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ROZWÓJ JEDNOSTRONICOWEJ APLIKACJI DO OBLICZANIA OCEN SZACHISTÓW Z WYKORZYSTANIEM SIECI NEURONOWEJ


Słowa kluczowe: aplikacja jednostronicowa, sztuczna sieć neuronowa; silnik szachowy; perceptron; ocena ELO, Node.js, Express.js.

DEVELOPMENT OF A SINGLE PAGE APPLICATION FOR CALCULATING THE RATING OF CHESS PLAYERS USING A NEURAL NETWORK

Summary: The article describes the development of an artificial neural network and a web application that allows you to calculate the rating of a chess player after a minimum number of computer games. Three parameters are used: the total value of the discrepancy between the quality of the player's moves and the moves calculated by the engine, the final position score and the number of moves. Stockfish chess engine, JavaScript technology Nodejs, Express.js were used.

Keywords: single page application, artificial neural network, chess engine, perceptron, rating ELO, Node.js, Express.js.

1. Introduction

Artificial neural networks (ANNs) are used in various fields of science, including information technology. They serve as a tool for modeling, processing and

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classification of large and complex data. ANNs allow you to solve complex problems in cases where conventional mathematical algorithms are ineffective, such as games and learning applications [1]. Chess is not only a sport, but also an interesting and popular game. Therefore, the gaming industry is constantly improving software products and applications for playing chess [2, 3]. When creating such applications, the urgent task is to calculate the ELO rating of chess players, which characterizes the individual strength factor of the player [4].

Similar applications and programs are used to calibrate new players in the electronic system. After all, now new users are either given a numerical value of the rating, or offered to choose the experience of playing chess from a list that can spoil the fun of the first few games. Or to determine your own rating in terms of the minimum number of games played. There are similar systems in free access, but they have significant drawbacks.

The purpose of the development is to create a software product for calculating the ELO rating of chess players, which uses effective advanced algorithms and has a web interface.

There are several programs that solve similar problems and have a high rating among players, for example, elometer.net, chessmaniac.com and lichess.org. Elometer.net is built as a website service that determines the rating of a chess player in the short term [5]. The player's moves in certain chess positions are used as input data. This website offers 76 unrelated chess positions. The site has several significant drawbacks. There is no time limit, there is no function to go again. If a situation arises that requires a page reload, the rating calculation is incorrect. For example, after repeating this operation repeatedly, the user receives the message "1035, with 95% confidence interval [899…1170]". This figure is incorrect. It had to be either much smaller or the site had to inform the user that the input data is insufficient for evaluation.

The lichess.org service is built on similar principles and has the same shortcomings [6]. Shessmaniac.com is a website service that is a modified version of elometer.net. It has a much smaller number of tasks: 10 vs. 76 in elometer.net. However, this number of tasks is not always enough to determine the objective rating of the player. Based on the results of the analysis, it was decided to provide for the creation of the application time limit - 10 minutes for each (player and computer) per game. And choose as a basis another technology that allows, starting from the starting position, each subsequent receive after 2 moves - the player and the computer, respectively. The rating is determined by no more than 51 positions processed by the player.

2. Materials and methods

The ELO rating is calculated according to the established rules. When player A plays against player B, the mathematical expectation of the number of points he must score in this game by formula (1) is calculated:

\[
E_A = \frac{1}{1 + 10^{(R_B - R_A) / 400}},
\]

where \(E_A\) - mathematical expectation of the number of points that player A will score in the game with B;
\(R_A\) - old rating of player A;
The new rating of player A is determined by formula (2):

\[
R'_A = R_A + K \times (S_A - E_A),
\]

(2)

where \( K \) - coefficient, the value of which is equal to 10 for chess players with a rating above 2400, 15 - for chess players with a rating below 2400 and 25 - for beginners (the first 15 games from receiving a FIDE rating);

\( SA \) - new rating of player A.

Creating an algorithm to determine the chess player's rating after one game with a computer is a difficult task, so a neural network was used to determine the weight of important factors [7,8].

Perceptron training is performed as follows:
- Initialization of weight matrices \( W \) (random values).
- Give input \( X \) and calculate the output \( Y \) for the target vector \( Y_T \).
- If the solution is correct - go to the next step; otherwise calculate the difference by formula (3):

\[
D = Y_T - Y.
\]

(3)

Modify the scales according to formula (4):

\[
w_{ij}(e + 1) = N_{ij}(e) + \alpha DX_i,
\]

(4)

where \( W_{ij}(e) \) - weight value from neuron i to neuron j before debugging;

\( W_{ij}(e + 1) \) - weight value after adjustment;

\( \alpha \) - learning speed ratio;

\( X_i \) - input of neuron i;

\( e \) - epoch number (iteration during training).

Follow the loop from the input feed step until the network stops making mistakes.

Calculate the answer by formula (5):

\[
OUT = \frac{1}{1+e^{-C \times NET}},
\]

(5)

where \( C \) - the coefficient of the width of the sigmoid along the abscissa; \( NO \) - summing block.

3. Results and discussion

The project consists of a neural network, client and server parts, installed modules: Express and Stockfish [9,10]. The block diagram of the project is shown on Fig. 1. The entire client part is in one separate directory. Its contents are sent by a server that can be located remotely. There are files in .html, .css, .js format.

The graphical user interface includes (Fig. 2):
- board with figures;
- two chess timers for each player with a set time of 10 minutes;
- two toggle buttons to select a color for the game;
- button to start a new game, a button for the player to admit his defeat;
- a list that opens with the names of the figures into which you can turn a pawn;
- list of moves made in PGN format, dialog box with a message about the player’s rating.

Figure 1. Block diagram of the project

The button to start a new game will return the position to the starting position. The button to admit your defeat becomes available after the first move made by the player. When the html-page is loaded, a script is executed, which receives a unique identifier from the server. After each player's move or from the beginning of the player's game, the black pieces are sent a request to the server with the following parameters: unique client ID, color of the player's pieces, logical parameter to run one or two position
analyzes, game history in the form of moves. After the request, the connection to the server is checked. In case of its absence the corresponding message is displayed on the screen. After this request, the computer timer is turned on and the server is expected to respond with the following parameters: computer speed; the best move for the player in the last position after the move of the computer; two chess position estimates (before and after the player's last move).

The party is terminated after the computer runs, provided:
- one of the parties ran out of time;
- position score is more than +5 in favor of the computer;
- the position score is more than +5 in favor of the player and the previous position before the player's move also had a score of +5 in his favor;
- more than 101 moves are made in the game if the player plays for whites, or more than 100 moves if a player plays for blacks;
- the player pressed the button to acknowledge his defeat.

At the end of the game, the difference between the best moves and the player's moves is calculated. In this case, the chess engine can make a big difference between the positions, even if the player's move is the best. Therefore, the odds change if the player's move does not match the best.

Next, the advantage factor is calculated. The party ends early provided:
- advantage on the side of the computer, the player admitted his defeat or the player ran out of time, with the coefficient assigned to -5;
- the advantage on the player's side is a factor of 5.

In the event that neither side has achieved an advantage of more than 5 points, the coefficient is assigned an estimate of the last position.

The last factor is the number of moves factor. When a player loses and a small number of moves are made in the game, that player plays worse than the loser, but lasts longer. It is better for both of them to play the player who wins the computer. The best player is the one who wins and makes the fewest moves. Therefore, the last coefficient is calculated by dividing the unit by the number of moves in the game and adding a minus in front, if the coefficient of advantage is less than zero. If the odds ratio is zero, then the odds ratio will also be zero. Thus, the input parameters are optimized so that all three parameters are in the range [-5; 5]. The player's ELO rating is determined by having as parameters the obtained 3 coefficients and the corresponding weights.

If a player plays for black pieces, he is added a certain number of points. The determined rating will be the closest to the rating of a chess player in a blitz party. If a player plays very poorly his rating does not count.

The neural network in this project is a multilayer perceptron with an input layer of 3 neurons, a hidden layer also of 3 neurons and an output layer of one neuron. The perceptron uses the principle of learning with a teacher with the weights of neurons, which from the beginning are assigned a random value [11].

The developed perceptron is presented on Fig. 3.
Neural network training follows the delta rule until the error increases. The sigmoid is used as a function of activation. The Android computer chess.com application is used as a player to receive the data set. Levels from 800 to 2900 ELO with a step of 150 points were tested. Less (2 lines) of data was recorded after playing with computers with an ELO of less than 1700, because they are less stable in terms of game quality. 6 lines are written for higher levels. After completing the training, you can enter coefficients for testing.

The results of network training are presented in table 1. The results of checking the correctness of the rating calculation are presented in table 2.

**Table 1. Network learning results**

<table>
<thead>
<tr>
<th>№ learning step</th>
<th>Network error</th>
<th>The ratio of the best moves with the moves of the player</th>
<th>Coefficient of advantage</th>
<th>The ratio of the number of moves</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.315329</td>
<td>0.39683</td>
<td>0.196941</td>
<td>0.496094</td>
</tr>
<tr>
<td>2</td>
<td>0.314404</td>
<td>0.393664</td>
<td>0.193891</td>
<td>0.492197</td>
</tr>
<tr>
<td>3</td>
<td>0.313461</td>
<td>0.390502</td>
<td>0.19085</td>
<td>0.488309</td>
</tr>
<tr>
<td>4</td>
<td>0.3125</td>
<td>0.387345</td>
<td>0.187818</td>
<td>0.484331</td>
</tr>
<tr>
<td>5</td>
<td>0.31152</td>
<td>0.384193</td>
<td>0.184796</td>
<td>0.480563</td>
</tr>
<tr>
<td>10</td>
<td>0.306329</td>
<td>0.368507</td>
<td>0.169837</td>
<td>0.461377</td>
</tr>
<tr>
<td>20</td>
<td>0.294343</td>
<td>0.337563</td>
<td>0.140791</td>
<td>0.423894</td>
</tr>
<tr>
<td>30</td>
<td>0.279971</td>
<td>0.307322</td>
<td>0.11318</td>
<td>0.387864</td>
</tr>
<tr>
<td>40</td>
<td>0.263204</td>
<td>0.27797</td>
<td>0.0873802</td>
<td>0.353647</td>
</tr>
<tr>
<td>50</td>
<td>0.243783</td>
<td>0.249732</td>
<td>0.0637954</td>
<td>0.32163</td>
</tr>
<tr>
<td>60</td>
<td>0.223218</td>
<td>0.222856</td>
<td>0.0428067</td>
<td>0.292187</td>
</tr>
<tr>
<td>70</td>
<td>0.201396</td>
<td>0.197598</td>
<td>0.0247085</td>
<td>0.265623</td>
</tr>
<tr>
<td>80</td>
<td>0.180474</td>
<td>0.174192</td>
<td>0.00965386</td>
<td>0.242124</td>
</tr>
<tr>
<td>90</td>
<td>0.162529</td>
<td>0.152809</td>
<td>-0.00237057</td>
<td>0.221729</td>
</tr>
<tr>
<td>100</td>
<td>0.146432</td>
<td>0.133539</td>
<td>-0.0115329</td>
<td>0.204331</td>
</tr>
</tbody>
</table>
Table 2. The results of checking the correctness of the rating calculation

<table>
<thead>
<tr>
<th>PGN</th>
<th>Player side</th>
<th>Expected</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Nf3 d6 2. d4 Nf6 3. c4 g6 4. Nc3 Bg7 5. e4 Nc6 6. h3</td>
<td>White</td>
<td>2070</td>
<td>2100</td>
</tr>
</tbody>
</table>


The server part of the application uses Express to exchange data with clients in JSON format. The server opens one of the ports for listening and downloads the files to send to the client. The Stockfish.js code is also running on the server. A separate engine object is created for each client. With each response of the engine, a line is generated, which indicates the depth of the search, position estimate, and subsequent moves, taking into account which the rating is set. At the end of the search, the engine offers a course according to the force specified in the parameters. To most accurately determine a player’s rating, the engine plays the strongest way only when he loses significantly in position. Otherwise, he makes a move that is simply not a gross mistake. In both cases, in the presence of alternatives that do not significantly change the assessment of the position, the course will be chosen randomly.

4. Conclusion

As a result, we got a web application that uses an artificial neural network to calculate a chess player’s rating after just one game with a computer. The parameters used are: the total value of the discrepancy between the quality of the player’s moves and the moves calculated by the engine, the final position score and the number of moves. Further research is related to the improvement of the project. Additional research is needed to determine the factors that affect the quality of a chess player’s game and to determine the weights of these factors. Use a faster and more accurate engine or neural network, such as the AlphaZero neural network, to estimate the position. Optimize neural network code and SPA and update user interface for best user experience. Expand the range of platforms on which the application will be available. This project can be reviewed by a source link: https://github.com/dendiod/elometer.
REFERENCES

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