Analysis of Perceptron Quantum Artificial Neural Networks to Classify the Feasibility of Prospective Debtors

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Abstract. Bank is a business entity whose activities are collecting funds from the public in the form of deposits and channeling them to the public in the form of loans or other forms to improve the lives of many people. This study aims to classify the feasibility data of prospective borrowers with the perceptron algorithm using quantum computing to facilitate the bank in determining the prospective debtor. The results of this study are an analysis of the feasibility of prospective borrowers using the perceptron algorithm with quantum computing.

1. Introduction
Bank is a business entity whose activities are collecting funds from the public in the form of deposits and channeling them to the public in the form of loans or other forms to improve the lives of many people. One of the bank’s products is the provision of credit to the public, where many people who apply for it according to needs. Of course the bank does not directly accept community requests. There are several concepts that become the principle in granting credit. There are several criteria that are met by the applicant, then proceed with an assessment of the eligibility of the prospective debtor by a team of analysts who assess the eligibility of the prospective debtor. If the prospective debtor is eligible, the bank provides a loan.

There are 9 variables to classify prospective debtor eligibility data, namely: Current Ratio, Quick Ratio, Debt to Equity, Profit Margin, Days of Receivable, Days of Inventory, Days of Payable, Guarantees and reputation. Data is classified into 2 classifications: Eligible and Ineligible.

To classify the feasibility of prospective debtor data, researchers used an artificial neural network perceptron algorithm. Computing the perceptron algorithm using quantum computation, namely quantum bit computing. By using quantum computing, the speed of learning or convergence is faster compared to classical computing using bits 0 and 1.
2. Methods

2.1. Artificial Intelligence
Artificial Intelligence is one area that is quite reliable in solving problems such as prediction (forecasting). AI is a very important discipline and it includes a number of well recognized and mature areas including Neural Network [1][2][3].

2.2. Artificial Neural Network
Artificial Neural Network (ANN) is one of the studies of Artificial Intelligence and is a new computing technology in the field of computer science study. Neural networks mostly used for problem-solving in pattern recognition, data analysis, control and clustering [4][5][6]. Artificial neural network is a computer model that can think like a human brain. The human brain consists of 3x10¹⁰ neurons where each neuron is interconnected to 10⁴ synapses [7]. This connection allows each neuron to transmit signals to other neurons as information is processed. However, not all connections are the same because every connection has a different weight [8]. Weight will be 0 if there is no connection between one neuron and another. This weight value determines the output of the neural network so that it can be said that the weight is a memory of the neural network.

2.3. Quantum Computation
Quantum computation theory is very inspired by the phenomenon of particles in quantum mechanics. This phenomenon is called superposition where a particle in quantum mechanics can have two states at once. Superposition of a particle if transformed into computing can be in the form of bits where the value of the bits consists of only 0 or 1 but in quantum computing the value of bits can be 0 or 1 or a combination of the two values [9][10]. Quantum Neural Network (QNN) is a form of artificial neural network that uses the concept of quantum computing [11]. In this method the form of network architecture still uses the classical neural network but from the determination of inputs, weights, learning algorithms and targets already use the quantum computational approach.

3. Result and Discussion

3.1. Research Stages
This research has several stages. The stages of the research can be seen in Figure 1:
3.2. Data Analysis
The data used in this study are the data of the request of prospective debtors from the Syariah Bank of Pematangsiantar City and the criteria for determining eligibility, which can be seen in table 1 and table 2.

| Eligibility | CR | QR | DER | PM | DOR | DOI | DOP | Reputation | Guarantee |
|-------------|----|----|-----|----|-----|-----|-----|-------------|-----------|
| Worthy      | G  | NG | G   | H  | NG  | G   | L   | G           | G         |
| Worthy      | NG | NG | G   | L  | NG  | G   | H   | G           | G         |
| Worthy      | NG | G  | G   | H  | G   | G   | H   | G           | G         |
| Not feasible| NG | G  | NG  | L  | G   | NG  | H   | NG          | NG        |
| Worthy      | G  | NG | G   | L  | G   | NG  | H   | G           | G         |
| Worthy      | NG | G  | NG  | L  | G   | L   | G   | G           | G         |
| Worthy      | NG | G  | G   | L  | NG  | G   | H   | G           | G         |
| Worthy      | NG | G  | G   | L  | NG  | G   | L   | G           | G         |
| Not feasible| NG | G  | L   | NG | G   | L   | NG  | NG          | NG        |
| Worthy      | G  | NG | G   | L  | NG  | G   | H   | G           | G         |
| Worthy      | NG | G  | G   | L  | NG  | G   | H   | G           | G         |
| Worthy      | NG | G  | G   | L  | NG  | G   | H   | G           | G         |
| Worthy      | NG | G  | G   | L  | NG  | G   | H   | G           | G         |
| Not feasible| NG | G  | G   | L  | NG  | G   | H   | G           | G         |
| Worthy      | G  | G  | G   | R  | NG  | G   | H   | G           | G         |
| Worthy      | G  | G  | G   | R  | NG  | G   | H   | G           | G         |
| Worthy      | G  | G  | G   | R  | NG  | G   | H   | G           | G         |
| Worthy      | G  | G  | G   | R  | NG  | G   | H   | G           | G         |
| Worthy      | G  | G  | G   | R  | NG  | G   | H   | G           | G         |
| Worthy      | G  | G  | G   | R  | NG  | G   | H   | G           | G         |
| Worthy      | G  | G  | G   | R  | NG  | G   | H   | G           | G         |
| Not feasible| G  | G  | R   | NG | NG  | R   | NG  | NG          | NG        |
| Worthy      | G  | G  | G   | R   | NG | NG  | H   | NG          | NG        |
| Worthy      | G  | G  | G   | R   | NG | NG  | H   | G           | G         |
| Worthy      | G  | G  | G   | R   | NG | NG  | H   | G           | G         |
| Worthy      | G  | G  | G   | R   | NG | NG  | H   | G           | G         |
| Not feasible| G  | G  | R   | NG | NG  | R   | G   | G           | G         |
| Worthy      | G  | G  | G   | R   | NG | NG  | R   | G           | G         |
| Worthy      | G  | G  | G   | R   | NG | NG  | H   | G           | G         |
| Worthy      | G  | G  | G   | R   | NG |NG  | H   | NG          | NG        |
| Not feasible| G  | G  | R   | NG | NG  | R   | G   | G           | G         |
| Worthy      | G  | G  | G   | R   | NG |NG  | R   | G           | G         |
| Worthy      | G  | G  | G   | R   | NG |NG  | H   | NG          | NG        |
| Not feasible| G  | G  | R   | NG | NG  | H   | G   | NG          | NG        |
| Not feasible| G  | G  | R   | NG | NG  | H   | NG  | NG          | NG        |
| Not feasible| G  | G  | R   | NG | NG  | H   | NG  | NG          | NG        |
Table 2. List of Criteria in Determining the Eligibility of Prospective Debtors

| No | Criteria | Range      | Information | Weight |
|----|----------|------------|-------------|--------|
| 1  | CR       | 71 - 100   | Good(B)     | 1      |
|    |          | 0 - 70     | Not Good(NG)| 0      |
| 2  | QR       | 71 - 100   | Good(B)     | 1      |
|    |          | 0 - 70     | Not Good(NG)| 0      |
| 3  | DER      | 71 - 100   | Good(B)     | 1      |
|    |          | 0 - 70     | Not Good(NG)| 0      |
| 4  | PM       | 71 - 100   | High(H)     | 1      |
|    |          | 0 - 70     | Low(L)      | 0      |
| 5  | DOR      | 71 - 100   | Good(B)     | 1      |
|    |          | 0 - 70     | Not Good(NG)| 0      |
| 6  | DOI      | 71 - 100   | Good(B)     | 1      |
|    |          | 0 - 70     | Not Good(NG)| 0      |
| 7  | DOP      | 51 - 100   | High(H)     | 1      |
|    |          | 0 - 70     | Low(L)      | 0      |
| 8  | Reputation | 71 - 100 | Good(B)     | 1      |
|    |          | 0 - 70     | Not Good(NG)| 0      |
| 9  | Guarantee | 71 - 100   | Good(B)     | 1      |
|    |          | 0 - 70     | Not Good(NG)| 0      |

Table 1 is preliminary data or raw data of Bank Syariah Mandiri prospective borrowers’ applications taken from the assessment forms and application files by prospective debtors which consist of 9 variables: current ratio (CR), quick ratio (QR), debt to equity ratio (DER), profit margin (PM), days of receivable (DOR), days of inventory (DOI), days of payable (DOP), guarantees and reputation. For the current ratio variable, quick ratio, debt to equity ratio, days of receivable, days of inventory, guarantee and reputation contain G, and NT. B means good, and NG means not good. For profit margin and days of payable variables containing H and L. H means high and L means low.

3.3. Stages of Analysis
At this stage, it is divided into several stages, namely:
1. Determine network architecture
2. Determine the weight and learning rate
3. Learning the quantum perceptron algorithm
4. Quantum perceptron testing
5. Evaluation

3.4. Final Stages/Analysis results
This stage will present the results of the convergence analysis by dividing it into several important parts to see the best results and existing weaknesses.

3.5. Learning perceptron
The following will describe the stages of perceptron learning with an example using 9-1-1 architecture and contact lens use dataset. First of all weights w and v are randomly assigned 0.1 as follows
\[ W1 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}, \quad W2 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}, \quad W3 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \quad W4 = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}, \quad W5 = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}, \quad W6 = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}, \quad W7 = \begin{bmatrix} 0 & 1 \\ 1 & 1 \end{bmatrix}, \quad W8 = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}, \quad W9 = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}, \quad V1 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \]

While the learning rate value is 0.1. Then the learning process starts from the first data with 
dataset number 1 namely 101101011 as input and 1 as the expected output.

Next for the output on hidden Z by using the following formula.

1. Output \( Z = W1 \ | \ X1 > + \ldots + W9 \ | \ X9 > = \left[ \frac{2}{3} \right] \)
2. Output \( Y = V1. \ | \ Z > = \left[ \frac{4}{5} \right] \)

Then the temporary output \( Y \) is compared with the expected output of \( Y = 1 > = \left[ \frac{9}{7} \right] \) where \( \left[ \frac{9}{7} \right] \neq \left[ \frac{4}{5} \right] \) then changes are made to each weight \( W_{i,j} \), \( V_{i,j} \) from \( |X1 > \) to \( |X9 > \) and calculation of the error value. First we made changes in weights for \( W1, W2, W3, W4, W5, V1 \) at \( Y \neq T \) as follows.

1. Weight \( W1_{\text{new}} = W1_{\text{old}} + \alpha (|Y > - |T >) \). \( < X1 = \begin{bmatrix} 0 & 0.6 \\ 1 & -0.4 \end{bmatrix} \)
2. Weight \( W2_{\text{new}} = W2_{\text{old}} + \alpha (|Y > - |T >) \). \( < X2 = \begin{bmatrix} -0.4 & 0 \\ 0.6 & 1 \end{bmatrix} \)
3. Weight \( W3_{\text{new}} = W3_{\text{old}} + \alpha (|Y > - |T >) \). \( < X3 = \begin{bmatrix} 1 & -0.4 \\ 1 & 0.6 \end{bmatrix} \)
4. Weight \( W4_{\text{new}} = W4_{\text{old}} + \alpha (|Y > - |T >) \). \( < X4 = \begin{bmatrix} 0 & -0.4 \\ 1 & -0.4 \end{bmatrix} \)
5. Weight \( W5_{\text{new}} = W5_{\text{old}} + \alpha (|Y > - |T >) \). \( < X5 = \begin{bmatrix} -0.4 & 0 \\ -0.4 & 1 \end{bmatrix} \)
6. Weight \( W6_{\text{new}} = W6_{\text{old}} + \alpha (|Y > - |T >) \). \( < X6 = \begin{bmatrix} 0 & -0.4 \\ 1 & -0.4 \end{bmatrix} \)
7. Weight \( W7_{\text{new}} = W7_{\text{old}} + \alpha (|Y > - |T >) \). \( < X7 = \begin{bmatrix} -0.4 & 1 \\ 0.6 & 1 \end{bmatrix} \)
8. Weight \( W8_{\text{new}} = W8_{\text{old}} + \alpha (|Y > - |T >) \). \( < X8 = \begin{bmatrix} 1 & -0.4 \\ 0 & 0.6 \end{bmatrix} \)
9. Weight \( W9_{\text{new}} = W9_{\text{old}} + \alpha (|Y > - |T >) \). \( < X9 = \begin{bmatrix} 1 & -0.4 \\ 0 & -0.4 \end{bmatrix} \)
10. Weight \( W10_{\text{new}} = W10_{\text{old}} + \alpha (|Y > - |T >) \). \( < X10 = \begin{bmatrix} -0.84 & -0.4 \\ -0.16 & -0.80 \end{bmatrix} \)

Temporary output values \( Y = \left[ \frac{4}{5} \right] \) and \( T = \left[ \frac{9}{7} \right] \) then error = \( (|Y > - |T >) = ( \left[ \frac{4}{5} \right] - \left[ \frac{9}{7} \right] ) = \left[ \frac{-2}{35} \right] \). Then this weight change is carried out continuously until the expected output value \( Y \) is the same as the temporary output value \( T \). In other words the weight value will continue to change until the condition \( Y = T \) is met or the error value is equal to 0.

4. Conclusion
This research is still limited to analysis, further research needs to be made for testing. To classify the feasibility of prospective debtor data used 9 variables, namely: Current Ratio, Quick Ratio, Debt to Equity, Profit Margin, Days of Receivable, Days of Inventory, Days of Payable, Guarantees and reputation. The algorithm used in classifying the feasibility of prospective debtor data is the perceptron algorithm using quantum computing.
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