



Virtual Currency and Smart Financial Management in Immersive Online Games in the Metaverse Environment

Jie Li¹  and Wenji Wang^{2*} 

¹School of Culture and Management, NanJing Communication University, NanJing, JiangSu, 210000, China, Jieli_ncu@163.com

²School of Management, Nanjing University of Posts and Telecommunications, JiangSu, 210000, China, 19961863187@163.com

Corresponding author: Wenji Wang, 19961863187@163.com

Abstract. In the future meta-cosmic era, all technology companies may be game companies, and the connotation of the game industry will be further extended, and the industrial scale will surely enter the highest stage in history. This article attempts to apply the financial management model combining back propagation neural network (BPNN) and collaborative filtering (CF) algorithm to the virtual currency and intelligent financial management in the online game of Metaverse. Because of the phenomenon of local extremum and random selection of parameters in the financial management pre-alarm model of neural network, the prediction results are quite random. The genetic algorithm (GA) with ergodic characteristics is introduced into the standard BPNN, which gives each particle ergodic characteristics, controls the aggregation degree of particles, avoids the occurrence of local extremum, obtains the global optimal value and ensures the pre-alarm results of the model. The financial management model is more accurate in predicting the financial situation of virtual currency in the online game of Metaverse. Compared with the traditional decision tree algorithm, the recall has increased by more than 15% and the accuracy rate has increased by more than 20%. The proposed financial analysis algorithm of Metaverse virtual currency can provide some theoretical and technical support for the intelligent financial management of virtual currency in the future immersive online games.

Key words: Metaverse; Online games; Virtual currency; Financial management

DOI: <https://doi.org/10.14733/cadaps.2024.S5.211-222>

1 INTRODUCTION

The trend of digitalization, internet and intelligence has become a subversive force in today's society, which has promoted the major changes in enterprise management and the intelligent growth of financial management. Data and algorithm are the basis of intelligent financial data analysis. Virtual

currency has gradually become a new micro-payment tool because of its convenience, which has greatly promoted the growth of e-business and virtual network economy, and the growth of Metaverse technology has further promoted the extension of virtual currency functions [4]. With the continuous growth of computer technology and internet technology, the network has become an indispensable part of daily life. The rapid growth of Internet economy has changed people's lifestyle, and also changed the business environment for enterprises to survive and develop [21]. Due to the growth of the Internet and the popularity of online games, there are more and more transactions of virtual goods. Driven by Internet value-added services, e-business and online games, online money has also entered an unprecedented stage of development [6]. Virtual currency has gradually become a powerful means to cultivate, develop and maintain loyal online customers in the era of internet economy, and is gradually being widely used in the field of online marketing [7]. The work and life in the Metaverse era can not be separated from virtual game scenes. Games will no longer aim at pure entertainment, but become an indispensable tool in life scenes [13].

"Virtual currency" was born in such an information age, with the rapid growth of its distribution types and circulation, its own characteristics such as partial currency attributes, external economy of the network, anonymity, almost zero marginal cost of distribution and universality of circulation [9]. Due to the growth of innovative science and technology, people's requirements for entertainment activities and information acquisition are gradually increasing. In the global information age, games not only have a single entertainment function, but also are the carrier of new social relations [1]. The emergence of virtual currency has successfully solved the problem of micro-payment between online users and Internet application service providers, and between online users and online users, and the problem of offline transactions between virtual currencies has aroused the concern of relevant regulatory agencies [12]. In the daily analysis process, the financial department often faces the problems of conflict or inconsistency of financial data sources, lack of clear data standards, manual processing of analysis process, imperfect data analysis foundation and so on [19]. With the diverse changes of people's needs, how to combine the financial management of virtual currency with game culture and continuously enrich the interactive experience of games is the frontier topic of game design in the Metaverse. This article attempts to apply the financial management model based on the improved CF algorithm to the virtual currency and intelligent financial management in the online game of Metaverse, so as to continuously improve the insight, planning ability and prediction accuracy of the financial management system and empower the financial management of Metaverse virtual currency.

At present, the Internet in China is in a new period of rapid growth. Due to the growth of the Internet in China, there are a large number of network service providers. While providing free services, these network service providers have continuously introduced various paid virtual network products and services [5]. With the wide application of virtual currency in the network economy and the substitution of virtual currency in virtual community transactions, the tentacles of virtual currency began to extend to the real economy, breaking through the trading space of virtual communities and having an impact on the real economy [23]. Driven by big data, more and more enterprises realize that relying on the characteristics of big data, such as large amount of data, variety of types and high speed of operation, they can innovate traditional financial management, improve the accuracy, objectivity and value of financial data, reduce financial risks and improve the profitability of virtual currency in the Metaverse [20]. Due to the widespread use and wide recognition of virtual goods and network virtual services, virtual currency began to appear in various application fields, and the payment field of virtual currency is also expanding [24]. In this article, the characteristics of interactive design of metacosmic games are analyzed in combination with people's current perceptual needs, and the diversified needs of users are fully considered, and the intelligent financial management mode of virtual currency in immersive online games under the metacosmic environment is put forward. The research includes the following possible innovations and contributions:

1. Based on the optimization of the financial management model of the future Metaverse virtual currency, this article puts forward an pre-alarm optimization model of the Metaverse virtual currency financial management based on the improved CF algorithm, which improves the reliability of the pre-alarm results.

2. GA with ergodic characteristics is introduced into the standard BPNN, which endows each particle with ergodic characteristics, controls the aggregation degree of particles, avoids the occurrence of local extremum, obtains the global optimal value, and ensures the pre-alarm result of the model.

2 RELATED WORK

Sun et al. think that financial management system is an important part of decision support system, which is mainly used to solve structured and semi-structured financial decision-making problems and transform unstructured financial decision-making problems into semi-structured or structured ones [17]. Smith pointed out that smart finance is to realize financial automation and intelligence by building a unified data platform of "integration of industry and finance", and provide accurate, timely and high-quality financial data for business analysis, business forecast, budget management, customer insight and other applications [16]. Al-Naser et al. combined with data mining and analysis technology to realize the management and decision-making of colleges and universities in view of a large amount of financial data generated by the management system of colleges and universities, and provided effective support for the management and operation of colleges and universities [2]. Zhu et al. summarized six factors that affect financial sharing service through questionnaire analysis and model test [25]. Namely, organizational structure, business process, culture, service, market-oriented management and target planning. Yang et al. believe that the application of big data technology can effectively solve the problems of diversified data processing and storage in current decision support systems, and effectively promote the transformation of single decision support systems to enterprise-level decision support systems [22]. Wang et al. pointed out that financial management pre-alarm is to monitor the hidden dangers and risks of enterprises in real time on the basis of enterprise informatization, combined with enterprise financial related data and report materials, and send risk pre-alarm to operators through appropriate methods [18]. Huang et al. built a new financial management system with database as the core and networked accounting accounts, and formulated a unified application order [8]. Jain et al. mentioned that financial sharing service is to concentrate the businesses existing in different companies or departments into one business unit, which uses its own organizational structure to provide high-value services for other companies or departments [11]. Jain et al. put forward an optimized neural network model method and applied it to risk prediction and pre-alarm of financial management [10]. Makarewicz et al. expounded that at present, most enterprises carry out financial management informatization, which is mainly used to solve various specific financial management problems, such as fund management, cost management and performance management [14].

In the pre-alarm stage of the above model, there are phenomena of slow convergence and premature particles, which cannot optimize the neural network well, thus affecting the pre-alarm results of the model. Based on optimizing the financial management mode of the future Metaverse virtual currency, this article puts forward an pre-alarm optimization model of the Metaverse virtual currency financial management based on the improved CF algorithm, and introduces GA with ergodic characteristics into the standard BPNN to avoid the occurrence of local extremum, obtain the global optimal value and ensure the pre-alarm result of the model.

3 INTELLIGENT FINANCIAL MANAGEMENT MODEL OF VIRTUAL CURRENCY IN METAVERSE ONLINE GAME

The COVID-19 epidemic accelerated the arrival of the Metaverse, and made people generally accept the concept of virtual world. The clustering effect of the growth of the Metaverse will lead to the rapid development and breakthrough of the underlying technologies of the Metaverse. For a long time to come, the innovation of the underlying technologies and the breakthrough of the integration of the Metaverse will bring profound influence and change to human society and daily life. Due to the widespread use and wide recognition of virtual goods and network virtual services, virtual currency began to appear in various application fields, and the payment field of virtual currency is also expanding.

3.1 Metaverse Online Game Financial Data Collection

In recent years, virtual currency has been greatly developed under the premise of the prosperity and growth of network economy, which has brought convenience to people and also caused some problems. These problems are caused by the operation technology of virtual currency operators, but more problems are not solved by virtual currency operators themselves. More and more people participate in online games, and the transactions of virtual currency in online games are becoming more and more frequent, resulting in many social problems such as the impact of virtual currency on China's financial market. In the view of "Metaverse", online games will greatly break through its current cultural and entertainment functions and influence and change social life in a wider dimension and deeper field. For example, the digital technology innovation driven by the growth of online game industry will apply and change the digital life format more deeply.

A remarkable feature of data is its extensive data sources and complicated data structures. Therefore, financial data integration needs to extract and integrate the required data, extract the relationships and entities between the data from the data sources, and store the data with a unified data structure after data association and data aggregation [15]. The data flow of Metaverse Virtual Currency Financial Management System is shown in Figure 1.

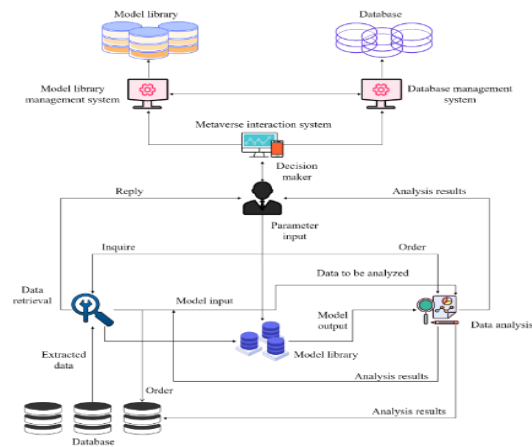


Figure 1: Data flow of the financial management system of the virtual currency in the universe.

Friendly interaction can link players and games, so that users can truly integrate into the game environment and truly feel the charm of the game world. The interactivity of the game is embodied in interactive means and interactive response, in how the player controls the content of the game and in what feedback effect the player receives. As a convenient and efficient means of payment, virtual currency has attracted many Internet application service providers to join the ranks of virtual currency issuing applications. While virtual currency has made the whole virtual world more

attractive, operators, distributors, third-party trading platforms and even users of virtual currency have also gained certain economic benefits because of its existence, especially the operators of virtual currency have obtained a lot of real money through the issuance of virtual currency.

Perceptual cognition originates from interaction, and interactive mode and interactive feedback form the whole stage of perceptual cognition. The way of interaction itself is also affecting the perceptual cognitive results. Game companies receive money after selling virtual currency, and there can be no refund according to the contract, so the reliability of income measurement is guaranteed. However, due to the remarkable diversification of virtual currency/commodities, it is difficult to define the completion schedule. Some virtual currencies/commodities will be exclusively used by a player after being purchased until the player does not appear in the game. In the game interaction, users can watch and taste the game world through real-time operation, and then promote the game process. In the interactive system design of the game, on the one hand, users' physiological and sensory needs are needed, on the other hand, the interactive feedback mechanism of the game needs to be adjusted in real time according to the emotional cognition of the players during the game, so as to promote the players to gradually integrate into the game world. The selection of models in the Metaverse financial management system is based on the characteristics of financial decision-making problems, which are selected from many models as the atomic model of financial budget, and then they are linked as needed to form a composite model, thus solving complex decision-making problems.

3.2 Financial Management Model of Metaverse Virtual Currency

The growth of the Metaverse is inseparable from the development and change of people's perceptual cognitive needs. As the main application direction of the construction of the Metaverse, the growth of games is based on the perceptual knowledge of the original internet games, and at the same time it will be subtly influenced by traditional games. Through the superiority of the Internet, big data technology has completely broken the time and space constraints and mined valuable information from the massive information. Driven by big data technology, the information feature is to present data in multiple ways, forming a huge information queue, which also implies the advantage of real-time. When the BPNN model predicts financial management, it takes financial management information as input, and its output is the current running state of the enterprise. The training of the model is completed through pre-alarm cases, ensuring that the output result corresponds to the differentiated input, and the prediction result is obtained through repeated learning, and this result is taken as the final pre-alarm result of the financial management state. The running stage of BPNN is shown in Figure 2.

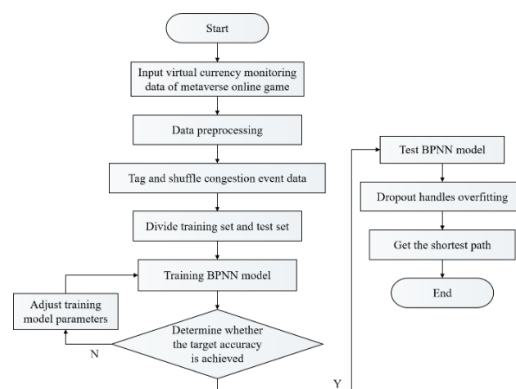


Figure 2: BPNN operation process.

The deep mining of massive data can not only promote the innovative growth of ideas and models, but also provide powerful data conditions for decision-making in various fields. The evaluation of financial projects by users of Metaverse online games can be regarded as an n -dimensional vector in space. The similarity between two users can be reflected by the cosine of the included angle of their vectors:

$$\text{sim}(i, j) = \cos(\vec{i}, \vec{j}) = \frac{\vec{i} \cdot \vec{j}}{\|\vec{i}\| \|\vec{j}\|} \quad (1)$$

Among them, the similarity $\text{sim}(u, v)$ of user i and user j is represented by the cosine of the angle between the vectors, and $\|\vec{i}\|$ is the modulus of the i vector. The modified cosine similarity takes into account both user i and user j 's set of rated financial items:

$$\text{sim}(i, j) = \frac{\sum_{u \in U} (R_{u,i} - \bar{R}_i)(R_{u,j} - \bar{R}_j)}{\sqrt{\sum_{u \in U} (R_{u,i} - \bar{R}_i)^2} \sqrt{\sum_{k \in R_m} (R_{u,j} - \bar{R}_j)^2}} \quad (2)$$

$R_{u,i}$ represents the score of the financial item i by user u , and \bar{R}_i represents the average score of the i -th financial item. Eliminate the effect of different user scoring habits by subtracting the average of user ratings:

$$\text{sim}(i, j) = \frac{\sum_{u \in U} (R_{u,i} - \bar{R}_u)(R_{u,j} - \bar{R}_u)}{\sqrt{\sum_{u \in U} (R_{u,i} - \bar{R}_u)^2} \sqrt{\sum_{k \in R_m} (R_{u,j} - \bar{R}_u)^2}} \quad (3)$$

\bar{R}_u is the average of the user's scores on all financial items, and $R_{u,i}$ is the user u 's score on the financial item i .

The key to building a financial decision support model is to keep the user's needs as the guide and develop, modify and improve it to meet the needs [11]. The attributes of decision support system support this development method that closely follows the needs of users. It is characterized by developing a small initial system first, and then improving and developing it at any time. Let the factor set U and the judgment level set V of Metaverse online game users:

$$U = \{u_1, u_2, \dots, u_m\} \quad (4)$$

$$V = \{v_1, v_2, \dots, v_m\} \quad (5)$$

Fuzzy judgment is performed on each factor in U according to the grade index in the judgment set, and the judgment matrix is obtained:

$$R = (r_{ij})_{n \times m} \quad (6)$$

Among them, r_{ij} represents the degree of membership of u_i with respect to v_i . After determining the importance index of each factor, record it as:

$$A = \{a_1, a_2, \dots, a_m\}, \quad \sum_{i=1}^n a_i = 1 \quad (7)$$

Synthesis:

$$\bar{B} = AR = (\bar{b}_1, \bar{b}_2, \dots, \bar{b}_m) \quad (8)$$

Therefore, the financial risk level of virtual currency of users of online games in Metaverse can be determined.

With the breakthrough of the underlying technology and the continuous improvement of services, Metaverse can gradually meet all kinds of perceptual needs of users. In the innovative interactive mode of the Metaverse, users can be the producers of content themselves and make secondary creation in the game. In this interactive mode, users become the most important production units. When running the model, or directly get the input parameters from the outside; Or retrieve data from the database as input parameters, and the results generated after the model runs are directly sent to the user through the dialogue component, or stored in the database first.

4 RESULT ANALYSIS AND DISCUSSION

The interactive design of meta-cosmic game economic system forms a unique interconnected economic system according to the development needs of users' perceptual cognition, thus promoting the growth of meta-cosmic interactive design. The extracted data should be converted into format storage, which is defined as the format of two-dimensional table. Unifying the format of data conversion and data loading requires the unification of data structure. The extracted source data is converted according to the requirements of the data warehouse. When noise exists in multiple attribute values of a tuple, the record can be deleted directly. By training the whole sample space, the training results can be more accurate. Compare the output data of this model with the actual virtual currency financial data, as shown in Figure 3.

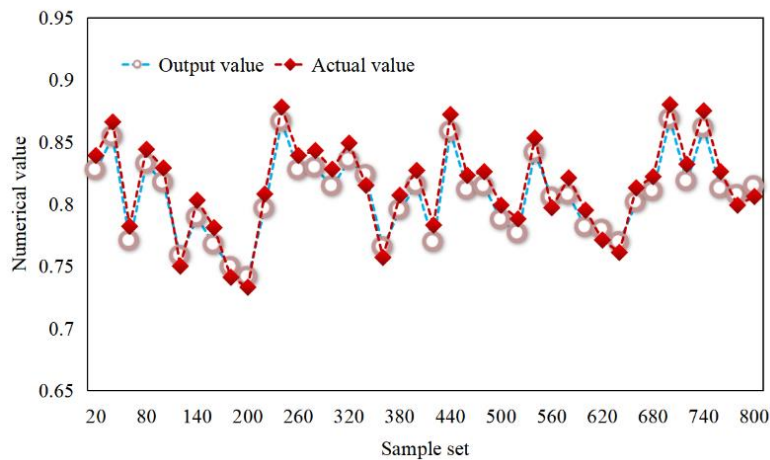


Figure 3: Learning results of this model.

The result of the financial situation forecast of virtual currency is convergent, which can approximate the original data well and has the basis for forecasting the future data. Meta-cosmic interaction design should shift from the traditional digital domain to the meta-cosmic environment as soon as possible to connect the virtual world with the real world. In decentralized interactive design, game governance is based on community consensus according to the change of users' perceptual cognitive needs, and no third-party platform is needed. Blockchain technology plays an important role in ensuring data security. With the help of data mining, the model can find the logical association between massive data and find the neglected influencing variables.

In the interaction of traditional games, there is almost no connection between games. However, with the cognitive growth of players and the maturity of blockchain and other technologies, players can realize cross-game trade, enhance the social attributes of players in the Metaverse game, and increase the playability and real experience of the game itself. In terms of the quality of useful information for decision-making, the application of the new system has realized the automatic collection, collation and analysis of financial data of virtual currency in the universe by computers in a vast range. This reduces the influence of human factors on data quality as much as possible, and also greatly improves the timeliness of financial management. The comparison results of the operational efficiency of the Metaverse virtual currency financial management model are shown in Figure 4.

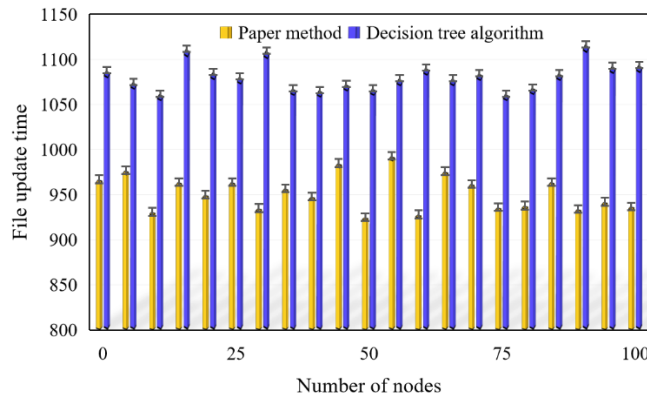


Figure 4: Comparison of operation efficiency of algorithms.

Relying on blockchain, artificial intelligence, big data, cloud computing and other technologies, the Metaverse virtual reality community is established, which further extends the financial decision-making ability of the Metaverse virtual currency management system. Compared with the traditional decision tree algorithm, the file update time of the proposed algorithm is obviously reduced, which proves that the algorithm in this article has higher operating efficiency for the financial situation analysis of virtual currency in the Metaverse.

In the Metaverse, data information is transparent and cannot be tampered with, and decentralized interaction meets the needs of users to efficiently complete the transaction of virtual goods in the game. The powerful data processing ability of the computer makes the model no longer need to be simplified, thus improving the accuracy of the model. Mining the logical relationship between data reduces the use of artificial experience, and improves the objectivity and reliability of the financial analysis and prediction results of the Metaverse. Compare the recall and accuracy of the algorithm in the prediction of the financial situation of virtual currency in the Metaverse, as shown in Figure 5 and Figure 6.

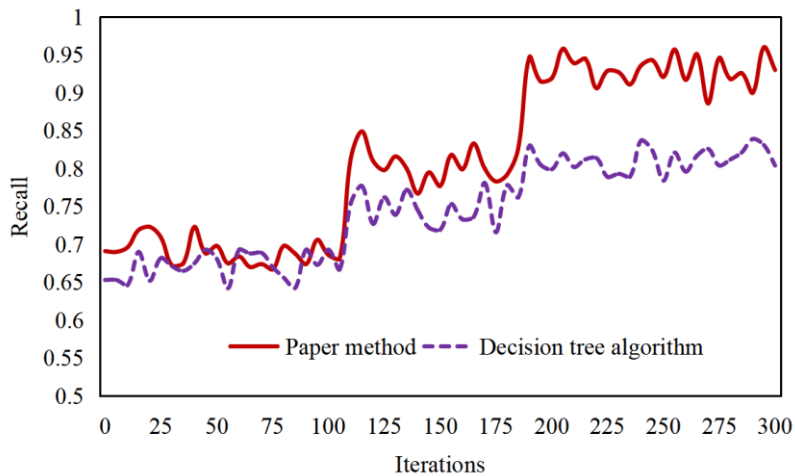


Figure 5: Recall of financial situation prediction of Metaverse virtual currency.

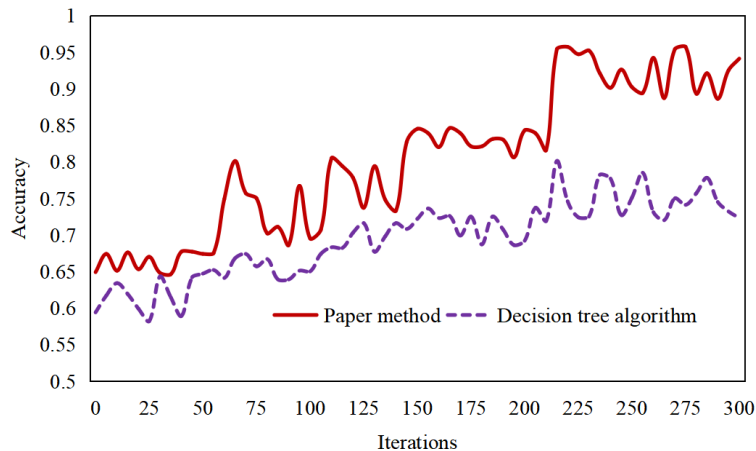


Figure 6: Accuracy of financial situation prediction of Metaverse virtual currency.

From the test results, it can be seen that the financial management model in this article is more accurate in predicting the financial situation of virtual currency in the online game of Metaverse. Compared with the traditional decision tree algorithm, the recall has increased by more than 15% and the accuracy rate has increased by more than 20%. The proposed financial analysis algorithm of Metaverse virtual currency has higher decision-making accuracy and efficiency, and is more intelligent, which can provide some theoretical and technical support for the intelligent financial management of virtual currency in the future immersive online games. Users' perceptual knowledge of the Metaverse has surpassed the role played by the single entertainment form of the game itself, and the sustainable interactive design of the Metaverse game is expected to play a more important role in the future. In the future, the continuous improvement of the underlying technology can better help people to work or study, perceive information and transmit information in the Metaverse.

5 CONCLUSION

The system dynamics research of virtual currency operation mainly focuses on the trading platform involved in the operation of virtual currency, the related subjects in the platform, the relationship between subjects, the influence of virtual currency operation on the virtual world and the real world, and how to monitor the operation of virtual currency. The sustainable interactive design of meta-cosmic games embodies the innovative design applied in interdisciplinary fields. Based on the optimization of the financial management model of the future Metaverse virtual currency, this article puts forward a pre-alarm optimization model of the Metaverse virtual currency financial management based on the improved CF algorithm. The simulation results show that the proposed financial analysis algorithm of Metaverse virtual currency has higher decision-making accuracy and efficiency, and is more intelligent, which can provide some theoretical and technical support for the intelligent financial management of virtual currency in the future immersive online games. The growth of Metaverse technology should promote the research of Metaverse more vigorously while the underlying technology advances, and design the Metaverse that meets the perceptual needs of users.

After testing, although the financial decision-making model has achieved good results, due to the complexity and diversity of the actual management of virtual currency in Metaverse and the fact that the growth of online games in Metaverse is still in the exploratory stage, some aspects of the financial management system are not well understood, which leads to some details being ignored in the system analysis and design. In the future, we can explore the construction of cloud intelligent Metaverse financial management system based on cloud technology, so as to further reduce the cost of financial management system, improve the degree of information sharing, and improve the timeliness, reliability and enforceability of financial decision-making.

ACKNOWLEDGEMENTS

This work was not supported by any funds. The authors would like to show sincere thanks to those techniques who have contributed to this research. This work was sponsored in part by Research on Collaborative Innovation of Financial Services of Jiangsu Small and Micro Cultural Enterprises:2020SJA2305.

Jie Li, <https://orcid.org/0009-0000-5089-6560>

Wenji Wang, <https://orcid.org/0009-0000-7602-3207>

REFERENCES

- [1] Akanfe, O.; Valecha, R.; Rao, H. R.: Design of an Inclusive Financial Privacy Index (INF-PIE): A Financial Privacy and Digital Financial Inclusion Perspective, *ACM Transactions on Management Information Systems*, 12(1), 2020, 1-21. <https://doi.org/10.1145/3403949>
- [2] Al-Naser, K.; Riyadh, H. A.; Albalaki, F.: The Impact of Environmental and Social Costs Disclosure on Financial Performance Mediating by Earning Management, *Journal of Cases on Information Technology*, 23(2), 2021, 50-64. <https://doi.org/10.4018/JCIT.20210401.0a5>
- [3] Anoh, K.; Maharjan, S.; Ikpehai, A.: Energy Peer-to-Peer Trading in Virtual Microgrids in Smart Grids: A Game-Theoretic Approach, *IEEE Transactions on Smart Grid*, 11(2), 2020, 1264-1275. <https://doi.org/10.1109/TSG.2019.2934830>
- [4] Chen, S. C.: Multimedia Research Toward the Metaverse, *IEEE multimedia*, 2022(1), 2022, 29-31. <https://doi.org/10.1109/MMUL.2022.3156185>

- [5] Chen, W.; Wang, J.; Wu, H.: The Application of ASP. NET to Realize the Integration of Personal Financial Management and Financial Awareness in College Students Under the Background of Shared Economy, *Revista De la Facultad De Ingenieria*, 32(2), 2017, 486-494.
- [6] Guo, H.; Hao, L.; Mukhopadhyay, T.: Selling Virtual Currency in Digital Games: Implications for Gameplay and Social Welfare, *Information Systems Research*, 30(2), 2019, 430-446. <https://doi.org/10.1287/isre.2018.0812>
- [7] He, T.: From Single-Player Games to Metaverse: A Futuristic Analysis of Challenging Legal Issues in the Video Game Industry in China, *GRUR International*, 2022(10), 2022, 10-15. <https://doi.org/10.1093/grurint/ikac039>
- [8] Huang, H.; Zhang, Z.: Virtual Standard Currency for Approximating Foreign Exchange Rates, *International Journal of Electronic Commerce*, 23(1), 2019, 33-62. <https://doi.org/10.1080/10864415.2018.1512273>
- [9] Huang, X.; Guo, F.: A Kernel Fuzzy Twin SVM Model for Pre-Alarm Systems of Extreme Financial risks, *International Journal of Finance And Economics*, 26(1), 2021, 1459-1468. <https://doi.org/10.1002/ijfe.1858>
- [10] Jain, A.; Sharma, Y.; Kishor, K.: Solid State Technology Financial Supervision And Management System Using MI Algorithm, *Solid State Technology*, 63(6), 2020, 18974-18982.
- [11] Jain, M.; Pandey, K. D.: A Blockchain based Fund Management Scheme for Financial Transactions in NGOs, *Recent patents on engineering*, 2022(2), 2022, 16-21. <https://doi.org/10.2174/1872212115666210615155447>
- [12] Letaief, K. B.; Takawira, F.; Worthman, B.: A Partnership in the Financial Management of ComSoc, *IEEE Communications Magazine*, 56(9), 2018, 4-5. <https://doi.org/10.1109/MCOM.2018.8466344>
- [13] Linton, O.; Zhang, Z.: Editorial for the Special Issue on Financial Engineering and Risk Management for Joe Sciencedirect, *Journal of Econometrics*, 208(1), 2019, 1-4. <https://doi.org/10.1016/j.jeconom.2018.09.002>
- [14] Makarewicz, T.: Traders, Forecasters and Financial Instability: A Model of Individual Learning of Anchor-and-Adjustment Heuristics, *Journal of Economic Behavior & Organization*, 190(4), 2021, 626-673. <https://doi.org/10.1016/j.jebo.2021.07.008>
- [15] Ry, A.; Lin, Y. B.; Yzc, D.: Big Data Analytics for Financial Market Volatility Forecast Based on Support Vector Machine – ScienceDirect, *International Journal of Information Management*, 50(10), 2020, 452-462. <https://doi.org/10.1016/j.ijinfomgt.2019.05.027>
- [16] Smith, C.; Kumar, A.: Crypto-Currencies - An Introduction To Not-So-Funny Moneys: Crypto-Currencies - An Introduction, *Journal of Economic Surveys*, 32(5), 2018, 1531-1559. <https://doi.org/10.1111/joes.12289>
- [17] Sun, J.; Zhi, L.: The Impact of Management Power on Financial Restatement, *ICIC Express Letters*, 13(3), 2019, 239-245.
- [18] Wang, R.; Yu, C.; Wang, J.: Construction of Supply Chain Financial Risk Management Mode based on Internet of Things, *IEEE Access*, 7(99), 2019, 110323-110332. <https://doi.org/10.1109/ACCESS.2019.2932475>
- [19] Wang, X.: A Study on the Risk Evaluation System for Financial Management in Colleges and Universities and its Model Construction Under The Background of Informatization, *Revista De La Facultad De Ingenieria*, 32(8), 2017, 289-296.
- [20] Wei, Z.; Yang, W.: Research on building of Cloud Accounting Financial Sharing Management Model Based on Analysis in the Era of Big Data, *Revista De La Facultad De Ingenieria*, 32(14), 2017, 34-40.
- [21] Wonglimpiyarat, J.: What is it About Strategic Implications of Using Financial Models in the Stage Of Technology Management?, *Journal of High Technology Management Research*, 30(1), 2019, 82-90. <https://doi.org/10.1016/j.hitech.2018.12.001>

- [22] Yang, Q.; Wang, Y.; Ren, Y.: Research on Financial Risk Management Model of Internet Supply Chain Based on Data Science, *Cognitive Systems Research*, 56(8), 2019, 50-55. <https://doi.org/10.1016/j.cogsys.2019.02.001>
- [23] Ye, S.: Research on the Enterprise Accounting Statement Evaluation and Financial Management Optimization Based on Computer Artificial Intelligence Method, *Boletin Tecnico/Technical Bulletin*, 55(20), 2017, 208-215.
- [24] Yue, H.; Tian, S.: Research on the Construction and Implementation Optimization of Ecommerce Financial Management System, *Boletin Tecnico/Technical Bulletin*, 55(10), 2017, 588-594.
- [25] Zhu, L.; Li, M.; Metawa, N.: Financial Risk Evaluation Z-Score Model for Intelligent IoT-based Enterprises, *Information Processing & Management*, 58(6), 2021, 102692. <https://doi.org/10.1016/j.ipm.2021.102692>