Design and Development of Game PlayingSystem in Chess usingMachine Learning

VIKRANT CHOLE[1], NIMISH GOTE[2], SHRADDHA UJWANE[3], PIYUSH HEDAOO[4], APARNA UMARE[5]

[1,2,3,4,5]*Department of Computer Science & Engineering, G.H. Raisoni Institute of Engineering & Technology, Nagpur, India*

---***---

Abstract - Game playing in chess is one of the important areas of machine learning research. Though creating a powerful chess engine that can play at a superhuman level is not the hardest problem anymore with the advent of powerful chess engines like Stockfish, Alpha Zero, Leela chess zero etc. Most of these engines still depend upon powerful and highly optimized look-ahead algorithms. CNN(convolutional neural networks) which is used primarily for images and matrix-like data is been proved successful with games like chess and go. In this project, we are treating chess like a regression problem. In this paper, we have proposed a supervised learning approach using the convolutional neural network with a limited look ahead. We have collected data of around 44029 chess games from the FICS chess database with players having an Elo rating of 2000 and above. Our goal is to create a zero-knowledge chess engine. The trained model is then paired with a minimax algorithm to create the AI. Our proposed supervised system can learn the chess rules by itself from the data. It was able to win 10% of the games and draw 30% of games when manually tested against Stockfish computer engine with Elo of 1300. We suggest that CNN can detect various tactical pattern to excel in games like chess even when using a limited lookahead search.

***Key Words*: Chess, Game Playing, CNN, look ahead algorithm, Evaluation Function**

1. Introduction

The idea of building a chess-playing machine dates back to the eighteenth century. Around 1769, the chess-playing automaton called The Turk became famous before being exposed as a hoax. Since then, chess enthusiasts and computer engineers have built, with increasing degrees of seriousness and success, chess-playing machines and computer programs. One of the few chess grandmasters to devote himself seriously to computer chess was former World Chess Champion Mikhail Botvinnik, who wrote several works on the subject. One developmental milestone occurred when the team from Northwestern University, which was responsible for the Chess series of programs and won the first three ACM Computer Chess Championships, abandoned type B searching in 1973. In 1997 DeepBlue, a brute-force machine capable of examining 500 million nodes per second, defeatedWorld Champion Garry Kasparov, marking the first time a computer has defeated a reigning world chess champion in standard time control. On December 5, 2017, the DeepMind team released a preprint introducing Alpha Zero, which within 24 hours of training achieved a superhuman level of play in these three games by defeating world-champion programs stockfish and the three-day version of AlphaGo Zero. AlphaGo Zero is trained by self-play reinforcement learning. It combines a neural network and Monte Carlo Tree Search in an elegant policy iteration framework to achieve stable learning.

Chess is a fully observable two-player zero-sum game. The chessboard is defined as a simple matrix of 8 x 8 containing pieces and blank spaces. There are two players one Blackand the other White. There is a total of 6 Pieces in chess they are Pawns, Rook, Knight, Bishop, King and Queen. Each piece moves uniquely on the board. The aim is to checkmate the opponent king. There are extra moves which are possible under certain conditions they are Short Castling, Long Castling and En passant.

The Chess engine takes the present state of the chessboard as the input and outputs the moves that it thinks is the best. Classical chess engine uses evaluation function to evaluate the position on the board. Most simply, it is some of your advantage minus the sum of the opponent advantage. Each piece is of some value it increases from pawns - 1 to Queen - 9 and king which can't be compromised. The chess engine uses decision-making algorithms or looks ahead algorithms used for zero-sum games with two players like minimax algorithm, alpha-beta pruning algorithm, null move heuristics, Quiescence searching algorithm, MCTS Algorithm et al. Their function is to look ahead moves depending on the certain depth and find the move which gives the most advantage to the player.

Neural Networks which are modelled after the working of neurons in humans are capableof performing various tasks like human beings. CNN a type of feed-forward neural network that is used in the task like image analysis can be very successful in various AI game playing challenges. It is now widely used in modern engines of the game of Go and Chess. The recent success of Alpha Zero is evident that CNN can be used to successfully predict professional level moves in chess. Our goal is to test how successful is CNN in evaluating the chess positions.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 04 | Apr 2021 www.irjet.net p-ISSN: 2395-0072

2. Literature Surveys

There is a lot of literature available on the application of machine learning in games like chess. Among the most notable ones is Sabatelli et al (2018) [1] in which they have put forward a supervised learning approach for training Artificial Neural Networks (ANN) toevaluate chess positions. In their work its been shown that training performance of training data increased when using bitboard representation instead of Algebraic chess notation. The results also show how relatively simple Multilayer Perceptron (MLPs) outperform Convolutional Neural Networks (CNNs) in all the experiments performed.

In Vikstrom(2019) [2] they trained a CNN to evaluate chess positions using publicly available data of the chess games which were analysed by stockfish game engine. The trained model shows a good sense of what a good move is and was able to find small strategies and tactics.

Some early work on using CNN in chess is in the paper of Oshri, Barak [2015] [3] in theirmodel they have used FICS database of the user having rating 2000 ELO and above. They treat the problem as a two-part classification problem in it they have trained one part of the CNN as a piece selector and the other part as a move selector. There approach reduce the intractable search space in chess by the square root of two.

In the paper by McIlroy, sen et al (2020) [4] they have trained fully connected residual convolutional neural networks and deep residual convolutional neural network. Both networks achieved the accuracy of 75.3% and 76.9%. The goal of the Maia chess engine is in bridging the gap between AI and humans. The Maia engine can predict humans move at a specific level of their rating at maximum accuracy.

In Arman Maesumi (2020) [5] they trained a deep neural network that serves as a static evaluation function which is paired with a limited look-ahead algorithm. The strength of their chess engine is measured by comparing the moves with the stockfish engine. The model suggests moves equal to that of stockfish 83% of the time in all the sample positions.

In David, Lior Wolf et al [2016] [6] come with an end-to-end learning method in chess thatrelies on the deep neural networks. The model with any prior knowledge learns the rule of chess using a combination of unsupervised and supervised training. The model beats many states of art classical chess engines.

3. Methodology

3.1 Dataset

[Dataset source, dataset form , data set analysis]

Similar to the Dataset provided in Oshri, Barak [2015] we have referred to the sameFICS (https://www.freechess.org/) chess database having an Elo rating of 2000 and above of the year 2020. All the chess game in the database is in PGN (Portable Game Notation) format. The chess database contains 44029 total games of chess.

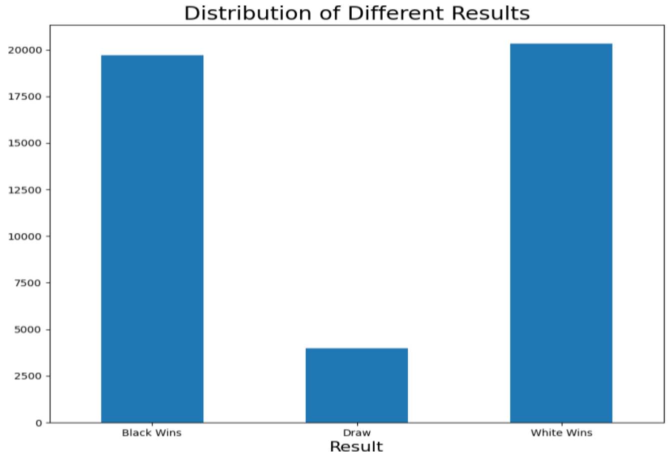


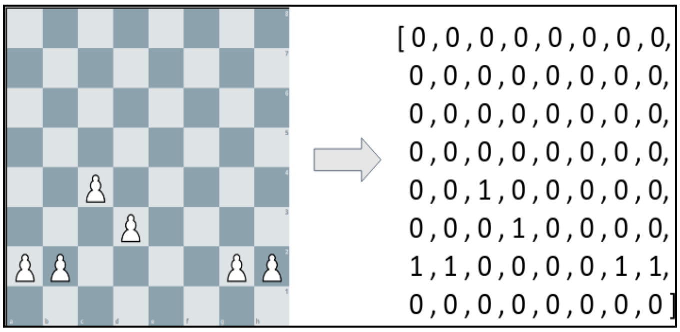
fig.1 histogram representing total wins of black/white and draws

3.2 Preprocessing of data

Bitboard representation gives the best performance during the training of the data compared to regular ACN(Algebraic chess notations) format[1]. In the bitboard representation the chess board is represented as 8x8x12 bit vector of 0's and 1's. where each 12 pieces is separately represented by array consisting 1's and blank space by 0's. The chess is represented in categorical form. Various other properties like turn bit (single bitto determine turn), castling bit (four bits representing castling right of both pieces) and check bit (two bits which represent whose king is in check) [5].

The chessboard representation is a vector with 775 binary features. The bitboard representation is used to denote the locations of each pieces in the vector. First 64 features represent the locations of white pawns, the next 64 features represent white knights, and so on. The bitboard representation of white pawns are shown in figure below:

fig 2. figure Showing bitboard representation of white



pawns on the board (The diagramon the right is a one-dimensional matrix)

All piece vectors are then concatenated with each other along with the turn bit, castlingbit and check bit.

3.3 Model

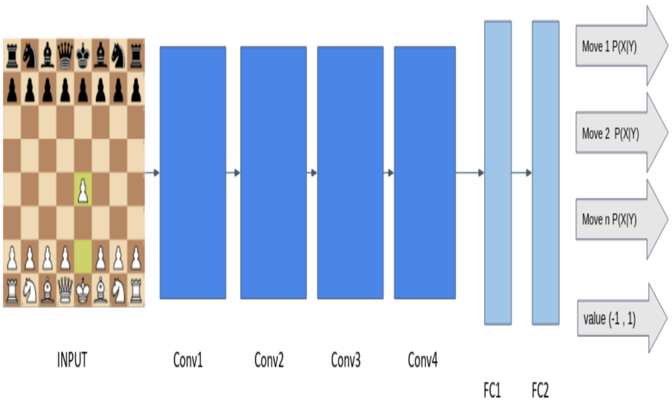


fig 3. Visualization of move prediction network and neural network architecture

The neural network is implemented using PyTorch. The convolutional neural network takes the chessboard as input in form of FEN(Forsyth Edward notation) which is transformed into a form of bitboard representation which is followed by 4 2D convolutional layers and 2 fully connected layers. The kernel size is 3x3 for the first layer, 2x2 for the second layer and 1x1 for the last two layers. The filters used were in order of 8,16, 32 and 64. All these layers use ReLU-activation. For value activation, the tanh activation function was used. MSE(Mean squared error) was used as the loss function and Adam's optimizer was used with a batch size of 256. The training took place over 100 epochs.

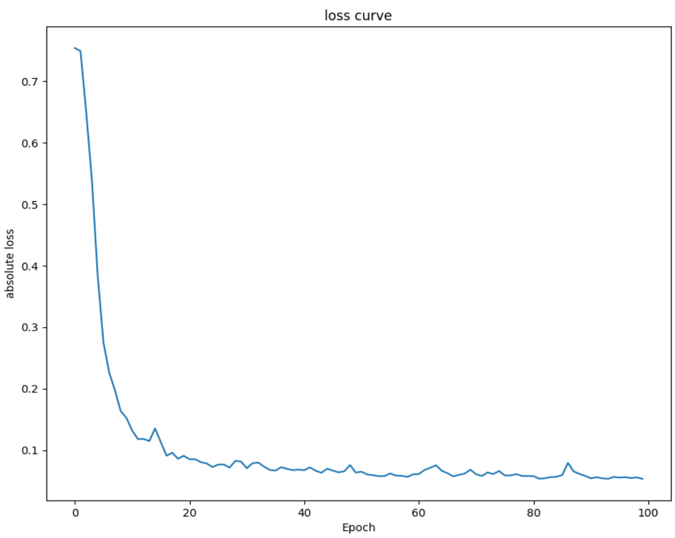


fig.4 Graph showing loss curve

4. Result

When tested against a stockfish engine of 1300 Elo rating it was able to win around 10% of the game and able to draw 30% of the games given a sample size of 100 games. With a stockfish engine of Elo 2000, it lost all the games.

It was able to detect various tactics as seen in the boards below

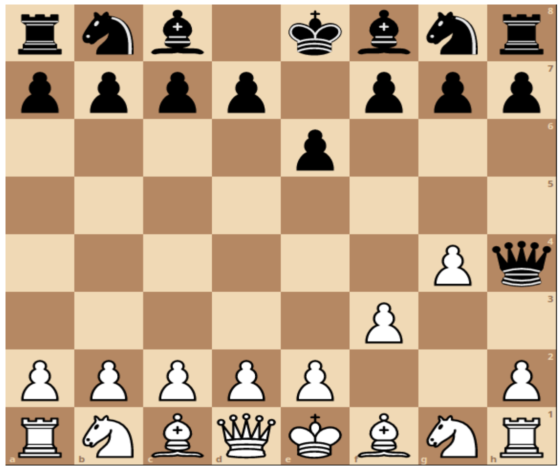


fig 5.1 Checkmate in one move Predicted

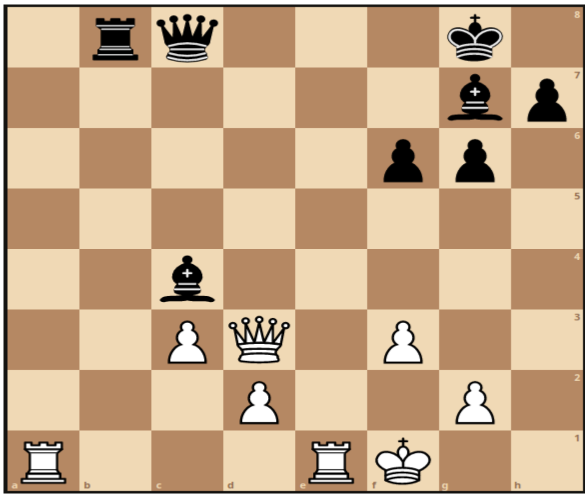


fig 5.2 pinning the queen

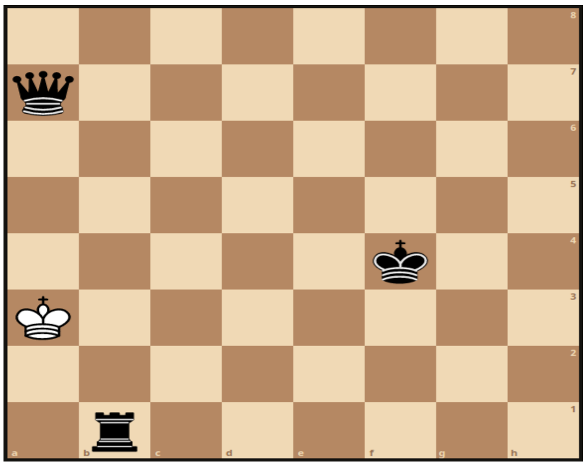


fig 5.3 In end game delivered the checkmate in 3 moves

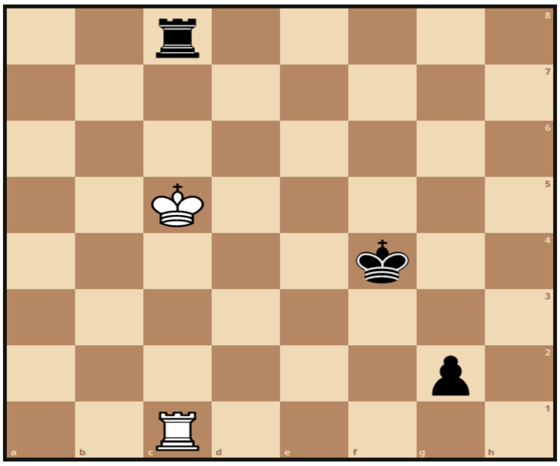


fig 5.4 checked the king to win the rook

4. CONCLUSIONS

We trained the convolutional neural network to play chess using the publicly available data at FICS. The trained model that we got was able to detect patterns on the chessboard and was able to deliver various tactics to improve and win the game. We conclude that a better model is possible with more refined and larger dataset having more high-level games. The model can be improved by giving more training time and can be benefited by using more better hardware. The network can be improved by using Residual ConvolutionalNeural Network in the neural net.

ACKNOWLEDGEMENT

[1] Sabatelli, Matthia, Francesco Bidoia, Valeriu Codreanu, and Marco Wiering. "Learning to Evaluate Chess Positions with Deep Neural Networks and Limited Lookahead." InICPRAM, pp. 276-283. 2018.

[2] Vikström, Joel. "Training a Convolutional Neural Network to Evaluate ChessPositions." 2019.

[3] Oshri, Barak. "Predicting Moves in Chess using Convolutional Neural Networks.'' 2015.

[4] Schrittwieser, Julian, Ioannis Antonoglou, Thomas Hubert, Karen Simonyan, LaurentSifre, Simon Schmitt, Arthur Guez et al. "Mastering atari, go, chess and shogi by planning with a learned model." arXiv preprint arXiv:1911.08265. 2019

[5] Maesumi, Arman. "Playing Chess with Limited Look Ahead." arXiv preprintarXiv:2007.02130. 2020.

[6] David, Omid E., Nathan S. Netanyahu, and Lior Wolf. "Deepchess: End-to-end deep neural network for automatic learning in chess." In International Conference on Artificial Neural Networks, pp. 88-96. Springer, Cham, 2016.

[7] Maddison, Chris J., Aja Huang, Ilya Sutskever, and David Silver. "Move evaluation in Gousing deep convolutional neural networks." arXiv preprint arXiv:1412.6564. 2014.

[8] McIlroy-Young, Reid, Siddhartha Sen, Jon Kleinberg, and Ashton Anderson. "Aligning Superhuman AI with Human Behavior: Chess as a Model System." In Proceedings of the 26th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining, pp. 1677-1687. 2020.

[9] Thrun, Sebastian. "Learning to play the game of chess." In Advances in neuralinformation processing systems, pp. 1069-1076. 1995.

[10] Lai, Matthew. "Giraffe: Using deep reinforcement learning to play chess." arXivpreprint arXiv:1509.01549 2015

[11] Erik Bernhardsson, "Deep Learning for... Chess", 2014 , https://erikbern.com/2014/11/29/deep-learning-for-chess.html

[12] Chess Programming Wiki "Neural Networks for chess" 2020, https://www.chessprogramming.org/Neural_Networks

[13] David Foster "Alpha go zero explained in one diagram" 2017, https://medium.com/applied-data-science/alphago-zero-explained-in-one-diagram-365f5abf67e0

[14] AI Chess Algorithms https://www.cs.cornell.edu/boom/2004sp/ProjectArch/Chess/algorithms.html

[15] Chess Programming wiki https://www.chessprogramming.org/Main_Page

[16] Chess Computer History https://en.wikipedia.org/wiki/Computer_chess

[17] Alpha zero tutorial https://web.stanford.edu/~surag/posts/alphazero.html

[18] Twitch chess https://github.com/geohot/twitchchess

[19] Predicting Professional Players Moves with Deep Learning https://towardsdatascience.com/predicting-professional-players-chess-moves-with-deep-learning-9de6e305109e