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# Optimizing AI Algorithms in Game Development

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## Abstract

As the field of artificial Intelligence is gaining popularity, the al- gorithms used in AI is plays crucial role. Developing AI based board games is challenging. We are developing a chess engine using an AI which will provide an optimal move against every best move created by human. This is the report which gives the practical and effective algorithms in AI based chess game which will defeat the human in chess. Chess is the game which is making its popularity in computer games and every year there is new implementation of chess engine launched which works better than previously existing engines. We are trying to make game tree shorter and efficient way to play around the GUI(Graphical User Interface). The tree is pruned with to provide best optimal move for player with static evaluation function.

***Keywords: Chess engine, AI Algorithms, Artificial Intelligence, Board games.***

## 1 Introduction

Chess is an ancient two player strategy game played on 64 squares arranged in eight by eight grid. Chess engine generates the moves by exploring way further future moves. When each player is moved piece 5 times each there are around 69 Trillion possible games that can be played. Chess engine will explore the further future moves at particular depth to get the best possible move for against the opponent player.

Chess engine is an expert system which has beyond human level intelligence andcan be used to play the chess as well as to analyse the game, also which will havethe rating beyond 2900 so it should be unbeatable by humans. So to make a chessengine that will play the optimum moves always and it will think of more levels ormoves one as compare to moves. Chess engine generates moves by calculating away further future moves. In short with the help ofArtificial Intelligenceto build an expert systemwhich will also suggest the best to worst moves so it will be helpful to analyse thegame.Chess is an ancient two player strategy game played on 64 squares arranged ineight by eight grid. Chess engine generates the moves by exploring way furtherfuture moves. When each player is moved piece 5 times each there are around 69Trillion possible games that can be played. Chess engine will explore the further fu-ture moves at particular depth to get the best possible move for against the opponentplayer.

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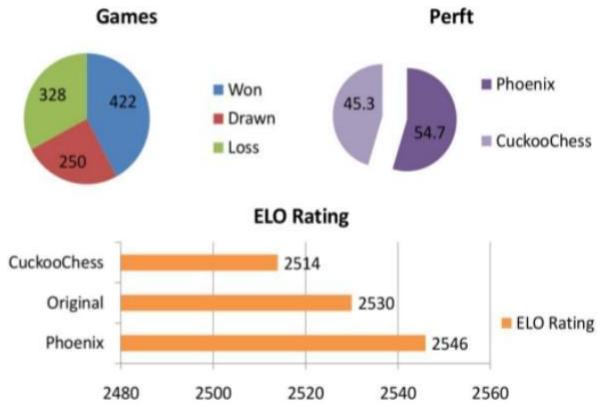
## 2 Literature survey

ZHANG-Congpin CUI-Jinling in [1] explained how heuristic approach is impor- tant domain for game playing. They have used Alpha-beta pruning to solve the problem in the board games using a Tree data structure. They proved that how alpha beta pruning technique can be improved the effect of search. They com- puted the estimated value of the nodes when they are expanded. Based on these values, the node with best estimated value inserted into the game tree. These paper concluded that as the deeper the tree is, more the alpha beta pruning method will cut down the trees.

A. R. Rahul and G. Srinivasaraghavan in [3] played the chess engine made by them with the other cess engines in the market to test its effectiveness. The paper discussed the two protocols of the chess engines.




Rahul A R et al [3] describes in this engine, that most game engines are beat by Grandmasters very easily since the engine does not calculate the future feects of a certain move made currently. This engine thus, evaluates the position evaluation and returns the material difference between the player positions. This is important as in a game of chess, sometimes a side willingly sacrifices a coin in order to layout a more elaborate trap. For the computer to this, it must evaluate the position and the moves in advance and niching and multi-niching is used to defeat the player. This engine also allows the players to use advance tactics such as castling, which has been possible only in the real life board game till recently. Thus, this engine has the closest, most efficient AI for the game of chess

## 3 Board Representation

Board representation in computer chess is a data structure in a chess program representing the position on the chessboard and associated game state.Board representation is fundamental to all aspects of a chess program including move generation, the evaluation function, and making and unmaking moves (i.e. search) as well as maintaining the state of the game during play. Several dif- ferent board representations exist. Chess programs often utilize more than one board representation at different times, for efficiency. Execution efficiency and memory footprint are the primary factors in choosing a board representation; secondary considerations are

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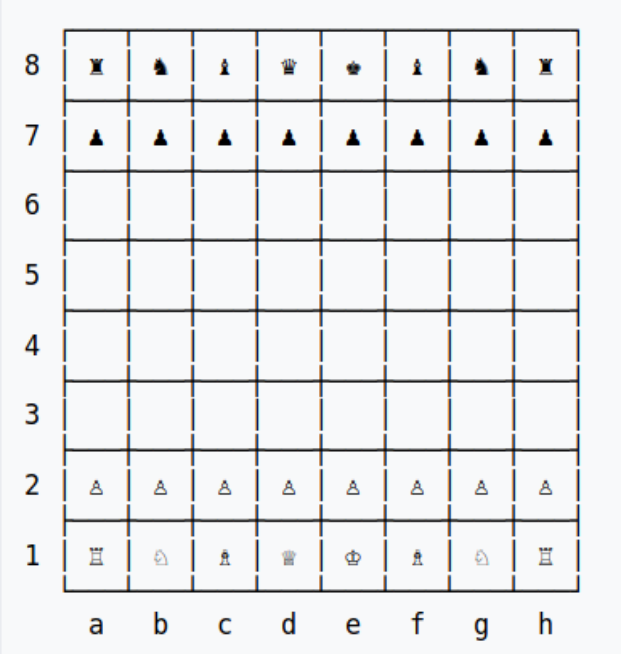
effort required to code, test and debug the appli- cation.

A full description of a chess position, i.e. the position ”state”, must contain the following elements:

1. The location of each piece on the board
2. Whose turn it is to move
3. Status of the 50-move draw rule. The name of this is sometimes a bit confusing, as it is 50 moves by each player, and therefore 100 half-moves, or ply. For example, if the previous 80 half-moves passed without a capture or a pawn move, the fifty-move rule will kick in after another twenty half- moves.
4. Whether either player is permanently disqualified to castle, both kingside and queenside.
5. If an en passant capture is possible.

Board representation typically does not include the status of the threefold repetition draw rule. To determine




this rule, a complete history of the game from the last irreversible action (capture, pawn movement, or castling) needs to be maintained, and so, is generally tracked in separate data structures. With- out this information, models may repeat the position despite having a winning advantage, resulting in an excessive amount of draws

The board state may also contain secondary derived information like which pieces attack a square; for squares containing pieces, which spaces are attacked or guarded by that piece; which pieces are pinned; and other convenient or temporary state.

The board state is associated with each node of the game tree, representing a position arrived at by a move, whether that move was played over the board, or generated as part of the program’s search. It is conceptually local to the node, but may be defined globally, and incrementally updated from node to node as the tree is traversed.

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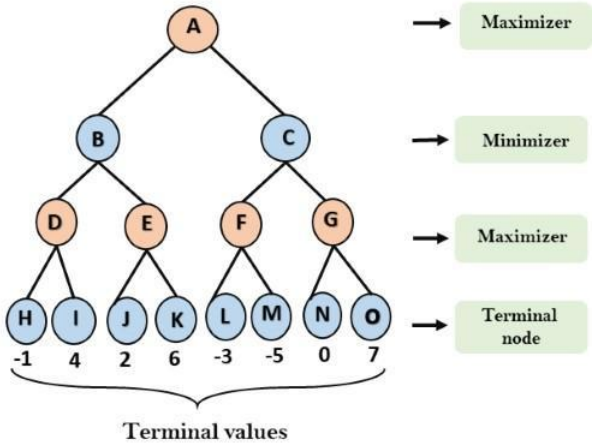
## 4 Algorithms in Game Playing

Understanding of Mini-max algorithm-

Mini-max algorithm follows recursion approach to get the decision in the game theory. It is used to get the best or the optimal move for the player as- suming that opponent player is also playing the game optimally. It uses the tree data structure and uses depth first search(DFS) approach to go to particular depth to evaluate the best moves. It takes current state(as root node) of the board as input and go to particular depth by using DFS and evaluates the static evaluation function at the terminal nodes. Mini-max algorithm is mostly used in Artificial intelligence (AI) board games. This algorithm computes the Min or Max deci- sion for the current state. 7




In the Mini-max algorithm two players plays the game one is called as Min player and other one is called as Max player. Min player is always tries to Minimizing the max player and Max player always tries to maximizing itself. Both the player are opponent to each other where max player always prefers the path which generates MAX value by the algorithm whereas MIN player always prefers the path which generates MIN value by the algorithm.

Quiescence Search - Quiescence searches are, of course, selective searches. They derive from the idea of expanding the search just enough, and only just enough, to avoid evaluat- ing a position where tactical disruption is in progress. Chess players can identify many types of ”tactical disruption.” The simplest notion, which leads to the idea of a capture tree, is to say that tactical dis- ruption is present if an immediate cap- ture is available. More sophisticated definitions would take account of checks, forks, trapped pieces, etc., and lead to more elaborate (and larger[) quiescence searches. It is tempting, but not quite accurate, to think that a quiescence search could be defined by giving the rules for selecting the moves that make up the quiescence search tree. (If the rules produced no moves at a particular position the position would be a terminal node of the tree. Alpha-beta would be used within the tree.) This description sounds complete if rather condensed, but it is not quite right. To see what is missing. However, it is a disadvantageous capture and White ends up losing

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two pawns worth of material. This value (-2 pawns) is the value returned by a ”quiescence search” according to the definition just given

A game search that stops at a fixed depth has a problem: If a tactical action is in progress at the end of the variation, the evaluation function may give unreliable answers. In a chess search, for example, the white's last move may be queen takes knight, and the evaluation function will report that white is up a knight. If the search looked one move deeper, it would see that black has the reply pawn takes queen, and realize that black is winning

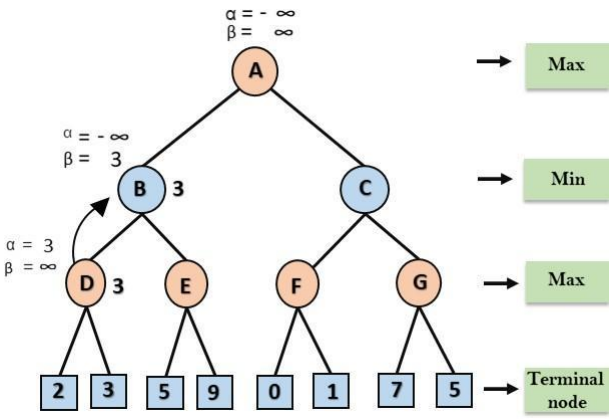
A quiescence search is an additional search, starting at the leaf nodes of the main search, which tries to solve this problem. In chess, quiescence searches usually include all capture moves, so that tactical exchanges don't mess up the evaluation. In principle, quiescence searches should include any move which may destabilize the evaluation function—if there is such a move, the position is not quiescent.

Alpha-beta Pruning -

There are various techniques used to optimize the minimax algorithm. One of them is Alpha-beta pruning. It is the tree optimization technique for the Mini- max algorithm. Minimax algorithm explores all the tree nodes(game positions) to get the optimal move as result it may also explore the worst move which is not required. Alpha beta pruning method will solves this problem. Alpha beta pruning can compute the same decision with less time as compared to minimax algorithm. This technique is known as pruning. It have two parameters alpha and beta so it is called alpha-beta pruning

Step 1: Initially $\alpha$ and $\beta$ value are set to - and + . These values are get passed to the node B and B passes the same to the node D. This process continues till terminal node occurs.

Step 2: At node D, value of is calculated for the max player. The value of is compared with 2 and 3 and maximum of them is considered as this is the turn for MAX player




Step 3: Now algorithm is backtrack to node B, and the value of beta will change as this is the turn for MIN player. So at node B, $\alpha$ = -∞ and $\beta$ = 3.

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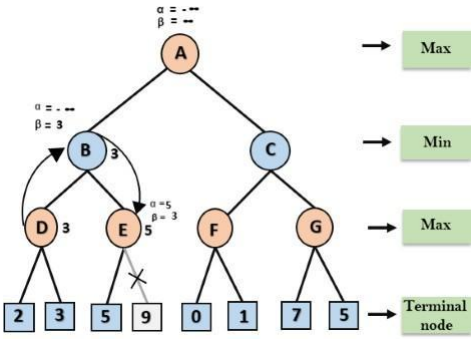
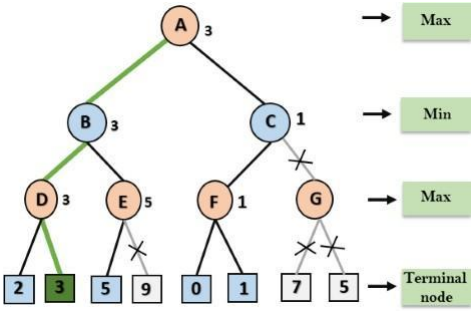


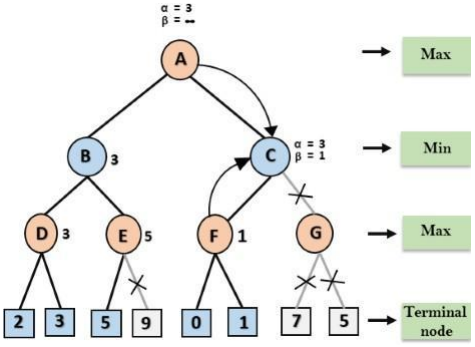

step 4: From node B values are get passed to node E then value of alpha is changed as max(-∞, +5). so value of $\alpha$ is changed to +5 and $\beta$ = 3.

step 5: Again the algorithm backtrack the tree from node B to node A.The value of $\alpha$ will changed to maximum value that is $\alpha$ = 3 and $\beta$ = +∞.

step 6: At node F, again the value of $\alpha$ is compared with both child and the max value of alpha remains the same but the node value of F will be 1.




step 7: At node F, again the value of $\alpha$ is compared with both child and the max value of alpha remains the same but the node value of F will be 1.




Look at the figure for the final state of the alpha beta pruning. The effective execution of alpha beta pruning is depend on the order in which each node is examined.

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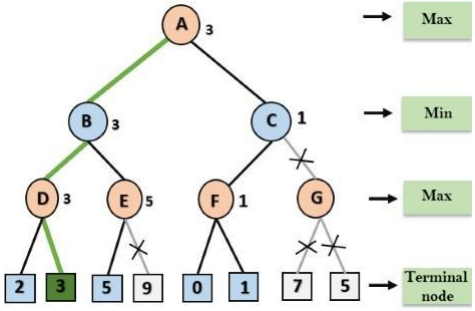


## 5 Methodologies

### 5.1 The term Artificial Intelligence

Oftentimes, terms artificial intelligence (Artificial Intelligence) and machine learning are used interchangeably but, the actual fact is that they are not the same. Artificial Intelligence is basically the umbrella concept, or the whole major part, or the super set and machine learning is a subset of artificial in- telligence. Artificial Intelligence and machine learning can be divided into two categories: supervised and unsupervised learning. Supervised learning is when the output is known by the supervisor and the training data is labelled as such. Supervised learning contains methods such as decision trees and classification, which, as the name suggests, classifies data into meaningful categories. This form of artificial intelligence is used continuously through game development.

### 5.2 Unsupervised Learning

n unsupervised learning, data is not labelled in a single format, and the output is not known. Unsupervised learning, contains methods that are usually interested in input patterns and the meaning of these patterns. The data that is gathered, in unsupervised learning, is grouped with similar data, in which it is easier to identify patterns. This is called clustering which is mostly used in Machine Learning [**?**].

### 5.3 Reinforcement learning

There is also Reinforcement learning, that is a hybrid technique. The general idea of Reinforcement Learning or teaching is to reward or discipline some- thing or someone after they perform a desired or undesired action. However, in relation to machine learning, Reinforcement Learning is machine learning by interaction in which the learner is reinforced according to which action they take in a specific situation. Therefore, the machine learns the best possible action to take in a certain situation or to a particular situation.

### 5.4 Neural Network

Neural Networks are a form of Artificial Intelligence algorithm that have a greater capacity to mimic how the actual human brain works and to self teach. Neural Net- work consists of layers (input, output, sometimes hidden layers), nodes (each layer contains nodes), connections (connection between nodes, con- nections start at the input layer, to the hidden layer, and then to the output layer), weight (nodes can contain different weights which have different impact on the network), and the node's net input (how the strength of the connec- tion between two nodes effects the output of other nodes connected to it). There are many Artificial Intelligence

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methodologies and topologies that are used for creating the perfect machine or one can say an expert system. Deep learning algorithms such as Neural Networks are also used in creating 'players' of famous video games in order to complete the game or rival human players. Video games provide an excellent testing field for developing Artificial Intelli- gence as there are no boundaries as well as limits or consequences a to what we can do as it is an endless possibility.

## 5.5 Finite State Machine(FSM)

Finite state machine(FSM) are also used in gaming and can be very useful to perform a particular action when certain condition arrives. FSMs are commonly used to organize and represent an execution flow that is nothing but a loop that goes on and on when the same condition arrives, which is useful to implement Artificial Intelligence in games. The "brain" of an enemy, for instance, can be implemented using a FSM, every state represents an action, such as attack , evade, run or can be anything [**?**].

Whole cycle of finite state machine can be used in Artificial Intelligence gam- ing. The Artificial Intelligence character can change it's state according to the need as if let's the character is attacking, it can suddenly changes it's state and can move for searching health[6].

## 5.6 Key Technologies Of Game Artificial Intelligence

The term Artificial intelligence technology is completely based on computer [**?**].Artificial Intelligence studies the activity of transforming the knowledge into artificial intelligence through electronic technology that is currently available. The main goal of Artificial Intelligence is to design, show intelligence and achieve the work that human intelligence can accomplish or in some cases cannot be accomplish. Nowadays, there is a clear difference between the type of artificial intelligence in commercial games and the type of artificial intelligence as a player playing games. Most of the problems in the game development can be solved perfectly by traditional qualitative Artificial Intelligence techniques such as state diagram search and regular script. The main application or the main purpose of using Artificial Intelligence technology in games is mainly to design immersive and interesting scenes for gamer, so that players can immerse themselves in this relatively real situation and they get the real experience. Normally, the computing capacity and storage capacity of the general computer cpu are very limited and not enough to adopt Artificial Intelligence technology.

In the most of the games the Artificial Intelligence technology in the game should not be too smart like the games which has been built for the only purpose of entertainment, at least not more than half of the player's level, otherwise the player will lose interest in the game as it's of no point how hard he try he will not be able to beat the perfect Artificial Intelligence bot. Therefore, when artificial intelligence technology is applied in games or for making Artificial Intelligence bots, on the one hand, it should limit its effectiveness, intelligence and prevent players from being frustrated, on the other hand, it should also increase the development process and application of intelligent technology in games. Advanced artificial intelligence has better original computing ability and thinking of course, or the machine has to face the solution thinking, or the like, but in the game, the designer hardly pays attention to it at all and yet these are the most important things but are to

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underrated . The main things that game designers actually want is for players to have a good as well as the real experience after playing games. Generally, while designing games, designers want to design an experience for players like a real experience. Designers want to know what players will experience when they reach some interesting point in the game. So, if an artificial intelligence is to be placed, it is strictly expected that the Artificial Intelligence is has to be predictable.

While designing games, game designers need to balance the virtual game world and has to keep many things in mind. On the one hand, they should attract players interest in games, and on the other hand, they should make games chal- lenging but not frustrating. Hence, all this things leads the design of artificial intelligence in games towards complication and it becomes so much difficult to built the games, also the the designer should focus on the quality of games. Therefore, to design a balanced and difficult game, the application of artificial intelligence technology is very important.

## 6 Conclusion

Various AI algorithms can be used to Design and implementation of chess en- gine. This paper introduced some of the chess engine algorithms and their optimiza- tion techniques. When the search reaches a certain depth(terminal node to evaluate heuristic function) to accumulate enough information, and its useful to prune the unwanted nodes or entire sub-tree to reduce the search time.

Since the algorithm side has a lot of research scope, the focus is on the graphics end on how to make the chess game visually appealing enough that players find it unique to the real life chess board. The GUI can be improved using light bit boards and the chessmen can be reinvented into whatever style intended for the game.

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