Quantum Perceptron in Predicting the Number of Visitors to E-Commerce Websites in Indonesian

Solikhun[1]*, Dinda Carissa Arishandy[2], Ela Roza Batubara[3], Poningsih[4]
Department of Informatics Engineering [1], [2], Department of Information Systems[3], Departemnt of Master Informatics[4]
STIKOM Tunas Bangsa
Pematangsiantar, Indonesia
solikhun@amiktunasbangsa.ac.id [1], dindaarishandy1@gmail.com [2], ela@amiktunasbangsa.ac.id [3], poningsih@amiktunasbangsa.ac.id [4]

***Abstract*— In the current digital era, e-commerce has become the backbone of Indonesia's digital economy, which is experiencing rapid growth. However, competition in this industry is becoming increasingly fierce, indicating the importance of predicting the number of website visitors for an effective marketing strategy. Quantum Perceptron, the latest quantum computing innovation, promises a more accurate and efficient approach compared to conventional methods such as classical Perceptron. This research proposes the use of Quantum Perceptron to predict the number of visitors on large e-commerce platforms in Indonesia. The data used in the research is data on the number of e-commerce visitors obtained from the katadata.com website. Data from Shopee, Tokopedia, Lazada, Blibli, and Bukalapak were used to analyze and compare predictions with classical perceptron methods, showing the significant potential of Quantum Perceptron in supporting the development of more efficient business strategies. The research results show that the Quantum Perceptron algorithm can make predictions very well compared to the classical perceptron, proven by the Quantum Perceptron having a perfect accuracy of 100% with a total of 2 epochs while the classical perceptron has 100% accuracy with a total of 10 epochs. Quantum perceptron has better performance and shorter time, this can be seen from the smaller number of epochs.**

Keywords*— *Quantum Perceptron, E-Commerce, Website Visitor Prediction, Quantum Computing, Marketing Strategies

I. INTRODUCTION

The rapid development of quantum technology and artificial intelligence (AI) has opened up huge opportunities in various sectors, including e-commerce. One application of this technology is the *quantum perceptron*, which combines the power of quantum computing with traditional machine learning models to produce faster and more accurate predictions [1], [2]. Quantum computing, which is supported by parallel processing capabilities through *qubits*, is able to significantly speed up large-scale data processing compared to classical computing [3], [4]. If classical perceptron computing can only process data in the range 0 and 1, then quantum perceptron processes data in the range 0, 1 and a combination of both 0 and 1. The initial data will be transformed into the range 0, 1 to be tested using a quantum perceptron.

In Indonesia, e-commerce has become an important part of the digital economy, with the number of visitors to e-commerce websites increasing every year. Predicting the number of visitors is crucial in determining marketing strategies, stock management, and other business decision-making [5]. However, conventional prediction methods based on classical computing often suffer from limitations in handling large data volumes and complex patterns [6].

The *Quantum perceptron* offers a solution to this challenge by utilizing quantum phenomena such as *superposition* and *entanglement*, which allows these models to process data more efficiently [7], [8]. Recent studies have shown that quantum perceptrons can produce more accurate predictions compared to traditional machine learning models in various applications, including the prediction of the number of website visitors [9]. The use of *quantum perceptron* in the e-commerce sector has the potential to improve prediction accuracy, especially in situations where the data at hand is very large and complex [10], [11].

In 2023, quantum technology began to gain greater attention in practical applications, especially in the commercial sector. Implementations of quantum-based systems have been applied in various fields, ranging from supply chain optimization to market prediction [12]. Particularly in the context of e-commerce, this technology offers a more sophisticated approach to monitoring and analyzing visitor behavior [13], [14]. Research shows that quantum algorithms are able to reduce computation time for predictions that previously required large computational resources [15].

In Indonesia, the rapid growth of the e-commerce market creates an urgent need for more advanced technological solutions to improve business competitiveness [16], [17]. Therefore, the use of *quantum perceptron* can be one way to address this challenge, especially in improving prediction accuracy and enterprise resource optimization [18], [19]. Moreover, the applications of quantum computing are expected to continue growing in the next few years, enabling wider adoption in various sectors of the economy [20].

Research in the field of *quantum machine learning* (QML) has shown promising results. QML not only offers higher computational speed but also an increased ability to discover patterns hidden in data [21], [22]. In 2022, further research

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i2.2334, Copyright ©2025
Submitted : April 22, 2025, Revised : May 12, 2025, Accepted : May 14, 2025, Published : May 26, 2025

strengthened the understanding that *quantum perceptron* can solve complicated non-linear problems more efficiently [23]. Thus, integrating quantum technology into prediction systems in e-commerce will provide significant advantages for companies looking to improve operational accuracy and effectiveness [24], [25].

This research aims to apply Quantum Perceptron algorithm as a more effective solution for predicting the number of e-commerce visitors in Indonesia. This research is expected to contribute to in supporting the development of more efficient business strategies.

II. METHODS

The Materials and Methods section is crucial in research as it details the framework and procedures used to conduct the study, ensuring the findings' transparency, reproducibility, and reliability. This section describes the stages of the research, data analysis methods, and specific techniques used in the study. By providing a clear methodology, this section allows other researchers to evaluate and replicate the study, thereby contributing to the cumulative knowledge in the field. In this research on predicting website visitor numbers using Quantum Perceptron for e-commerce platforms in Indonesia, the Materials and Methods section will describe the research stages, data analysis techniques, and the application of Quantum Perceptron in transforming visitor prediction data. This section guides an understanding of how the study was conducted, from data collection to analysis and interpretation

A. Research Stages

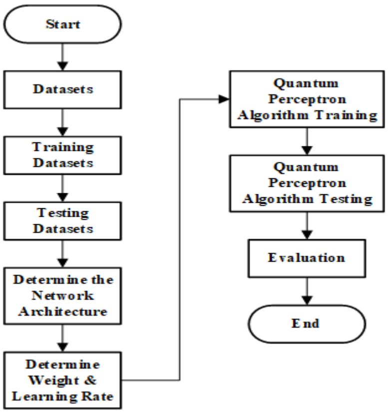

Fig. 1. Research Stages

The research design begins with the data collection stage, where the dataset used for training and testing the model is gathered. The dataset utilized in this study is secondary data, specifically the number of visitors to an e-commerce website, obtained from the website katadata.com. The dataset is then divided into two parts: the training dataset, which is used to train the model, and the testing dataset, which is used to evaluate the model's performance after training. Next, the architecture of the Quantum Perceptron is determined, including the number of layers and units in each layer. Quantum Perceptron is chosen as a solution because it offers shorter computation time and more accurate results compared to classical perceptron. Subsequently, initial parameters such as weights and learning rate are set to ensure the training process runs optimally. The next stage involves training the Quantum Perceptron algorithm using the prepared training dataset. Once the training is complete, the trained model is tested using the testing dataset to assess its performance in making predictions. The testing results are then evaluated to determine the accuracy and effectiveness of the model in solving the prediction task. Once the evaluation results are obtained, the research process is considered complete.

B. Data Analyst

The Materials and Methods section is crucial in research as it details the framework and procedures used to conduct the study, ensuring the findings' transparency, reproducibility, and reliability. This section describes the stages of the research, data analysis methods, and specific techniques used in the study. By providing a clear methodology, this section allows other researchers to evaluate and replicate the study, thereby contributing to the cumulative knowledge in the field. In this research on predicting website visitor numbers using Quantum Perceptron for e-commerce platforms in Indonesia, the Materials and Methods section will describe the research stages, data analysis techniques, and the application of Quantum Perceptron in transforming visitor prediction data. This section guides an understanding of how the study was conducted, from data collection to analysis and interpretation.

C. Qubit Transformation and Superposition

The number of website visitor data for e-commerce is transformed into binary form, which is 0 and 1. The transformation follows the rules outlined in Table 1.

TABLE I. DATA CRITERIA

No	Criteria	Information	Weight
1	Shopee	Shopee < 11200000	00
		Shopee >= 11200000 and Shopee <= 124100000	01
		Shopee >= 124100000 and Shopee <= 237000000	10
		Shopee > 237000000	11
2	Tokopedia	Tokopedia < 11200000	00
		Tokopedia >= 11200000 and Tokopedia <= 124100000	01
		Tokopedia >= 124100000 and Tokopedia <= 237000000	10
		Tokopedia > 237000000	11
3	Lazada	Lazada < 11200000	00
		Lazada >= 11200000 and Lazada <= 124100000	01
		Lazada >= 124100000 and Lazada <= 237000000	10
		Lazada > 237000000	11
4	Blibli	Blibli < 11200000	00

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i2.2334, Copyright ©2025
Submitted : April 22, 2025, Revised : May 12, 2025, Accepted : May 14, 2025, Published : May 26, 2025

		Blibli >= 11200000 and Blibli <= 124100000	01
		Blibli >= 124100000 and Blibli <= 237000000	10
		Blibli > 237000000	11
5	Bukalapak	Bukalapak < 11200000	00
		Bukalapak >= 11200000 and Bukalapak <= 124100000	01
		Bukalapak >= 124100000 and Bukalapak <= 237000000	10
		Bukalapak > 237000000	11

Table 2 shows data on the number of e-commerce website visitors in Indonesia from January 2023 to September 2023.

TABLE II. VISITOR DATA FOR E-COMMERCE WEBSITES IN INDONESIA

Shopee	Tokopedia	Lazada	Blibli	Bukalapak
171300000	128100000	91200000	28600000	20000000
143600000	108100000	74200000	23200000	17100000
159000000	114900000	84300000	24500000	17100000
165800000	109200000	82500000	33000000	15400000
161200000	106400000	70700000	24400000	17300000
173900000	106000000	70400000	23900000	14000000
199900000	102600000	63400000	28000000	13000000
213400000	99700000	45600000	28300000	12900000
237000000	88900000	47700000	28900000	11200000

The data on the number of e-commerce website visitors in Indonesia is transformed into binary format following the rules in Table 1. The results of this data transformation are shown in Table 3.

TABLE III. TRANSFORMED DATA RESULTS

Shopee	Tokopedia	Lazada	Blibli	Bukalapak
10	10	01	01	01
10	01	01	01	01
10	01	01	01	01
10	01	01	01	01
10	01	01	01	01
10	01	01	01	01
10	01	01	01	01
10	01	01	01	01
10	01	01	01	01

III. RESULT AND DISCUSSION

The Quantum Perceptron utilizes the unique properties of qubits, such as superposition and entanglement, to process information more efficiently and quickly than classical perceptron [7]. Initial research indicates that the Quantum Perceptron can address some limitations of conventional neural networks, such as high computational demands and issues with overfitting.

Visitors from various major e-commerce platforms in Indonesia are expected to provide results that are more relevant to and applicable to the Indonesian e-commerce industry.

The Quantum Perceptron combines quantum concepts with classical perceptron algorithms. This method uses quantum bits (qubits), which are properties of atoms in quantum mechanics, for quantum computation. Qubits can exist in multiple states simultaneously and have different probability values. The steps to implement the Quantum Perceptron can be seen below and in Equations 1, 2, 3, and 4:

1) Initialize all inputs, weights, targets, and biases. Calculate the net value using the formula:

$$|Z_i\rangle = \sum | W_{ij}\rangle . |Xi \quad (1)$$

2) Calculate the output using the formula:

$$|y_i\rangle = \sum | Z_i\rangle . |Vij\rangle \quad (2)$$

3) If $|y\rangle \neq |t\rangle$, then:

$$W_{new} = W_{old} + \alpha \cdot (|y\rangle - |t\rangle) \cdot \langle X_i| \quad (3)$$

4) If not

$$W_{new} = W_{old} \quad (4)$$

5) If $(y = t)$, then stop.

This quantum perceptron learning architecture uses a 9-1-2 configuration and the dataset of e-commerce website visitor numbers in Indonesia. Initially, weights w and v are given random values of {0,1} as follows:

$W_{1,1} = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ $W_{1,2} = \begin{bmatrix} 0 & 0 \\ 1 & 1 \end{bmatrix}$ $W_{2,1} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

$W_{2,2} = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}$ $W_{3,1} = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$ $W_{3,2} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$

$W_{4,1} = \begin{bmatrix} 0 & 1 \\ 1 & 1 \end{bmatrix}$ $W_{4,2} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ $W_{5,1} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$

$W_{5,2} = \begin{bmatrix} 0 & 1 \\ 0 & 1 \end{bmatrix}$ $W_{6,1} = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ $W_{6,2} = \begin{bmatrix} 0 & 0 \\ 1 & 1 \end{bmatrix}$

$W_{7,1} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ $W_{7,2} = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}$ $W_{8,1} = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$

$W_{8,2} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$ $V_{1,1} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ $V_{1,2} = \begin{bmatrix} 0 & 0 \\ 1 & 1 \end{bmatrix}$

$V_{2,1} = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}$ $V_{2,2} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$

The learning rate value tested is 0.1. The learning process starts with the first data from dataset number 1, `10100101` as the input and `01` as the expected output. Next, the output for the hidden units $Z1$ and $Z2$ is calculated.

1) Output Z1

$$= W1,1. |X1 > + W2,1. |X2 > + W3,1. |X3 > + W4,1. |X4 > + W5,1. |X5 > + W6,1. |X6 > + W7,1. |X7 > + W8,1. |X8 >$$

$$= \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} .|1> + \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} .|0> + \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix} .|1> + \begin{bmatrix} 0 & 1 \\ 1 & 1 \end{bmatrix} .|0> +$$

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i2.2334, Copyright ©2025
Submitted : April 22, 2025, Revised : May 12, 2025, Accepted : May 14, 2025, Published : May 26, 2025

$\begin{bmatrix}1 & 0\\0 & 0\end{bmatrix}.|0> + \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix}.|1> + \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}.|0> + \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix}.|1>$
$= \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix}.\begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}.\begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix}.\begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}0 & 1\\1 & 1\end{bmatrix}.\begin{bmatrix}1\\0\end{bmatrix}$
$+ \begin{bmatrix}1 & 0\\0 & 0\end{bmatrix}.\begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix}.\begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}.\begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix}.\begin{bmatrix}0\\1\end{bmatrix}$
$= \begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}0\\1\end{bmatrix}$
$= \begin{bmatrix}5\\3\end{bmatrix} = [5 \quad 3] = \|5 \quad 3\| = \sqrt{5^2 + 3^2} = \sqrt{5,831} = 1$

2) Output Z2
$= W1,2.|X1> + W2,2.|X2> + W3,2.|X3> + W4,2.|X4> + W5,2.|X5> + W6,2.|X6> + W7,2.|X7> + W8,2.|X8>$
$= \begin{bmatrix}0 & 0\\1 & 1\end{bmatrix}.|1> + \begin{bmatrix}0 & 0\\1 & 0\end{bmatrix}.|0> + \begin{bmatrix}1 & 0\\1 & 1\end{bmatrix}.|1> + \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}.|0> + \begin{bmatrix}0 & 1\\0 & 1\end{bmatrix}.|0> + \begin{bmatrix}0 & 0\\1 & 1\end{bmatrix}.|1> + \begin{bmatrix}0 & 0\\1 & 0\end{bmatrix}.|0> + \begin{bmatrix}1 & 0\\1 & 1\end{bmatrix}.|1>$
$= \begin{bmatrix}0 & 0\\1 & 1\end{bmatrix}.\begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}0 & 0\\1 & 0\end{bmatrix}.\begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}1 & 0\\1 & 1\end{bmatrix}.\begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}.\begin{bmatrix}1\\0\end{bmatrix} +$
$\begin{bmatrix}0 & 1\\0 & 1\end{bmatrix}.\begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}0 & 0\\1 & 1\end{bmatrix}.\begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}0 & 0\\1 & 0\end{bmatrix}.\begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}1 & 0\\1 & 1\end{bmatrix}.\begin{bmatrix}0\\1\end{bmatrix}$
$= \begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}1\\0\end{bmatrix} + \begin{bmatrix}0\\0\end{bmatrix} + \begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}0\\1\end{bmatrix}$
$= \begin{bmatrix}1\\6\end{bmatrix} = [1 \quad 6] = \|1 \quad 6\| = \sqrt{1^2 + 6^2} = \sqrt{6,08276} = 1$

3) Output Y1
$= V1,1.|Z1> + V2,1.|Z2>$
$= \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}.|1 + \begin{bmatrix}0 & 0\\1 & 0\end{bmatrix}.|1$
$= \begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}0\\0\end{bmatrix}$
$= \begin{bmatrix}0\\1\end{bmatrix} = [0 \quad 1] = \|0 \quad 1\| = \sqrt{0^2 + 1^2} = \sqrt{1} = 1$

4) Output Y2
$= V1,2.|Z1> + V2,2.|Z2>$
$= \begin{bmatrix}0 & 0\\1 & 1\end{bmatrix}.|1 + \begin{bmatrix}1 & 0\\0 & 0\end{bmatrix}.|1$
$= \begin{bmatrix}0\\1\end{bmatrix} + \begin{bmatrix}0\\0\end{bmatrix}$
$= \begin{bmatrix}0\\1\end{bmatrix} = [0 \quad 1] = \|0 \quad 1\| = \sqrt{0^2 + 1^2} = \sqrt{1} = 1$

Then, the temporary outputs $Y1$ and $Y2$ are compared with the expected outputs where $Y1 = 0$ and $Y2 = 0$. Since $1 \neq 0$ and $1 \neq 0$, the weights $Wi,j\ Vi,j$ from $|X1>$ to $|X8>$ are updated, and the error value is computed. First, weight updates are performed for $W1,1$ to $W8,1, V1,1, V2,1$, where $Y1 \neq T1$ as follows:

1) Weight $W1,1$ new = $W1,1$ old + $\alpha.(|Y1> - |T1>).< X1|$
$= \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix} + 0,1.(1 > -0 >).< 1| = \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix} + 0,1.\left(\begin{bmatrix}0\\1\end{bmatrix} - \begin{bmatrix}1\\0\end{bmatrix}\right).[0 \quad 1] = \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix} + 0,1.\begin{pmatrix}-1\\1\end{pmatrix}.[0 \quad 1] = \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix} + 0,1.\begin{pmatrix}0 & -1\\0 & -1\end{pmatrix}$
$= \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix} + \begin{bmatrix}0 & -0,1\\0 & 0,1\end{bmatrix} = \begin{bmatrix}0 & 0,9\\1 & 0,1\end{bmatrix}$

2) Weight $W2,1$ new = $W2,1$ old + $\alpha.(|Y1> - |T1>).< X2|$
$= \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} + 0,1.(1 > -0 >).< 0| = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} + 0,1.\left(\begin{bmatrix}0\\1\end{bmatrix} - \begin{bmatrix}1\\0\end{bmatrix}.\ [1 \quad 0]\right) = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} + 0,1.\begin{pmatrix}-1\\1\end{pmatrix}.[1 \quad 0] = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} + 0,1.\begin{pmatrix}-1 & 0\\1 & 0\end{pmatrix}$
$= \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} + \begin{bmatrix}-0,1 & 0\\0,1 & 0\end{bmatrix} = \begin{bmatrix}0,9 & 0\\0,1 & 1\end{bmatrix}$

3) Weight $W3,1$ new = $W3,1$ old + $\alpha.(|Y1> - |T1>).< X3|$
$= \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix} + 0,1.(1 > -0 >).< 1| = \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix} + 0,1.\left(\begin{bmatrix}0\\1\end{bmatrix} - \begin{bmatrix}1\\0\end{bmatrix}.\ [0 \quad 1]\right) = \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix} + 0,1.\begin{pmatrix}-1\\1\end{pmatrix}.[1 \quad 0] = \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix} + 0,1.\begin{pmatrix}0 & -1\\0 & -1\end{pmatrix}$
$= \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix} + \begin{bmatrix}0 & -0,1\\0 & 0,1\end{bmatrix} = \begin{bmatrix}0 & -0.1\\0 & 1,1\end{bmatrix}$

4) Weight $W4,1$ new = $W4,1$ old + $\alpha.(|Y1> - |T1>).< X4|$
$= \begin{bmatrix}0 & 1\\1 & 1\end{bmatrix} + 0,1.(1 > -0 >).< 0| = \begin{bmatrix}0 & 1\\1 & 1\end{bmatrix} + 0,1.\left(\begin{bmatrix}0\\1\end{bmatrix} - \begin{bmatrix}1\\0\end{bmatrix}.\ [1 \quad 0]\right) = \begin{bmatrix}0 & 1\\1 & 1\end{bmatrix} + 0,1.\begin{pmatrix}-1\\1\end{pmatrix}.[1 \quad 0] = \begin{bmatrix}0 & 1\\1 & 1\end{bmatrix} + 0,1.\begin{pmatrix}-1 & 0\\1 & 0\end{pmatrix}$
$= \begin{bmatrix}0 & 1\\1 & 1\end{bmatrix} + \begin{bmatrix}-0,1 & 0\\0,1 & 0\end{bmatrix} = \begin{bmatrix}-0,1 & 1\\1,1 & 1\end{bmatrix}$

5) Weight $W5,1$ new = $W5,1$ old + $\alpha.(|Y1> - |T1>).< X5|$
$= \begin{bmatrix}1 & 0\\0 & 0\end{bmatrix} + 0,1.(1 > -0 >).< 0| = \begin{bmatrix}1 & 0\\0 & 0\end{bmatrix} + 0,1.\left(\begin{bmatrix}0\\1\end{bmatrix} - \begin{bmatrix}1\\0\end{bmatrix}.\ [1 \quad 0]\right) = \begin{bmatrix}1 & 0\\0 & 0\end{bmatrix} + 0,1.\begin{pmatrix}-1\\1\end{pmatrix}.[1 \quad 0] = \begin{bmatrix}1 & 0\\0 & 0\end{bmatrix} + 0,1.\begin{pmatrix}-1 & 0\\1 & 0\end{pmatrix}$
$= \begin{bmatrix}1 & 0\\0 & 0\end{bmatrix} + \begin{bmatrix}-0,1 & 0\\0,1 & 0\end{bmatrix} = \begin{bmatrix}0,9 & 0\\0,1 & 0\end{bmatrix}$

6) Weight $W6,1$ new = $W6,1$ old + $\alpha.(|Y1> - |T1>).< X6|$
$= \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix} + 0,1.(1 > -0 >).< 1| = \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix} + 0,1.\left(\begin{bmatrix}0\\1\end{bmatrix} - \begin{bmatrix}1\\0\end{bmatrix}\right).[0 \quad 1] = \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix} + 0,1.\begin{pmatrix}-1\\1\end{pmatrix}.[0 \quad 1] = \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix} + 0,1.\begin{pmatrix}0 & -1\\0 & -1\end{pmatrix}$
$= \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix} + \begin{bmatrix}0 & -0,1\\0 & 0,1\end{bmatrix} = \begin{bmatrix}0 & 0,9\\1 & 0,1\end{bmatrix}$

7) Weight $W7,1$ new = $W7,1$ old + $\alpha.(|Y1> - |T1>).< X7|$
$= \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} + 0,1.(1 > -0 >).< 0| = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} +$

p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i2.2334, Copyright ©2025
Submitted : April 22, 2025, Revised : May 12, 2025, Accepted : May 14, 2025, Published : May 26, 2025

$$0{,}1.\left(\begin{bmatrix}0\\1\end{bmatrix} - \begin{bmatrix}1\\0\end{bmatrix}.\ \begin{bmatrix}1 & 0\end{bmatrix}\right) = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} + 0{,}1.\begin{pmatrix}-1\\1\end{pmatrix}.$$

$$\begin{bmatrix}1 & 0\end{bmatrix} = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} + 0{,}1.\begin{pmatrix}-1 & 0\\1 & 0\end{pmatrix}$$

$$= \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} + \begin{bmatrix}-0{,}1 & 0\\0{,}1 & 0\end{bmatrix} = \begin{bmatrix}0{,}9 & 0\\0{,}1 & 1\end{bmatrix}$$

8) Weight $W8{,}1$ new = $W8{,}1$ old + $\alpha.(|Y1> - |T1>).< X8|$

$$= \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix} + 0{,}1.(1> - 0>).< 1| = \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix} +$$

$$0{,}1.\left(\begin{bmatrix}0\\1\end{bmatrix} - \begin{bmatrix}1\\0\end{bmatrix}.\ \begin{bmatrix}0 & 1\end{bmatrix}\right) = \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix} + 0{,}1.\begin{pmatrix}-1\\1\end{pmatrix}.$$

$$\begin{bmatrix}1 & 0\end{bmatrix} = \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix} + 0{,}1.\begin{pmatrix}0 & -1\\0 & -1\end{pmatrix}$$

$$= \begin{bmatrix}0 & 0\\0 & 1\end{bmatrix} + \begin{bmatrix}0 & -0{,}1\\0 & 0{,}1\end{bmatrix} = \begin{bmatrix}0 & -0.1\\0 & 1{,}1\end{bmatrix}$$

After modifying the weights $W1{,}2$ to $W12{,}2$, $V1{,}1$to $V2{,}2$, the learning process continues with the second data point. This algorithm will update the weights until the expected output (T) matches the current output (Y) or the error value reaches zero. The weight optimization process will continue until the set goal is achieved. After carrying out the testing process, it was found that the prediction result had perfect accuracy, namely 100%.

```
Pengujian Quantum Perceptron
Epoch 1:
  Data 1: Inputs=[1, 1, 1, 0], Expected=0, Output=1, Correct=False
  Data 2: Inputs=[1, 1, 1, 0], Expected=0, Output=1, Correct=False
  Data 3: Inputs=[1, 1, 1, 0], Expected=0, Output=1, Correct=False
  Data 4: Inputs=[1, 1, 1, 0], Expected=0, Output=0, Correct=True
  Data 5: Inputs=[1, 1, 1, 0], Expected=0, Output=0, Correct=True
  Data 6: Inputs=[1, 1, 1, 0], Expected=0, Output=0, Correct=True
  Data 7: Inputs=[1, 1, 1, 0], Expected=0, Output=0, Correct=True
  Data 8: Inputs=[1, 1, 0, 0], Expected=0, Output=0, Correct=True
  Data 9: Inputs=[1, 1, 0, 0], Expected=0, Output=0, Correct=True
Epoch 2:
  Data 1: Inputs=[1, 1, 1, 0], Expected=0, Output=0, Correct=True
  Data 2: Inputs=[1, 1, 1, 0], Expected=0, Output=0, Correct=True
  Data 3: Inputs=[1, 1, 1, 0], Expected=0, Output=0, Correct=True
  Data 4: Inputs=[1, 1, 1, 0], Expected=0, Output=0, Correct=True
  Data 5: Inputs=[1, 1, 1, 0], Expected=0, Output=0, Correct=True
  Data 6: Inputs=[1, 1, 1, 0], Expected=0, Output=0, Correct=True
  Data 7: Inputs=[1, 1, 1, 0], Expected=0, Output=0, Correct=True
  Data 8: Inputs=[1, 1, 0, 0], Expected=0, Output=0, Correct=True
  Data 9: Inputs=[1, 1, 0, 0], Expected=0, Output=0, Correct=True

Akurasi: 100.00%
```

Fig. 2. Quantum Perceptron Result

Based on the results in Figure 2, it can be seen that the Quantum Perceptron has high accuracy, namely 100% with a number of epochs of 2 epochs.

```
Epoch: 1/10
Epoch: 2/10
Epoch: 3/10
Epoch: 4/10
Epoch: 5/10
Epoch: 6/10
Epoch: 7/10
Epoch: 8/10
Epoch: 9/10
Epoch: 10/10
Bentuk predictions: (9, 1)
Bentuk y: (9, 1)
Accuracy: 100.0
```

Fig. 3. Perceptron Result

Based on the results in Figure 3, it can be seen that the Perceptron has high accuracy, namely 100% with a number of epochs of 10 epochs.

TABLE III. COMPARISON RESULT

Model	Accuracy	Epoch
Perceptron	100%	10
Quantum Perceptron	100%	2

IV. CONCLUSION

The research results show that the Quantum Perceptron algorithm can predict the number of visitors to e-commerce websites in Indonesia. After carrying out the training stage on all the data tested, the result was that the quantum perceptron algorithm was able to make very good predictions, proven by perfect accuracy, namely 100% with a total of 2 epochs, while the classical perceptron had the same accuracy with a larger number of epochs, namely 10 epochs. Quantum perceptron has better performance and shorter time, this can be seen from the smaller number of epochs. In future research, it is hoped that other quantum computing-based algorithms can be explored to increase computing time more efficiently.

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p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i2.2334, Copyright ©2025
Submitted : April 22, 2025, Revised : May 12, 2025, Accepted : May 14, 2025, Published : May 26, 2025

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p-ISSN 2301-7988, e-ISSN 2581-0588
DOI : 10.32736/sisfokom.v14i2.2334, Copyright ©2025
Submitted : April 22, 2025, Revised : May 12, 2025, Accepted : May 14, 2025, Published : May 26, 2025