Check for updates

Classifying of Diabetes Symptoms Using the Backpropagation Neural Network Method

Putu Wina Sahyuni[1], Putu Sugiartawan[2]*, Wayan Sauri Peradhayana[3]

[1,2,3] Faculty of Technology and Informatics, Institut Bisnis dan Teknologi Indonesia, Bali, Indonesia
*sugiartawan@instiki.ac.id

Abstract. This study aims to develop a technology that can help diagnose diabetes symptoms accurately. The Backpropagation Neural Network method is used to classify diabetes symptoms based on various parameters such as blood pressure, heart rate, body temperature, sugar levels, cholesterol, uric acid, and oxygen levels. The network training process is carried out using Visual Gene Developer 2.1, with a learning rate of 0.01, momentum of 0.1, and a maximum iteration limit of 50,000 times. The number of neurons in the hidden layer is varied between 1 and 10 at each training session. The results show that the smallest final Sum of Squared Errors (SSE) value is produced by an architecture that uses 7 neurons in the hidden layer, namely 0.0389. In the validation stage, the architecture used is a network that achieves the smallest SSE value during the training process. Validation is carried out using data that is not included in the training on each network. The best network architecture is selected based on the smallest SSE value obtained during the validation stage. The validation results for a 10-7-1 network architecture with a binary activation function of 0.1 show an SSE value of 0.4387. The Backpropagation Neural Network method is chosen because of its ability to learn complex patterns from input data and produce output with a high level of accuracy. By using this method, it is hoped that it can produce an accurate and reliable health classification to improve understanding of diabetes symptoms. The results of this study can be used to improve the quality of health services provided by Health Center I in East Denpasar City to the community, especially in the diagnosis and treatment of diabetes.

Keywords: Backpropagation, Diabetes, Classifying.

1 Introduction

Health plays a very important role for all humans. Health enables people to move well and perform well in their professional and social lives. Apart from individual health factors, environmental factors also influence human health significantly [1]. Difficulties in diagnosing diseases can occur due to the similarity of symptoms of each disease and long waiting times, so that temporary diagnoses are limited and less accurate [2]. This can cause patients to receive inappropriate initial treatment and worsen their health

K. Dharmawan and N. A. Sanjaya ER (eds.), *Proceedings of the First International Conference on Applied Mathematics, Statistics, and Computing (ICAMSAC 2023)*, Advances in Computer Science Research 110,
https://doi.org/10.2991/978-94-6463-413-6_7

condition. To overcome this problem, we need a technology that can help identify diseases based on the symptoms felt by the patient. In the health sector, technological advances have helped solve various problems, one of which is the problem of disease classification [3].

The use of technology can help improve health supervision in certain areas, such as in companies, hospitals, and government agencies [4], especially the East Denpasar City Health Center I which is a health center that provides comprehensive services to the community in Denpasar City, Bali Province. As a center for health information, this puskesmas also coordinates health programs at the village or kelurahan level. Health Center I in East Denpasar City plays an important role in improving the quality of life of the people of Denpasar with affordable and quality health services. In improving public health, the government and health institutions must ensure the availability of accurate and up-to-date health data by monitoring [5]. Health Center I in East Denpasar City plays an important role in collecting and providing health data to the public through continuous health monitoring. The process of monitoring patient health can be done by monitoring several parameters [6]. This monitoring produces health data and environmental factors that influence it to be processed and analyzed in order to obtain information about the level of diabetes symptoms. In data processing, classification techniques are used to facilitate the determination of health categories, such as normal and diabetes. With this data and information, Health Center I in East Denpasar City can improve the quality of health services to the community better and more effectively.

To overcome the challenges in diagnosing diabetes symptoms, it is necessary to use technology that can help recognize the disease based on the symptoms experienced by the patient. One approach that can be applied is to use computers and artificial neural networks with backpropagation algorithms to perform classification [7]. The application of this method can contribute to increasing the accuracy of disease diagnosis. Backpropagation is a supervised learning model used by artificial neural networks with many layers (multilayer perceptron). Its role is to optimize the weight of the neurons connected to the hidden layer. By making adjustments to these weights, artificial neural networks can learn and improve their ability to classify the symptoms faced by patients so that they can assist in diagnosing diseases more accurately [8]. In this algorithm, the value of the weights is changed backwards by using the output error as a reference [9].

The Backpropagation Neural Network method to classify diabetes symptoms uses various parameters such as blood pressure, heart rate, body temperature, sugar levels, cholesterol, uric acid and oxygen levels. The results of this research will be a classification into health categories, namely not indicated diabetes and indicated diabetes, based on input data that has been processed and analyzed through data processing using classification techniques. The use of the Backpropagation Neural Network method was chosen because of its ability to learn complex patterns from input data and produce output with a high level of accuracy. By using this method, it is hoped that it can produce an accurate and reliable health classification to improve understanding of diabetes symptoms.

2 Related Works

The first research, research conducted by C. Adi nurrohkhim, Darujati [10], with the title "Classification of calculus disease (tartar) using digital image processing with the backpropagation artificial neural network method". The problem raised in this research is the difficulty in classifying calculus disease, so this method was created to make it easier for dental medical personnel to classify calculus disease using the scientific field of digital image processing and backpropagation artificial neural networks. This research uses the Backpropagation method. The test results obtained show that for training data, researchers used 30 training data with composition (12 heavy calculus images, 9 medium calculus images, and 9 small calculus images), having an accuracy level of 100%. To test the data, the researchers used 20 tartar image test data with composition (8 images of heavy calculus, 6 images of medium calculus, and 6 images of small calculus). Has quite good accuracy, namely 90%.

The second research, research conducted by B Herawan Hayadi, IGI Sudipapa,AP Wind [11], with the title "Classification of Patients with Diabetes Using Neural Network Backpropagation to Predict Recovery". The problem raised in this research is the lack of information about the early symptoms and dangers of the disease itself. Because of this lack of information, a system is needed that can provide information about the disease and how to deal with it, such as early diagnosis and treatment. The test results obtained are that one method that can be applied in a classification system is Neural Network Backpropagation, this method is very good at carrying out classification based on previous events. accuracy of 92.48%, precision value of 94.36%, recall value of 94.88% and the smallest MAE with a value of 0.000142 on 250 datasets.

The third research, research conducted by by J. Permadi, H. Rhomadhona, W. Aprianti [12], with the title "Forecasting model for active family planning participants in the government pathway using Artificial Neural Network Back-propagation models for active family planning participants in the government pathway". The problem raised in this research is that population growth in Indonesia continues to increase every year and is not accompanied by the availability of employment opportunities that can accommodate the entire workforce, which can lead to unemployment and crime, which also intersects with damage to public morality. This research uses the Artificial Neural Network Back-propagation method. The test results obtained show that the 4-8-5-1 architectural model is the best and is used as a reference for predicting active family planning participants on government channels with an accuracy rate of 71% (the best of the 4 other architectural models). The ANN model can be implemented to make predictions about active family planning participants in government channels so that the government can make plans for the future.

The fourth research, research conducted by A. Pramono, N. Nuryati, D. Santoso et al [13], with the title "Classification of Healthy Heartbeat Sounds Using the ANN-BP Multi Perceptron Model". The problem raised in this research is the lack of differentiation or recognition of whether a heartbeat can be said to be healthy, normal or sick. This research uses the Back-propagation method. The test results obtained show that processing the data to match the criteria in the model in data preprocessing is carried out in three processes, namely sampling the data, then separating the training data and testing data with a ratio of 80:20. After data preprocessing, a classification process is carried out, in this process training and testing is carried out on the model, model predictions on new data (validation data). Then the next process is to evaluate performance using the accuracy curve method so that the final accuracy value for training is 98.19% and validation accuracy is 96.54%.

The fifth research, research conducted by A. Argina [14], with the title "Comparison of K-Nearest Neighbor and Backpropagation neural network in predicting the risk of early stage diabetes". The problem raised in this research is comparing the backpropagation method with KNN in predicting diabetes. This research uses the Back-propagation and KNN methods. The test results obtained show that Backpropagation is a better classification method compared to KNN in predicting the risk of early stage diabetes. Backpropagation with learning rate $\alpha = 0.3$, $\alpha = 0.4$ or $\alpha = 0.5$ and number of hidden nodes = 5 units, has an accuracy level of 90%, precision of 90% and recall of 90%. Meanwhile, KNN with K = 5, K = 7 or K = 9 has an accuracy level of 83.75%, precision of 85.5497% and recall of 83.75%.

3 Method

This study aims to increase the accuracy of diabetes symptom classification using the Backpropagation Neural Network method. The process of forming a classification model consists of several important stages. Phase 1: Data representation with a value range between 0 and 1. Phase 2: model training using backpropagation neural netwok. Phase 3: model testing using backpropagation. Diabetes symptom classification research aims to show that the backpropagation artificial neural network approach can increase the accuracy of diabetes symptom classification. By increasing the classification accuracy, it is hoped that the ability to diagnose diabetes early will improve, so that patients can be treated more accurately and effectively.

3.1 Health Classification

Health classification is a system used to classify health data and information based on the types of diseases, medical conditions, and certain risk factors, making it easier to analyze and make decisions regarding care, treatment, and disease prevention more effectively and efficiently [15]. The health classification system also helps health professionals to understand and learn more about the epidemiology of diseases, risk factors, and patterns related to public health.

3.2 Diabetes

Diabetes is a metabolic condition caused by increased levels of glucose or blood sugar, which play an important role as a source of energy for cells and body tissues. The inability to effectively manage diabetes can potentially lead to complications such as heart disease, stroke, obesity, and problems with the eyes, kidneys, and nerves [16].

3.3 Health Parameters

Health parameters are signs or factors used to measure or assess a person's health condition. These parameters provide important data regarding body function, disease risk, and overall well-being [17]. The monitoring of health parameters is an integral part of diagnosing, treating, and monitoring health conditions. Monitoring health parameters allows medical professionals to obtain a comprehensive picture of a person's health. This aids in the identification of health problems, disease prevention, and management of medical conditions. Several parameters used to identify diabetes include blood pressure, heart rate, body temperature, sugar, cholesterol, uric acid, and oxygen levels [18].

3.4 Neural Networks

An Artificial Neural Networks is a model that simulates the biological brain to understand patterns in data and imitate biological adaptive learning processes with a lower level of complexity [19]. After undergoing a training process with the data, the ANN can carry out classification by detecting similarities or similar patterns from the input data. Although ANN is not able to achieve perfection of the human brain's biological system, it has abilities such as learning, abstraction, and instinct. ANN simplifies biological systems and is used as an alternative [20]. There are many challenges in human life that cannot be overcome by conventional computers, but humans can solve them well. However, owing to their learning capabilities, ANN can solve problems that conventional computers cannot. The ANN training process does not involve traditional programming but instead uses examples. Training is carried out by providing input repeatedly to identify various patterns and relationships, then the system progressively optimizes node weights to find relationships between these inputs, this process is known as "learning."

Artificial Neural Networks are included in the category of artificial intelligence and are considered black boxes that can be classified from the input patterns that they recognize [21]. To achieve this, Artificial Neural Networks must first undergo training using a Supervised Learning method by providing input patterns and the desired targets for each input pattern. After the training process is complete, the ANN can be used immediately to classify or process new data.

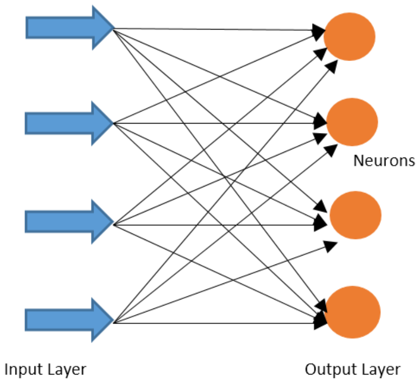

Fig. 1 Artificial Neural Network

An ANN can recognize similarities between inputs, even when some of the inputs have not been trained or provided before [22]. This is because ANN has extraordinary interpolation capabilities, making it possible to use it as a direct replacement for data analysis techniques. When data are analyzed using ANN, classification of important patterns can be performed with a level of skill similar to that of data analysis by an expert, because ANN can behave like an expert in the field. In addition, ANN can overcome interference from inaccurate input data.

3.5 Machine Learning

Machine Learning is a combination of scientific knowledge and creativity in programming computers to be able to learn from the data provided [23].

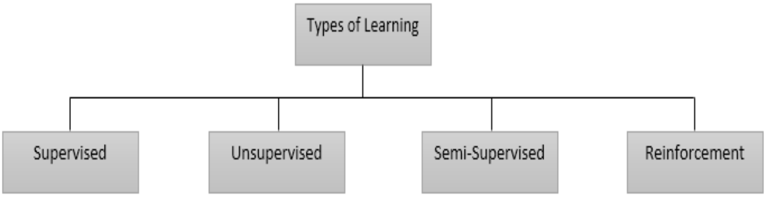

Fig. 2 Types of Learning

The following are the four types of learning often used in Machine Learning:

Supervised learning

Supervised learning is a type of learning dataset that is used to obtain labels. This label functioned as an identifier for each dataset. Spam email classification is an example of supervised learning.

Unsupervised learning

Unsupervised learning is a type of learning dataset that does not contain labels to be used. The unsupervised learning model automatically learns to provide the labels.

Semi-supervised learning

Semi-supervised learning, that is, some datasets used for training, have labels, while others do not.

Reinforcement Learning

Reinforcement Learning is a type of learning where the learning model uses a system of rewards and penalties. The learning model looks for ways to earn rewards and avoid punishments.

3.6 Backpropagation

The backpropagation algorithm is used with many layers to adjust the weights to connect neurons in the hidden layer [24]. The learning algorithm is supervised and uses the output error to adjust the weights backwards. Before performing backpropagation, the forward propagation step must be executed to obtain the errors. Backpropagation is a multi-layer Artificial Neural Network (ANN) training method that involves three layers in the process, namely the input layer, hidden layer, and output [25]. The presence of a hidden layer in backpropagation has an important role in reducing the error rate in a network with one layer because the hidden layer functions as a place to update and adjust weights more effectively.

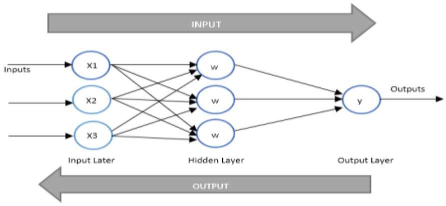

Fig. 3 Backpropagation

Using the Backpropagation method, an artificial neural network is trained to achieve a balance between its ability to recognize input patterns that are similar to the training patterns that have been used. The following is the calculation of the backpropagation algorithm:

Determine the initialization of all weights with random numbers.

Determine the maximum epok, maximum error.

If the stop conditions are not met, repeat step 4.

Epoch = Epoch + 1;

Each input unit that receives a signal or signal will be advanced to hidden.

Calculating hidden unit output (Zj):

$$Znet\, j = V_{jo} + \sum_{i}^{n}=1\, X_i\, V_{ji} \tag{1}$$

Calculate the output in the hidden layer using the activation function.

$$Z_j = \frac{1}{1 + \exp\left(-Z_{net}\right)} \tag{2}$$

Compute the network in the output layer (Y).

$$y\_net_k = w_{ko} + \sum_{j}^{p}=1\, zj\, Wkj \tag{3}$$

Calculating the output layer output with the activation function.

$$Z_j = \frac{1}{1 + \exp}\left(-Y_{netk}\right) \tag{4}$$

Calculate the output layer error on the external input.

$$\delta k = (t_k - y_k)y_k(1 - y_k) \tag{5}$$

Calculating Wjk weight fixes.

$$\Delta W_{jk} = \alpha . \delta k . Z_j \tag{6}$$

Calculating $\delta netj$ on the hidden layer. (7)

$$\delta \mathrm{netj} = \delta_{kW_{jk}}$$

Calculating errors in hidden layers.

$$\delta \mathrm{j} = \delta_{netj} . Z_j (1 - Z_j \quad (8)$$

Calculating the weight fix Vij.

$$\Delta V_{ij} = \alpha . \delta_j . X_i \quad (9)$$

Update all new weights.

$$W_{jk}(\mathrm{Baru}) = W_{jk}(\mathrm{Lama}) + \Delta W_{jk} \quad (10)$$

3.7 Accuracy

Accuracy is the evaluation percentage that is used to measure whether or not the model is accurate in classification or prediction in making a correct assessment of the data. This percentage gives an idea of the extent to which the model can predict precisely and accurately based on the data provided. The model is trained using training data and then tested with test data. To calculate the number of correct predictions, the results of the model's predictions are compared with the true values of the test data [26].

$$\textbf{Accuracy} = \frac{\textbf{\textit{Number of correct predictions}}}{\textbf{\textit{Amount of data}}} \; \boldsymbol{x} \; \mathbf{100\%} \quad (11)$$

4 Results and Discussion

4.1 Network Training

Network training using backpropagation, momentum, and learning rate algorithms is carried out using Visual Gene Developer 2.1. This training focuses on training data with a learning rate of 0.01, momentum of 0.1, and a maximum iteration limit of 50,000 times. The network training process will stop when it reaches the maximum iteration limit of 50,000 or when the predetermined error target is met. In addition, the number of neurons in the hidden layer is varied between 1 and 10 at each training session.

Table 1. Training Results with network architecture

Network architecture	Number of Hidden Neurons	Number of Epochs	SSE
10-1-01	1	50.000	0.0483
10-2-01	2	50.000	0.0510
10-3-01	3	50.000	0.0488

10-4-01	4	50.000	0.0451
10-5-01	5	50.000	0.0403
10-6-01	6	50.000	0.0535
10-7-01	7	50.000	0.0389
10-8-01	8	50.000	0.0407
10-9-01	9	50.000	0.0393
10-10-01	10	50.000	0.0416

In table 1, it can be seen that the smallest final SSE value is produced by an architecture that uses 7 neurons in the hidden layer, namely 0.0389.

4.2 Validation Stage

The architecture utilized during the validation phase is the one that attains the lowest SSE value during training. Validation is conducted with data separate from the training set for each network. The optimal network configuration is chosen based on the minimum SSE value acquired during the validation stage. Below are the validation outcomes for a 10-7-1 network structure employing a binary activation function set at 0.1:

Table 2. Network architecture validation results

Data to-	Target	Output	Error
1	0.031622	0.500000	0.0009990
2	0.031622	0.500000	0.0009990
3	0.028227	0.028227	0.000999984
…	…	…	…
…	…	…	…
100	0.031621	0.031598	0.000999976

Calculation of the SSE value between the target and network output, namely:

$SSE = ½ \times \Sigma(y - y^2)^2$

$= ½ \times (0.123092 - 1.059825)^2$

$= 0.438734$

4.3 Network Training and Validation Results

From the data listed in Tables 1 and 2, it can be seen that the network using the sigmoid function achieved the lowest training SSE value, 0.0389, with the 10-7-1 architecture. During the validation stage, the network with the sigmoid function produced the lowest SSE value of approximately 0.4387.

Table 3. Network Training and Validation Results

Training		Validation
Network	SSE	SSE

Sigmoid	0.0389	0.4387

4.4 Accuracy

In the process of testing the model on the dataset, it was found that out of a total of 100 data tested, there were 10 data that did not match the model predictions. In contrast, the model succeeded in providing appropriate predictions on the other 90 data. It is known that out of 100 research data, the model succeeded in providing accurate predictions on 90 data. In this research, the accuracy of the Backpropagation Neural Network (BNN) model is calculated using the formula.

$$\textbf{Accuracy} = \frac{\mathbf{90}}{\mathbf{100}}\ \boldsymbol{x}\ \mathbf{100\%} = \mathbf{90\%} \tag{12}$$

The accuracy of the model in this study reached 90%, demonstrating its capability to predict diabetes symptoms with a high success rate on the utilized dataset.

5 Conclusion

In conclusion, the application of the Backpropagation Neural Network method to classify diabetes symptoms yielded promising results. Creating technology solutions for accurate diagnosis of diabetes symptoms. Using the Backpropagation Artificial Neural Network method, this research focuses on classifying symptoms based on several parameters, including blood pressure, heart rate, body temperature, sugar levels, cholesterol, uric acid and oxygen levels. The network training process uses Visual Gene Developer 2.1, with specific parameters such as learning rate 0.01, mo-mentum 0.1, and a maximum iteration limit of 50,000 times. Variations in the num-ber of neurons in the hidden layer were explored, with the smallest final Sum of Squared Errors (SSE) value identified as 0.0389 in the architecture using 7 neurons. During the validation phase, the selected architecture is assessed using data not in-cluded in the training process, ultimately leading to the identification of the best net-work architecture based on the smallest SSE value. The selected 10-7-1 network ar-chitecture, with a binary activation function of 0.1, shows an SSE value of 0.4387 during validation. And It is known that out of 100 research data, the model succeeded in providing accurate predictions on 90 data. The accuracy of the model in this study reached 90%, demonstrating its capability to predict diabetes symptoms with a high success rate on the utilized dataset. The Backpropagation Neural Network method is preferred because of its ability to learn complex patterns and produce highly accurate output. Through the analysis of a comprehensive dataset and implementation of the neural network model, several important observations can be made.

References

[1] D. Satriawan, A. J. Pitoyo, and S. R. Giyarsih, "Faktor-faktor yang Memengaruhi Kepemilikan Jaminan Kesehatan Pekerja Sektor Informal di Indonesia," *Tataloka*, vol. 23, no. 2, pp. 263–280, 2021, doi: 10.14710/tataloka.23.2.263-280.

[2] C. P. Harahap, "Klasifikasi Penyakit Demam Menggunakan Jaringan Syaraf Tiruan Algoritma Backpropagation," *J. Informatics Data Sci.*, vol. 1, no. 2, pp. 1–6, 2023, doi: 10.24114/j-ids.v1i2.38680.

[3] F. Khaireururizal, "PREDIKSI PENYAKIT THT (TELINGA, HIDUNG, TENNGOROKAN) DENGAN METODE JARINGAN SYARAF TIRUAN PERCEPTRON," 2021.

[4] G. Priscila and P. Robin, "Pengaisan Big Data & Dunia Kesehatan," *Public Corner*, vol. 16, no. 1, pp. 37–57, 2021, doi: 10.24929/fisip.v16i1.1472.

[5] N. S. Jambago, E. Ennimay, Y. Priwahyuni, J. Yunita, and D. Jepisah, "Penerapan Aplikasi e-Puskesmas dengan Pendekatan HOT-Fit di Kabupaten Siak (Studi Kualitatif)," *J. Kesehat. Masy. Indones.*, vol. 17, no. 1, p. 58, 2022, doi: 10.26714/jkmi.17.1.2022.58-66.

[6] S. Somantri, I. Fazriawan, A. Laila Putri, and R. Ariaty Maulani, "Self Services And Monitoring Of Weak Heart Disease Based On The Internet Of Things And Mobile App Using Certainty Factor," *J. Informatics Telecommun. Eng.*, vol. 5, no. 2, pp. 384–394, 2022, doi: 10.31289/jite.v5i2.6195.

[7] M. Ali, B. S. Wiriaatmadja, and A. D. Hartanto, "Klasifikasi Pasien Pengidap Diabetes Menggunakan Neural Network Backpropagation Untuk Prediksi Kesembuhan," *Semin. Nas. Teknol. Komput. Sains*, pp. 135–141, 2020.

[8] D. F. Auliasari, G. Febrianti, A. P. Windarto, and D. Hartama, "Analisis Model Backpropagation Dalam Meramalkan Tingkat Penjualan Saldo ' Link Aja ,'" vol. 2, no. 1, pp. 10–16, 2022.

[9] Mardiasmo, "Digital Digital Repository Repository Universitas Universitas Jember Jember Digital Digital Repository Repository Universitas Universitas Jember," 2020.

[10] C. Adi nur rohkhim, Darujati, "KLASIFIKASI PENYAKIT KALKULUS (KARANG GIGI) MENGGUNAKAN PENGOLAHAN CITRA DIGITAL DENGAN METODE JARINGAN SARAF TIRUAN BACKPROPAGATION," vol. 9, no. 2, pp. 71–75, 2020.

[11] B. H. Hayadi, I. G. I. Sudipa, and A. P. Windarto, "Model peramalan pada peserta KB aktif jalur pemerintahan menggunakan Artificial Neural Network Back-propagation Artificial Neural Network Back-propagation models for active family planning participants in the government pathway," vol. 21, no. 1, 2021, doi: 10.30812/matrik.v21i1.1273.

[12] J. Permadi, H. Rhomadhona, and W. Aprianti, "Perbandingan K-Nearest Neighbor Dan Backpropagation Neural Network Dalam Prediksi Resiko Diabetes Tahap Awal," *Kumpul. J. Ilmu Komput.*, vol. 08, no. 3, pp. 352–365, 2021.

[13] A. E. Pramono, N. Nuryati, D. B. Santoso, and M. F. Salim, "Ketepatan Kodifikasi Klinis Berdasarkan ICD-10 di Puskesmas dan Rumah Sakit di Indonesia: Sebuah Studi Literatur," *Hernawan, dkk, 2016*, vol. 4, no. 2, pp. 98–106, 2021.

[14] A. M. Argina, "Penerapan Metode Klasifikasi K-Nearest Neigbor pada Dataset

Penderita Penyakit Diabetes," *Indones. J. Data Sci.*, vol. 1, no. 2, pp. 29–33, 2020, doi: 10.33096/ijodas.v1i2.11.

[15] N. D. Ariani, S. S. Tjahjati, A. Sudrajat, and A. Kusdiantini, "Kegiatan Pengabdian Kepada Masyarakat (PKM) Cek dan Konseling Kesehatan di Lingkungan Lapangan Tegalega Bandung," vol. 03, no. 01, pp. 92–102, 2023.

[16] E. P. Sari and S. Sayekti, "Korelasi Kadar HbA1c dengan C-Reactive Protein Pasien Diabetes Melitus Tipe 2 Correlation Of HbA1C Levels With C-Reactive Protein In Type 2 Diabetes Mellitus Patients," vol. 4, no. 1, pp. 74–80, 2023.

[17] Y. N. Hanuun, D. Cahyono, A. Virtual, J. S. Tiruan, and D. Printing, "Agen Virtual Berbasis Text menggunakan algoritma Jaringan Syaraf Tiruan," vol. 1, no. 1, pp. 1–10, 2023.

[18] E. D. Lestari, "Analisa Efek Samping Vaksin Pada Masyarakat Menggunakan Metode Backpropagation," *Semin. Nas. Inform.*, vol. 6, no. 3, 2022, [Online]. Available: https://www.jurnal.kaputama.ac.id/index.php/SENATIKA/article/view/1052

[19] S. S. Mukrimaa *et al.*, *Kecerdasan Buatan*, vol. 6, no. August. 2016.

[20] R. Riyanda, A. H. H. Pardede, and R. Saragih, "Jaringan Syaraf Tiruan Memprediksi Kebutuhan Obat-Obatan Menggunakan Metode Backpropagation (Studi Kasus : UPTD Puskesmas Bahorok)," *Semin. Nas. Inform.*, pp. 47–55, 2021.

[21] M. Idris, R. I. Adam, Y. Brianorman, R. Munir, D. Mahayana, and S. Tinggi, "Kebenaran dalam Perspektif Filsafat Ilmu Pengetahuan dan Implementasi dalam Data Science dan Machine Leaning," *J. Filsafat Indones.*, vol. 5, no. 2, p. 174, 2022, [Online]. Available: https://ejournal.undiksha.ac.id/index.php/JFI/article/view/42207

[22] N. Sianturi, "Jaringan Syaraf Tiruan Pengaruh Infuse Pada Berat Badan Pria dengan Menggunakan Metode Backpropagation," *J. Comput. Syst. Informatics*, vol. 1, no. 3, pp. 134–140, 2020, [Online]. Available: http://ejurnal.seminar-id.com/index.php/josyc/article/view/141

[23] rahayu deny danar dan alvi furwanti Alwie, A. B. Prasetio, R. Andespa, P. N. Lhokseumawe, and K. Pengantar, "JARINGAN SYARAF TIRUAN UNTUK IDENTIFIKASI PENYAKIT KANKER DARAH (LEUKEMIA) AKUT MENGGUNAKAN EKSTRAKSI CITRA DARAH," *J. Ekon. Vol. 18, Nomor 1 Maret201*, vol. 2, no. 1, pp. 41–49, 2020.

[24] M. D. Nawawi, D. Swanjaya, T. Informatika, F. Teknik, U. Nusantara, and P. Kediri, "Integrasi Self Organizing Maps Dan Backpropagation Pada Model Prediksi Penjualan," 2021.

[25] R. Aryanti, T. Misriati, and R. Hidayat, "Klasifikasi Risiko Kesehatan Ibu Hamil Menggunakan Random Oversampling Untuk Mengatasi Ketidakseimbangan Data," *KLIK Kaji. Ilm. Inform. dan Komput.*, vol. 3, no. 5, pp. 409–416, 2023.

[26] P. Purwono, P. Dewi, S. K. Wibisono, and B. P. Dewa, "Model Prediksi Otomatis Jenis Penyakit Hipertensi dengan Pemanfaatan Algoritma Machine Learning Artificial Neural Network," *Insect (Informatics Secur. J. Tek. Inform.*, vol. 7, no. 2, pp. 82–90, 2022, doi: 10.33506/insect.v7i2.1828.