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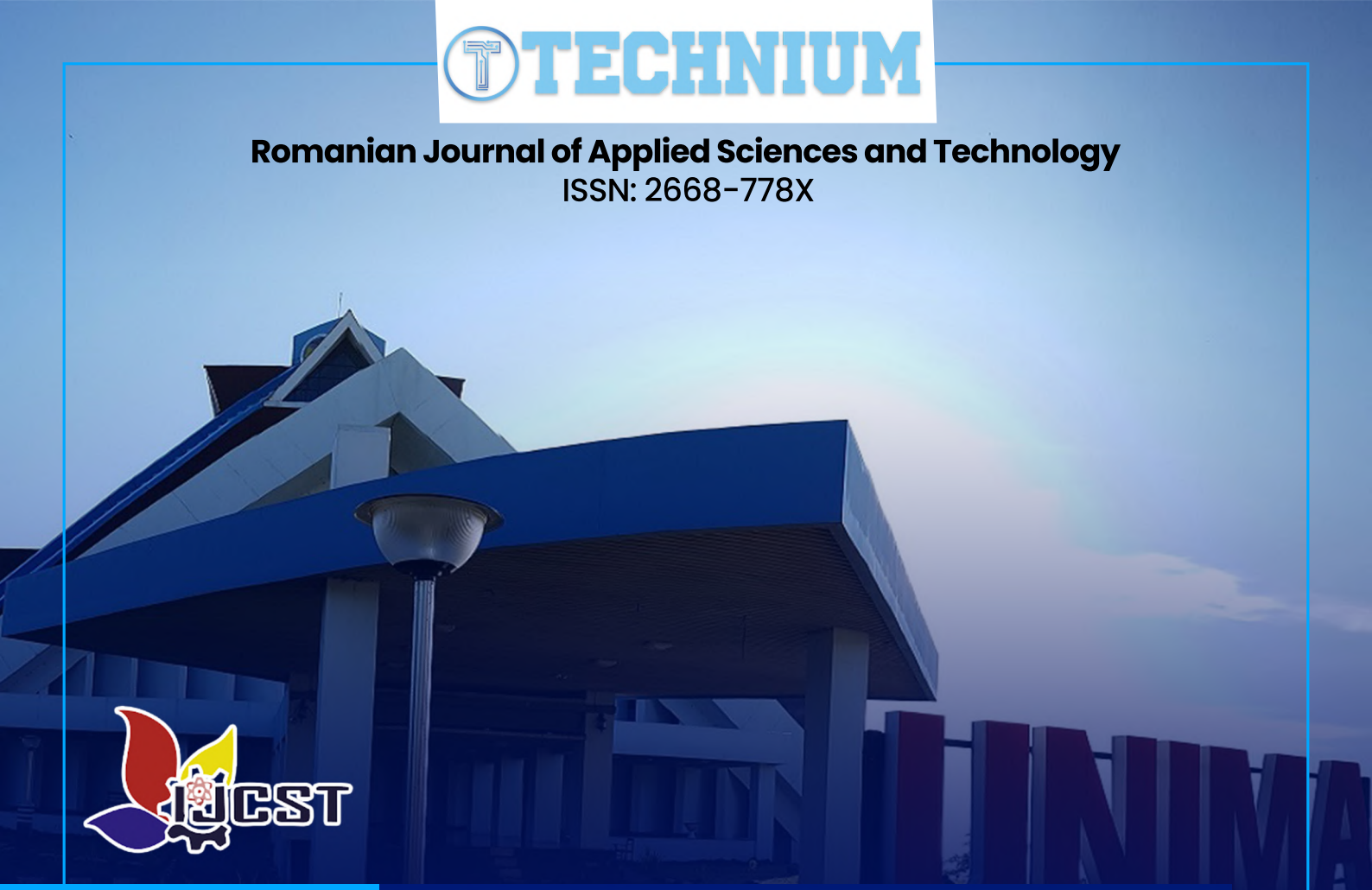

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Implementation Deep Learning Method On Decision Support System For Smart Indonesia Card Scholarship At University Of KH. Bahaudin Mudhary Madura

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Abstract. Scholarships are financial aid or funds awarded to individuals or groups to support education, research, or other academic development. There are many types of scholarships such as academic achievement scholarships, non-academic achievement scholarships, financial scholarships, and others. College scholarships are financial aid or funds provided to students to assist them in their pursuit of higher education. Scholarships in tertiary institutions can be full such as smart card scholarships or partial such as free tuition scholarships, and the aim is to encourage wider access to education and help students who are talented but face financial constraints in pursuing their education. At the University of KH. Bahaudin Mudhary Madura for scholarship applicants there are very many, there are hundreds or even nearly thousands of students who register, especially on the smart Indonesian card scholarship and this also requires very fast time and a good level of accuracy in decision making. Therefore, it requires a decision support system. In this study, the deep learning method was applied to a decision support system with a loss of 1.43%, an accuracy rate of 98.57% and a system runtime of 77ms/step.

1 Introduction

Scholarships are financial aid or funds awarded to individuals or groups to support education, research, or other academic development. Scholarships can be full or partial, and the source can come from the government, educational institutions, private organizations, foundations, or individuals. Scholarships are usually awarded based on academic achievement, non-academic achievement, financial need, interest in the field of study, or other criteria relevant to the purpose of the scholarship. The main aim of the scholarships is to encourage access to education and help individuals reach their potential without having to be constrained by financial problems [1]–[4].

Scholarships can have a variety of criteria to determine who is eligible to receive them. These criteria often vary and may vary from one scholarship awarding institution to another. There are many types of scholarships such as academic achievement scholarships, non-academic achievement scholarships, financial scholarships and others [5].

College scholarships are financial aid or funds provided to students to assist them in their pursuit of higher education. Scholarships in tertiary institutions can be full or partial, and their aim is to encourage greater access to education and help talented but financially constrained students pursue their education [6].

For applicants for smart Indonesian card scholarships, especially at KH. Bahaudin Mudhary Madura scholarship selection participants are very large and can exceed the quota limit given, so it is necessary to do a very fast and accurate selection system.

Quick decision making, can be done with the support of a Decision Support System (DSS)[7]–[11]. The concept of decision making with the help of a computerized system allows for faster and more accurate decision making [12]. There are several alternative methods available for DSS. The first is the SAW (Simple Additive Weighting) method which is relatively simpler as shown [13]. Then, the AHP (Analytical Hierarchy Process) method [14]. Then, another alternative is the TOPSIS approach [15]. In his research, [16] shows the incorporation of some of these methods in decision making. The development of techniques in the field of machine learning, also affects the implementation in DSS, as shown [17]. The development of data mining techniques and their implementation in DSS is also shown in the research [18]. However, no previous studies have specifically discussed deep learning approaches that have better performance potential.

So this research will apply deep learning techniques, namely using neurons arranged in several layers, to form a Scholarship Selection Decision Support System to determine the speed and level of accuracy of the deep learning method.

2 Material and Method

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2.1 Decision Support System

Decision support system is defined as a computer application program that analyzes data and presents it so that users can make decisions more easily. Decision support system is an information application. A decision support can present information graphically and can include expert systems or artificial intelligence [19], [20].
According to [21], in his book entitled Introduction to Information Technology, states that Decision Support Systems are computer-based information systems that combine models and data to provide support to decision makers in solving semi-structured problems or dependency problems involving users in depth.

2.2 Deep Learning Method

Deep learning is a subset of machine learning that uses artificial neural network (ANN) architectures to process data and learn complex patterns. In decision support systems, deep learning is used to assist decision making by identifying patterns from large and complex data, and providing predictions or recommendations based on the analysis performed [22].
Artificial Neural Network (ANN) consists of a collection of several connected neuron units, where each connection can transmit signals. Each neuron will process the received signal and produce an output from the processing results. The signals on the connections between these neurons are real values, and the output of the sum of all the processing results of the neurons is entered into a non-linear function. In each connection, there is usually a weight to adjust the level of the input scale on each neuron. One of the earliest proposed models of these neurons is the perceptron model which was first developed [23]. This model is shown in Fig 1.

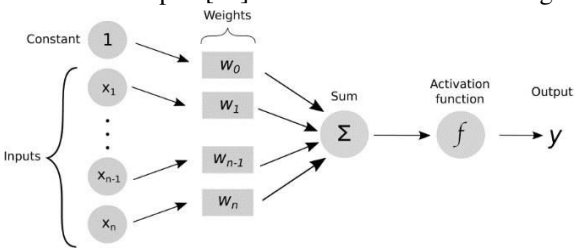

Fig 1. Perceptron Models
(Source: D. Lopez-Bernal, 2021)

The use of the perceptron was initially considered promising, because it offers a computational model that allows the learning process to obtain the inherent pattern of a physical phenomenon. However, a problem was discovered, when it was found that the perceptron was unable to solve a very simple problem, namely the XOR problem. These findings then direct the use of perceptron towards deep learning, where perceptron are arranged into several layers, where each layer solves a problem or creates a feature which is a synthesis of several features in the previous layer. The application of deep learning improves the overall performance of this model [24].

The use of deep learning itself can be stated based on the architecture used, including deep neural networks, deep belief networks, recurrent neural networks, and convolutional neural networks, in which these architectures have been applied to the realms of image recognition, speech recognition, natural language processing (NLP), translation, bioinformatics, drug design, to medical image analysis. In previous research [25], it is also concluded that in the applications of one of them in image classification and pattern recognition, the performance of deep learning is able to exceed the performance of human recognition.
The use of the term deep in deep learning refers to the use of multiple layers within the neural network architecture used. Meanwhile, in deep learning architecture, more than one hidden layer is used, as shown in Fig 2.

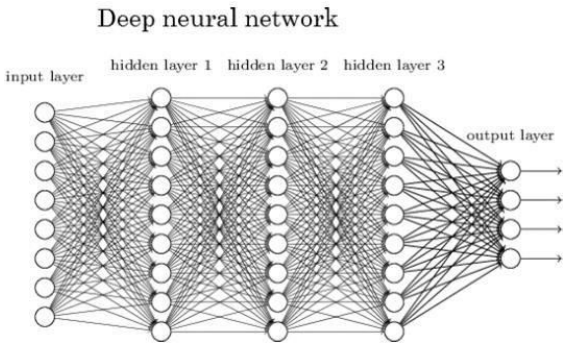

Fig 2. Deep Learning Diagram
(Source: H. Suparwito, 2019)

There are several calculation methods for conducting this training, one of which is the Gradient Descent method. Gradient Descent (GD) method as proposed [26], trying to optimize a function, by iteratively moving the input in the direction where the tangent to the curve of the function to be optimized, points in the most negative direction. In the deep learning training process, this approach is used to minimize the cost function. For example, if the cost function of a deep learning model can be expressed by Equation (1).

$$(m, b) = \frac{1}{N}\sum_{i=1}^{n} (y_i - (mx_i + b))^2 \quad (1)$$

m : weight parameters
b : bias parameters
n : amount of data
i : data index

By using this equation as a cost function, we can find the gradient of the function at a point, using Equation (2).

$$f'(m, b) = \begin{bmatrix} \frac{df}{dm} \\ \frac{df}{db} \end{bmatrix} = \begin{bmatrix} \frac{1}{N}\sum -2x_i (y_i - (mx_i + b)) \\ \frac{1}{N}\sum -2(y_i - (mx_i + b)) \end{bmatrix} \quad (2)$$

m : weight parameters
b : bias parameters
n : amount of data

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i : data index

So, to find the gradient, we iterate over all the data points used, for each value of m and b, and calculate the derivative of the partial equation.

2.3 Confusion Matrix

The Confusion Matrix or more commonly known as the contingency table is a matrix that may be very large. In this matrix, a correct classification action is contained in the diagonal axis of the matrix. In any other column, the entire matrix is false. A genetic algorithm uses a set of rules to test the suitability of these rules for the problem at hand, its derivatives [27]. In this case the confusion matrix is used to assess the suitability level of the classification process, in classifying a decision with the actual conditions. An example of a confusion matrix is shown in table 1.

Table 1. Confusion Matrix Cost

	Classification as A	Classification as B
Actual Class A	0	1
Actual Class B	1	0

Then, in use, each classification decision taken, is compared with the actual class, to get the value of the cost of that decision. The calculation is done using Equation (3).

$$C = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} \quad (3)$$

C :total *Cost*
i : classification decision index
j : actual indexs

3 Research Methods

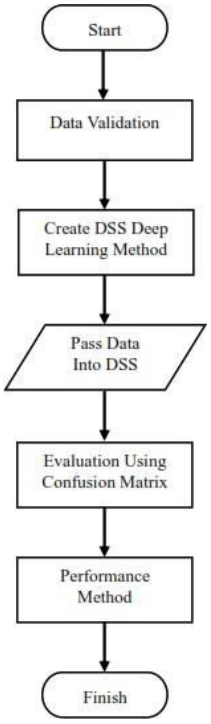

Fig 3. Research Flowchart

3.1 Testing Method

This model receives input data from the input layer, then forwards it to the processing layer, or is called the hidden layer. The processing results will then be displayed as a value in the output section, where this value is a probability value, or recommendation, that a student is eligible to be submitted to the scholarship category. Calculations for each hidden layer will use neurons with the perceptron computational model according to Equation (4). In this equation, there is input i to output on perceptron j.

$$y_j = f_a(w_{1,j}.x_1 + w_{2,j}.x_2 + \cdots + w_{i,j}.x_i + b_j) \quad (4)$$

y : perceptron external element
x : perceptron input element
f_a: activation function
b : bias
w : weight
i : input index
j : output index
n : input index to n

After creating this deep learning model, a training process will be carried out on the model. This training aims to change the parameters contained in the model, namely the weight and bias in it. Parameter changes in this model will be based on the Stochastic Gradient Descent Method, where the current parameter values will be entered into the cost function to determine the renewal of the existing parameters, to reduce the cost function. This cost function is shown in Equation (2).

$$f_c(m,b) = \frac{1}{n}\sum_{i=1}^{n} (h_\theta(x_i) - y_i)^2 \quad (2)$$

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f_c : cost function
m : weight
b : bias
n : the number of evaluation data, in this study using 32 data per batch
h_θ : prediction function with m and b as parameters
x_i : input data to i
y_i : output data to i

Based on the costs generated, all parameters contained in this deep learning model will be updated with the aim of reducing costs, which in turn is expected to increase the accuracy of this model. Data on the previous year's scholarship recipients will be broken down by a ratio of 80-20. More data will be used to train the model, and less data will be used to perform validation tests, in which deep learning models are validated by looking at their performance against never-before-seen datasets.

4 Result And Discussion

4.1 Data Validation

Preparation for this data consists of an initial exploration stage, followed by a validation process. The process of exploring the data is carried out to look at the data and plan actions that need to be taken on the data, so that the data can be used. Next, validation is carried out on the data of prospective scholarship recipients. This validation process is shown in Table 2.

Table 2. Data Validation Results for Smart Indonesia Card Scholarships

No	Problems	Action
1	Blank Data	Giving a value of 0 to empty data
2	Personal data of prospective scholarship recipients must be anonymous	Personal data such as name, nickname, address and mobile phone number will be deleted
3	Filled data is not a numeric value	Convert data into numeric values
4	The data consists of several categories	Changing data into categorical data

4.2 Model Building

This model is used for the smart Indonesian card scholarship scheme, which will use an input data width of 36. The parameters for the smart Indonesian card scholarship model are shown in Figure 4.

```
Layer (type)                 Output Shape              Param #
=================================================================
dense_10 (Dense)             (None, 2000)              74000

dense_11 (Dense)             (None, 1500)              3001500

dense_12 (Dense)             (None, 1000)              1501000

dense_13 (Dense)             (None, 500)               500500

dense_14 (Dense)             (None, 1)                 501

=================================================================
Total params: 5,077,501
Trainable params: 5,077,501
Non-trainable params: 0
_________________________________________________________________
```

Fig 4. Model overview for the Indonesia smart card scholarship

The figure above shows that this model has 5,077,501 parameters. The number of parameters is actually more than enough when compared to the width of the input data which is only 36 data.

4.3 Model Training

At this stage the algorithm for optimization will use Adam's algorithm, while for loss calculations it will use the binary_crossentropy approach. Completely, model training is carried out using the training parameters as listed in Table 3.

Table 3. Model Training Parameters.

No	Parameters	Value
1	Optimizer	Adam
2	Loss	Binary_crossentropy
3	Metrics	Binary_accuracy
4	Callbacks	Early Stopping

Then training is carried out on the model for prediction of scholarships. Training of the first model runs for 43 training epochs before the callback occurs. The training results are shown in Figure 5, Figure 6 and Figure 7. It was found that the minimum loss value was 1.4382, with an accuracy value of 98.57%, and runtime DSS 77 ms/step.

```
Epoch 13/500
2/2 [==============================] - 0s 99ms/step - loss: 5.0177e-04
Epoch 14/500
2/2 [==============================] - 0s 77ms/step - loss: 1.4382e-04
Epoch 15/500
2/2 [==============================] - 0s 77ms/step - loss: 1.4866e-05
Epoch 16/500
2/2 [==============================] - 0s 88ms/step - loss: 2.5739e-06
Epoch 17/500
2/2 [==============================] - 0s 95ms/step - loss: 9.5372e-07
Epoch 18/500
2/2 [==============================] - 0s 86ms/step - loss: 3.4823e-07
Epoch 19/500
2/2 [==============================] - 0s 76ms/step - loss: 2.1348e-07
Epoch 20/500
2/2 [==============================] - 0s 84ms/step - loss: 1.7829e-07
Epoch 21/500
2/2 [==============================] - 0s 75ms/step - loss: 1.6801e-07
Epoch 22/500
2/2 [==============================] - 0s 78ms/step - loss: 1.6793e-07
Epoch 23/500
2/2 [==============================] - 0s 84ms/step - loss: 1.7567e-07
```

Figure 5. Training Results at the 14th Epoch Optimum Point

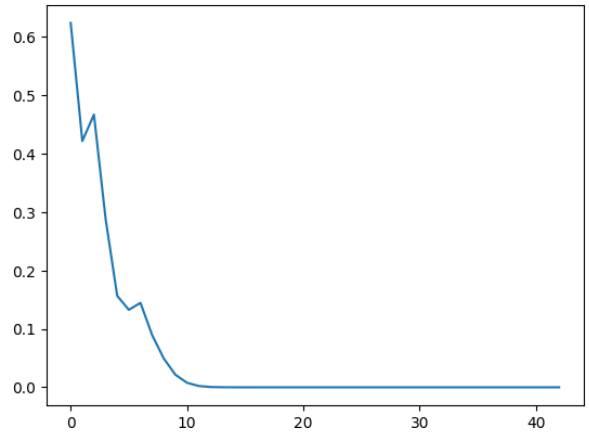

Figure 5. Graph of training loss values against training epochs

```
(36,)
(1, 36)
1/1 [==============================] - 0s 77ms/step
```

Figure 7. Average Result of System Runtime Time

5 Conclusion

Research activities have been carried out, and the results of the accuracy, loss, and runtime performance of the decision support system from a supervised learning approach based on deep learning.
The DSS model with a deep learning approach has been successfully created with an accuracy performance that produces a schematic data loss rate of 1.43%, accuracy 98.57%, and DSS runtime 77ms/step.

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