The Asian Journal of Technology Management Vol. 16 No. 3 (2023): 95-108

NFT Investments Analysis: A Strategic Approach with Ranking Insights and Sales Forecasting System for Informed Decision-Making

Vivi Aida Fitria[12*], Arif Nur Afandi[1], Aripriharta[1], Lilis Widayanti[12] and Danang Arbian Sulistyo[12]
[1]Teknik Elektro dan Informatika, Universitas Negeri Malang
[2]Teknik Informatika, Institut Teknologi dan Bisnis Asia Malang

Abstract. *The non-fungible token (NFT) is a unique token used to represent digital assets such as art, music, videos, and other collections. NFT has gained significant attention from the business and industry sectors in recent years. This study reports an increase in the number of active NFT users from 77,000 to 222,000 in early 2021. Investment in NFT has advantages and disadvantages, and one of the challenges faced by investors is that they may not have enough knowledge about investing risks and may find it difficult to recognize and evaluate potential dangers. To address this problem, this study proposes a system that provides information on NFT collection sales rankings and volume sales forecasts. The simple additive weighting (SAW) method is used to determine the NFT collection rankings, and exponential smoothing is used to forecast sales volume. The Particle Swarm Optimization (PSO) method is applied to optimize the parameter alpha of the Exponential Smoothing method. With an accuracy rate of 80.38%, the combination of using the Single Exponential Smoothing method with PSO optimization can provide good predictions for future NFT sales. The proposed system aims to provide investors with accurate information to make informed decisions when investing in NFT.*

Keywords: *Forecasting system, pso, ranking system, saw, single exponential smoothing*

1. Introduction

A non-fungible token (NFT) is a unique token used to represent digital assets such as art, music, video, and other collectibles (Wilson et al., 2022). In recent years, NFT has received extraordinary attention from business and industry players. According to a report from NonFungible.com, a platform that monitors the NFT market, as of 2020, there will be approximately 77,000 active NFT users worldwide. However, at the start of 2021, that number increased sharply to around 222,000 active users. According to (Q. Wang et al., 2021) it is reported that the average trading volume of NFTs can account for 1.3% of the entire cryptocurrency market in just a short time (5 months).

Investing in NFTs (non-fungible tokens) has advantages and disadvantages, just like investing in other assets. One of the problems faced by people who want to invest in NFTs is that investors who may not have enough knowledge about investing risk may find it difficult to recognize and evaluate potential dangers. As a result, judgments may be made that are not ideal or that are based on insufficient risk assessment. This can cause the investment to experience large losses. Therefore, investors need to carry out careful market research and analysis before investing in an NFT. One solution that can solve this problem is the availability of an information system about the sales ranking of NFT collections and sales volume forecasting.

*Corresponding author. Email: viviaida@asia.ac.id
Received: May 22th 2023; Revised: October 24th 2023; Accepted: December 29th 2023
Doi: http://dx.doi.org/10.12695/ajtm.2023.16.2.2
Print ISSN: 1978-6956; Online ISSN: 2089-791X.

The method used in determining the ranking of the NFT collection is the Simple Additive Weighting (SAW) method. The SAW method is one of the best decision support system methods. One of the advantages of this method is that it can produce a ranking taking into account the weight given to each criterion (Komang Yanti Suartini et al., 2023), (N. D. Fitria & Wibawa, 2021), (Zakaria et al., 2019). While the method used to forecast sales volume is the exponential smoothing method, the exponential smoothing method has become a powerful forecasting tool (Ferdinand et al., 2020). For example, in the research conducted by (Baykal et al., 2022) in predicting future climate boundary maps (2021–2060), one of the problems with the Exponential Smoothing method is determining the right alpha parameters to produce a high level of accuracy. Research on parameter optimization has been carried out by (V. A. Fitria, 2019a) using the Golden Section optimization method. In that study, it was found that the alpha parameter is more optimal but requires a lot of iterations. Therefore, this study uses the Particle Swarm Optimization (PSO) optimization method.

Based on previous research, it has been determined that the Single Exponential Smoothing approach for forecasting and the SAW method for ranking have proven to be efficient in creating data that can serve as a resource for stakeholders. Nevertheless, none of the studies have addressed the ranking and prediction of NFT sales values. Thus, the primary objective of this research is to rank NFT collections based on the weights that investors give to various criteria; the SAW approach is used to give greater weight to characteristics that investors consider more significant. The second objective of this research is to estimate the sales value of NFTs by using the Single Exponential Smoothing approach optimized with the PSO algorithm. It is intended that both objectives of this research will provide resources for potential NFT investors for NFT market research and analysis.

2. Literature Review

Table 1 describes earlier research on the backdrop of this study.

Table 1.
State-Of-The-Art

Article	Result
Non-Fungible Token: A Systematic Review and Research Agenda (Bao & Roubaud, 2022)	After reviewing thirteen papers, Bao and Rouband offered recommendations for potential future NFT study subjects. The development of technological literacy in the context of NFT threats is one of the recommended study areas.
The Implementation of the Simple Additive Weighting (SAW) Method in the Decision Support System for the Best School Selection in Jambi (Ibrahim & Surya, 2019)	The Simple Additive Weighting (SAW) approach is used in this study to provide data on the choice of the top schools in Jambi. The weighting and criterion-based computation results may be quickly and simply shown by the SAW-based decision support system. quickly and effectively. Because it is a straightforward computation, testing in various situations may be completed quickly and simply. Due to the ease of computation, it may be completed rapidly.

Table 1. (Continued)
State-Of-The-Art

Article	Result
Comparison Analysis of Simple Additive Weighting (SAW) and Weighted Product (WP) In Decision Support Systems (Wira Trise Putra & Agustian Punggara, 2018)	The Weighted Product (WP) method and the Simple Additive Weighting (SAW) method are the two ranking techniques that are compared in this study. Because the SAW approach is predicated on predefined values and weights, its findings are more comprehensible. preset weights and values
Non-fungible Token Price Prediction with Multivariate LSTM Neural Networks (Branny et al., 2022)	This study does not forecast sales from the NFT collection; rather, it focuses on the prediction of NFT selling prices using Multivariate LSTM Neural Networks.
Prediction of NFT Sale Price Fluctuations on OpenSea Using Machine Learning Approaches (Z. Wang et al., 2023)	This study uses a machine learning technique to create a prediction model for NFT pricing volatility. In this study, the NFT prediction model serves as a forewarning to lessen investor investment failure.
Comparison of Double Exponential and Single Exponential Smoothing Accuracy in Krakatau Steel Demand Forecasting Fitted Model (Maretania et al., 2021)	This study compares the most effective methods for estimating Krakatau Steel demand and addresses the forecasting debate that many organizations encounter while creating new, optimum strategy strategies. To forecast demand in 2019, the Double Exponential Smoothing and Single Exponential Smoothing methods were employed. MAPE, MAD, MSD, and MSE are metrics used to quantify accuracy. It was discovered that the single exponential smoothing approach outperformed the double exponential smoothing method in terms of accuracy.

A systematic review of the non-fungible token has been carried out by (Bao & Roubaud, 2022). Bao and Roubaud have reviewed 13 articles and provided suggestions for future NFT research topics. One of the suggested research topics is to develop technology literacy in the field of NFT risks. Providing knowledge about NFT sales forecasting and NFT collection ranking is one of the technical literacies that may be achieved. Therefore, the technology developed in this research is a forecasting and ranking system needed by investors. By having a better information system about selling NFTs, investors can reduce their investment risk and choose safer NFTs to buy (Bhujel & Rahulamathavan, 2022). The importance of the NFT forecasting system for investors is to determine the value of the NFT because investors can determine the potential value of an NFT and decide whether it is a good investment or not (Almajed et al., 2023). In addition, NFT sales forecasting can also help investors identify market trends and make better investment decisions. Meanwhile, the importance of the NFT ranking system is that it provides information about the value and demand of certain NFT collections and helps collectors and investors decide where they should allocate their resources.

In this study, the ranking system was taken from a website that provides information and analytical data about the NFT market. The website also provides information on ranking the top NFT collectibles, such as digital art and other collectibles. However, the ranking system generated on the Cryptoslam web is based on only one criterion. The ranking methodology mentioned in this work takes into account five weighted factors, namely the SAW method. One way to resolve multi-attribute choice issues is the Simple Additive Weighting (SAW) method. It is predicated on the idea of a weighted summation, in which the system searches for a weighted total of each alternative's performance across all attributes. The option with the highest score is then suggested as the best one. To use SAW, the decision matrix must be normalized to a scale that can be compared to all of the ratings of the available options. (Taherdoost, 2023).

The advantages of the SAW method are simple and easy to apply; the ability to handle predetermined criteria and preference weights makes it useful for multi-attribute decision problems to produce more effective decisions; and it can be applied in various fields (Kraujalienė, 2019); (Wira Trise Putra & Agustian Punggara, 2018). One of the studies on the implementation of the SAW method was conducted by Ibrahim (Ibrahim & Surya, 2019), which proved to be able to produce the best decision with easy calculation. However, there is no single piece of research that discusses the implementation of the SAW method in determining the best NFT.

In addition to the ranking system, this study also discusses the NFT sales forecasting system using the single exponential smoothing method. Research on NFT forecasting has been carried out by (Branny et al., 2022) using the Multivariate LSTM Neural Networks method, (Z. Wang et al., 2023) using machine learning approaches, and there has not been a single NFT forecasting study using the exponential smoothing method. Single Exponential Smoothing (SES) is a widely used method for smoothing univariate time series data and is considered a simple yet powerful forecasting technique (Majid, 2018). The Single Exponential Smoothing (SES) approach has been established as the most accurate and best exponential smoothing method among the methods examined based on the results of a study conducted by (Maretania et al., 2021). The accuracy of the forecasting system using the SES approach was measured using real-life data from 2019, and the findings revealed that it performed better than other methods, such as double exponential smoothing. Always keep in mind that the optimal approach will vary depending on the particular issue at hand and the ideal ratio of precision to simplicity. In several articles, researchers have compared and examined various exponential smoothing techniques, including Holt's Double Exponential Smoothing (DES) and Triple Exponential Smoothing (TES). The approaches' efficacy varies based on the data's parameters and the problem that has to be solved (Siregar et al., 2017); (Pamungkas et al., 2021).

The Simple Exponential Smoothing (SES) method requires the selection of a smoothing factor parameter (α). The selection of this parameter is critical to the accuracy of the forecasting results. The selection of the smoothing factor determines the weight given to the past data, while the initial level determines the starting point for forecasting. One way to select parameters in SES is to use subjective judgment, where the forecaster determines the parameter values based on their experience and knowledge of the data. Another way is to try various parameter values by trial and error. However, both of these approaches may be unreliable and may produce suboptimal results. Therefore, another method is needed to determine the parameter values that produce the best forecasts, one of which uses the particle swarm optimization algorithm. A PSO-based optimization technique for exponential smoothing parameters that is specific to predicting power consumption was presented in research (Deng et al., 2021). According to the study, the PSO algorithm can be a useful tool for choosing parameters in the exponential smoothing approach. The population-based optimization technique known as PSO is capable of finding optimal solutions quickly. The accuracy of predicting results can be increased by choosing parameters for the exponential smoothing approach using the PSO algorithm (Mao et al., 2022).

The researcher tries to discuss the ranking of NFT collections from the Cryptoslam web using the SAW method. This approach can generate a ranking for NFT collections by considering criteria from investor analysis and assigning weights to each criterion. Research on NFT ranking has never been done before. In addition to NFT ranking, this research discusses NFT sales forecasting using the Single Exponential Smoothing approach optimized using the Particle Swarm Optimization algorithm as additional information for potential NFT investors. As shown by previous researchers in Table 1, the Single Exponential Smoothing (SES) method is a simpler forecasting technique with good accuracy. The PSO algorithm is very helpful in this study in finding the best parameter values for the SES technique to increase the accuracy value.

3. Methodology

The study technique in this work is divided into two stages: the first is a ranking system that employs the SAW method, and the second is a forecasting system that employs the single exponential smoothing method and is improved using particle swarm optimization. Figure 1 depicts the research procedure.

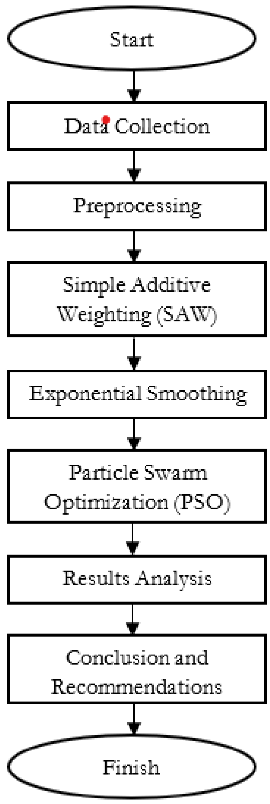

Figure 1.
Study Flowchart

The Non-Fungible Token (NFT) data collection method, which includes sales data, transaction data, buyer data, the seller and owner data, is the first step in the research process. The collected data is then carefully cleaned and processed to ensure accuracy and consistency in the subsequent analysis. Next, the NFT collections are ranked according to predefined criteria using the Simple Additive Weighting (SAW) approach. The sales volume of NFTs is then predicted using an exponential smoothing approach, which considers previous trends and patterns. The alpha parameter of the exponential smoothing technique is optimized using a particle swarm optimization (PSO) approach to improve forecasting accuracy.

3.1 Data

The ranking mechanism used in this study was sourced from www.cryptoslam.io, a website that offers information and analytical data regarding the NFT industry. The main focus of the Cryptoslam web is data and analysis about NFT sales and transactions on various platforms such as OpenSea, Rarible, and SuperRare (Cryptoslam, n.d.). In this study, alternative data in the form of NFT collection data from the cryptoslam.io portal was used; a total of 250 partial NFT collections are shown in Table 2 below.

Table 2.
NFT Collections

NFT Collection	Alternatives
Azuki	A1
Nakamigos	A2
Bored-ape-yacht-club	A3
Lucky-bird	A4
Mutant-ape-yacht-club	A5
⋮	⋮
Ethlizards-1	A249
Space-id	A250

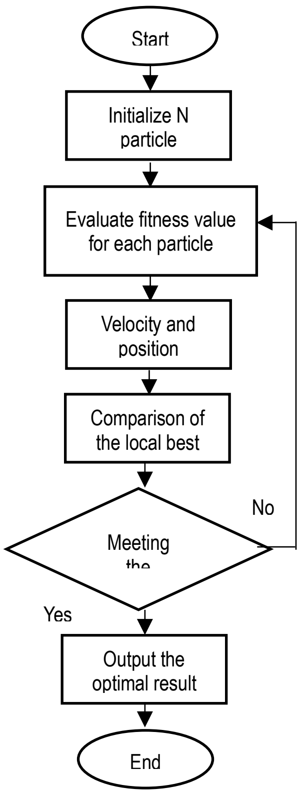

Figure 2.
Flowchart of the PSO algorithm

The Sorare Collection, the best NFT collection produced by the ranking algorithm, is the NFT collection to which the forecasting data utilized in this study is applied. Sales data (USD) for the period from January 2022 to April 2023, totaling 454 records, is the time series data used in this study.

3.2. Ranking System

The stages of implementing the SAW method on NFT sales data are: 1. Determine the NFT ranking criteria. The criteria used in this study are sales volume, number of transactions, buyers, sellers, and owners. 2. Give weight to each criterion; in this study, the weight given to each criterion is 0.2. 3. Determine matrix normalization with formulas $R_{ij} = \frac{x_{ij}}{Max\ x_{ij}}$, if *j* is the benefit attribute and $R_{ij} = \frac{Min\ x_{ij}}{x_{ij}}$, if *j* is the cost attribute. 4. Calculate the preference value for each alternative with the formula $V_i = \sum_{j=i}^{n} W_j r_{ij}$, with *W* as the predetermined weight and *r* as the normalized matrix. 5. Rank the NFT collection (Nurmalini & Rahim, 2017); (Anggraini & Sihotang, 2019); (Sihombing et al., 2021)

3.3. Forecasting System

The next stage in this research is implementing a forecasting system using the single exponential smoothing method, which is optimized with the particle swarm optimization algorithm (Swari et al., 2022).

The data used in this study is sales data from the NFT Collection, which is in first place according to the results of the previous ranking system. The stages are: 1. Forecast NFT sales data using a formula $F_{t+1} = \alpha X_t + (1-\alpha)F_t$, where $F_{t+1}$is the forecasting result, X_t is the NFT sales time series data and α is the parameter between 0 to 1 (V. A. Fitria, 2019b). 2. Utilize the PSO algorithm to determine the ideal parameter value. Figure 1 depicts the PSO algorithm's steps (Vijayakumar & Vinothkanna, 2020); (Gad, 2022),(Wibawa et al., 2022).

The advantage of using the single exponential smoothing method in this study is that the selection of the alpha parameter does not need to be done by trial and error. Parameter tuning in the study used the PSO algorithm. Researchers also analyzed forecasting computations utilizing double exponential smoothing and triple exponential smoothing before deciding on the single exponential smoothing approach for forecasting NFT data. Based on these computations, the single exponential smoothing approach yields the best-predicting results. The error resulting from the Double Exponential Smoothing approach is 29%, whereas the error resulting from the Triple Exponential Smoothing method is 26%. To obtain the best prediction results, the research employed the single exponential smoothing approach. This fits both the seasonal data patterns and the NFT data pattern, which is univariate data without any trend. Single exponential smoothing, or SES, is a useful technique for univariate time series data that does not exhibit seasonal patterns or trends. This approach is usually applied when the data exhibits a steadily changing average but no discernible trend or seasonal pattern (Pamungkas et al., 2021).

4. Findings and Discussion

The information system worked on in this study focuses on NFT collection ranking information using the SAW method and NFT sales forecasting information using the exponential smoothing method, which is optimized with PSO.

4.1 Ranking Information

To determine the ranking of the NFT collection in the study, criteria were given that affected the ranking. The criteria used in this study are shown in Table 3 below.

Table 3.
Criteria Name

No	Criteria	Criteria Name	Type
1	Sales	C1	Benefit
2	Transaction	C2	Benefit
3	Buyers	C3	Benefit
4	Sellers	C4	Benefit
5	Owners	C5	Benefit

NFT collection data on the cryptoslam.io web is used as alternative data in this study, namely a total of 250 NFT collections, shown in Table 4 below.

Table 4.
NFT Collection Data

Alternatives	C1	C2	C3	C4	C5
A1	1252971	27	50	60	4755
A2	1235927	700	434	457	5920
A3	1135180	10	13	13	6346
A4	896263	18	9	9	95
A5	802051	36	53	58	12439
⋮	⋮	⋮	⋮	⋮	⋮
A249	5970	4	4	4	1620
A250	5898	350	131	89	389791

Then determine the normalization matrix using the formula in step 3, resulting in.

$$R = \begin{pmatrix} 1 & 0.0026 & 0.0115 & 0.015 & 0.00236 \\ 0.986 & 0.0585 & 0.10018 & 0.1145 & 0.00293 \\ 0.906 & 0.0008 & 0.003 & 0.0033 & 0.00314 \\ 0.715 & 0.0015 & 0.002 & 0.002 & 0 \\ 0.64 & 0.003 & 0.012 & 0.0145 & 0.006 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 0.005 & 0.0003 & 0.0009 & 0.001 & 0.0008 \\ 0.005 & 0.029 & 0.03 & 0.022 & 0.193 \end{pmatrix}$$

The next stage is calculating the preference value of each alternative with the formula in step 4. The largest preference value is the best alternative or the highest rank. The weight of each criterion in this study was 0.2, so the best NFT collection was A10, namely the Sorare collection. The top 10 rankings of the NFT collection resulting from the SAW method with 5 criteria are shown in Table 5.

Table 5.
NFT Collection Rangking

Ranking	NFT Collection
1	Sorare
2	Axie Infinity
3	Nakamigos

Table 5. (Continued)
NFT Collection Rangking

Ranking	NFT Collection
4	Planetix
5	NBA top shot
6	Azuki
7	Bored Ape Yacht Club
8	Gemesis
9	Lucky bird
10	Mutant Ape Yacht Club

In the dynamic landscape of digital collectibles, similar to the volatility that occurs in financial markets, Non-Fungible tokens (NFT) collectible ratings are subject to daily fluctuations. This study introduces an innovative methodology, the Simple Additive Weighting (SAW) method, designed to dynamically adjust these rankings based on investor-defined criteria. In essence, this method allows investors to customize the level of importance given to various factors in the NFT market. Similar to deciding which car to buy, some potential buyers emphasize fuel efficiency, while others prioritize safety features. The SAW method is similar to the process of customizing decision-making to align with what is most important to potential investors. For example, if transaction frequency is considered to be the most important factor, investors can give it a higher 'weight' in the SAW system, thereby giving NFTs a change in ranking. This approach empowers investors to make more informed decisions by aligning the rankings with their specific priorities, similar to tailoring decisions to individual preferences.

4.2 Forecasting Information

The forecasting system in this study is implemented in one of the NFT collections, namely the best NFT collection resulting from the ranking system in the previous discussion, the Sorare Collection. The method used in this forecasting system is single exponential smoothing because the pattern of NFT sales data is horizontal. Horizontal patterns are data patterns that fluctuate around the average value. This is shown in the sales data graph in Figure 3 below.

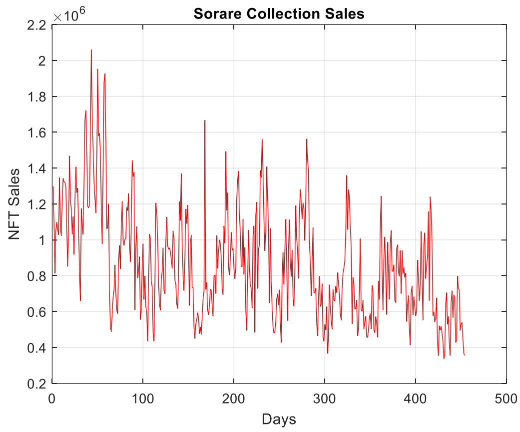

Figure 3.
Sorare Collection sales data graph

Measure the accuracy of the Single Exponential Smoothing method by calculating the value of the Mean Absolute Percentage Error (MAPE) and Root Mean Squared Error (RMSE). Therefore, evaluate the fitness of the PSO algorithm by calculating the MAPE and RMSE values. From the calculation results, the smallest MAPE was found at alpha 0.9605, which was 19.62%, and the smallest RMSE was 211028.38. In other words, the accuracy rate of this method is 80.38%. According to the Lewis scale (Javed & Cudjoe, 2022), an accuracy rate above 80% is included in the good forecasting criteria. It is proven that the implementation of the PSO algorithm in tuning the alpha parameter can reduce forecasting errors when compared to parameter tuning, which is done by trial and error by trying one of the alpha values between 0.1 and 0.9. The smallest MAPE with trial error is located at alpha 0.9, which is 19.66%, and the smallest RMSE is 211099.76. The following MAPE and RMSE values for each alpha are shown in Table 6. From Table 6, it can be seen that the greater the alpha value, the smaller the error value. This happens because the NFT sales data for the Sorare Collection is very volatile.

Table 6.
MAPE and RMSE Value Of Each Alpha.

Alpha	**MAPE (%)**	**RMSE**
0.1	25%	242670.65
0.2	22.4%	225735.29
0.3	21%	217548.48
0.4	20.3%	213670.48
0.5	20%	211835.57
0.6	19.97%	211099.76
0.7	19.85%	211139.82
0.8	19.73%	211912.27
0.9	19.66%	213490.99
0.9605 (PSO Alpha)	19.62%	211028.38

This proves that the exponential smoothing method combined with the PSO algorithm is a forecasting method that, although simple to generate future NFT sales values, can provide high accuracy even though the data is very volatile. The following is a graphical image of the comparison between actual data and forecasting results using the single exponential smoothing method optimized using the PSO algorithm. The following is a graphical image of a comparison between actual data and forecasted data using the single exponential smoothing method, which is optimized using the PSO algorithm:

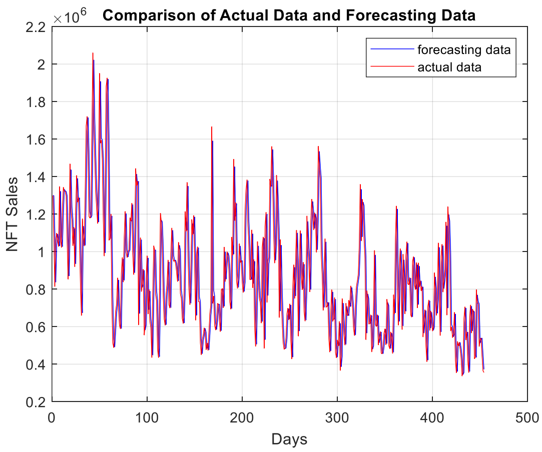

Figure 4.
Comparison Chart Between Actual Data And Forecast Data

The analysis of the comparison graph between the actual data and the forecasting results of NFT sales shows a significant degree of conformity. In Figure 4, the forecasting result curve almost intersects or overlaps closely with the actual NFT sales data curve, reflecting the good precision of the forecasting model used. The close intersection between the two curves indicates that the forecasting model can capture the patterns and dynamics of NFT sales with good accuracy. Although there are 3 points whose values are far from the predicted results, for most of the points, the predicted values are almost identical to the actual sales values, illustrating a good fit between the model and the reality of the NFT market. This is supported by the resulting accuracy value of NFT sales forecasting of 80.38%. This opens up opportunities for potential NFT investors to use these forecasting results as a strategic foundation for making decisions and designing future steps in the NFT market.

5. Conclusions

The SAW method proposed in this research is proven to produce ranking results by considering five existing criteria, namely sales, transactions, buyers, sellers, and owners. In contrast to the information provided on the cryptoslam.io page, which is based on ranking only one sales criterion, By combining five criteria with dynamic value weighting based on investors, this method succeeds in providing information to investors on recognizing and evaluating dangerous potential before investing in NFTs, e.g., by not investing in low-ranked NFT collections. This study found that the Sorare collection was the best NFT collection. However, the sales data on the Sorare collection has increased and decreased significantly, so potential investors need to analyze further before investing in the Sorare collection. Further investment can be made by looking at the results of forecasting NFT sales in the Sorare collection in the future. In this research, NFT sales forecasting in the Sorare collection uses a combination of the Single Exponential Smoothing method with the PSO algorithm. The use of the PSO algorithm for parameter tuning in the single exponential smoothing method can improve accuracy in forecasting NFT sales in a more efficient way, namely without trial-error parameter selection. The error generated in forecasting NFT sales using the Single Exponential Smoothing method with the PSO algorithm is 19.62%. This shows that the combination of using single exponential smoothing with PSO optimization can provide fairly accurate predictions for future NFT sales data.

By knowing the ranking information for NFT collectibles, investors can more easily choose assets or collectibles that have a higher potential increase in value. Rankings can provide insight into the popularity and demand for an NFT, helping investors choose more promising investments. The SAW method is a simple and easy-to-apply method and has been proven to produce appropriate NFT rankings. Meanwhile, knowing information about the predicted sales value of NFTs helps investors plan and manage their investment risk. By having an estimated sales value, investors can understand potential gains and losses and make more informed investment decisions. The Single Exponential Smoothing method combined with the PSO algorithm is proven to be able to produce predictions of NFT sales values with fairly good accuracy.

However, the limitations of this research are the absence of statistical analysis regarding the correlation between criteria used in the SAW method and the absence of statistical analysis of outlier data used in determining the results of future NFT sales forecasting. The absence of statistical analysis regarding the correlation between criteria makes it uncertain whether the criteria used in this study are appropriate or not according to the needs of investors. Meanwhile, the absence of statistical analysis of outlier data causes the accuracy of forecasting results to decrease. Therefore, this problem can be used as a topic for further research.

References

Almajed, R., Abualkishik, A. Z., Ibrahim, A., & Mourad, N. (2023). Forecasting NFT Prices on Web3 Blockchain Using Machine Learning to Provide Forecasting NFT Prices on Web3 Blockchain Using Machine Learning to Provide SAAS NFT Collectors. *Fusion: Practice and Applications (FPA)*, *10*(2), 55–68. https://doi.org/10.54216/FPA.100205

Anggraini, D., & Sihotang, H. T. (2019). Decision Support System For Choosing The Best Class Guardian With Simple Additive Weighting Method. *Jurnal Mantik*, *3*(3), 1–9. http://iocscience.org/ejournal/index.php/mantik/article/view/882/595

Bao, H., & Roubaud, D. (2022). Non-Fungible Token: A Systematic Review and Research Agenda. *Journal of Risk and Financial Management, 15*(5), 215. doi: 10.3390/JRFM15050215

Baykal, T. M., Colak, H. E., & Kılınc, C. (2022). Forecasting future climate boundary maps (2021–2060) using exponential smoothing method and GIS. *Science of The Total Environment*, *848*, 157633. doi: 10.1016/J.SCITOTENV.2022.157633

Bhujel, S., & Rahulamathavan, Y. (2022). A Survey: Security, Transparency, and Scalability Issues of NFT’s and Its Marketplaces. *Sensors, 22(8833)*, doi: 10.3390/S22228833

Branny, J., Dornberger, R., & Hanne, T. (2022). Non-fungible Token Price Prediction with Multivariate LSTM Neural Networks. *2022 9th International Conference on Soft Computing and Machine Intelligence, ISCMI 2022*, 56–61. doi: 10.1109/ISCMI56532.2022.10068442

Deng, C., Zhang, X., Huang, Y., & Bao, Y. (2021). Equipping Seasonal Exponential Smoothing Models with Particle Swarm Optimization Algorithm for Electricity Consumption Forecasting. *Energies 2021, 14*(13), 4036. doi: 10.3390/EN14134036

Ferdinand, M. A. B., Wibawa, A. P., Zaeni, I. A. E., & Rosyid, H. A. (2020). Single Exponential Smoothing-Multilayer Perceptron Untuk Peramalan Pengunjung Unik Jurnal Elektronik. *Mobile and Forensics*, *2*(2), 62–70. doi: 10.12928/mf.v2i2.2034

Fitria, N. D., & Wibawa, A. P. (2021). Sistem Pembobotan Berdasarkan Teknik Analisis Korelasi Untuk Penerimaan Siswa Baru Menggunakan Metode SAW. *JURNAL MEDIA INFORMATIKA BUDIDARMA*, *5*(3), 1116. doi: 10.30865/mib.v5i3.3080

Fitria, V. A. (2019a). Parameter Optimization of Single Exponential Smoothing Using Golden Section Method for Groceries Forecasting. *ZERO: Jurnal Sains, Matematika Dan Terapan*, *2*(2), 89. doi: 10.30829/zero.v2i2.3438

Fitria, V. A. (2019b). Peramalan Harga Sembako di Kota Malang Menggunakan Metode Single Exponential Smoothing. *Jurnal Sains Matematika Dan Statistika*, *5*(1). http://siskaperbapo.com/harga/tabel

Gad, A. G. (2022). Particle Swarm Optimization Algorithm and Its Applications: A Systematic Review. *Archives of Computational Methods in Engineering 2022 29:5*, *29*(5), 2531–2561. doi: 10.1007/S11831-021-09694-4

Ibrahim, A., & Surya, R. A. (2019). The Implementation of Simple Additive Weighting (SAW) Method in Decision Support System for the Best School Selection in Jambi. *Journal of Physics: Conference Series*, *1338*(1), 012054. doi: 10.1088/1742-6596/1338/1/012054

Javed, S. A., & Cudjoe, D. (2022). A novel grey forecasting of greenhouse gas emissions from four industries of China and India. *Sustainable Production and Consumption*, *29*, 777–790. doi: 10.1016/j.spc.2021.11.017

Komang Yanti Suartini, N., Gede Hendra Divayana, D., & Joni Erawati Dewi, L. (2023). Comparison Analysis of AHP-SAW, AHP-WP, AHP-TOPSIS Methods in Private Tutor Selection. *I.J. Modern Education and Computer Science*, *1*, 28–45. doi: 10.5815/ijmecs.2023.01.03

Kraujalienė, L. (2019). Comparative Analysis

Of Multicriteria Decision-Making Methods Evaluating The Efficiency Of Technology Transfer. *Business, Management and Education*, *17*, 72–93. doi: 10.3846/bme.2019.11014

Majid, R. (2018). Advances in Statistical Forecasting Methods: An Overview. *Economic Affairs*, *63*(4). doi: 10.30954/0424-2513.4.2018.5

Mao, Y., Pranolo, A., Wibawa, A. P., Putra Utama, A. B., Dwiyanto, F. A., & Saifullah, S. (2022). Selection of Precise Long Short Term Memory (LSTM) Hyperparameters based on Particle Swarm Optimization. *2022 International Conference on Applied Artificial Intelligence and Computing (ICAAIC)*, 1114–1121. doi:10.1109/ICAAIC53929.2022.9792708

Maretania, I., Alfadjri, M. R., Paramesywarie, P. U., & Nurcahyo, R. (2021). Comparison of Double Exponential and Single Exponential Smoothing Accuracy in Krakatau Steel Demand Forecasting Fitted Model. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 356–364.

Nurmalini, & Rahim, R. (2017). Study Approach of Simple Additive Weighting For Decision Support System. *International Journal of Scientific Research in Science and Technology*, *3*(3), 541–544. https://doi.org/10.32628/IJSRST1733198

Pamungkas, A., Puspasari, R., Nurfiarini, A., Zulkarnain, R., & Waryanto, W. (2021). Comparison of Exponential Smoothing Methods for Forecasting Marine Fish Production in Pekalongan Waters, Central Java. *IOP Conference Series: Earth and Environmental Science*, *934*(1), 012016. doi: 10.1088/1755-1315/934/1/012016

Sihombing, V., Siregar, V. M. M., Tampubolon, W. S., Jannah, M., Risdalina, & Hakim, A. (2021). Implementation of simple additive weighting algorithm in decision support system. *IOP Conference Series: Materials Science and Engineering*, *1088*(1), 012014. doi: 10.1088/1757-899X/1088/1/012014

Siregar, B., Butar-Butar, I. A., Rahmat, R., Andayani, U., & Fahmi, F. (2017). Comparison of Exponential Smoothing Methods in Forecasting Palm Oil Real Production. *Journal of Physics: Conference Series*, *801*, 012004. doi: 10.1088/1742-6596/801/1/012004

Swari, M. H. P., Handika, I. P. S., Satwika, I. K. S., & Wahani, H. E. (2022). Optimization of Single Exponential Smoothing using Particle Swarm Optimization and Modified Particle Swarm Optimization in Sales Forecast. *Proceeding - IEEE 8th Information Technology International Seminar, ITIS 2022*, 292–296. doi: 10.1109/ITIS57155.2022.10010034

Taherdoost, H. (2023). Analysis of Simple Additive Weighting Method (SAW) as a MultiAttribute Decision-Making Technique: A Step-by-Step Guide. *Journal of Management Science & Engineering Research*, *6*(1). doi: 10.30564/jmser.v6i1.5400

Vijayakumar, T., & Vinothkanna, M. R. (2020). Efficient Energy Load Distribution Model using Modified Particle Swarm Optimization Algorithm. *Journal of Artificial Intelligence and Capsule Networks*. doi: 10.36548/jaicn.2020.4.005

Wang, Q., Li, R., Wang, Q., & Chen, S. (2021). *Non-Fungible Token (NFT): Overview, Evaluation, Opportunities and Challenges*. doi: 10.48550/arxiv.2105.07447

Wang, Z., Chen, Q., & Lee, S.-J. (2023). Prediction of NFT Sale Price Fluctuations on OpenSea Using Machine Learning Approaches. *Computers, Materials & Continua*, *75*(2), 2443–2459. doi: 10.32604/cmc.2023.037553

Wibawa, A. P., Mahmudy, W. F., Rizki, A. M., Yuliastuti, G. E., Tama, I., & Pambudi. (2022). Multi-Site Aggregate Production Planning Using Particle Swarm Optimization. *Journal of Engineering, Project, and Production Management*. https://doi.org/10.32738/JEPPM-2022-0006

Wilson, K. B., Karg, A., & Ghaderi, H. (2022). Prospecting non-fungible tokens in the digital economy: Stakeholders and ecosystem, risk and opportunity. *Business Horizons*, *65*(5), 657–670. doi: 10.1016/J.BUSHOR.2021.10.007

Wira Trise Putra, D., & Agustian Punggara, A. (2018). Comparison Analysis of Simple Additive Weighting (SAW) and Weigthed Product (WP) In Decision Support Systems. *MATEC Web of Conferences*, *215*, 01003. doi: 10.1051/matecconf/201821501003

Zakaria, Elmunsyah, H., & Fahmi, A. (2019). Implementasi algoritma simple additive weighting untuk menentukan reviewer PKM pada portal PKM di Universitas Negeri Malang. *TEKNO*, *28*(2), 149. doi: 10.17977/um034v28i2p149-165