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Research Article

A Hybridize Heuristic Based Method in Evolving Mancala Game/ Awale

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Abstract This paper presents a hybrid of minimax search technique with Aggregate mahalanobis distance function and propabilistic distance clustering with an improved end game database to elvove the traditional mancala game player. The aim of choosing this hybrid technique to to help improve the efficiency of minimax search algorithm since, minimax search through the aid of end game database can help to suggest a best move that will give a player the highest possible outcome within a short periodof time without looking into the dataset of the game. The system developed has been tested severally and an excellent performance was obtained as the results in other words, the system was efficiently imlpemented and effectively running.

Keywords Hybridize, Heuristic, Minimax search, Awale, Mahalanobis Distance, Probabiistic Distance Clustering

Introduction

Minimax search and its variants such as alpha beta pruning has still remain the best algorithm for designing of any computer game due to its capability of classifying the game strategies into various classes and suggesting the best strategy that will give a player the best possible outcome [1].

Several techniques are used in analyzing many situations of conflicts among some individuals as this is been defined by the game theory [2]. Artificial intelligence domain in the field of computer science has provided the opportunity for human being to compete against the computer. This computer game includes Awale/Ayo, Chess, Poker, Bagamonn and others. These are games both children and adult play regularly and competitively without Games grant players the knowledge to compete with other players who also have their own different playing strategies (tactics) in mind.

Major challenging problem of game playing in the field of computer science has been its difficulty in designing of game playing algorithms.

Searching is the only possible solution for games and this is of two types namely; Exhaustive search which uses depth first or breath first to search for a solution. Secondly, heuristic search is a search with a pattern. Heuristic search technique and its variants like alpha beta pruning cannot in any way be compared to exhaustive search due to its ability to cut off some nodes that there are no need in searching for and thereby reducing the amount of time that would have been used in searching for those areas.

Minimax search algorithm of Heuristic search techniques and its variants such as alpha-beta pruning are normally used in game of strategy(two or more persons game exluding the nature) such as poker, Bagamonn, chess, poker, Awale and others.

The major challenging problems in development of minimax search algorithms is the problem on how to design and apply an evaluator for the game tree where as, an evaluator is very important to computer game programs and so most of the computer simulated players are categorized based on the efficiency of their evaluation function. Traditional mancala game popularly known as ayo by the Yoruba's, dara by the Hausa's and ncho by

Igbo's, is an African traditional board game played by African and its adjacent countries but mostly, Nigerians . The game has been described to come from a family of mancala board game.
This paper describes a hybrid heuristic based method of evolving mancala/ Awale game player.

Related Works

Minimax search algorithm has been used by Akinyemi to evolve Ayo. In her work "A Refinement Based Heuristic Method for Decision making in the context Ayo Game" studied the extent by which minimax search algorithm can be improved using the method mentioned above in playing of Ayo game. They also studied how to use CDG (an end game strategy) in generating good strategies for the game in such a way that only good moves will be made available for the game player at any given point in time [3].
Probabilistic Distance Clustering Based Technique was used by Randle to evolve Awale player. In his study, he developed a new game technique that was used to evolve an Awale game player which according to him, an appealing results was obtained but not to compare when the end game database was improved [4]. Oluwarotimi and his co writers in their research work "An overview of unsupervised machine learning techniques to evolve Mancale Game player" reported that, the game of Mancala/Awale/Awari/Ayo has been greatly developed using supervised learning of the learning algorithms which has already been used to to evolve Awale game players and the results obtained from the techniques are not so much appealing [5].
Ibidapo and her co writers has presented a machine learning Approach in elvolving Ayo Game. In their work, they explains that, the main purpose of observing game scenarios is to look out for a new strategy possible of making the players to win the game which they implemented using a refinement based heuristic as technique . The results of their work showed that this technique is more effective for decision making than other previous works.
Minimax search algorithm has been greatly used by Akinyemi and her colleagues to evolve Ayo. In their work "An empirical judgment of computer simulated Ayo Game for Decision Making" presents, the process of making decision on the basis of knowledge of game playing as a major key that characterized human. They simulated Ayo game player on a digital computer and then, empirically evaluated the behavior of the prototype simulation. Empirical judgment was also carried out on how experts play Ayo game as a means of evaluating the performance of the heuristics used to evolve the Ayo player in the simulation. The work projects a novel means of solving the problem of computer game playing of Ayo game [6]. Iyigun has also descibed a Probabilistic Distance Clustering method in evolving ayo [7].
Learning Distance Functions Algorithms was used by Tomer to elvove Awale player. The result of their work was found to be more adoptable than other existing systems. Randle and his co writers has compared the performance of supervised and unsupervised machine learning techniques in evolving Awale/Mancala/Ayo Game player. In their study, they compared the performance of some techniques of the machine learning algorithms with minimax search algorithm and then develop a new technique that will help to improve the efficiency of minimax search algorithm [8].
Minimax search and end game databases was also used by Ngwira and other of his co writers to evolve Awale Game player of which their end game databases needs to be improved . Co-evolutionary method was used by James and other of his colleagues to evolve an Awari player. The result of their work shows that, this technique is among the best because it has proven to defeat Awale shareware in three stages of play although needs to be improved.
In this paper, we have tried to describe a hybrid heuristic based method to evolve mancala /awale game player for an improved and efficient result.

The Hybrid Technique

This paper implemented a hybrid method of minimax search with agggregate mahalanobis distance function and probabilistic distance clustering to evolve an expert traditional wazobia mancala game player. The proposed system is designed in a way that the traditional mancala game strategies were grouped into two categories, C_1 and C_2 representing classes of good and bad strategic moves. The good strategy will eventually lead the player in winning the game whereas, the bad move prompt the player in losing the game as well.

Minimax Search

Minimax search technique cannot work alone due to the following reasons;

1. The difficulty in developing game evaluators whereas, game evaluators are very important to computer games because there are highly used to access the effectiveness of most computer games.
2. The problem of knowing how to choose a correct strategy without any assumptions that the opponent player will play better.

The minimax search employ in this work is that, the max player increases his game's minimum value whereas, the min player tries also to reduce his game's maximum value as the two players' plays to their optimal values. The mathematical illustration of the stockman formula is written [9] below as:

$$F(n) = \begin{cases} \text{Max}\{f(c)/c \text{ is a child node of n}\} - f(n), \text{ if n is a min node} \\ \text{Min}\{f(c)/c \text{ is a child node of n}\} + f(n), \text{ if n is a max node} \end{cases} \quad (1)$$

There are three main components of heuristic based algorithm namely;

i) Game tree building

ii) Game value computation

iii) Best move suggestion after evaluation moves.

The game tree building approach build a game tree using a top- down approach The game value computation stage computes the value of the game using bottom up method as in the equation (1) above and lastly, the "predict move" predict the best move using move refinement procedure (MRP).

Minimax search classifies moves into two classes C_1 and C_2 representing the classes of good and bad strategic moves where the good class of move is the one that will give the both players the the best advantage for winning.

Aggregate Mahalanobis Distance Function (AMDF)

Aggregate Mahalanobis Distance function was first proposed by P.C. Mahalanobis in the statistics community[10]. Suppose the game strategy x is given, the refinement based procedure calculates mahalannobis distances d(x, C_1) and d(x,C_2) between x, and the clusters of good and bad game strategies as they are represented by their centurions C_1 and C_2. Then, the aggregate mahalanobis distance (AMD) D_x^m of the strategy x to the clusters C_1 and C_2 is calculated [4] below as;

$$D_1^m = \frac{\{(x-C_2)^T \sum_2^{-1} (x-C_2)\}^{1/2}}{\{(x-C_2)^T \sum_2^{-1} (x-C_2)\}^{1/2} + \{(x-C_1)^T \sum_1^{-1} (x-C_1)\}^{1/2}} \quad (2)$$

Where the value of D_x^m is between 0 and 1. The values nearest to 0 suggest that x is the worst strategy and value close to 1 suggest that x is the best strategy so far. This decision rule of the hybrid system suggests a strategy with the highest aggregate mahalanobis distance.

The mahalanobis distance function is given as [10,4];

$$d(x, ck) = \{x\text{-}c_k^T (\Sigma_k^{-1} x - c_k)\}^{1/2} \quad (3)$$

Where A^T is the transpose vector of A and $\sum_k^{-1} U$ the universe matrix of the covariance matrix $\sum_k$ given by [4]

$$\sum_k = \frac{\sum_i^N uk(xi)\, xi - (ck\, xi - c_k)^T}{\sum_{i-1}^N uk(xi)} \quad (4)$$

Probabilistic Distance Clustering

Probability distance clustering has the capability of clustering every valid input data without erroneous or missing data. In probability distance clustering principle, the probability of P_1 (x) where x is a member of D is written as;

$$\underline{P_k(x) d_k(x)} = k \quad (5)$$

The Proposed Algorithm

Step 1: Assuming a state of a game and given the game move (n) = {m_1, m_2, ...m_n} represents a set of (n) possible moves.

M_n =head and M_1 =tail. Then a strategic move is always reserved for the next player when is not possibly picked by the current player.

a) If (n)= 1, then choose the only feasible move and stop

b) If M_n/M_1 is not reserved for the first/second players respectively, then choose it, else pick the move with the best advantage.

Step 2: Sort out the strategic moves into the classes of C_1 and C_2 using an improved end game database

Step 3: If C_1 and C_2 classes are not actually bad classes, then, look for the inverse (covariance) of both classes, which are inverse of good and inverse of bad classes (1g and 1b) respectively.

Step 4: Let Mg = //C_1//and Mb = //C_2// where Mg and Mb are the means of good and bad classes of moves respectively.

Step 5: If Cg = I which as a determinant (mean) of Cg and of good strategies satisfies the equation below

$$Dg = \sqrt{((S - Mg) * 1g * (S - Mg)^T)}$$

Else select C_b = 0 to satisfy the following equation

$$Db = \sqrt{((S - Mb) * 1b * (S - Mb)^T)}$$

Step 6: Compute the aggregate distance

$$D = \frac{Db}{Db + Dg}$$ Where Db and Dg are the distances

to the classes of bad and good moves respectively.

Step 7: After the evaluation, Choose the move that will give the player the highest possible score with the highest value of D as the distance.

Step 8: Repeat the steps for all turn until the game is over.

Experimental Test

A PC with the following features; windows XP as the operating ,system Pentium processor of 1GHz speed, 120GB of hard disk, 32bit Screen Resolution, 1GB-RAM and 256MB virtual memory was used to implement this system. In order to test the performance of the system developed, we registered and organized to play with the versions of awale shareware(Initiation, Beginner, Amateur and Grandmaster). The results obtained was tabulated in table 1 below.

Results

Results of test of the expert traditional evolved Wazobia mancala game player have been tabulated in Table 1 below, using the various strategies. The evaluation of the game performance accuracies are read and recorded before a given set of trial plays and the average computed. The results shows a reasonably good performance of the system implemented after larger number of plays due to improved learning of expert player.

Table 1: Results of Simulation Experiment

Awale Levels	No of moves made by Awale (average)	No of moves made by the evolved player (average)	No of seeds/points won by Awale (average)	No of seeds/points won by the evolved player (average)
Initiation	14	10	20	28
Bginner	12	8	23	25
Amateur	10	10	22	26
Grandmaster	14	15	24	24

Discussion

From table 1 of experimental results above, it can be clearly seen at Awale Initiation level that, the number of moves made by Awale was 14 (forteen) as against 10(ten) moves that was made by the evolved player resulting to the winning of the elvolved player with 28 (twenty- eight) points as against 20 (twenty) points made by Awale. At biginners level, Awale made12 (twelve) moves against 8 (eight) moves made by the evolved player amounting to the total winning points of 25 (twenty- five) by the evolved player as against 24 (twenty – four) points made by Awale plyer. At amateur, it was draw movement resulting to the total loosing points of 22(t wenty- two) by Awale as against 26 (twenty-six) winning points by the evolved player. At the last stage which is the Grandmaster, Awale made 15 moves while 14 moves was made by the evolved player resulting to the draw points of 24 (twenty- four) seeds won by each player.

At each level, the total number of points won by Awale and that of the evolved player add together gives total number of 48(forty- eight) which is the total number of seeds found on the current board at the start of any game.

Conclusion

We have finally fulfilled our aim of this research and so, we have evolved traditional mancala/ Awale game using a hybrid heuristic based method of minimax search, aggregate mahalanobis distance funtion and propabilistic distance clustering with an improved endgame database. The entire system developed has already been tested and the results shows a reasonably good performance of the evolved system therefore, the system was effectively implemented and efficiently running.

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