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Detecting Human Behavioral Pattern in Rock, Paper, Scissors Game Using Artificial Intelligence

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ABSTRACT

As entertainment tools, computer games are important phenomena in the world, which are considered as a popular medium, an effective educational solution and a considerable economy resource. In this paper, Multi-Layer perceptron (MLP) neural network was used to detect human behavior pattern in rock, paper, scissors game. The similarity of artificial neural networks (ANNs) to the human brain is the main motivation of this study. MATLAB software was used to implement the network code. These codes consisted of two phases: 1) training the ANN to learn the human behavioral pattern considering forty games. 2) real play against a human by doing ten games. After the implementation of the network, its effectiveness in detecting human behavioral patterns was investigated. The network was tested on 40 people (20 women and 20 men). Each player played with the target network in three stages. The results of this study showed that the win percentage of computers with MLP neural network was 57.5% for men and 60.8% for women. While the percentage of the computer without neural networks and with random selections in 60 games was 52.5% for men and 42.5% for women.

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1. Introduction

Playing games is a voluntary activity aimed at recreation and leisure. A game consists of a set of players, their moves or ways, a set of rules that each player tries to use to win the game. Games are often well-known and have social, climatic and cultural contexts [1]. One of the most popular games is the rock paper scissors game.

Rock, paper, scissors is a simple and traditional game played by players' hand, and people of all ages can enjoy it. This two-player game is usually used as a way of starting the beginning of other games [2]. This game describes cyclic dominance three competing species in social network, economics and biological systems. It is a famous three-strategy game [3]. Each player turns their hand to one of the three allowed modes, rock, paper or scissors, shown in Figure 1. The general rule of this classic game is: The rock will break the scissors, the paper will break the scissors and the paper will break the rock. This game is a adaptive, meaning that the strategy used by each player changes over time [4].

Fig. 1. The general rule of Rock paper scissors game.

Psychologically, the behavior of people who play this game is based on an accident, and all they all can do is throw out whatever comes to their mind. Therefore, the Rock Paper Scissors Game is a good model for testing and investigating the theory of human short-term memory behavior [2]. Many concepts and examples in game theory can provide useful models for the development of abstract evolutionary systems [2]. Some of these systems and strategies are used to create an intelligent smart rock, paper, scissors game player. A common need for intelligent player development is the need to adapt their behavior to that of other players [4]. This is very important in the gaming industry as creating adapting and intelligent players regarding the rival can increase the game's difficulty level. Many studies have been carried out in this area so far.

2. Review of literature

Fathelalem et al. used genetic algorithms to train intelligent players in Rock paper scissors game. In this way, instead of impartial decisions, a rule is taken so that the results of the games can be seen in the past few times, and then decisions are made based on that. Such a strategy is coded

with a genetic sequence, generating good sequences in subsequent generations, and eventually developing an evolved system for intelligent player training [2]. DeSouza et al., using the WIZARD weightless neural network, proposed a suitable strategy for the creation of intelligent rock, paper, and scissors players. This strategy includes a new function for encoding the input data, three new training algorithms to classify the input patterns over time, and a method for dealing with incomplete information in the input arrays [4]. Cenggoro et al., proposed a method for detecting human behavior patterns in rock paper scissors game using feed-forward neural network [5]. Salvetti et al. proposed a new method for predicting the right moment to use rock, paper or scissors during the game based on Local Lyapunov Exponent (LLE) and Entropy indices. In this way, the emphasis is not on predicting the opponent's future behavior per se, but on predicting the best moment. The best moment is the moment when the future behavior of the opponent is more predictable. Then, the intelligent player makes a choice to defeat the other player [6]. Chen et al, applied image processing techniques to detect hand postures (rock, paper, scissors). In this method, the hand image is extracted from successive photographs, and then the overall threshold and skin color are used to produce binary image and filter interference. Finally, the distance between the two fingers is used to prevent error, which is difficult to detect the scissor condition in some cases and segmentation techniques, skin color, histogram and angle criteria have been used to solve this problem [7]. Matsumoto et al. developed a program to classify validation criteria for automatic judgment in Rock paper scissors game. In this work, first, the number and locations of hands in rock, paper, scissors (RPS) images are estimated using C_Means classification with valid clustering methods, and then the winner and loser judgments are made according to the difference between categories compression [8]. Hasuda et al. designed a robot that performs the rock paper scissors game in front of a human. This designed robot is capable of expressing emotions through sound, body movements and facial expressions that vary depending on game results [9]. Gang et al. proposed a method for classifying EMG signals by hand modes (rock, paper, scissors) using a multilayer perceptron. In this method, the EMGs are applied to the He-zajac-levine two-way activation model; then the model output was used for MLP inputs and finally, the MLP could classify three different hand modes with high accuracy [10].

In this paper, Multi-Layer perceptron (MLP) Artificial neural networks were used to create intelligent players for rock, paper, scissors game. This algorithm detects the behavioral pattern of the human in the next game and then provides an appropriate response to defeat him. Then, the network's effectiveness in recognizing players' behavior patterns and computer win percentage was investigated. In addition, the percentage of PC wins without a neural network was calculated with completely random choices in the real human-game.

3. Simulation structure

3.1. Artificial neural networks

Artificial neural networks (ANN) is an idea for information processing that is inspired by the biological nervous system and processes information like the human brain. Therefore, it has abilities that look like the human brain.

Based on this assumption:

1) Information processing occurs in simple elements called neurons.

2) The signals are transmitted between the neurons on the junctions.

3) Each link has a related weight that multiplies the transmitted signals in the neural network.

4) Each neuron applies an activator function to its input to determine the output signal [11].

Computer scientists use these networks to perform complex tasks such as analytical prediction, planning, and recognizing user behavior patterns.

3.1. Multi-layer perceptron network (MLP)

Multilayer perceptron network (MLP) is the most widely used type of multilayer neural network that is a Feedforward network with at least three layers: one input layer, one or several hidden layers, and one output layer [12]. Each layer has at least 1 neuron. The neurons in each layer connected to all the neurons in the next layer. The backpropagation algorithm is the most widely used method for teaching multilayer networks [13]. The MLP network structure designed to detect the human behavior pattern is shown in Figure 2.

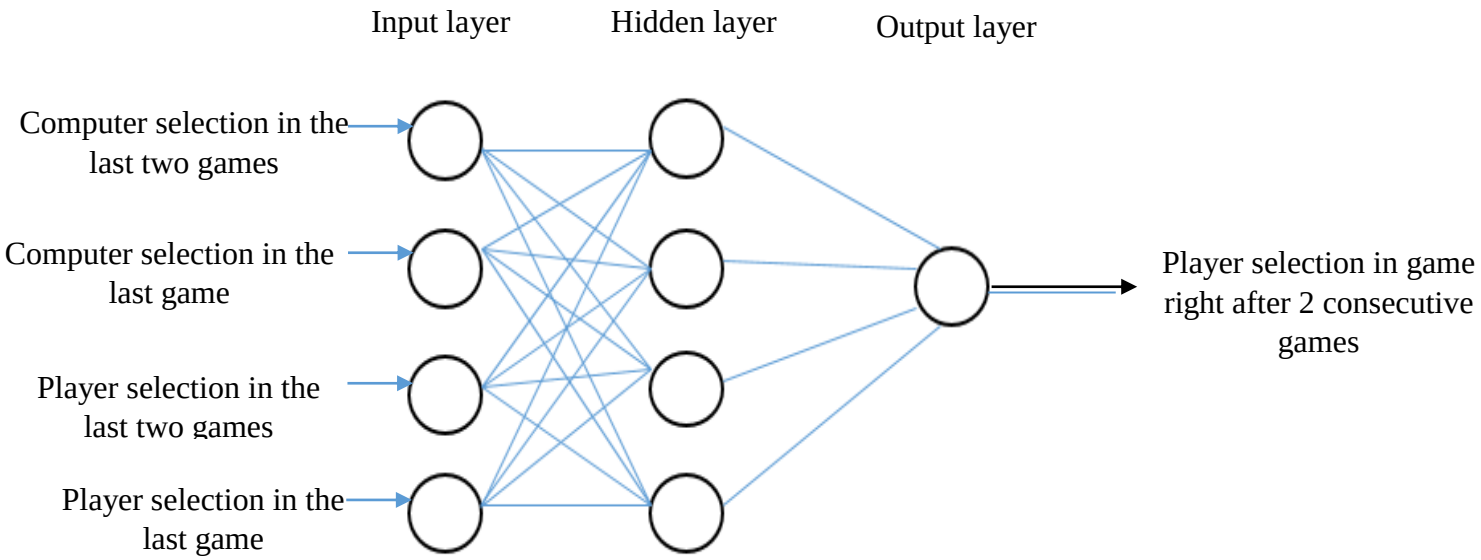


Fig. 2. MLP network structure designed to detect human behavior patterns.

As shown in Fig. 2, the designed input network layer has four neurons that are computer and player choices in two consecutive games. The target output of this network is player selections in the game just after two consecutive games.

Table 1 shows the characteristics of the artificial network designed to detect human behavioral patterns.

Table 1

Artificial grid specifications designed to detect human behavior patterns.

Applied network	**MLP**
The number of neurons in the input layer	4
The number of neurons in the hidden layer	4
The number of neurons in the output layer	1
Epochs Count	60
Activation function	Tansig

3.2. Game design algorithm

The game design algorithm consists of two phases:

1) Neural network training 2) Real game

The flowchart design of the Rock paper scissors game with a neural network is shown in Figure 3.

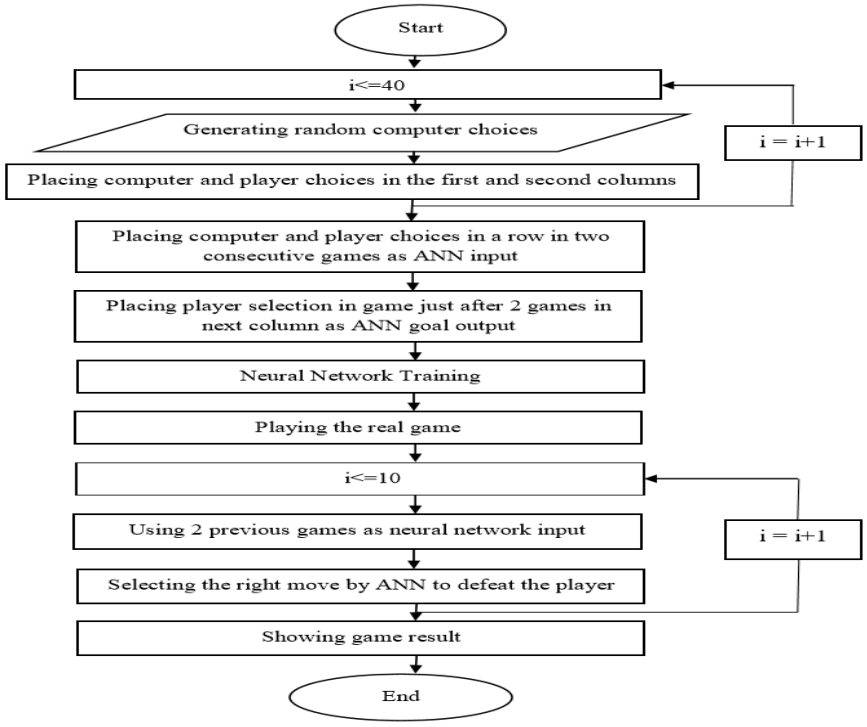


Fig. 3. Flowchart of rock, paper, scissors game designed with the neural network.

3.2.1. First phase

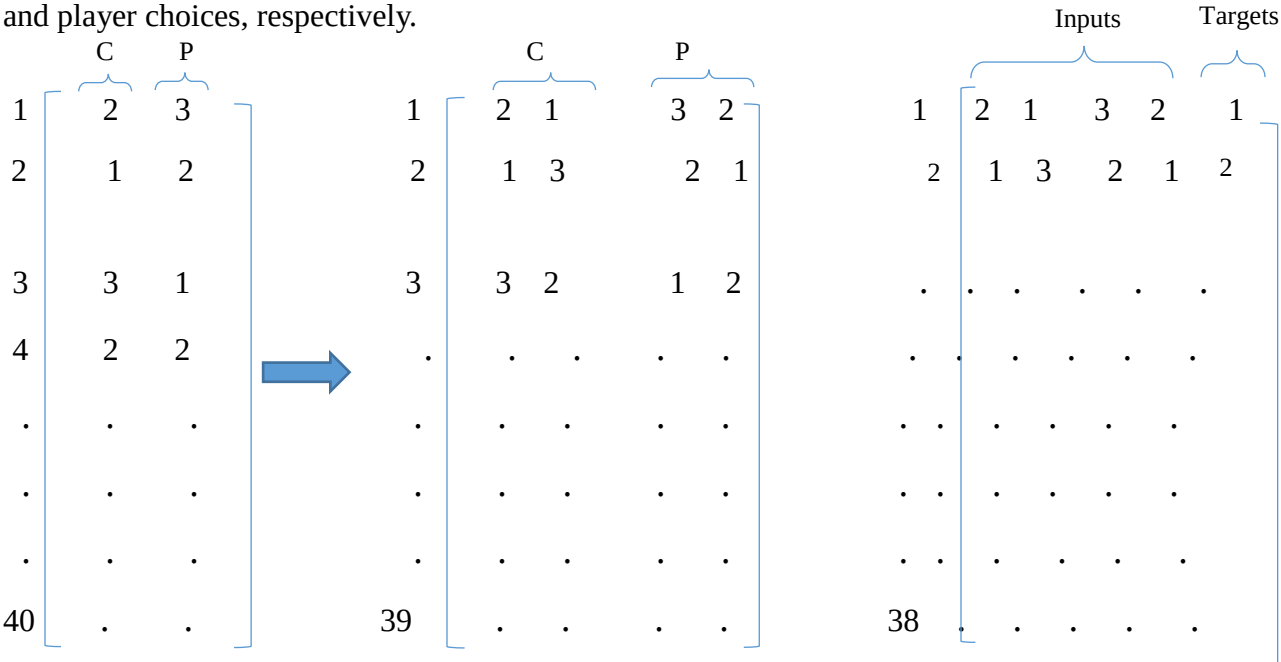
The first phase in the proposed algorithm was that the ANN could learn the general pattern of player behavior. People can not produce random numbers. In the rock, paper, scissors game, the player's choice is usually influenced by the two previous choices. Forty matches are played

between the computer and the player at this stage. All computer choices are random. The input data matrix for training and testing the network in this phase will be formed simultaneously with the computer and player games. Therefore, the input data is different depending on the computer and player choices in each game. The index defines each of the hand modes in Table 2.

Table 2
Hand modes.

Hand modes	Index
Rock	1
Paper	2
Scissor	3

The steps of forming the Input Data Matrix and Target Output are as follows:
1. In the first step, a matrix of 40 rows and two columns is formed. The first and second columns are the computer and player selections, respectively.
2. In the second step, the matrix is written in another way so that the first and second choices of the computer and player (in two consecutive games) are in the first row and then the second and third choices in the next row. The process continues until the 40th game. Finally, the new matrix is transformed into a matrix with 39 rows and four columns.
3. In the third step, another column is added to the previous matrix to place the target output. This column is the player selection in the game just after two consecutive games. Finally, the matrix of the preceding step is transformed into a matrix with 38 rows and five columns.
4. In the last step, the first to fourth columns are considered as Input data and the fifth column as Target output. For example, suppose the computer and player choices are as follows.
The steps of matrix formation are shown in Fig. 4. In the figure below, c and p are the computer and player choices, respectively.



To develop the ANN model, the whole data was divided into three categories: 70% for training, 15% for testing and 15% for validation.

3.2.2. The second phase

After the neural network has learned the general pattern of player behavior, it is ready for the real game against the player. There are ten games (41 to 50) for this stage. In the real game, the ANN will use the player and computer choices in the previous two consecutive games as input data and will predict the player's behavior in the game just after the two games and then make a choice to defeat the player. For example, in Game 41, player and computer choices in Game 39 and 40 (2 consecutive games) will be given to the neural network to predict player behavior.

In the real game, the neural network's effectiveness in detecting human behavior patterns and the percentage of computer wins will be determined.

Next, another program was written without the neural network for Rock paper scissors game in front of humans. The purpose of this work is to determine the percentage of PC wins without neural networks. In order to create the same conditions as the neural network, 50 games are played between the computer and the player, and the last ten games were considered the real games. All computer choices in this program are random.

4. Results

The Multi-Layer perceptron neural network designed to detect human behavior patterns was tested among 40 individuals (20 females and 20 males). Each player played with the target network during three stages. The percentage of computer wins and ANN's effectiveness in defeating players were calculated. According to the results presented in Tables 3 and 4, the win percentage of a computer with MLP neural network for 60 games was 57.5% for men and 60.8% for women. While the percentage of wins without a neural network between male and female players with the same number of games were 52.5% and 42.5%, respectively. The input data of the MLP network varies according to the game strategies used by each player overtime. The response of MLP network is not definite and constant and in this network the probability of overtrain is high. Therefore, it can not be expected that the win percentage over 60% from this type of network. The results showed that the neural network performed well in detecting human behavior pattern in Rock paper scissors game. The network's effectiveness in defeating female players is greater than that of male players.

Table 3
Game results and computer winning percentage in men with and without neural network.

Name	Age	Education	Game results						Computer winning percentage	
			With neural network			Without neural network			With neural network	Without neural network
			1	2	3	1	2	3		
1.Mohsen Jabari	33	P.H.D	Me: 3 You:3 Tie:4	Me:9 You:0 Tie:1	Me:3 You:2 Tie:5	Me:2 You:6 Tie:2	Me:3 You:5 Tie:2	Me:4 You:2 Tie:4	83.33%	33.33%
2.Saman Asadi	31	Masters	Me:3 You:5 Tie:2	Me:6 You:2 Tie:2	Me:2 You:3 Tie:5	Me:5 You:1 Tie:4	Me:6 You:2 Tie:2	Me:0 You:6 Tie:4	33.33%	66.66%

3.Bahram Azimi	41	Bachelor	Me:3 You:2 Tie:5	Me:2 You:5 Tie:3	Me:3 You:3 Tie:4	Me:1 You:4 Tie:5	Me:6 You:3 Tie:1	Me:3 You:4 Tie:3	50%	33.33%
4.Sadegh Qasemi	60	Masters	Me:2 You:4 Tie:4	Me:4 You:4 Tie:2	Me:3 You:5 Tie:2	Me:3 You:5 Tie:2	Me:5 You:4 Tie:1	Me:4 You:4 Tie:2	16.66%	50%
5. Amin Ghasri Tabar	16	student	Me:4 You:2 Tie:4	Me:2 You:4 Tie:4	Me:4 You:4 Tie:2	Me:3 You:5 Tie:2	Me:4 You:2 Tie:4	Me:3 You:6 Tie:1	50%	33.33%
6.Sadegh Rahimi	30	Bachelor	Me:7 You:3 Tie:0	Me:4 You:3 Tie:3	Me:4 You:3 Tie:3	Me:4 You:2 Tie:4	Me:4 You:3 Tie:3	Me:3 You:3 Tie:4	100%	83.33%
7.Milad Darabi	31	Bachelor	Me:2 You:1 Tie:7	Me:3 You:2 Tie:5	Me:3 You:3 Tie:4	Me:4 You:2 Tie:4	Me:5 You:2 Tie:3	Me:4 You:2 Tie:4	83.33%	100%
8.Ehsan Khanjari	27	Bachelor	Me:5 You:4 Tie:1	Me:4 You:3 Tie:3	Me:4 You:5 Tie:1	Me:2 You:5 Tie:3	Me:4 You:2 Tie:4	Me:5 You:3 Tie:2	66.66%	66.66%
9. Ali Qasemi	24	Bachelor	Me:5 You:2 Tie:3	Me:3 You:3 Tie:4	Me:0 You:5 Tie:5	Me:3 You:5 Tie:2	Me:3 You:4 Tie:3	Me:3 You:3 Tie:4	50%	16.66%
10.Amin Haghparast	31	Masters	Me:4 You:0 Tie:6	Me:3 You:4 Tie:3	Me:3 You:2 Tie:5	Me:4 You:2 Tie:4	Me:5 You:2 Tie:3	Me:5 You:2 Tie:3	66.66%	100%

Name	**Age**	**Education**	**Game results**						**Computer winning percentage**	
			With neural network			**Without neural network**			**With neural network**	**Without neural network**
			1	**2**	**3**	**1**	**2**	**3**		
11.Mohammad Sharifi	30	Bachelor	Me:2 You:3 Tie:5	Me:1 You:9 Tie:0	Me:2 You:3 Tie:5	Me:3 You:4 Tie:3	Me:5 You:1 Tie:4	Me:0 You:5 Tie:5	0%	33.33%
12. Reza Hosseini	28	Bachelor	Me:0 You:4 Tie:6	Me:4 You:2 Tie:4	Me:3 You:2 Tie:5	Me:4 You:2 Tie:4	Me:4 You:4 Tie:2	Me:3 You:4 Tie:3	66.66%	50%
13. Emad Qasemi	29	Masters	Me:3 You:6 Tie:1	Me:3 You:2 Tie:5	Me:2 You:1 Tie:7	Me:3 You:5 Tie:2	Me:3 You:3 Tie:4	Me:3 You:6 Tie:1	66.66%	16.66%
14.Mohammad Haddadi	21	Bachelor	Me:5 You:4 Tie:1	Me:3 You:3 Tie:4	Me:3 You:3 Tie:4	Me:2 You:4 Tie:4	Me:2 You:4 Tie:4	Me:5 You:2 Tie:3	66.66%	33.33%
15. Arslan Asgari	27	Bachelor	Me:2 You:5 Tie:3	Me:2 You:4 Tie:4	Me:6 You:3 Tie:1	Me:4 You:1 Tie:5	Me:3 You:3 Tie:4	Me:3 You:3 Tie:4	33.33%	66.66%
16. Ali Khosravi	50	P.H.D	Me:3 You:4 Tie:3	Me:0 You:0 Tie:10	Me:2 You:1 Tie:7	Me:2 You:4 Tie:4	Me:0 You:4 Tie:6	Me:3 You:7 Tie:0	50%	0%
17. Said veisi	26	Bachelor	Me:4 You:2 Tie:4	Me:3 You:2 Tie:5	Me:4 You:3 Tie:3	Me:6 You:0 Tie:4	Me:3 You:4 Tie:3	Me:3 You:5 Tie:2	100%	33.33%
18.Mohammad Khosravi	22	Bachelor	Me:2 You:6 Tie:2	Me:1 You:3 Tie:6	Me:5 You:4 Tie:1	Me:5 You:4 Tie:1	Me:4 You:2 Tie:4	Me:3 You:1 Tie:6	33.33%	100%

19.Moein Feizollahi	34	Bachelor	Me:6 You:1 Tie:3	Me:4 You:4 Tie:2	Me:2 You:5 Tie:3	Me:3 You:2 Tie:5	Me:3 You:0 Tie:7	Me:4 You:4 Tie:2	50%	83.33%
20.Amir Mohammad Karimi	13	student	Me:0 You:6 Tie:4	Me:4 You:4 Tie:2	Me:6 You:1 Tie:3	Me:5 You:2 Tie:3	Me:2 You:3 Tie:5	Me:3 You:3 Tie:4	50%	50%

Table 4
Game results and computer winning percentage in women with and without the neural network.

Name	**Age**	**Education**	**Game results**						**Computer winning percentage**	
			With neural network			**Without neural network**			**With neural network**	**Without neural network**
			1	**2**	**3**	**1**	**2**	**3**		
1.Pardis Karimi	24	Masters	Me:4 You:3 Tie:3	Me:1 You:5 Tie:4	Me:5 You:2 Tie:3	Me:2 You:6 Tie:2	Me:6 You:3 Tie:1	Me:3 You:4 Tie:3	66.66%	33.33%
2.Mahya Ghorbani	27	Bachelor	Me:6 You:3 Tie:1	Me:3 You:3 Tie:4	Me:2 You:4 Tie:4	Me:3 You:6 Tie:1	Me:3 You:4 Tie:3	Me:3 You:5 Tie:2	50%	0%

Table 4
(continued). Game results and computer winning percentage in women with and without the neural network.

Name	**Age**	**Education**	**Game results**						**Computer winning percentage**	
			With neural network			**Without neural network**			**With neural network**	**Without neural network**
			1	**2**	**3**	**1**	**2**	**3**		
3.Niusha Sayad	24	Masters	Me:3 You:1 Tie:6	Me:1 You:6 Tie:3	Me:2 You:4 Tie:4	Me:3 You:3 Tie:4	Me:1 You:3 Tie:6	Me:5 You:1 Tie:4	33.33%	50%
4.Mahsa Sharifi	30	P.H.D	Me:4 You:3 Tie:3	Me:2 You:4 Tie: 4	Me:5 You:4 Tie:1	Me:4 You:5 Tie:1	Me:4 You:4 Tie:2	Me:2 You:6 Tie:2	66.66%	16.66%
5.Fatemeh Razmgir	23	Bachelor	Me:2 You:3 Tie:5	Me:5 You:2 Tie:3	Me:3 You:6 Tie:1	Me:4 You:5 Tie:1	Me:1 You:4 Tie:5	Me:2 You:6 Tie:2	33.33%	0%
6. Andia Azimi	11	student	Me:4 You:3 Tie:3	Me:2 You:1 Tie:7	Me:6 You:3 Tie:1	Me:2 You:5 Tie:3	Me:3 You:2 Tie:5	Me:5 You:2 Tie:3	100%	66.66%
7.Kimia Yarijani	24	Bachelor	Me:4 You:3 Tie:3	Me:0 You:5 Tie:5	Me:4 You:4 Tie:2	Me:4 You:4 Tie:2	Me:3 You:5 Tie:2	Me:3 You:3 Tie:4	50%	33.33%
8.Azadeh ghazi	40	Bachelor	Me:4 You:2 Tie:4	Me:0 You:8 Tie:2	Me:2 You:4 Tie:4	Me:5 You:4 Tie:1	Me:4 You:2 Tie:4	Me:3 You:4 Tie:3	33.33%	66.66%
9.Shadi Ghiyasi	29	P.H.D	Me:2 You:4 Tie:4	Me:4 You:3 Tie:3	Me:6 You:0 Tie:4	Me:2 You:4 Tie:4	Me:3 You:3 Tie:4	Me:4 You:3 Tie:3	66.66%	50%
10. Golshan Sedighian	50	Bachelor	Me:3 You:1	Me:5 You:3	Me:3 You:3	Me:2 You:2	Me:3 You:4	Me:2 You:0	83.33%	50%

			Tie:6	Tie:2	Tie:4	Tie:6	Tie:3	Tie:8		
11. Maryam Zanganeh	27	Bachelor	Me:5 You:2 Tie:3	Me:3 You:6 Tie:1	Me:4 You:2 Tie:4	Me:3 You:3 Tie:4	Me:6 You:2 Tie:2	Me:1 You:5 Tie:4	66.66%	50%
12.Elnaz Qasemi	30	P.H.D	Me:1 You:3 Tie:6	Me:5 You:3 Tie:2	Me:4 You:4 Tie:2	Me:1 You:7 Tie:2	Me:5 You:2 Tie:3	Me:4 You:1 Tie:5	50%	66.66%
13. Sara Faraji	24	Bachelor	Me:3 You:5 Tie:2	Me:2 You:4 Tie:4	Me:5 You:2 Tie:3	Me:2 You:3 Tie:5	Me:4 You:0 Tie:6	Me:1 You:4 Tie:5	33.33%	33.33%
14.Narges Ekhtiyari	20	Student	Me:2 You:2 Tie:6	Me:2 You:3 Tie:5	Me:4 You:4 Tie:2	Me:3 You:3 Tie:4	Me:1 You:3 Tie:6	Me:4 You:3 Tie:3	33.33%	50%
15. Masoumeh Amiri	26	Bachelor	Me:5 You:3 Tie:2	Me:4 You:6 Tie:0	Me:3 You:4 Tie:3	Me:4 You:4 Tie:2	Me:3 You:4 Tie:3	Me:3 You:4 Tie:3	33.33%	16.66%
16. Fatemeh Darabi	19	Diploma	Me:4 You:3 Tie:3	Me:4 You:1 Tie:5	Me:3 You:3 Tie:4	Me:4 You:1 Tie:5	Me:4 You:4 Tie:2	Me:1 You:4 Tie:5	83.33%	50%
17.Tina Ghanbari	14	student	Me:6 You:0 Tie:4	Me:5 You:1 Tie:4	Me:4 You:2 Tie:4	Me:3 You:4 Tie:3	Me:4 You:1 Tie:5	Me:3 You:6 Tie:1	100%	33.33%
18.Elham Azimi	47	Bachelor	Me:6 You:3 Tie:1	Me:1 You:4 Tie:5	Me:4 You:2 Tie:4	Me:4 You:4 Tie:2	Me:3 You:6 Tie:1	Me:7 You:3 Tie:0	66.66%	50%

Table 4
(continued). Game results and computer winning percentage in women with and without the neural network.

Name	**Age**	**Education**	**Game results**						**Computer winning percentage**	
			With neural network			**Without neural network**			**With neural network**	**Without neural network**
			1	**2**	**3**	**1**	**2**	**3**		
19.Rezvan Bahrami	25	Bachelor	Me:3 You:1 Tie:6	Me:6 You:1 Tie:3	Me:6 You:1 Tie:3	Me:4 You:3 Tie:3	Me:2 You:6 Tie:2	Me:4 You:2 Tie:4	100%	66.66%
20.Elahe Rostami	55	Masters	Me:5 You:0 Tie:5	Me:5 You:2 Tie:3	Me:3 You:6 Tie:1	Me:4 You:1 Tie:5	Me:3 You:2 Tie:5	Me:3 You:2 Tie:5	66.66%	100%

In the tables above, Me and You are equal to the number of computers and player wins, respectively, and Tie is equal to the number of draws.

5. Conclusion

Play and entertainment have played an important role in human life since the beginning of time. Today, games are formed as computer games. The main purpose of this study was to create an intelligent rock, paper, scissors player that can detect the human behavior pattern and defeat him or her. Multi-Layer Perceptron (MLP) neural network was used to accomplish this. The results of the MLP survey designed for men and women indicated that the network was performing well in

recognizing players' behavioral patterns. It is worth noting that the percentage of computer wins with the network above is higher than the percentage of computers without neural networks.

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