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Hangman–Hangaroo Game Design Using Automata Theory

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***Abstract*—Automata theory plays an important role in various areas especially in game design. This paper describes the concept of automata theory in designing one of the most popular classical game which is Hangman. In this study, we focused on a game called Hangaroo, which implemented the same concept as in Hangman game. We studied and discussed the combination of automata and game theory that can be considered in order to design the game. As a result, we found that, automata theory is the fundamental access in designing and developing Games.**

***Keywords*—Finite Automata, Hangman, Game Theory, Hangaroo**

I. INTRODUCTION

Automata theory is a theoretical branch of computer science (Theoretical Computer Science) and mathematics (Discrete Mathematics). It is a theory that discuss about the mathematical study of abstract machines and automata in order to solve a computational problem. The term automata originate from Greek word "αὐτόματα" which means “self-acting”. It means that automaton is an automated process that will be carried out by an abstract machine in a fixed sequence of operation.

There are a few classes of automaton which is finite-state automata, pushdown automata, linear-bounded automata and Turing machine. For better understanding, these classes of automaton can be transformed into a hierarchal form where Turing machine is the most complex automaton and finite-state automata is the simplest one out of the others. Therefore, we will be focusing on finite-state automata as it is the easiest to understand. This automaton contains a finite number of states, a set of input events as well as transitions. According to its transition functions, the automaton will make a transition from a state to another state by taking its current state and recent input events. There are two types of finite-state automata which deterministic finite-state automata (DFA) and non-deterministic finite-state automata (NDFA) where each of them has their own distinct features but still share the same basic working principle. The only different of NFA from NDFA is the transition function. The state of NFA can have many or no outgoing edges for an alphabet symbol evolving from it. NFA does not essentially take the string execution to a unique next state [1]. Automata theory is frequently used in research areas in designing games. Automata theory plays important role in designing and evolving the computing and video games. Automata theory is straightforward to understand, and with the help of Game theory, we can develop computer games to a higher level which we cannot conceive. This paper gives an overview of designing Hangaroo game using simple automata theory and knowledge of the DFA and NDFA.

Game design is one of the areas that applied the concept of automata. The integration of automata with Game theory plays a significant role in achieving a great advancement in the development and design of computer games. Hangman is a classical game where it requires the players to guess a word based on the category that they choose. It can be played by 1 or 2 players although this paper will only focus on the single player game. The player will start the game by choosing their desired category of word. Based on this category, the game will generate a random word that is related to the category. The player will choose a set of alphabets (A – Z) to fill in the word. The player is able to choose the alphabets as long as it is correct. However, if the player chooses the wrong alphabets, a diagram of the hangman will be drawn a little by little. When the drawing of the hangman is complete, the player won’t be able to choose the alphabets anymore and they will lose the game. After that, the game will be ended.

Nevertheless, this paper will explain on how a simple game such as Hangman can be designed using the concept of finite state automata along with game theory.

II. Literature Review

Jamil *et al.* (2016) presented a paper about an infinite runner game that was designed using automata theory. In this game, Abid *et al.* use deterministic finite automaton (DFA) logic theory to create a logical design about the flow of the game. They designed the game using infinite loops logic with some conditions in which it will breaks the loop and the game then will enter Game End state. In this paper, they demonstrated the use of DFA to model every possible action that can happen when the user makes certain action in the game. The idea is that, when the runner hits any hurdle, enemy or when the fuels runs out, the game will enter a final state where the game will end with the game showing the user their high scores. On the other hand, the game will keep on the endless journey loop until the user make an action that can trigger the conditions for final state.

Ezhilarasu *et al.* (2015) demonstrated the use of finite automata in text search application [3]. In this paper, they discussed about the process of performing the text search. The problem statement for this paper is to construct the finite automata for accepting keywords "ezhil", "hills" and "Isbuss". On input keyword enters, the non-deterministic automaton (NDFA) will be responsible for accepting the keywords. NDFA will be converted into DFA for further searched using the input paragraph and then displayed the numbers of occurrence for each keyword for the input paragraph. This application of finite automata is using a theory of NDFA-DFA design structure in which the NDFA must be converted into DFA for implementation.

In game theory, presenting players with strategies will directly affects the player's performance. The use of automata theory for game concept is one way to achieve this strategy. This paper illustrates different types of automata and their application that were used in games. The authors found that many finite automata are widely used to represent the player strategies in game theory and significantly improved the player's performance [4, 5].

III. Methodology

This version of Hangman is a bit more modern than the traditional one. For the traditional one, the game needs to be played by two players which the first player needs to think of a word and show it in form of blank space to second players and the second player will need to guess the word [6]. But for this version of Hangman, there will be only one player [7]. The objective is to get the correct answer without making mistakes more than six times. For further understanding, refer to the flowchart in Fig. 1.

The flowchart in Fig. 1 shows the sequence of how the game will operate when a player plays the game. It starts with player choosing the categories from what is given. Then after the player choose the category, the game will display blank space for a word that the player will need to guess based on the category that they choose. For the guessing, the player will need to choose any alphabet from A to Z and no special character will be inside the word. For Instance, the player will only have six chances to do mistakes on guessing because when the user makes mistake, hangman will start to be drawn. For first mistake it will draw a head, then followed by body, left hand, right hand, left foot and finally right foot. When hangman's figure is complete, it means that the player has loses. However, if the player manages to guess all the letter correctly without making mistakes more than six, the player will win, and the game will end [8, 9, 10].

On the other hand, there is also a game similar to the Hangman, which is Hangaroo. The game is almost likely same with Hangman, but the game only allows the player to make three mistakes otherwise they will lose. There is even more game that is similar to the Hangman and have the same automata theory because a game like this is easy to play and develops. Besides, this game can also increase people's knowledge in various point of view because it is a game where people plays with words.

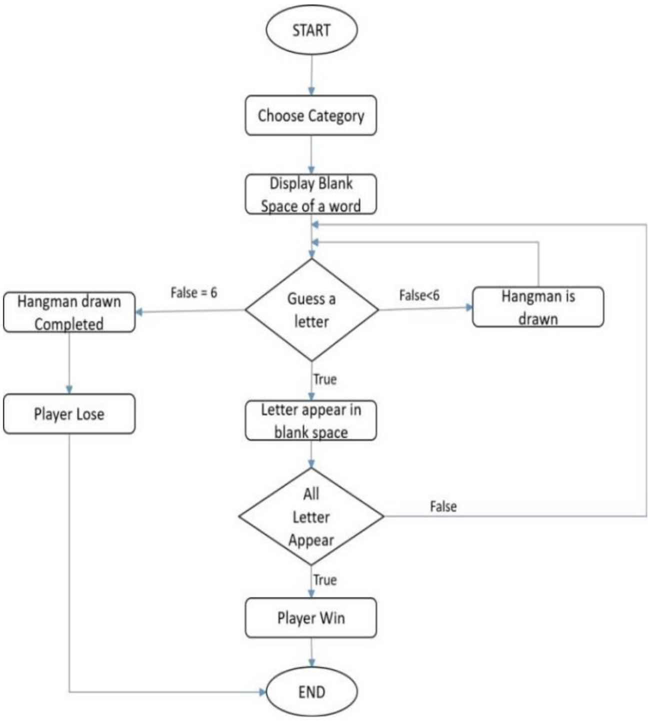

Fig. 1. Flowchart of Hangman Game

IV. Case Study - Hangaroo

Below Fig. 2, 3, 4 and 5 are the screenshots of a game similar to Hangman which is Hangaroo. Player are given three attempts to guess the word for each level and Player will need to finish ten level for them to win the game.

When player first enter the game, they will see a display like in Fig. 2. A word or sentence will be displayed and the player will need to guess by entering letter by letter. When the player enter a wrong guess, Fig. 3 will be displayed and if they entered a correct guess, Fig. 4 will be displayed.

If all the three attempts have been used, if the player make another wrong guess, the player will lose the game. Fig. 5 will be displayed. If the user makes a full guess, Fig. 6 will be displayed.

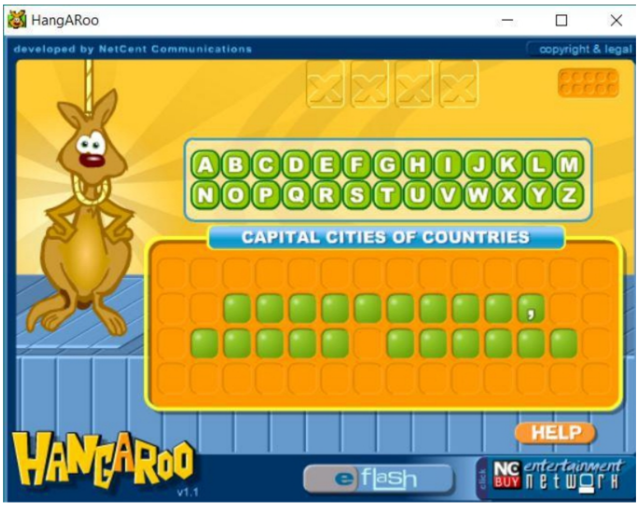
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Fig. 2. Start game with sentence to guess

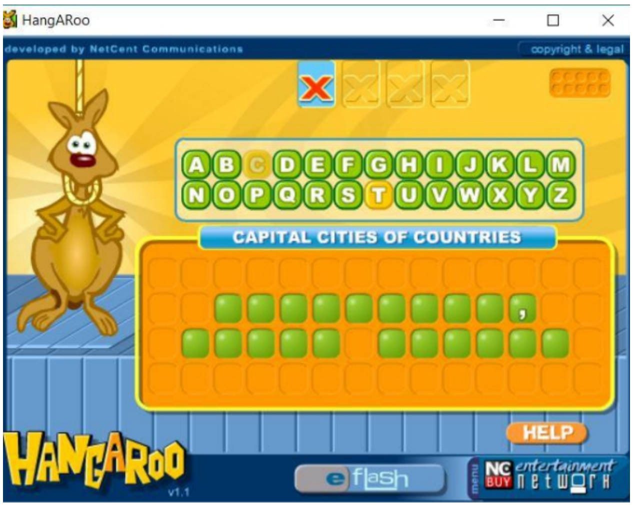
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Fig. 3. Incorrect guess

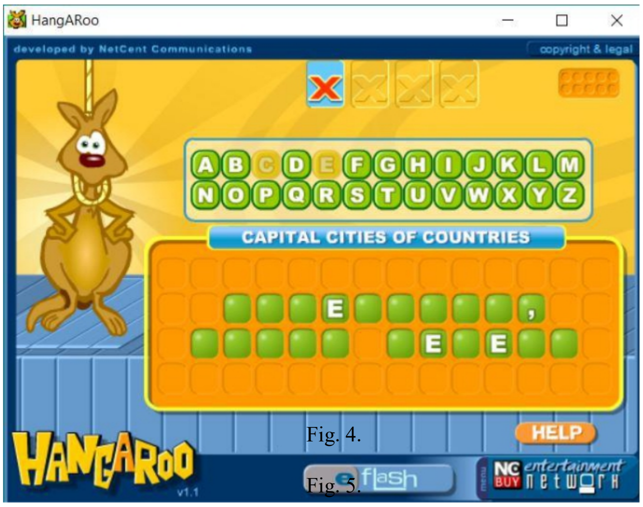
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Fig. 4.

Fig. 5.

Fig. 6. Correct guess, correct letter will reveal

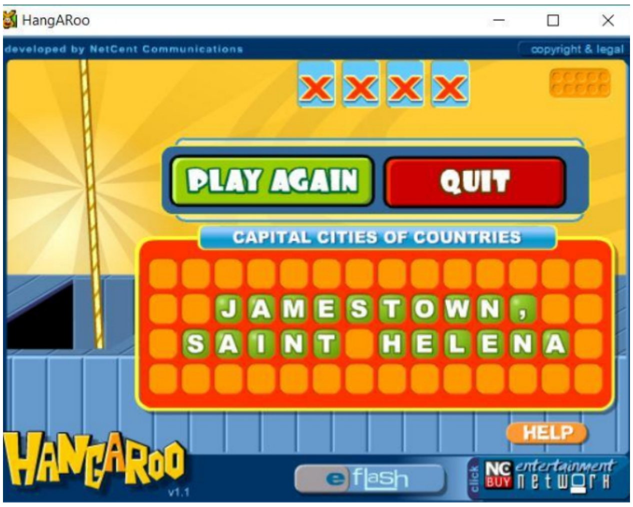

Fig. 7. Lose all three attempts.

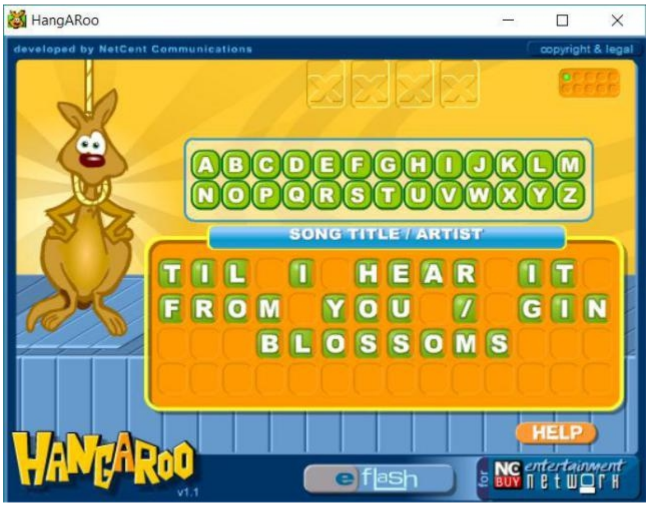

Fig. 8. The sentence is fully filled

V. Automata Design for Hangaroo

Below is the description of our designed automata for Hangaroo Game. It is a Finite Automata with five tuples. The formal definition of the game stated as below.

Formal definition:

Let M = (Q, Σ, δ, q0, F)

M: Q = {Start Game, Choose Category, Guess Letter, Draw Hangaroo, Win, Lose, End Game}

Σ = {sg, cg, ig, hi, hc, wc}

q0 = {Start Game}

F = {End Game}

TABLE I. TRANSITION TABLE FOR HANGAROO

δ	sg	cg	ig	hi	hc	wc	ε
Start Game (q0)	-	-	-	-	-	-	q1
Choose Category (q1)	q2	-	-	-	-	-	-
Guess Letter (q2)	-	q2	q3	-	-	q4	-
Draw Hangaroo (q3)	-	-	-	q2	q5	-	-
Win (q4)	-	-	-	-	-	-	q6
Lose (q5)	-	-	-	-	-	-	q6
End Game (q6)	-	-	-	-	-	-	-

Fig. 7 shows the automaton for Hangaroo Game that we had come up with and Table 1 explains about the states exist in the automaton and Table 2 describes the transition exist.

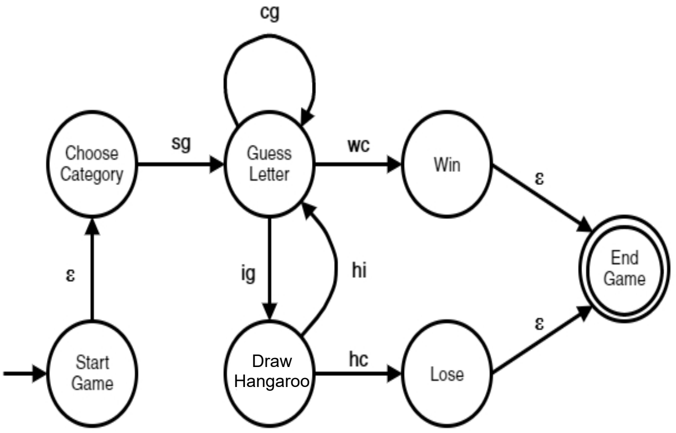

Fig. 9. Flowchart of Hangman Game

TABLE II. STATE DESCRIPTION

State (Q)	Description
Start Game	Idle state where the game start.
Choose Category	The player will need to choose a category from a set of categories that the game provided. Once a category is chosen, a random word/sentence related with the category will be displayed for the player to guess.
Guess Letter	Player enters a letter in order to guess the word/sentence given.
Draw Hanagaroo	Hangaroo will be drawn starting from the head to its leg.
Win	Word is correctly guess.
Lose	Word is incorrectly guess.
End Game	State where the game ends.

TABLE III. TRANSITION DESCRIPTION

Transition, δ	Description
sg	Game start
cg	Correct guess
ig	Incorrect guess
hi	Hangaroo incomplete
hc	Hangaroo complete
wc	Word Complete

VI. CONCLUSIONS

In this study, we implied the basic theory of automata in observing the flow of a game. We picked one game called Hangaroo to be the domain of our study. In the methodology, we studied and described the logic of the game and how the game operates. We then designed the finite automata that matched to the concept of Hangaroo game for better understanding of the game flow as described in the methodology. As a whole, the implementation of automata theory plays an important role in developing a game software. Learning the automata theory will give better understanding on the underlying applications. We found that, understanding the fundamental of Computer Science theory is very important in becoming a good developer. Not only limited to game development, automata theory is very useful for applications with uncertainty. The concept of automata theory is simple in structure and can be implemented easily in software and hardware.

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