An Empirical Judgment of Computer Simulated Ayo Game for Decision Making

Akinyemi I. O., Longe H. O. D., Olugbara O. O., Oyelami O. M.

Abstract— Decision making plays an important role in the life of every living creature. Virtually on daily basis, people must make one or more decision. A faulty decision can lead to defeat in any competition. This paper presents the process of making decisions on the basis of knowledge of game playing as a major key in defining human characteristics. We simulated Ayo game playing on a digital computer and empirically evaluated the behavior of the prototype simulation. Empirical judgment was 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. A paper-based questionnaire was designed and administered to the Ayo game players which were used for the assessments of players' perceptions of the prototype simulation, which gives room for statistical interpretation. This projects a novel means of solving the problem of decision making in move selections in computer game-playing of Ayo game.

Index Terms— Decision making, Ayo game, computer simulation, iIntelligence, prototype, payoff, heuristics.

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1 INTRODUCTION

GAME theory has provided analytical tools for examining strategic interactions amongs two or more participants [1]. It is the study of intelligent decision making in a situation where the gain (or loss) depends not just on what is done but also on what others does [2]. It is also the science of strategic decision making in situations where parties compete, and possibly cooperate, to influence the outcomes of the parties' interaction to each party's advantage [3]. From the above definitions, one could adjudge that every aspect of human life revolves round game playing, which is basically a function of decision making. According to [4], a mistake in a decision made can make one lose a game.

The basic constituents of any game are its participating autonomous decision makers, called "players" [5]. Games have existed among many ancient peoples and are known in all contemporary human cultures. It has been suggested that the playing of games is one of the keys defining characteristics of man. Games elicit a strong imaginative response, and thus have come to occupy a prominent place among the metaphors, which have been employed for human life. Game occurs in diverse ways. For example, entertaining games, such as, chess, poker, tic-tac-toe, bridge, computer game, and so on are known today. Moreover, there is a vast area of economic games [6, 7] and political games [8, 9, 10]. A game is designed for a primary purpose other than pure entertainment is called a serious game [11, 12].

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This paper presents a computer simulation process of decision making in playing *Ayo* game . The rest of the paper is organized as follows. Section 2 presents a brief insight to *Ayo* game. Section 3 discusses the simulation-based decision making in *Ayo* and the game architecture. Section 4 presents the experimental tests and results of the study. The paper is concluded in Section 5.

2 AYO GAME

Ayo is a game that requires rigorous calculations and strategies, with the aim of capturing as many seeds as possible [13]. Such a game is called combinatorial game, and has captured the attention of many Artificial Intelligence (AI) researchers, mathematicians and computer scientists. Two persons play *Ayo* turn-by-turn at a time with the board put in between them. The board is a hollow plank of wood consisting of two rows of six pits each belonging to either row and each pit contains four seeds of plant c*aeselpinia crista* [14] such that a total of forty-eight seeds are contained in a board at the start of the game. A move in *Ayo* consists of a player choosing a non–empty pit on his row, removing all of the seeds contained in that pit and distribute them one seed per pit, exempting the starting pit in counter–clockwise direction. A capture is made when the last pit for which seed is distributed is on the opponent's row and contains either two or three seeds. Thus, the seeds in the pit and the preceding pits, which meet the same conditions are captured and removed from the opponent's row. A detailed description of the game rules and strategy could be found in [3].

3 Framework for Decision Making in Ayo Game

3.1 The Game Architecture

The game architecture is divided into three conceptual layers: the Game-Agent Interface, the Game-Play Interface and the Game-Logic Interface as shown in Figure 1. The Game-Agent interface handles external communications and manages the

flow of the game by interacting with and executing command requests from the game player (for suggesting best move) in the simulation process. It queries the Game-Play interface for all intelligent behaviour regarding the game. It also includes a game parser for building a compact internal representation for referencing needed by the Game-Play interface. The parser converts moves sent from the game player into the internal form. Upon receiving a message, the agent saves the description in the message to a file where appropriate evaluation of action (or move) to be taken is carried out.

The Game-Logic interface encapsulates the state space of the game, provides information about available moves, and tells how a state changes when a move is made and determines whether the state is terminal with respect to the goal value. It also provides a well-defined interface for the Game Controller. Once initialized by the Game Agent layer, it initiates an external process for translating the previously saved game description into C code. The generated code is compiled into a library responsible for all game-specific state-space manipulations.

The Game Play Interface is the main artificial intelligence part of the agent responsible for its move decisions. The design for the play logic – called Game Players – uses a well-defined interface allowing different Game Player implementations to conveniently plug into the layer and use its services. Three different heuristic metrics (Angular, Canberra, and Correlation) were used to evaluate the game position relative to move selection (see sections 3.2).
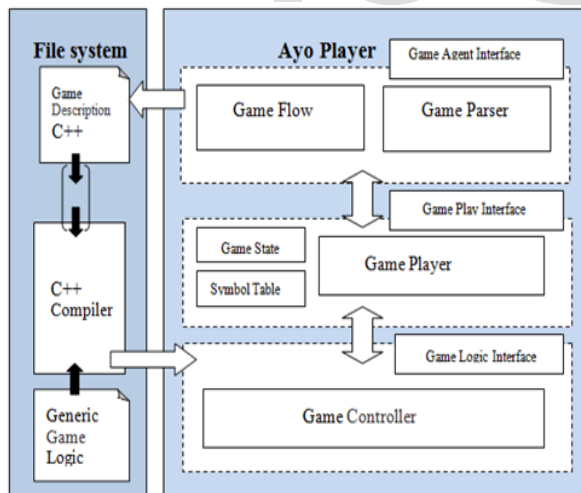

Fig 1.The Game Architecture

3.2 Prototype Simulation of Ayo Game

Following the architecture described in section 3.1 above, the game design for the prototype simulation of the *Ayo* game was developed using C++ builder and it is divided into three parts; the menu bar, the game position evaluation part, and the game play interface. The menu bar has five other options, which are controlled by the game agent and the game logic. They are; **retry**, **cancel**, **payoff**, the **south/north** pit, and **close**. The game agent controls the retry, cancel, south/north pit and close, while the payoff is controlled by the logic. The game position evaluation part is made up of the move gain and game value for each of the pits denoted as S_1, S_2, . . ., S_6. The heuristic metrics (i.e. Canberra, Correlation and Angular) are used to evaluate the respective game values for each position by using a 4-ply look-ahead and thereby suggesting the best move for the player as soon as the payoff button is clicked in the course of the game play. Best move refers to the best pit to play from, by taking cognizance of the opponent reaction (play). The game play interface is a typical board representation of *Ayo* game with four seeds in each pit on either side of the board at the start of the game with a store for each player. A typical screenshot of the simulated *Ayo* player is shown in Figure 2 below.
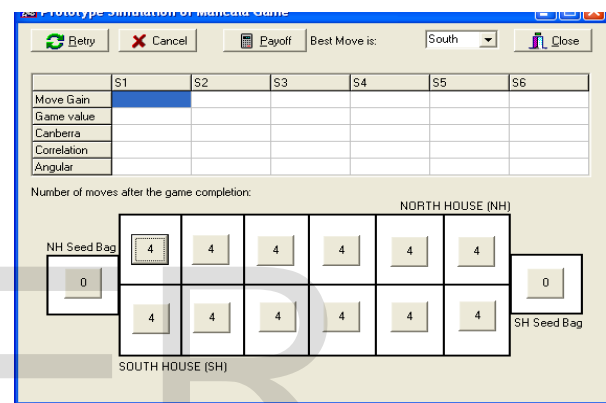

Fig. 2.Screenshot of the Ayo Game Simulation

To play the game, the player would have to choose a pit (south or north), but by default, south is chosen. Any of the players (south or north) could start the game first. We have experimented with several cases whereby the computer started the game first and as well started it second. When playing the game, as soon as it is the turn of the computer to play, payoff menu (button) on the interface is clicked, this initiates the game evaluation section and the respective game values are computed. Suggestion is then made on the best pit to move from. This is indicated in front of the payoff button as shown in Figure 3.
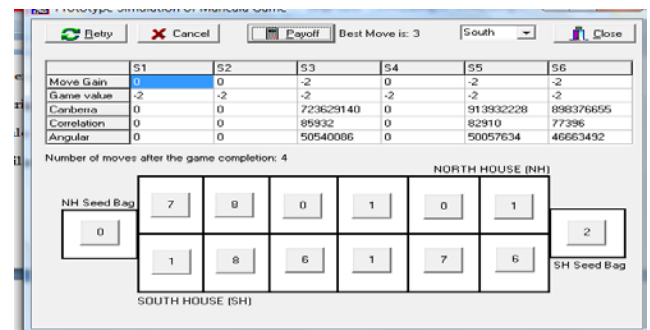

Fig. 3. A Typical Screenshot of Ayo Simulation Showing Best Move.

As seen in Figure 3, the payoff has suggested that move should be made from pit three (3) that has six (6) seeds; this gives rise to the capture of 2 seeds.

4 EXPERIMENTAL TEST AND RESULTS

4.1 Experimental Test

We implemented a simple Heuristic Decision Making (HDM) system to evolve *Ayo* player on a PC with Microsoft Windows XP Professional operating system and Pentium (R) 4, 3.00GHz, 80GB hard disk with 1GB RAM. The performance of the prototype simulation was evaluated by playing series of games with Awale shareware (simply referred to as Awale).

4.2 RESULTS

4.2.1 Performance Evaluation

In order to test the prototype application, we registered to play with Awale at its various available levels, that is, Initiation, Beginner, Amateur and Ground Master. Subsequently, some human players (experts and novices) of *Ayo* game were contacted and the developed application was made to play with them. The results obtained from six of the series of game played at each level having allowed each player to start thrice are recorded in Table 1 using the playing rules and the strategies described in section 2.

TABLE 1
RESULTS OF GAME PERFORMANCE EVALUATION FOR HDM AND AWALE

Average Response Time (per sec)		Size on Disk (MB)		Play Levels	Tournament	Average Moves	Seeds Captured	
HDM	Awale	HDM	Awale				HDM	Awale
1.84	2.11	2.12	3.33	Initiation	1	19	26	4
					2	18	28	11
					3	20	26	9
					4	23	30	14
					5	28	29	12
					6	17	26	17
2.21	2.63	2.12	3.33	Beginner	1	37	26	11
					2	38	25	10
					3	36	27	10
					4	39	26	16
					5	42	27	15
					6	33	26	17
2.21	2.63	2.12	3.33	Amateur	1	36	15	27
					2	41	21	18
					3	48	25	14
					4	38	20	23
					5	33	26	15
					6	41	27	19
2.21	2.63	2.12	3.33	Ground Master	1	36	14	28
					2	41	17	25
					3	41	25	15
					4	52	29	12
					5	47	27	16
					6	63	27	14

From Table 1, it can be seen that the HDM performed better than Awale in the various tournaments irrespective of the level. Again, the average response time for which the HDM suggests move is faster than Awale, and even takes less memory space compared with Awale.

The move-by-move account of a typical game play for two different game tournaments played between HDM (south (S) player) and Awale grandmaster (north (N) player) when each of them started first is represented in figures 4 and 5 below with the pits numbered from left to right.
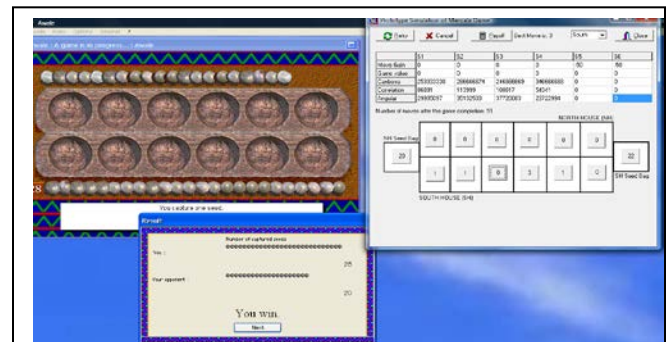

Fig. 4. Screenshot Showing Complete Game Play with Total Seeds Captured and Number of Moves When HDM Starts First.
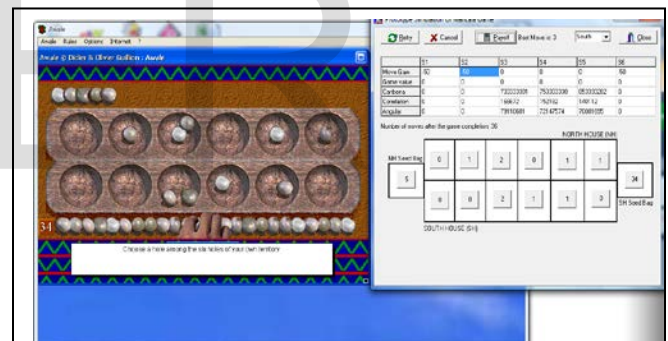

Fig. 5. Screenshot Showing Complete Game Play with Seeds Captured and Numbers of Moves When Awale Starts First.

4.2.2 Userbility Evaluation

In this work, we empirically evaluated the usability of the HDM as relating to the advantages of using the prototype *Ayo* game for decision making in learning the game by any game player (see section 4.2.2.1 for detail report). The HDM application was made to play with 10 human players (experts, novices and interested learners) twice, and all the players were made to start first on each game played so as to carry out a prototype usability testing in order to assess the performance of the HDM in terms of the accuracy of move suggestions, seed distributions, functionality and reliability of features, and hence obtain timely feedback from the players.

A paper-based questionnaire was designed and administered to the *Ayo* game players. The questionnaire were used for the recording of the players' perceptions of the prototype

system. The players interacted with the prototype system by performing a regular game playing on *Ayo* board. For the purpose of objectivity, the players in the game tournaments were made to use the prototype system against the opponent to suggest the pit to move from, thereby validating the correctness and fastness of move suggestions by the prototype simulation as opposed to human mental reasoning. The questionnaires were administered immediately after each game played to capture the players' view about the *Ayo* game prototype system. All data were collated using a five-point scale from "1", being "Strongly disagree" to "5" being "Strongly agreed".

4.2.2.1 Data Analysis

The feedbacks obtained from game players through the questionnaire were analysed using Statistical Package for Social Sciences (SPSS 15.0 for Windows) to generate the frequency distribution, mean score, standard deviation, and variance for all the ratings for the prototype application based on the various usability metrics used for the evaluation of the prototype application. Table 2 shows the mean scores of the parameters used in the questionnaire for the evaluation. From the result, a mean score of above 4 in nine out of the 12 parameters considered from the questionnaire was obtained. Several usability studies have revealed that a system should have a mean score of 4 on a 1-5 scale and 5.6 on a 1-7 scale [15]. Since the adopted approach used a 1-5 scale, it is therefore sufficient to conclude that the prototype application developed for this work has a "Good Usability" as most users expressed satisfaction with the prototype application.

TABLE 2.
DESCRIPTIVE STATISTICAL ANALYSIS OF QUESTIONNAIRE DATA

	Layout Fascinating	Feel Comfortable using the Prototype	Satisfy with Performance	Friendly Game Interface	Flexible interface Design	Work the way I want
Mean	4.31	4.08	4.24	4.02	4.10	4.20
Std. Deviation	0.675	1.281	1.367	0.679	0.926	0.341
Variance	0.456	1.724	1.868	0.421	0.854	0.727

	Can use the prototype without Instruction	Recover from mistakes quickly	Need more computing skills	Easy to learn	Fun to use	Suggestion wonderful and Accurate
Mean	2.42	4.58	3.44	4.17	3.55	4.17
Std. Deviation	1.495	0.579	1.388	0.947	1.313	1.147
Variance	2.234	0.318	1.926	0.896	1.725	1.726

5 CONCLUSION

This paper presents the process of taking decisions on the basis of the knowledge of game playing as a major key in defining human characteristics. The paper has provided a simple heuristic approach to simulate an *Ayo* player which turns out to be a novel means of solving the problem of decision making in move selections in computer game-playing of *Ayo* game. The

heuristic is computationally efficient and predicts best move within a very short time. The HDM can improve artificial intelligence performance and make computer players more adaptable and responsive. It has tendency to incorporate new play strategies in form of fictitious play or expert instruction and thus become sensitive to its mistakes/weaknesses and can change tactics at any point in time.

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