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The Estimation of the Set Results in 2016/2017 Vestel Venus Sultans League Games by Artificial Neural Network

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Abstract: The objective of this study is to estimate the set result via Artificial Neural Network (ANN) by considering the scores of the volleyball teams at technical time-outs (8th and 16th points) and 21st point. In the study, 132 games, 984 sets and 4152 points that were played and scored during a season by 12 teams playing in 2016/2017 Vestel Venus Sultans League were examined separately. 85% of all sets that teams played in one season were randomly reserved for training and 15% for test. Verbally winning or losing was modeled as 0 (zero) or 1 (one) numerically. Since the produced value was between the ranges of 0 – 1, for a trained network, it was multiplied with 100 and thus the possibility of winning was obtained. Consequently, it was determined that the developed model estimated the set result for many teams (test dataset) with an accuracy rate over 95%. By means of competition analysis to be made using ANN model in volleyball, it is thought that technical officers can reach fast and accurate conclusions at the moment of the set is played. It can be said that these conclusions will provide technical officers with a warning mechanism to take necessary technical and tactical measures while the set is being played.

Keywords: artificial neural network; estimation; volleyball

1. Introduction

Today, as in all branches of sports, different fields such as training sciences, health and technology are used to achieve success in volleyball. Recently, the increase in the use of digital technologies for different purposes such as technical improvement, statistics and analysis in volleyball is attracted attention. Especially competition analysis programs are commonly used by an expert assistant coach in the technical team (Fernandez-Echeverria et al., 2017; Palao & Hernández-Hernández, 2014). In many studies conducted on analysis programs, programs are considered as useful by coaches (Palao & Hernandez-Hernandez, 2014; Joao et al., 2019). Therefore, it has become possible to reach a great number of data by analysis programs developed as special to the branch. These data help coaches in matters such as planning trainings, determining the team tactics and reaching the statistical information of the opposing team (Baacke, 2005).

Artificial neural networks are the systems that operate in a way that can process the data trying to model the main features of the brain based on the biological neural network formed by many nerve cells in human brain. Artificial neural networks, which is applied by simulating electronic circuits or computer software, is a parallel distributed processor having the skills such as collecting information and storing it by intercellular links as it is in the brain's method of processing the information (Sağıroğlu et al., 2003). The ability of ANN to anticipate future situations help revealing the unknown relationships of the data between each other or the mutual relation that is difficult to be understood. In order to train the ANN and achieve the target results, intensive input and output sequences are required. According to the characteristics of human brain, ANN can be applied in fields such as analyzing, generalizing, associating, optimization, learning and classifying successfully (Öztemel, 2003). Artificial neural networks have found a wide range of application in the modeling and control of complex systems due to its advantages such as learning simple structures specific to the problem, generalization, the abilities of parallel processing and tolerating errors, and presenting easy solutions to non-linear complex problems that are difficult to be modeled (Sağıroğlu et al., 2003).

The high number of data obtained from the analysis programs used in volleyball can be considered as a limiting factor in achieving fast and accurate inferences. It is thought that the data to be obtained by an analysis performed via ANN model during the competition will be more objective and faster. When the literature was reviewed, it was seen that evaluations regarding volleyball by using ANN model were limited (Kautz et al., 2017; Koch & Tilp, 2009; Jörg et al., 2017; Tümer & Koçer, 2017). In addition, no study that was conducted to predict sets in volleyball using artificial intelligence applications was found. Thus, the objective of this study is to estimate the set result by ANN model according to the technical time-outs of the teams in the played set and the scores they get until the 21st point.

2. Materials and Methods

Model Variables —

Team Ranking — There are 12 teams in the volleyball league, and they are ranked between the range of 1 and 12 according to the total points in the end of the season. The team ranking variable among the model variables was created by the classification of the 12 teams in 3 groups. In this classification, teams were categorized as the 1st group (1st, 2nd, 3rd and 4th teams), 2nd group (5th, 6th, 7th and 8th teams) and 3rd group (9th, 10th, 11th and 12th teams). Being based on this, the group including the opposing team was used categorically in the team ranking input variable.

Played Set — In the volleyball game, the team reaching the 25th point with at least 2 points difference wins the set. In case of the tie of 24-24 or 25-25 in the set, the game continues until reaching 2 points of difference. In order the teams to win the game; they should win at least 3 sets. If there are 2-2 ties in the game, then a decision set of 15 points is played. If there are 14-14 ties in this set, the team reaching 2 points of difference wins the final set and the game (FIVB, 2019). The set number used in the model can get 5 values categorically. This variable was added to the network model by being predicted as a parameter to affect the set result since the teams' motivations can be different due to the existing score according to the played set.

1st Technical Time-Out — The 1st technical time-out, according to the rules, is given by referees in the case of one of the teams' reaching the 8th point. The difference value occurred in technical time-outs is one of the most important parameters used in the estimation of the set score. When the 1st technical time-out is reached, if the point difference is in favor of the host, it is stated as positive, and if it is in favor of the opposing team, negative. For instance, when X and Y teams are playing, if the score is 6 for X team and 8 for Y team at the 1st technical time out, the 1st technical time-out variable is included in the model as (-2). In

the games with a high difficulty level, the difference is very little.

2nd Technical Time-Out — The 2nd technical time-out, according to the rules, is given by referees when one of the teams reaches to the 16th point. If the point difference is in favor of the host, it is stated as positive, and if it is in favor of the opposing team, negative. For instance, when X and Y teams were playing, if the score is 16 for X team and 8 for Y team at the 2nd technical time-out, 2nd technical time-out variable is included in the model as (8).

21st Point — It is possible to get the scores of the teams at the 8th, 16th and 21st points in the game report. The 21st point is a score recorded to the game report automatically by the game analysis program. As it is in the 1st and 2nd technical time-outs, when one of the teams reached to the 21st point, the current scores of the teams are recorded to the game report by the game analysis program. As it is in the other time-outs, the score difference of the teams is recorded as the 21st point variable.

Since the data used in this study are the values of 2016-2017 season, according to the technical time-out rule of the related season, technical time-outs were given automatically in the first 4 sets when the sets reach at the 8th and 16th points, and at the 5th set, when they reach at the 8th point. However, this rule was changed by Turkish Volleyball Federation at the end of the season, and now technical time-outs are given only at the 12th points.

Game Data and Analysis — The data used in the study were obtained by the analysis of the 132 games, 984 sets and 4152 points played and scored by the 12 teams in Vestel Venus Sultans League in 2016-2017 season. The play-off games played for the league ranking at the end of the season were not included in the study, and only the games in the season were included. Since the numbers of the sets in the games were not the same, the number of the training/test data were not fixed. The numbers of the sets were introduced in table 1. 85% of the all sets played by a team in a season were reserved for training, and 15% for test. Separation process was performed randomly.

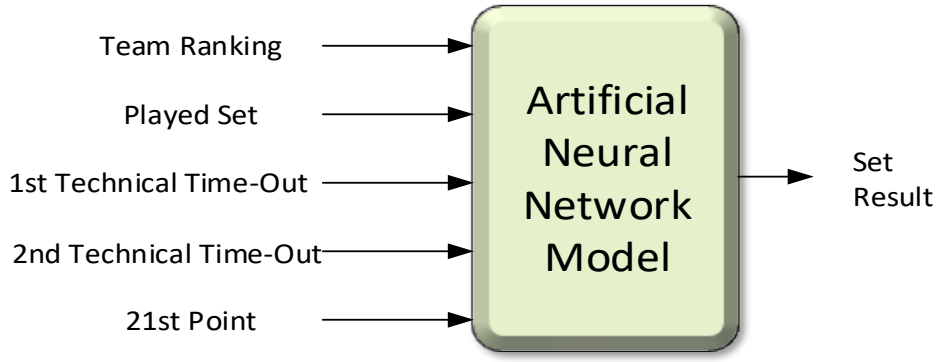

Figure 1. Artificial neural networks model developed for set result estimation.

3. Results

Modeling Results with Artificial Neural Networks

R2 and mean squared error (MSE) results, which are among the indicators by which the performance of the developed model can be evaluated, are presented in table 1. total set number each team played is introduced for information, and it is added only to state the size of the data set. Different network structures were tried, and the hidden layer neuron numbers are in the network structure which gave the best results are presented in network structure columns. R2 and MSE results were calculated for training and test data sets separately.

R2, which is one of the performance indicators of the developed model, presents the correlation / relation power of the model with real values. In other words, the

developed model reveals a performance of above 95% for training and test data sets. MSE is the mean of the differences between the real values and estimated values of the model.

The model was developed by MATLAB, and the graphs of the performance indicator were presented in figures 2, 3 and 4. Training and test results of the ANN model of the Team 1 are presented in Figure 2, Team 6's results are in Figure 3, and Team 12's results are in Figure 4. The results of the first, middle and last teams are given for sample. Similar curves exist for all teams and they can be presented when required. Since the output variable was modeled as winning or losing the game, there are no other values except for 0 and 1. At the end of the training of the model, the rate of winning can be obtained for each team according to the input variables. In other words, the possibility of winning the game can be provided according to the technical time-outs during the game.

When Figure 2 is examined, it is seen that wined games are predominant and they were estimated accurately to a large extent in test result graph. In contrast, it was estimated that the lost games would be won by approximately 45%. Considering that the team is the top of the league and the number of sets lost is quite low, it is understandable that the model made mistakes in this way.

When Figure 3 is analyzed, it is seen that the team that finished the league in sixth place had very high estimation results for both training and test data. The fact that won and lost games were estimated quite close to the result by the developed model can be understood from the linearity and the high rate of intersection of the data clearly.

When Figure 4 was analyzed, it was found that the consistency of the training values of the team completing the league last was better, but test data did not reveal the same performance. The reason of this situation can be evaluated as a result of the inconsistency of the team's winning and losing performance. While the team loses the set they can win; they can also win the set they may lose inconsistently. In this situation, it is seen that it is difficult to model the team, and the results have lower estimation rates.

Table 1. R^2 and mean squared error results of the developed artificial neural networks model.

Team No	Number of the set played	Network Structure		R^2		MSE	
		1. Hidden Layer	2. Hidden Layer	Training	Test	Training	Test
1	71	10	5	0,9907	0,9992	2,20E-01	2,22E-02
2	86	20	15	0,9764	0,9982	1,05E-02	1,00E-03
3	81	10	10	0,9674	0,9590	1,25E-02	1,92E-02
4	80	10	5	0,9999	0,9978	2,32E-06	1,30E-03
5	82	10	5	0,9536	0,9983	2,27E-02	8,61E-04
6	87	10	5	0,9985	0,9909	7,64E-04	6,70E-03
7	80	10	5	0,9990	0,9985	5,83E-04	1,00E-03
8	86	10	5	0,9730	0,9961	1,34E-02	1,30E-03
9	76	10	5	0,9630	0,9999	1,52E-02	1,20E-08
10	88	10	5	0,9924	0,9555	4,20E-03	4,24E-02
11	81	10	5	0,9721	0,9554	1,05E-02	1,82E-02
12	80	10	8	0,9985	0,9831	7,01E-04	5,91E-02

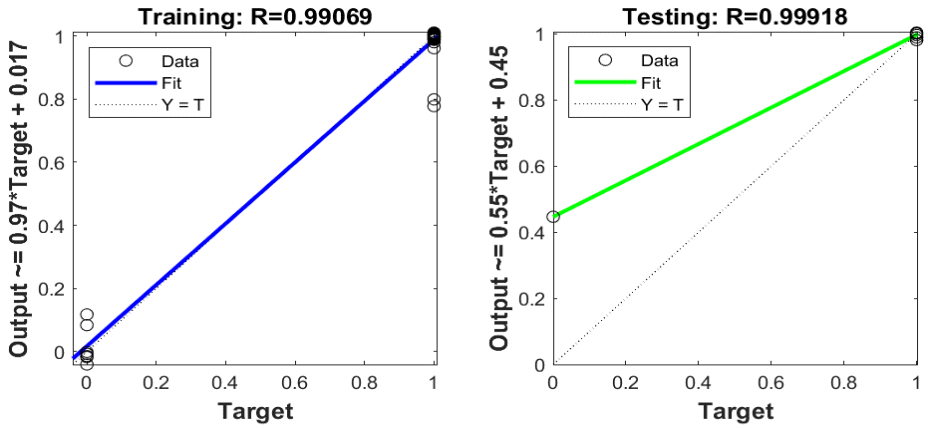

Figure 2. Training and test results obtained from modeling Team 1 set scores.

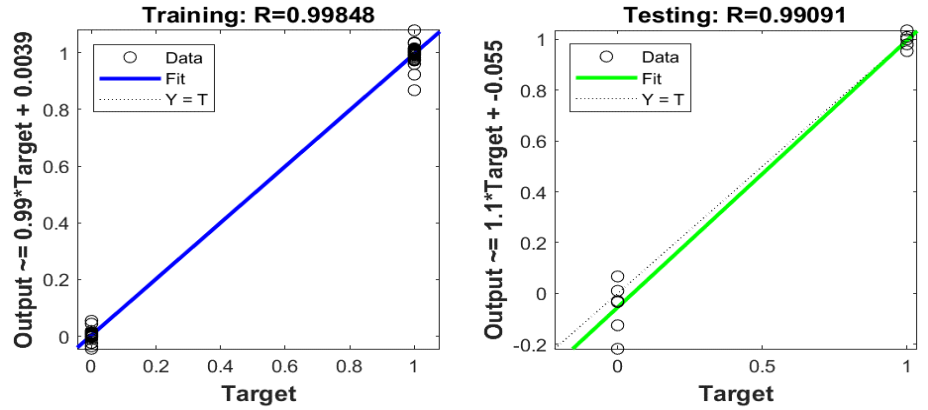

Figure 3. Training and test results obtained from the modeling of the set scores of the team 6

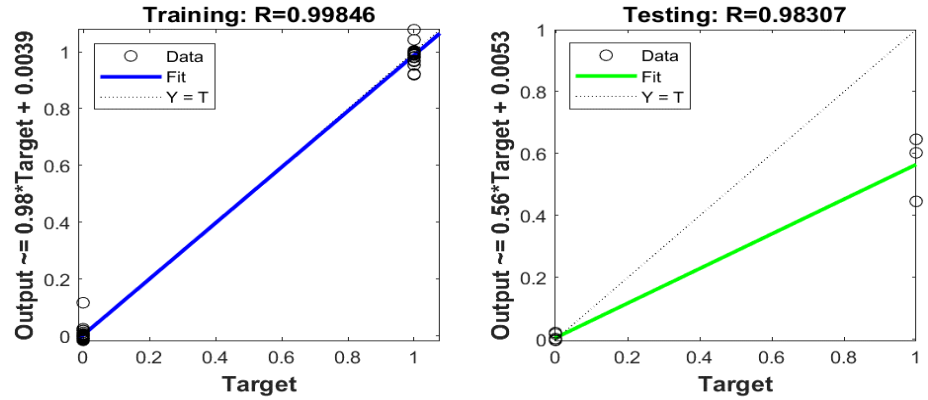

Figure 4. Training and test results obtained from modeling the set scores of Team 12.

4. Discussion

This study was conducted to estimate the set result via Artificial Neural Network (ANN). The scores of the 12 elite women volleyball teams at the technical time-outs (8th and 16th points) and at the 21st point in all sets in 132 games were considered as input variables. A model was developed to estimate the results of the sets played by the teams in the study depending on some parameters. Instead of stating the model mathematically, the design created by using ANN having 'closed box' structure was preferred. As input variables, the number of the set of the game, the group of four in which the opponent was included and the point differences occurred at technical time-outs were determined. The output variable is chosen as winning or losing the match, with 1 and 0. According to the study results,

it was determined that set score could be estimated with 95% of accuracy when the input parameters of the teams were given. The fact that the effect of the field studies of the data obtained by classical analysis methods was limited (Sarmento et al., 2015) is a restrictive situation for trainers to decide depending on these data (Wright et al., 2014). Also, the fact that the performance component has a complex structure consisting of many parameters (Drikos et al., 2009) causes the performance to be variable and difficult to be estimated (González-Silva et al., 1997; Sánchez-Moreno et al., 2015). However, it is thought that the analysis performed by ANN model will be a determinant in trainers' decisions both about the performance of the players and time-out and game system during the game. During the sets played in the competitions, the head coaches and assistant coaches can continuously monitor the numerical data of both their own team and the opposing team through computer aided programs. Determining whether going ahead in technical time-outs at the 8th or 16th points creates an advantage for the teams may enable the coaches to use different strategies. In the 2016/2017 season, when the study data were collected, the technical time-out rule was applied for the 8th and 16th points, but this rule was changed by the TVF (Turkish Volleyball Federation) as the technical time-out at only 12th point in a set (www.tvf.org.tr). Despite the change of the rule, it is thought that being ahead or behind at the 8th, 16th and 21st points of the set will provide more tactical strategy for coaches. In addition, being ahead or behind at the beginning, in the middle and at the end of the set in volleyball can have some psychological effects on the players. This situation reveals the assumption that athletes should be prepared not only technically-tactically but also psychologically during training. Therefore, the inferences to be made according to the set score in technical time-outs and at the 21st point can guide the coaches for correct analysis in technical, tactical and mental aspects both in the competition and training processes.

No study on the evaluation of the set results in volleyball by ANN model was found in the literature, and the studies for the evaluation of the games of other branches were limited. In a similar study, Akarçeşme et al., (2020) predicted the volleyball team ranking in the Rio Olympics via the ANN model developed according to nine different input variables. Volleyball team ranking in the Rio Olympics was predicted with an accuracy of over 98% in women's category and over 99% in men's via the ANN model developed as a result of the study by Akarçeşme et al., (2020). In another study, Tümer & Koçer (2017) predicted Turkish Volleyball League with an accuracy of 98% by using ANN model (Tümer & Koçer, 2017). The results obtained in these studies support our results in terms of estimating league ranking and game results by ANN and high rate of inference determined.

The number of competition analysis studies to determine the winner in volleyball is quite high. The increase in numerical data, especially with the development of competition analysis programs, facilitated objective evaluations for coaches and sports scientists. While some of these studies searched for the effects of the technical elements on the set or game result (Afonso et al., 2010; Akarçeşme, 2017; Alexandros & Athanasios, 2011; Costa et al., 2017; Florence et al., 2008; González-Silva et al., 2020; Hughes & Bartlett, 2002; Marcelino et al., 2012), others made comparisons between genders (Sotiropoulos et al., 2019; Kountouris et al., 2015). The common aim of the researchers is to make common inferences from the high number of statistical data obtained. However, when the methods of the literature studies reviewed are examined, there are no studies on technical time-outs that are carried out with artificial neural networks and try to determine the team that is ahead in different stages of the game. Although this adds originality to the study, it leads to limitations in the results of the study.

5. Conclusions

As a consequence, the set results in volleyball games were estimated with a high accuracy (95%) by ANN model using the points gained until technical time-outs. It is thought that, by means of these inferences, necessary technical and tactical interference can be possible for trainers during the set. Also, it can be stated that the analysis done by ANN model can be a warning mechanism for time-outs and player substitutions for technical officers when their teams reached at the 8th, 16th and 21st points. Analyses performed by ANN model can be evaluated as a factor increasing team performance when they are evaluated for their effects on game results. They can also be a guide to reidentify the offensive and defensive organizations according to the analyses performed after games.

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