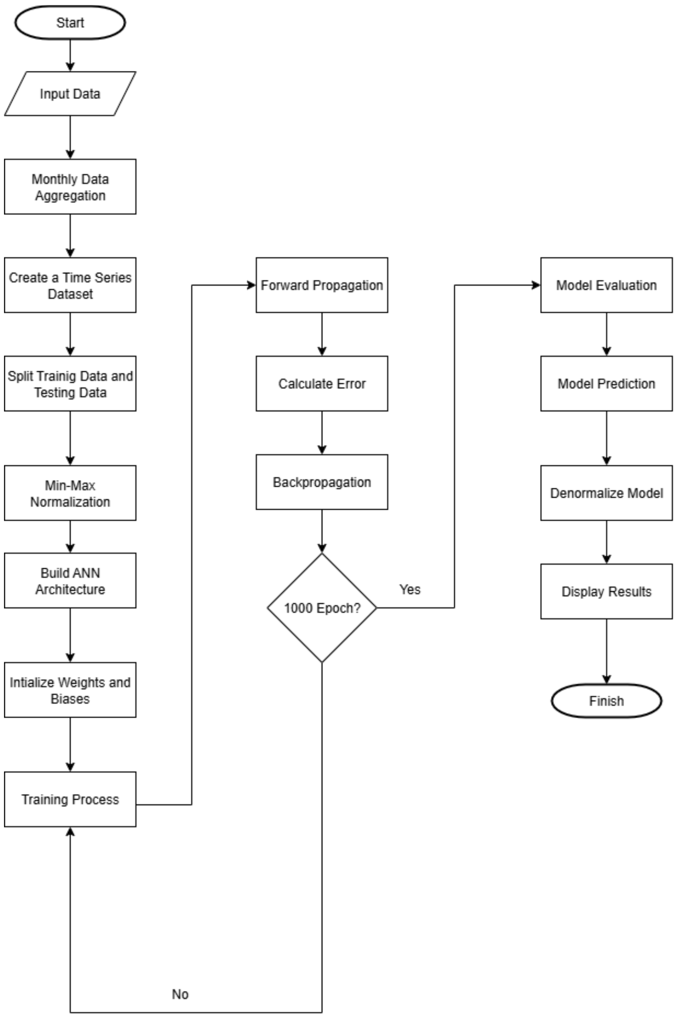

Fig. 2: Flowchart of the Artificial Neural Network process

4. Implementation and Discussion

4.1. Testing

The Patient Data Input Page serves as the primary interface for entering and storing new patient information related to abscess cases into the system. At the top of this page, the form consists of several fields, including Name, Age, Diagnosis, Treatment, Gender, and Date. Each field is designed to capture essential medical information that reflects the patient's condition. Once all the required data is filled in, users can press the Save Patient button, which automatically records the information into the system's database. This feature ensures that patient records are well-organized, easily retrievable, and available for further processing in prediction and analysis tasks

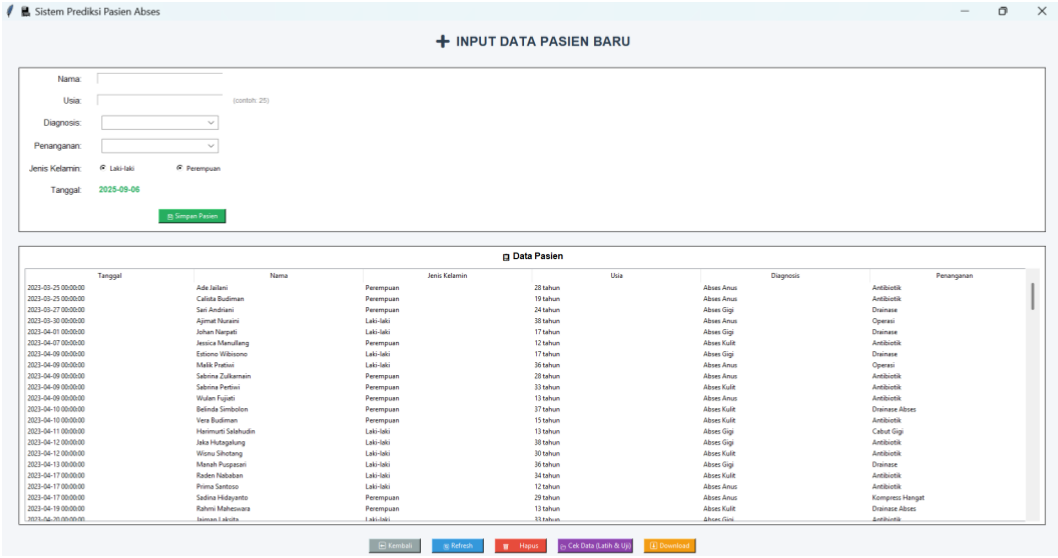

Fig. 3: Patient Input

Based on the forecasting results using the Exponential Smoothing model, the average number of abscess patients per month is projected to increase by 14.33% over the next 12 months compared to the historical period. The historical average was 14.9 patients per month, while the forecasted average for the upcoming year is expected to reach 17.0 patients per month.

The performance evaluation of the model shows a Mean Absolute Percentage Error (MAPE) of 244.25%. Although this value indicates relatively high error, the model is still capable of capturing the general trend of patient growth. These findings provide useful insights for healthcare planning, particularly in preparing medical facilities, human resources, and treatment strategies to address the potential rise in abscess cases

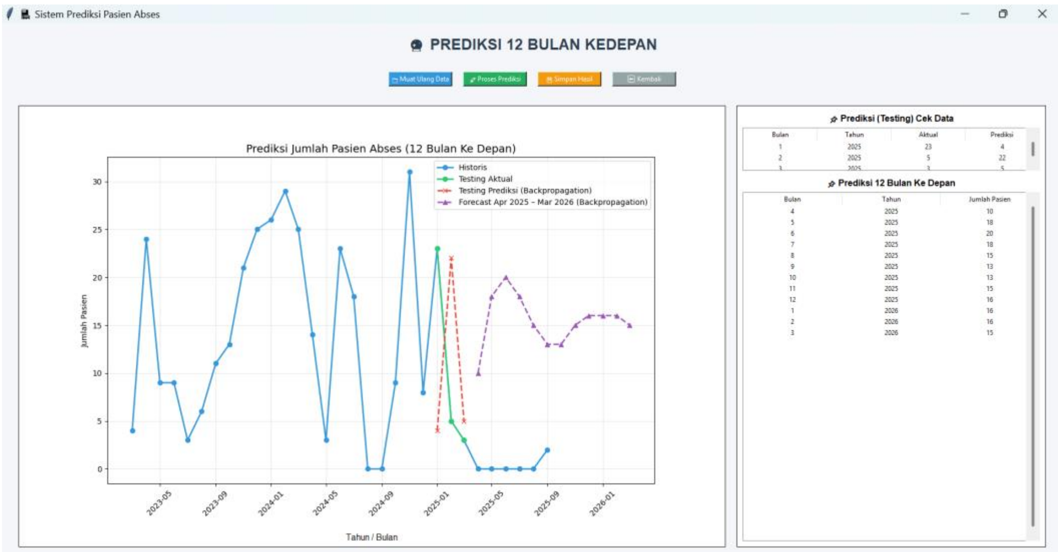

Fig. 4: Prediction Page

5. Conclusion

Based on the development and implementation of the abscess patient prediction system using an Artificial Neural Network (ANN) with the Backpropagation algorithm, several important conclusions can be drawn. The system successfully predicted the number of abscess patients for the next 12 months with reasonable accuracy, utilizing historical data from March 2023 to March 2025. The ANN model demonstrated its capability to capture fluctuating patterns within patient data, even when monthly variations were relatively high. The selected ANN architecture of 3-4-1 combined with a sliding window size of three proved to be effective for short-term time series forecasting. Through the training process, the Backpropagation algorithm was able to minimize the Mean Squared Error (MSE), resulting in a stable and reliable model. Furthermore, the application of Min-Max Scaling with a minimum value of 0 and a maximum value of 25 during the training phase ensured data consistency and helped reduce the risk of overfitting during both evaluation and prediction stages.

References

[1] M. Yusran, “Kecerdasan Buatan dalam Diagnosis Retinopati Diabetik,” *J. Kedokt. Univ. Lampung*, vol. 6, no. 1, pp. 16–20, 2022, doi: 10.23960/jkunila.v6i1.pp16-20.

[2] A. Zakilah Ifani, V. Alviani, D. Suryanti, and N. Wahdanial Asbara, “Pengoptimalan Internet of Medical Things (IoMT) untuk Pelayanan Kesehatan,” *J. Fokus Elektroda Energi List. Telekomun. Komputer, Elektron. dan Kendali)*, vol. 9, no. 4, pp. 234–238, 2024, doi: 10.33772/jfe.v9i4.949.

[3] Y. Edwar, R. Rendy, and J. Sanoto, “Jaringan Syaraf Tiruan Mendeteksi Penyakit Pneumonia Infeksi Saluran Pernafasan Akut Dengan Algoritma Backpropagation,” *Innov. Res. Informatics*, vol. 4, no. 2, pp. 42–49, 2022, doi: 10.37058/innovatics.v4i2.5161.

[4] V. Lestari, H. Mawengkang, and Z. Situmorang, “Artificial Neural Network Backpropagation Method to Predict Tuberculosis Cases,” *Sinkron*, vol. 8, no. 1, pp. 35–47, 2023, doi: 10.33395/sinkron.v8i1.11998.

[5] N. Sri Hanifah and Gunawansyah, “Prediksi Pertumbuhan Umkm Di Kota Bandung Menggunakan Metode Autoregressive Integrated Moving Average,” *Infotronik J. Teknol. Inf. dan Elektron.*, vol. 9, no. 2, pp. 59–72, 2024, doi: 10.32897/infotronik.2024.9.2.3839.

[6] E. P. Dewi, M. Zunaidi, and F. Sonata, “Sistem Pakar Dalam Mendiagnosa Penyakit Abses Periodontal (Gusi Bernanah) Menggunakan Dempster Shafer,” *J. Sist. Inf. Triguna Dharma (JURSI TGD)*, vol. 2, no. 2, p. 219, 2023, doi: 10.53513/jursi.v2i2.5893.

[7] N. P. Amalia, Y. Yuziani, and A. Syafridah, “Gambaran Penggunaan Antibiotik pada Pasien Abses Submandibula di Bagian Bedah Gigi dan Mulut Rumah Sakit Umum Daerah Cut Meutia Aceh Utara Tahun 2022,” *Galen. J. Kedokt. dan Kesehat. Mhs. Malikussaleh*, vol. 3, no. 2, p. 1, 2024, doi: 10.29103/jkkmm.v3i2.12829.

[8] J. Kesehatan Gigi, I. Gede Surya Kencana, and I. Ayu Dewi Kumala Ratih, “Aplikasi Asuhan KesehatanGigi dan Mulut pada Keluarga Bapak I WY. S denganAnak Menderita Karies Gigi di Wilayah Kerja Puskesmas Denpasar Selatan tahun 2023,” *Dent. Heal. Journal)*, vol. 10, no. 2, pp. 131–142, 2023, doi: 10.33992/jkg.v.

[9] S. Anjayati, “Review Artikel: Analisis Kualitas Pelayanan Terhadap Kepuasan Pasien Di Puskesmas Menggunakan Metode Servqual,” *Nurs. Care Heal. Technol. J.*, vol. 1, no. 1, pp. 31–38, 2021, doi: 10.56742/nchat.v1i1.7.

[10] F. Kharismatus Ikhyana, F. E. B. Setyawan, P. Pratama, and Y. Iswanti, “Keefektifan Sistem Pendaftaran dan Antre Online Terhadap Pelayanan Kesehatan,” *CoMPHI J. Community Med. Public Heal. Indones. J.*, vol. 4, no. 1, pp. 103–110, 2023, doi: 10.37148/comphijournal.v4i1.148.

[11] Diaz Kuncoro, Akim M.H. Pardede, and Siswan Syahputra, “Jaringan Syaraf Tiruan Memprediksi Penyakit Gerd menggunakan Metode Backpropagation,” *Bridg. J. Publ. Sist. Inf. dan Telekomun.*, vol. 2, no. 4, pp. 269–287, 2024, doi: 10.62951/bridge.v2i4.251.

[12] F. Aulia and Yahfizham, “Mengenal Bahasa Pemrograman pada Algoritma Pemrograman,” *J. Informatics Busisnes*, vol. 1, no. 4, pp. 223–228, 2024.