Hindawi
Scientific Programming
Volume 2022, Article ID 4240244, 10 pages
https://doi.org/10.1155/2022/4240244

Research Article

Optimal Model of Horse Racing Competition Decision Management Based on Association Rules and Neural Network

Shuang Zhang

Wuhan Business University, Wuhan, Hubei, China

Correspondence should be addressed to Shuang Zhang; tiredhiker@wbu.edu.cn

Received 28 December 2021; Revised 21 January 2022; Accepted 7 February 2022; Published 11 March 2022

Academic Editor: Sheng Bin

With the vigorous development of horse racing, people's attention to horse racing has increased significantly. Some experts and scholars have conducted research on the decision-making management and predictive analysis methods of horse racing. Today, with the rapid development of information technology, the amount of data and data dimensions of horse racing competitions continue to explode. The increase in data scale and feature dimensions provides new challenges for competition management and competition prediction research. At present, traditional prediction algorithms can no longer meet the needs of horse racing situation prediction, but research has found that association rules and neural network algorithms provide a good solution to the classification and prediction problem. Based on the advantages of association rules and neural networks in analyzing data, according to the requirements of horse racing decision management, this paper adopts the B/S structure to realize the construction of the horse racing decision management optimization model from the three aspects of hierarchical structure, functional structure, and forecasting process. Combined with the horse racing decision management optimization model, based on a large number of experimental training data, the final conclusion is drawn: first, the factors that affect the horse racing performance are from large to small. The order of arrangement is: race schedule > age > gender > weight > rating > horse top three rate > jockey > weight load > harness > ranking > field nature > field > trainer; the second is the prediction and actual results of the neural network algorithm. The closest one, which is slightly higher than 90%, has the highest prediction accuracy; third, the average value of the horse racing performance prediction of this system during the review is only 2.01 s, and the misappraisal rate is 0.12%, indicating that the application value of this system is significant; fourth, in the average time spent in the two seasons, the average time spent in the second season was reduced compared with the average time spent in the first season, with a maximum reduction of 0.984 s, indicating a slight improvement in the performance of the 2020 season. Using this system to predict horse racing, results can improve the optimization of horse racing decision management to a certain extent.

1. Introduction

Modern horse racing is an outdoor sport that is popular with all walks of life. It is a comprehensive industry integrating sports, entertainment, gambling, and commerce. There are 3.2 million competitions each year, and the total prize money for horse racing in the world amounts to 360 billion yuan [1]. At present, there are more than 70 countries and regions developing horse racing in the world. Horse racing in the United States, Britain, France, Australia, Japan, Hong Kong, and so on has developed well and has become one of the most important industries in the country [2]. Horse racing is the link of economic activities, the pillar of public welfare and charity organizations, and the big tax collector of the country. It is the carrier of interpersonal communication and an important entertainment method in people's lives [3]. It is fashionable for people to participate in horse racing activities and to become a member of the horse club and horse owner as a symbol of their identity and status.

With the tremendous improvement in people's living standards, horse-racing-related undertakings are also advancing quickly and steadily. As one of the horse-racing-related industries, the horse racing lottery has also received national support and people's attention. Driven by the horse racing lottery, more and more ordinary people participate in horse racing. Taking the UK as an example, the horse racing industry has an output of more than 1 billion pounds and has developed into the second-largest sports industry after football. With the increasing popularity of the horse racing industry, about 130 million people around the world participate in horse racing lottery guessing. People began to summarize general laws in various types of horse racing, trying to find a way to improve the level of winning and losing guessing [4]. Today, with the vigorous development of normalization, traditional horse racing prediction models generally have low prediction accuracy and imperfect system architecture design, which can no longer meet the needs of horse racing management and competition outcome prediction. How to build a horse racing decision-making management model and apply scientific methods to solve forecasting problems has become a problem that more scholars and the public are concerned about.

Information technology has played a huge role in promoting the development of horse racing. The advancement of science and technology has not only promoted the advancement of horse racing but also has higher requirements for the decision-making management and performance prediction of horse racing [5]. Based on the research of a large amount of data, this paper introduces association rules and neural network algorithms to establish a horse racing competition decision-making management optimization model. It provides decision-makers with powerful means and tools, provides an effective quantitative basis for making reasonable training management decisions and training programs, and provides scientific predictions for public participation in horse racing.

2. Related Work

Horse racing is a speed competition that tests humans to control and control horses. It is one of the main events of equestrian sports. Its forms are changeable, but the principles are basically speed competitions. Horse racing is also a worldwide traditional competition event [6]. According to textual research, horse riders were found in stone carvings of the Neolithic Age, and as early as the beginning of the seventh century BC, the four-horse driving sports event appeared in the Olympic Games held in ancient Greece. Later, the project was changed to human driving for competition [7]. In the beginning, horse racing was only used as a method and means to select good horses. Only the most prominent and outstanding horses on the racetrack can be used for breed breeding. In modern times, with the continuous development and prevalence of horse racing, organization, management, and competition have become more and more important compared with ancient horse racing events, and the method is more scientific and more advanced [8].

With the continuous popularity of horse racing, many scholars have conducted research on horse racing. Ghezelsefloo proposed: based on the theory of service operation management, transplant the theoretical knowledge of the discipline system of service operation management into the operation management of horse racing events [9]. Fenner et al. emphasized that guided by model theory and method, the service operation management mode of Hong Kong horse racing events and the service operation management mode of Japanese horse racing events are analyzed from the perspective of service [10]. Zhang and Liu proposed horses are a unique match between two life forms of equestrian events, and the health of horses directly affects the event, which requires a very high level of organization and management of our events [11]. Research by Quintana et al. shows that among the participants of high-level equestrian competitions, the injury rate is also the highest, and equestrian competitions require skilled emergency medical services [12]. Research by Fenner et al. pointed out that it is necessary to establish a comprehensive long-term planning system for events, pursue the irreplaceability of the equestrian event brand, develop the characteristic highlights of the equestrian event, and propose the establishment of a professional talent training system [13]. Research by Sun and Li shows that in the context of equestrian sports, competitions can promote and drive related consumption [14]. Padalino et al. explored the characteristics of the development of large-scale sports events in Hong Kong, analysis of sports development and management mechanisms, and the characteristics of horse racing to drive and promote the development of Hong Kong's gaming industry and sports culture [15]. Hoseini and Amani proposed an equestrian event management system based on the B/S model to facilitate event informatization [16].

Information technology is the foundation and symbol of modern society. With the development of artificial intelligence and big data, many experts use information technology to manage and predict sports events. In the research on the comprehensive evaluation and prediction of national gold medal rankings in the Olympic Games, Xiao and others used tracking statistics + comprehensive evaluation + comparative analysis + expert consultation on the comprehensive evaluation of Olympic gold medal rankings for the Olympic events in the world's major competitions during the Olympic cycle from 1989 to 1992. Method of prediction: based on the comprehensive and timely grasp of the strength level and development changes of the Olympic events in various countries and regions, the strength pattern, number of gold medals, and team rankings of the Olympic Games were predicted [17]. In the analysis of the strength of the diving powers in the 2000 Sydney Olympics and the study of gold medal predictions, Chen used the sports expert method to analyze the strengths of the diving powers in the 2000 Sydney Olympics and predicted the gold medal situation of the Chinese diving team [18].

At present, the research and application of predictive management have penetrated into various research fields, and the field of horse racing research is no exception. Predictions can be made in horse racing strategy research, decision-making, coaches, athlete team construction, training programs, and so on. In recent years, different prediction algorithms have been widely used in nonlinear prediction in various fields, such as BP neural network, wavelet neural network, support vector machine regression, and so on. Among them, association rules and neural networks have become the most successful prediction methods in the field of horse racing because they are easy to implement any complex nonlinear mapping function. Forecast through scientific methods; recognize the direction, trend, and law of the development and change of things; and take effective measures to control the codevelopment, so as to better optimize the management of horse racing decisions.

3. Realization of Horse Racing Competition Decision Management Model

The purpose of horse racing decision management is to accurately predict the development and changes in the horse racing system, adjust the influence of other factors, and finally realize the optimization of horse racing decision management [19]. Based on association rules and neural network algorithms, this chapter realizes the establishment of a horse racing competition decision management optimization model from three aspects: the level construction of horse racing competition decision management, functional structure, and competition prediction process.

3.1. Model Hierarchy. The horse racing decision-making management system adopts a four-layer architecture design. From bottom to top, they are the horse racing data collection layer, data service layer, system business logic layer, and user interface layer. Each layer of the system completes the corresponding function and will exchange data between each layer; the hierarchical structure diagram is shown in Figure 1.

User interface layer: It provides users with an interface into the horse racing decision management system, which realizes the overall design of human-computer interaction, operation logic, and beautiful interface of the horse racing decision management and displays it to users in the form of a graphical interface. When the user sends a request to the image system, the system first performs the request and data analysis at the bottom layer and then transmits the calculation result to the user interface layer to display it to the user. When a user sends a request to the system, the system first performs the request and data analysis at the bottom layer and then transmits the calculation result to the user interface layer to display it to the user. The design of the user interface display layer needs to comply with the principles of aesthetics, intuitiveness, and fault tolerance. Due to the needs of different users, the carrier devices of the user layer are not the same, mainly smartphones, desktop computers, and portable notebooks.

Business logic layer: It is the core part of the entire horse racing decision-making management system, mainly for business logic-related analysis and processing. By receiving the information of the user interface display layer and performing business processing, the system command service is completed on the basis of the data service layer, and the business processing results are stored in the database and returned to the user interface layer for display.

Data service layer: As the middle layer, it mainly manages the horse racing information management system data effectively. Due to the huge amount of competition data, there is incomplete and invalid information in the data. By processing it at this layer, the integrity and correctness of the data can be ensured. The data managed by the data service layer mainly come from two aspects. On the one hand, it is through data collection equipment, stored in the data service layer and provided to users for use; on the other hand, it is basic information such as query requests received through the business logic layer. The basic data and historical information are stored in the database and transmitted to the upper layer. At the same time, in order to ensure the robustness of the database, the data service layer also regularly backs up the database and files.

Data collection module: It includes game data collection and training data collection. The data obtained by the system through the data acquisition subsystem can analyze the recent physical state, technical and tactical state, and overall cooperation state of the horse and jockey, so as to formulate corresponding training plans; at the same time, the data acquisition module provides data for the prediction of the horse racing conditions studied in this paper support. In the horse racing decision-making management system, it is mainly completed by the staff and mobile devices to provide accurate and timely basic information for the horse racing situation prediction to ensure the normal operation of the horse racing situation prediction system. Collectors record the trajectory of horse racing on the competition field through the mobile phone client. Since manual input will produce some abnormal data, when using the collection layer data to predict the game conditions, it is necessary to process the abnormal data to ensure data reliability.

3.2. Model Functional Structure. This paper combines the key technology of demand analysis and horse racing decision management model to design the prototype of a horse racing decision management optimization system. The system is roughly divided into system management, personnel information management modules, data collection, event management, and points query. The system functions are shown in Figure 2.

Data collection module: The main function of data collection is to collect data from horse racing or training, which provides data support for the study of the horse racing decision management model in this article. It is divided into three modules: competition data collection, training data collection, and data statistics.

Event management module: The main function is to browse, release, and update events. Nonadministrator users can browse the game. For a game that has ended, the user can view the score of each quarter of the game and the final game status; for a game that has not started, the user can make an appointment to watch the game and predict the game status.

Game prediction module: It consists of four functions: data preprocessing, parameter optimization, model training, and prediction. The data preprocessing, parameter optimization, and model training are part of

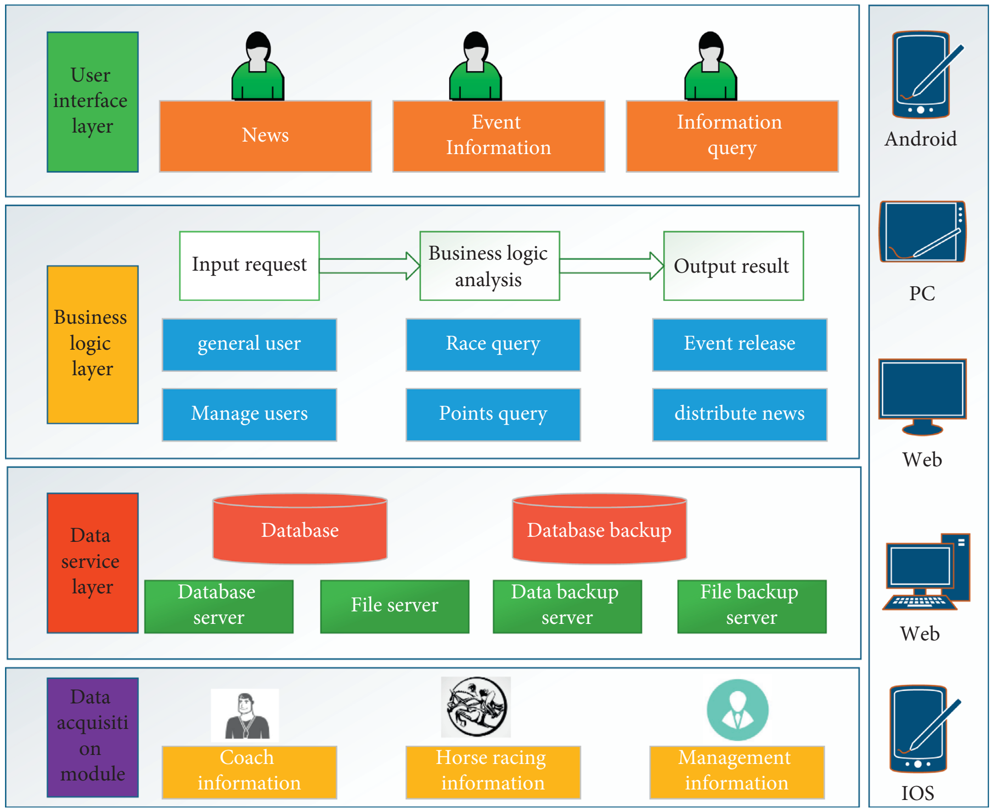

Figure 1: The system hierarchy diagram.

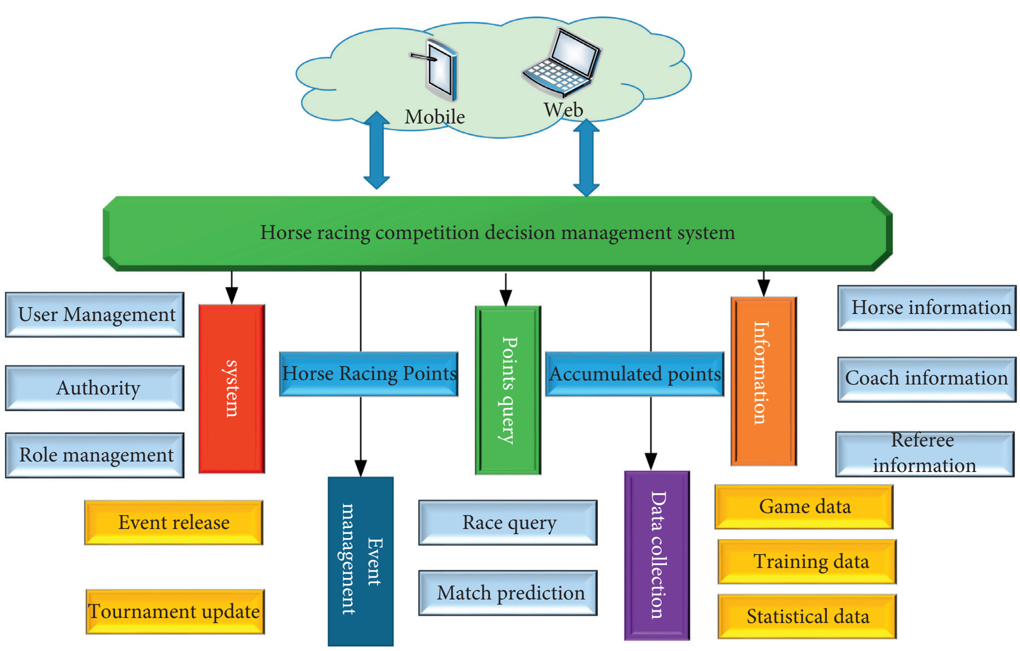

Figure 2: System function module diagram.

the system background administrators, and the game prediction is a user use function. The user selects a game in the viewing schedule interface and clicks the “Pre-match” hyperlink. After the server receives the request, it will feed back the data comparison between the two sides of the game. The user can clearly see the comparison of the relevant game data before the game between the two sides through the interface. Upon clicking the “Predict” button, the system will make a prediction by completing the following steps.

Points query module: Mainly to query points, this module includes horse racing points query and season points query. Users can query related postregular season standings and horse racing standings. The system receives the score query request from the user, initializes the scoreboard information, and displays the scoreboard to be queried.

System management module: It includes system login and registered user audit, system authority management, and role management. Mainly by reviewing the registration, new users maintained the system's roles, permissions, password management, and so on to ensure the normal use and operation of the system. The system classifies users into different role categories according to actual usage and assigns different permissions to different roles.

The news module is mainly to display the news related to horse racing events, including the latest race news, horse racing, season news, and so on. Features include horse racing news releases, horse racing news update, and news information retrieval functions.

The information management module includes basic management functions such as the addition, deletion, modification, and query of horse racing athlete information, coach information, and referee information, as well as the management of the relationship between roles.

3.3. Game Prediction Process. The administrator client development of the horse racing decision management system adopts the B/S structure. In order to simultaneously apply to the computer side, mobile terminals (Android and IOS), the user side development of the horse racing situation prediction system adopts the web app website development model, and the game situation prediction module is divided into four parts: data preprocessing, parameter optimization, model training, and prediction. The data preprocessing, parameter optimization, and model training are part of the system background administrator's use, and the game situation prediction belongs to the user's use function. First, log in to the system to retrieve the user login table and determine whether it is an administrator login or an ordinary user login. If the administrator logs in, read the game data statistics table, use the ISSFS algorithm to select the characteristics of the game data, use the HGAPSO algorithm to select the penalty factor for the SVM parameter C and function parameter g, and input the reduced data as the training set of the model into the neural network to train the predictive model; if the logged-in user is a nonadministrator user, you can choose an unfinished game and win against the home team of the game. The negative situation is predicted, and the prediction process is shown in Figure 3.

3.4. Implementation of Key Algorithms in the Model. Compared with traditional algorithms, association rules and neural networks have strong nonlinear relationship mapping ability, adaptive ability, and learning ability and also have a certain fault tolerance ability. Therefore, applying association rules and neural networks to the horse racing decision management model can predict horse racing more accurately.

Since there are many factors that affect horse racing performance, neural network modeling is used; various influencing factors are used as neurons; and association rules are used to find out the interconnection between each neuron and determine the connection strength between the neuron and the neuron source, which is the proportion of each influencing factor in the forecast. The output of the final neuron is the prediction result. Next, the two key algorithms involved in the horse racing decision management system-association rules and neural network algorithms will be described in detail.

3.4.1. Neural Network Algorithm. A neural network is a kind of backpropagation network, proposed by Rumelhart and Mc Celland in 1986, composed of backpropagation and error information communication [20]. The neural network includes an input layer, a hidden layer, and an output layer. To transfer the function from the input layer to the hidden layer and from the hidden layer to the output layer, the formula is as follows:

$$\begin{aligned} net_1 &= e^T x - c_1, h = f_1(net_1),\\ net_2 &= q^T x - c_2, \hat{y} = f_2(net_2). \end{aligned} \tag{1}$$

Get the function model and loss model as follows:

$$\begin{aligned} \hat{y} &= f_2(net_2) = f_2\left(q^T f_1(net_1) - c_2\right),\\ E(\omega) &= \sqrt{2}\sum_{i=1}^{2}\left(y_i + \hat{y}_i\right)^2 \end{aligned}, \tag{2}$$

where x is the initial value of the neurons in each layer; c_1 and c_2 are the intercept terms; e^T and q^T are the weight values of the connection between the layers; net_1 and net_2 are the output values of the function transfer between the layers; f_1 and f_2 are sigmoid functions; y is the output value of the BP neural network; y_i is the actual value; and $E(\omega)$ is the total error of the BP neural network.

The data as the input value need to be normalized data preprocessing to achieve the input value range in the [0,1] interval. Using standardized methods for data processing, the formula is as follows:

$$\hat{x} = (x_i - x_{\min}) \times (x_{\max} - x_{\min}), \tag{3}$$

where x_i represents the time of the first game of the device and $x_{\min}$ and $x_{\max}$ represent the minimum and maximum values of the data, respectively.

The output value obtained after BP neural network calculation is normalized, and the formula is as follows:

$$\hat{y} = y_i \times y_{\max}. \tag{4}$$

Determine the number of artificial neurons in the hidden layer: under the premise of fully considering the approximate accuracy, user experience, and experimental methods to determine the number of artificial neurons in the hidden

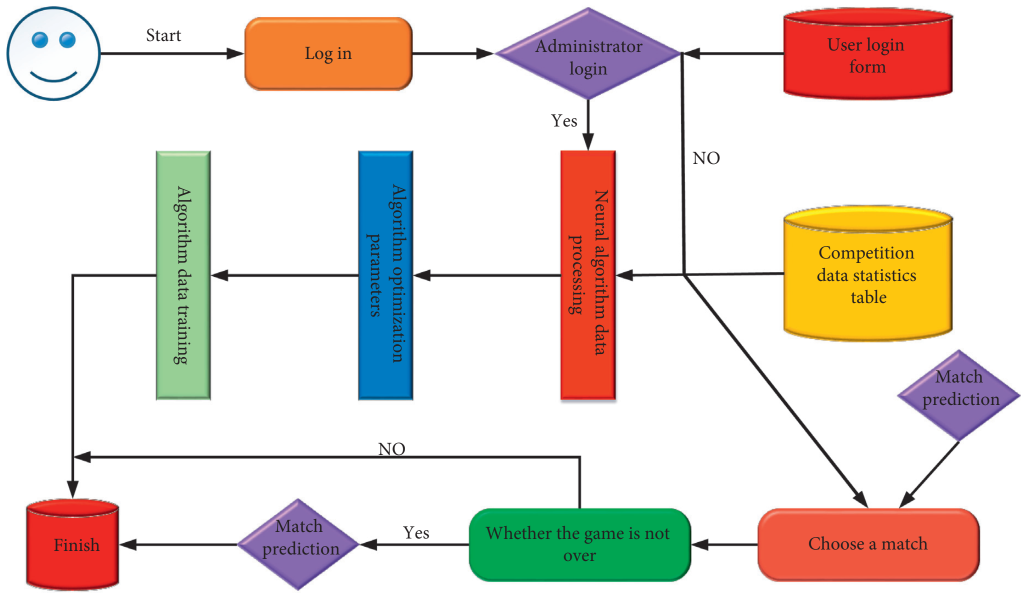

Figure 3: Game forecast flow chart.

layer. Suppose the number of artificial neurons in the input layer is M, the number of artificial neurons in the output layer is N, and the ideal number of artificial neurons in the hidden layer is generally within the following range:

$$a = (M + N) \times 3 + L - (M - N) + 8 = b. \tag{5}$$

According to the above ideas and steps, use Python software to learn data through network learning and constantly adjust the number of hidden layer neurons to optimize the algorithm. Determine the number of artificial neurons in the hidden layer according to the minimum error and optimal performance of the network and finally get the structure of the BP neural network.

3.4.2. Association Rules. Discover the association rules between various factors through data mining. The reliability function of a single horse race is obtained through the neural network. The reliability function represents the health of the racehorse. When the association rules are probabilistic, the reliability functions between the various factors with the association relationship are linked. Next, the unknown variables are calculated from the known variables through the probabilization of the association rules; the formula is as follows:

$$\begin{aligned} T(y \mid x) &= T(xy) \div T(x), \\ T(\overline{xy}) &= 1 + T(x) + T(y) - T(xy). \end{aligned} \tag{6}$$

It can be obtained from the above formula that

$$\begin{aligned} T(\bar{x} \mid \bar{y}) &= T(\overline{xy}) \times T(\bar{x}) \\ &= [1 + T(x) + T(y) - T(xy)] \times (1 + T(x)). \end{aligned} \tag{7}$$

The probability function can be transformed by the association rules as follows:

$$\begin{aligned} conf\,(x \rightleftharpoons y) &= T(x \mid y), \\ \sup(x) &= T(x), \\ \sup(y) &= T(y), \\ conf\,(\overline{x \rightleftharpoons y}) &= T(\bar{x} \mid \bar{y}). \end{aligned} \tag{8}$$

Based on the excavated horse racing game X's first match time, the three-parameter Weibull distribution is used to obtain the reliability function and failure rate function of the horse racing X. Then the reliability function of horse racing Y is obtained from the mined association rules.

$$S(Y_T) = S(X_T) S(\bar{x} \mid \bar{y}). \tag{9}$$

According to the structural framework of the BP neural network, the input Weibull reliability function has a projection relationship with the BP neural network function, and the error value between the two variables is also close to the maximum error given in the network learning process. In this article, the maximum error value E is the fixed error of input data and output data, and the following function is obtained by adding a formula to the conversion function.

$$S(Y_{BT}) = S(y_{AT}) - E(\omega) T(\bar{x} \mid \bar{y}), \tag{10}$$

where y_{At} represents the predictive model of match A and Y_{BT} represents the predictive model of match B.

This paper combines the probabilization of association rules with the prediction model of the BP neural network, and finally, the prediction model of match B is obtained. From the above formula inference, it can be known that a horse racing game with an association relationship can calculate a predictive model based on the data of various factors, and at the same time, the predictive model of other competitions can be deduced by the association rules, so as to realize the performance prediction of the horse racing game.

4. Optimization and Analysis of Horse Racing Decision Model

4.1. The Weight of Factors Affecting Horse Racing. Many factors in horse racing have a direct impact on the outcome of the race. To construct a horse racing decision-making model, the most important thing is to understand the factors that affect horse performance, including gender, scoring, ranking, weight, age, horse top three rate, harness, race schedule, venue, nature of the venue, and jockey, training 13 factors such as Ma Shi [21]. The premise of this experimental study is that the ranking of the 13 factors is to analyze the impact on the performance of horse racing.

It can be seen from Figure 4 that on the basis of the model, a large amount of data is studied and analyzed, and the influence of factors on the prediction results is arranged in the order of: schedule > age > gender > weight > score > horse top three rate > jockey > negative scale > harness > qualifying > field nature > field > trainer. The arrangement is roughly divided according to the four major categories of influencing factors. These four categories of influencing factors are the decisive influencing factors (schedule), the influencing factors of the horse itself (age, gender, and weight), the influencing factors that describe the quality of the horse (score and the rate of top three horses), and the external influencing factors (jockey, weight-bearing, harness, qualifying, field nature, field, and trainer). The most important of course is the decisive factor, the schedule, because the results of different schedules are very different.

4.2. Multiple Algorithms Predict Accuracy Results. In this paper, evaluation indicators are selected to choose a variety of optimization algorithms, namely quadratic moving average (A algorithm), triple exponential smoothing (B algorithm), gray model (C algorithm), and neural network algorithm. After more than 5,000 training and competitions in 9 schedules in recent years, the following conclusions are drawn, and the results are shown in Figure 5.

As can be seen from Figure 5, in the 1,000 m, 1,200 m, 1,400 m, 1,600 m, 1,650 m, 1,800 m, 2,000 m, 2,200 m, and 2,400 m multiple competition events, a variety of prediction algorithms are used to make predictions. The prediction neural network algorithm is the closest to the actual results, which is slightly higher above 90%; it has the highest prediction accuracy. Secondly, the gray system algorithm is better than the two-time moving average and three-time exponential smoothing algorithm, and it has a higher prediction accuracy, reaching more than 80%. Therefore, it can be seen that the neural network algorithm has obvious advantages in predicting the results of the competition. This model uses the neural network algorithm to improve the accuracy of the prediction.

4.3. System Predictive Efficiency Analysis. In order to deeply test the auxiliary effect of this system on the decision-making prediction of horse racing competitions, two systems are used to implement comparative tests. When testing the two

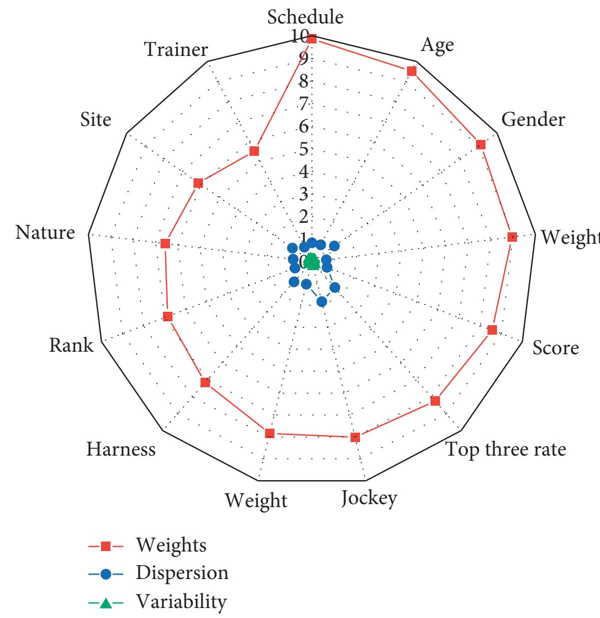

Figure 4: Horse racing influencing factor weight map.

systems to predict the results, the prediction time, and the error rate of the competition data, the results are shown in Figure 6.

As can be seen from the figure, after comparing the two systems, it can be seen that the average prediction consumption of the horse racing performance of the system in this paper during the review is only 2.01 s, and the average time consumption of the previous system is 3.75. The training time and prediction time consumption of the system in this paper are the least. The average error rate of this system is 0.12%. The average error rate of the previous system is 0.35%, and the highest rate of error is 0.88%. It can be seen that the review performance of the system in this paper has significant application value in similar systems.

4.4. Analysis of Horse Racing Performance Improvement. One of the design goals of the horse racing decision-making system is to continuously predict the performance of the horse race, find out the shortcomings in the horse race, and constantly adjust and revise so that the decision-making management is continuously optimized, and finally, the actual game performance is improved. Through a comprehensive study of venues, horse racing, trainers, and knights in the 2019 and 2020 seasons, it was found that the combined factors of the two seasons had little effect, further illustrating the authenticity and validity of the results. This summary compares and analyzes the competitions of different schedules in the two seasons after adopting this model, as shown in Figure 7.

It can be seen from Figure 7 that the average time spent in each game of the top three in the two seasons of 2019 and 2020, except for the 2,000 m schedule, the average time of the top three in the rest of the schedule has been reduced; the results have been improved; and the highest has been

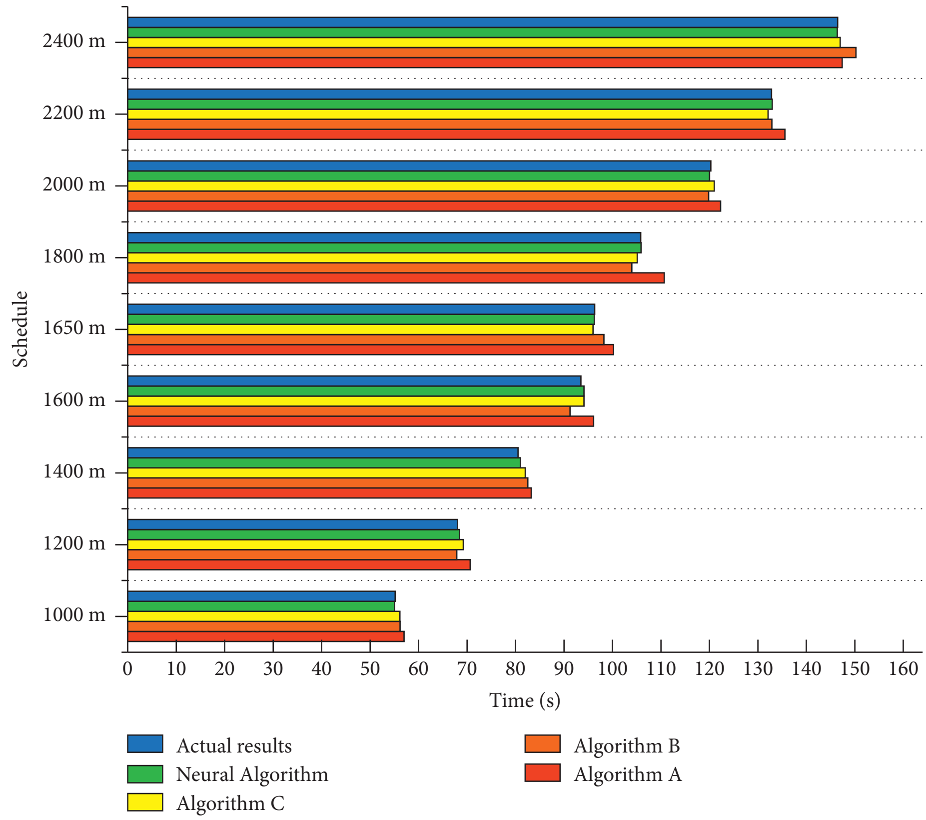

Figure 5: Neural network algorithm accuracy rate.

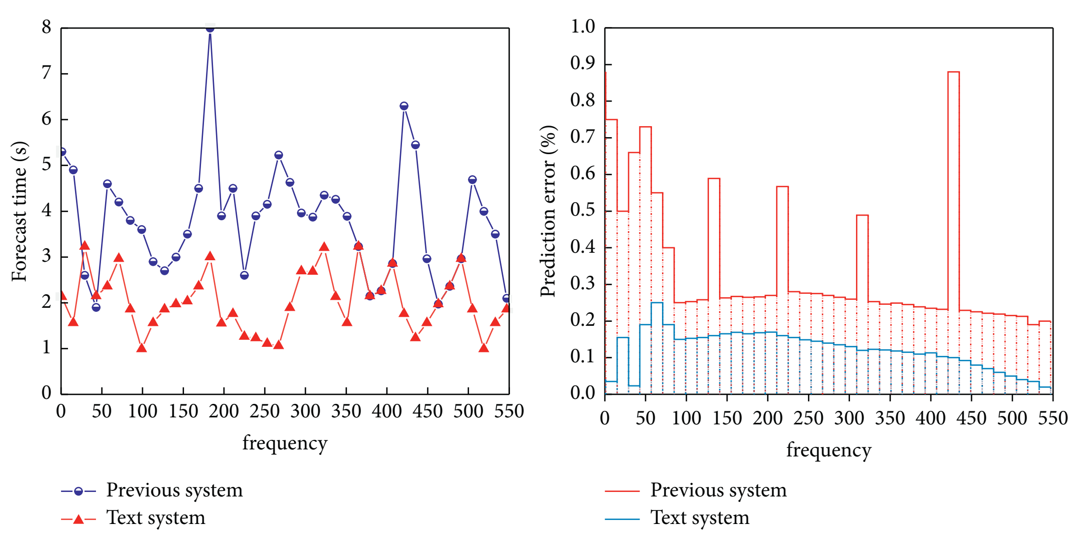

Figure 6: System predictive performance analysis.

reduced 0.984 s; In the fastest time of the two seasons, there is no difference in the average time of the 1,400 m, 1,600 m, 1,650 m, and 1,800 m races. The average time of the other races in the second season has been reduced compared with the first season, and the highest reduction is 0.7 s. It shows that the race results in the 2020 season have improved, which further verifies the predictive science of the system and has a certain improvement in horse racing results.

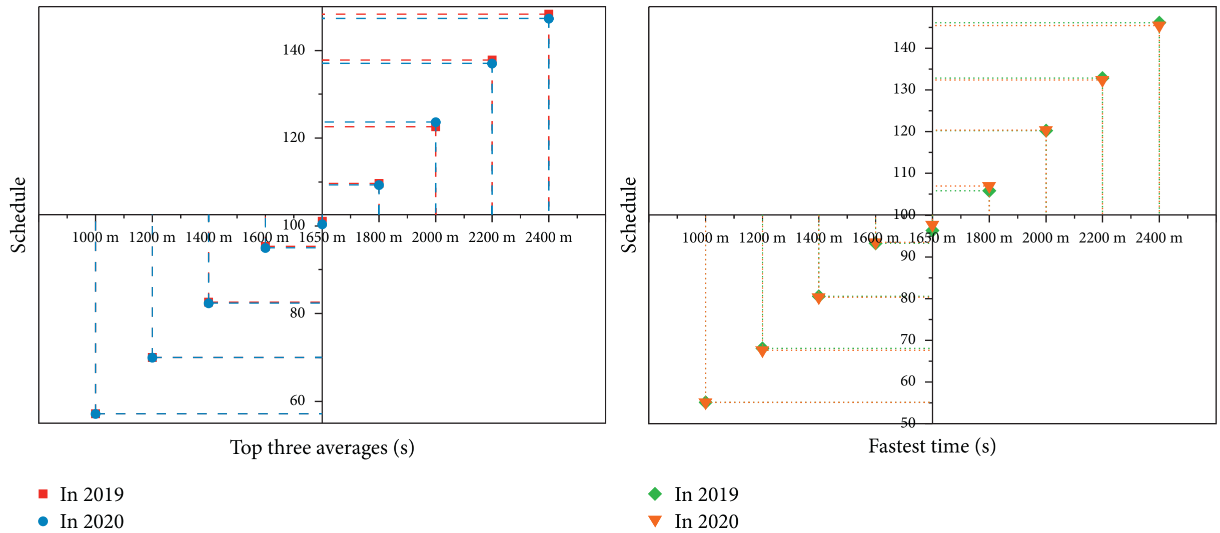

Figure 7: 2019–2020 horse racing results comparison.

5. Conclusion

With the rapid development of information technology, the data dimension and data volume of horse racing forecast data have grown rapidly. The increase in the scale of data and feature dimensions has led to the problem of large-scale data and dimensionality disasters during model training. Association rules and neural network algorithms with a strong ability to process nonlinear data have been widely concerned by experts and scholars. Based on the research of a large amount of data, this paper introduces association rules and neural network algorithms to establish a horse racing competition decision-making management optimization model. An example is used to simulate the regular season, and it is proved that the accuracy of this model is as high as 90%, the average predicted consumption is only 2.01 s, and the error rate is 0.12%. This system provides powerful means and tools for decision-makers to optimize management, an effective quantitative basis for making reasonable training management decisions and training programs, scientific comparisons for improving horse racing performance, and scientific predictions for public participation in horse racing.

At present, the system can operate normally, but the system still has some deficiencies, the function is not perfect, and the accuracy of the final prediction also needs a large amount of data to verify. The next step is to improve the existing system, continuously improve the association rules and neural network algorithms, and improve the accuracy of prediction.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was supported by the Wuhan Equine Industry Development and Horse Racing Event Transformation and Upgrading Project (The Design and Implementation of China Horse Industry Information Management System), Project Number: WHSM-2019122401.

References

[1] P. L. Hitchens, K. Ryan, and S. I. Koch, “A sustainable structure for jockey injury data management for the North American horse racing industry,” *Injury*, vol. 50, no. 8, pp. 1418–1422, 2019.

[2] J. M. Fiedler and P. D. McGreevy, “Reconciling horse welfare, worker safety, and public expectations: horse event incident management systems in Australia,” *Animals*, vol. 6, no. 3, pp. 16–35, 2016.

[3] E. Juckes, J. M. Williams, and C. Challinor, “Racing to a staffing solution: an investigation into the current staffing crisis within the UK horseracing industry,” *Comparative Exercise Physiology*, vol. 17, no. 1, pp. 73–89, 2021.

[4] S. H. Kang and G. S. Park, “Overcoming ethical issues through symbolic management, cultivating proponents and storytelling: the institutionalization of Korea’s horseracing industry,” *Asia Pacific Business Review*, vol. 22, no. 3, pp. 439–451, 2016.

[5] E. Davies, W. McConn-Palfreyman, and J. M. Williams, “The impact of COVID-19 on staff working practices in UK horseracing,” *Animals*, vol. 10, no. 11, pp. 2003–2034, 2020.

[6] S. Zhang and M. Liu, “Design of horse race registration system based on wireless network and simulation system,” *Techniques and Applications*, vol. 34, no. 17, pp. 1661–1669, 2021.

[7] K. Clayton-Hathway and U. Fasbender, “Women as leaders and managers in sports: Understanding key career enablers and constraints in the British horseracing industry,” *Women, Business and Leadership*, vol. 7, no. 3, pp. 309–322, 2019.

[8] Z. Ma, “Research on system and developing path of talents collaborative cultivation in horse racing industry between hubei and xinjiang,” *Education Science and Economic Management*, vol. 16, no. 23, pp. 612–615, 2017.

[9] H. Ghezelsefloo, "Designing structural model of elemental, behavioral and motivational traits in horse racing betting with mix method," *Applied Research in Sport Management*, vol. 9, no. 2, pp. 99–110, 2020.

[10] K. Fenner, K. Dashper, and J. Serpell, "The development of a novel questionnaire approach to the investigation of horse training, management, and behaviour," *Animals*, vol. 10, no. 11, pp. 56–68, 2020.

[11] S. Zhang and M. Liu, "Computer aided management system of sports horse registration based on distributed storage system and deep Fusion learning," *Microprocessors and Microsystems*, vol. 56, no. 26, pp. 3144–3153, 2021.

[12] C. Quintana, B. Grimshaw, and H. E. Rockwood, "Differences in head accelerations and physiological demand between live and simulated professional horse racing," *Comparative Exercise Physiology*, vol. 15, no. 4, pp. 259–268, 2019.

[13] K. Fenner, M. Hyde, and A. Crean, "Identifying sources of potential bias when using online survey data to explore horse training, management, and behaviour: a systematic literature review," *Veterinary Sciences*, vol. 7, no. 3, pp. 18–33, 2020.

[14] Z. Sun and Y. Li, "Research on Chinese speed horse racing guessing lottery issuance based on internet big data," *Design Engineering*, vol. 183, no. 59, pp. 405–476, 2020.

[15] B. Padalino, S. L. Raidal, and E. Hall, "Survey of horse transportation in Australia: issues and practice," *Australian Veterinary Journal*, vol. 94, no. 10, pp. 349–357, 2016.

[16] S. V. R. Hoseini and M. Amani, "Impact of constraints and behavioral motivations on loyalty of horse racing spectators," *Journal of History Culture and Art Research*, vol. 7, no. 2, pp. 14–27, 2018.

[17] Y. Xiao, C. Xing, and T. Zhang, "An intrusion detection model based on feature reduction and convolutional neural networks," *IEEE Access*, vol. 117, no. 2, pp. 103–187, 2019.

[18] R. Y. Chen, "A traceability chain algorithm for artificial neural networks using T–S fuzzy cognitive maps in blockchain," *Future Generation Computer Systems*, vol. 183, no. 23, pp. 109–119, 2018.

[19] M. Hahsler and R. Karpienko, "Visualizing association rules in hierarchical groups," *Journal of Business Economics*, vol. 87, no. 3, pp. 317–335, 2017.

[20] T. Osadchiy, I. Poliakov, and P. Olivier, "Recommender system based on pairwise association rule," *Expert Systems with Applications*, vol. 115, no. 12, pp. 1871–1888, 2019.

[21] R. Rekik, I. Kallel, and J. Casillas, "Assessing web sites quality: A systematic literature review by text and association rules mining," *International Journal of Information Management*, vol. 38, no. 1, pp. 201–216, 2018.