THE APPLICATION OF NEURAL NETWORKS AND MIN-MAX ALGORITHM IN DIGITAL CONGKAK

Noraziah ChePa[1], Asmidah Alwi[2], Aniza Mohamed Din[1], and Muhammad Safwan[1]

[1]*School of Computing, University Utara Malaysia, Malaysia, aziah@uum.edu.my, anizamd@uum.edu.my*
[2]*School of Multimedia & Communication, University Utara Malaysia, Malaysia, asmidah@uum.edu.my*

ABSTRACT. To date, there are lots of intentions and efforts made to attract young generations with cultural games by promoting, preserving and cultivating cultural games using myriad mediums such as books, e-books, blogs, social media and portals. Supporting the efforts, this paper presents works of digitizing one of Malaysian traditional games, namely Congkak. A digital Congkak was developed based on Mancala, African traditional game which is similar to Congkak. To make it intelligent, its player agent was developed using a combination of Neural Networks and Min-Max algorithm. Methods, findings and evaluation of the digitized Congkak are presented and discussed.

Keywords: digital games, Congkak, Neural Networks, Min-Max algorithm

INTRODUCTION

Congkak is a Malaysian cultural game used to play by women during ancient times. It has evolved since the day it was played, starting on the ground, moved to a board and the latest version is running on machine platform. Known as a game of strategy, it is played by two players; each player will have seven holes in a row with one large hole at their left end respectively called home or *storehome*. Each hole will consist of seven balls, often made of pebbles, tamarind seeds or even shells. It involves counters or pieces being moved on a surface or board according to a set of rules. Unlike chess or checkers, Congkak board game refers to the holes being housed on a wooden board as illustrated in Figure 1.

To play the game, each player will start simultaneously and will move to their left (clockwise) while depositing one pebble in each hole including the “home”(same move rule applied) until both had ended their turn. Then, the last player who ended their turn last will go first in the next turn. The endgame is reached whenever a player had the entire holes on his side empty. Both players will count the total pebbles collected in their storehouse. Player with the highest number of pebbles wins, and player who lose will start first in the next round.

To start the next round, both players will fill back their empty holes with pebbles from their storehouse. The players must do it from the left to the right hole (on their side), and each hole must be filled with exactly seven pebbles and the remainder will be stored in the storehouse. A non-filled hole is considered “burnt” and will be ignored during game (this is called burnt_house rule). The burnt_house rules allow the loosing player to reclaim pebbles from their opponent in next round (Yaakub, 1981).

Figure 1. The traditional Congkak board

In Malaysia, there are lots of intentions and efforts are made to attract young generations with cultural games by promoting, preserving and cultivating cultural games using myriad mediums such as books, e-books, blogs, social media and portals. The Ministry of Culture, Arts and Heritage has established Jabatan Warisan Negara (JWN) to cultivate, conserve, preserve and protect national heritage for younger generations through their portal. Digitizing Malaysian cultural games can be seen as one of the efforts in preserving our national heritage. To support the effort, we developed one of the cultural games, namely Congkak as a start.

Although there are some efforts are made to digitize Congkak, but none of them have used any Artificial Intelligence (AI) technique. In order to make our digital Congkak more intelligent, we used AI based player agent that can be configured to play with human player. To play the game, the player agent will use a combination of Neural Networks, Min-Max algorithm, and random move.

DIGITAL CONGKAK

A digital Congkak was developed to simulate the traditional Congkak. A combination of Congkak's playing rules and algorithm of Mancala have been used in the development of the digital Congkak. Mancala is a traditional game originated from Africa that has similar rule and board shape to Congkak (Voogt, 2001). Although played on the same board design and using a similar rule (except for house burnt concept applied in Congkak), Mancala is simpler. Mancala is using alpha-beta cut off function and alpha-beta forward pruning function. The Min-Max algorithm in Mancala works by searching the game-state for a profitable amount of pebbles in the storehouse, and alpha-beta works by excluding game-state that lead to non-profitable outcome (thus lessening the size of the state search) (Bylander & Tom, 2007). It is found that this Adam Cofer's algorithm is fully compatible with Congkak and requires only minimal changes for it to be functional.

Unlike Congkak, Mancala does not feature multi-lap move, no multi-stage game and no burnt_house concept. Mancala player start playing the game by picking up pebbles from a hole on the player's side and move counter clockwise while deposited a pebble each time the player passes a hole or storehouse. If the player emptied his hand on an empty hole then he will lose the current turn. If this hole is his own side then he can capture pebble from the opposite hole and put them (and the last pebble he deposited) into his storehouse. However, if this hole is his opponent's hole then he must leave the pebble there. Mancala player can deposit pebbles in any hole except his opponent storehouse which he must skip (Cofer, 2003). Table 1 depicts differences between Congkak and Mancala.

Table 1. Congkak vs. Mancala

	Congkak	Mancala
House burnt concept	Yes	No
Fixed number of pebbles	Yes	No
Fixed number of holes	Yes	No
Jump-score	Yes	No

To make our digital Congkak more intelligent, Artificial Neural Networks (NN) and Min-Max have been used. Min-Max is an algorithm that uses state searching to find the best possible move. Many board games (such as Mancala) used Min-Max algorithm as an AI agent and as a benchmark to other artificial agent because of its completeness in finding solution. Min-Max algorithm is known as the most effective algorithm for creating an artificial agent for board game. For the digital Congkak, the Min-Max evaluation function is the amount of pebble contained in the agent's storehouse minus the pebbles contained in the opponent's storehouse (the difference of pebbles).

A simple user interface of the digital Congkak is shown in Figure 2. Two sets of seven boxes arranged in a row shows the main holes of Congkak, the two big boxes at the corner are the homes or homestore. Numbers in each box indicates number of pebbles in that particular round. Numbers in boxes with five (5) indicates number of pebbles in hand.

Figure 2. Graphical interface of Digital Congkak

NN AND DIGITAL CONGKAK

The goal of using NN in developing Congkak is to make a better predictor for the winning move, which consequently lead to a better player (Sutton, 2005). NN is trained in the above said configuration, and when a new data point arrives, the old data point is shifted backward in time and the new data point is set as the new output neuron. The goal is to make NN learns the behaviour of the data points in time-series. NN will learn faster if the data point shows a repeating pattern (Carter-Greaves, 2011).

For Congkak, the board state and the move state is the data point, and this point is separated from each other by the player's turn. Only a winner's turn is used for the output neurons, (input neuron uses both turn). The training aims to detect the patterns that lead to this winning state. In this project, a data point is flagged as significant or insignificant by reducing or increasing the NN's "max_training_error". Training will be performed with more iteration to achieve the desired minimum-error or is interrupted early. When a player reclaimed their burnt holes (gained lost hole) or caused the opponent to loose hole (have more burnt holes), or when a move increases the storehouse count and prolonged turn, then the moves are considered significant.

MIN-MAX ALGORITHM

Min-max algorithm is the most common AI algorithm for board games. Min-Max is an algorithm that uses state searching to find the best possible move. Many board games (such as Mancala) use Min-Max as an artificial agent and as a benchmark to other artificial agent because of its completeness in finding solution. It is reported that Min-Max algorithm is the most effective algorithm for creating an artificial agent for board games. It works by creating a secondary copies of the present game during play and exhaustively tested moves on this copies to get the outcome, and when the desired outcome was found: it retrieve the move that is responsible for this outcome and send it to the present game. Min-Max can work on any board game as long as the game's instance is copyable and it can make a perfect copy and its game state is easily evaluated by calculation or algorithm.

The Min-Max evaluation function for this Congkak system is the amount of pebble contained in the agent's storehouse/homestore minus the pebbles contained in the opponent's storehouse (the difference of pebbles). This is similar to Mancala's evaluation function. Since Min-Max is similar to greedy-search algorithm, then it can be imagined in term of search-tree. This project adapted Adam Cofer's depth-first-search with alpha-beta cut-off function. The algorithm starts by opening a child nodes and evaluate it, and then it open another node and evaluate it along the way until it reaches the endgame node (or until a cut-off depth), when it reach the end: it pass the endgame's evaluation value to its parent node, the parent will then select the highest evaluation value (from several child node) to be pass on to the grandparent node and so on until it reach original board state, the original board will select the nodes with highest evaluation value as its next move.

The alpha-beta cut-off function works by immediately returning the best move value whenever a specific condition is meet. This will skip the entire Min-Max space-search and saves processing time. Min-Max can still return the same value if without alpha-beta cut-off, but with more searching. (Samuel, 1967; Lim, 2007).

FINDINGS AND DISCUSSIONS

A first version of digital Congkak is presented and discussed. It has been tested in terms of its functionality. It runs perfectly as the traditional Congkak is played. Due to time constraint, the digitization only concentrated on the functionality, thus only simple GUI is produced.

For comparison, our Congkak was tested with different player agents; NN, Min-Max algorithm and random move. Table 1 shows the win-lose count for all artificial agents. Min-Max scored highest point for all games, while Neural Networks is the lowest.

Table 1. Win-lose count for player agent

Artificial Agent	Winner		Tie	# of games	Win ratio
	Player 1	Player 2			
Random vs. MinMax	1	19		19	0|1
Neural MinMax vs. MinMax	0	20		20	0|1
Neural MinMax vs. random	52	1		53	1|0.02
NN vs. Neural Min Max	0	100		100	0|1
NN vs. random	39	59	2	100	0.66|1
NN vs. MinMax	0	30		30	0|1
Neural MinMax vs. Neural MinMax	60	40		100	3|2
NN vs. NN	50	50		100	1|1
Random vs. random	41	42	8	90	0.98|1
MinMax vs. MinMax	0	54		54	0|1

Each testing is capped at maximum 10 rounds, and the test is repeated for 10 times for each combination of agents; resulting in total of 100 rounds for each combination. Min-Max is played less than 100 rounds; this is because Min-Max immediately wins in each game; and on average Min-Max only need 2 rounds to defeat the other agent: so it only played a maximum of 10x2=20 games.

CONCLUSION

A first version of digital Congkak is successfully developed by using both NN and Min-MAX algorithm as its player agent. Although it runs perfectly, there are rooms for improvement especially it's GUI. Series of tests are recommended to be conducted involving different levels of player to see their acceptance of the digital version of our cultural games. This digital version of Congkak can be seen as a basis for future research in digitizing other cultural games. Potential future work is to make it run on a different platform such as mobile gadgets.

REFERENCES

Amory, A., Naicker , K., Vincent, J. & Adams, C. (1999). The use of computer games as an educational tool: identification of appropriate game types and game elements. *British Journal of Educational Technology,* 30**,** 311 - 321.

Carter-Greaves, Laura E. T*ime Series Prediction With Feed-Forward Neural Networks*. Retrieved on 13.3.2011 from http://neuroph.sourceforge.net/TimeSeriesPredictionTutorial.html

Cofer, Adam (2003), *MancalaIn Java: Experiment in Artificial Intelligence and Game Playing.* Departmental Honor Thesis. University of Tennesse at Chattanooga.

Dyck, J., Pinelle, D., Brown, B. & Gutwin, C. (2003). Learning from Games: HCI Design Innovations in Entertainment Software. *In:* Graphics Interface Canada.

Grace, L. (2005). Game type and game genre. Available: http://www.lgrace.com/documents/Game_types_and_genres.pdf.

Hasibuan, Z. A., Isal, Y. K., N.C., B. A., Ahmad, M. & Selviandro, N. (2011). Preservation of Cultural Heritage and Natural History through Game Based learning. *International Journal of Machine Learning and Computing,* 1**,** 460 - 465.

Kirriemuir, J. & McfFarlane, A. (2004). Report 8: Literature review in Games and Learning. *Futurelab Series.* Futurelab.

Malone, T. W. (1984). Heuristics for designing enjoyable user interfaces: Lessons from computer games. *In:* Thomas, J. C. & Schneider, M. L. (eds.) *Human Factors in Computer Systems.* New Jersey: Ablex Publishing Corporation.

Ramli, N. S. (2009). Digital Traditional game. Kuala Lumpur: Universiti Malaya.

Sutton, Richard S.; Barto, Andrew G. (2005). *Reinforcement Learning: An Introduction*. The MIT Press, Cambridge. Retrieved on 22.3.2011 from http://neuro.bstu.by/ai/RL-3.pdf

Von Ahn, L. (2006). Games with a purpose. *Computer,* 39**,** 92-94.

Voogt, A. de. (2001). Mancala: A Game That Count. *Expedition Philadelphia*, Issue 2001.Penn Museum. Retrieved on 10.3.2011 from http://www.penn.museum/documents/publications/expedition/PDFs/43-1/Mancala.pdf

Yaakub Rashid (1981). *Revival of Congkak*. The Strait Times, National Library Board, Singapore.NewspaperSingapore. Retrieved on 3.4.2011 from http://newspapers.nl.sg/Digitised/Article/straitstimes19811006.2.130.6.1.aspx

Wolf, M. J. P. (ed.) 2002. *The Medium of the video game*, Texas: University of Texas Press.