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An Infinite Runner Game Design using Automata Theory

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ABSTRACT

Automata theory has immense importance in automated game design and development. In this paper, we present Game Design of an infinite runner game "Hungry bird" using Mealy Machines and Theory of Automation. In existing literature game design had been structured using NFA (Non-Deterministic Finite Automata) and DFA (Deterministic Finite Automata) in which NFA must be converted to DFA for implementation of game design but using Mealy machines the design becomes even explicit. This paper discusses the design theory and design of "hungry bird". It is observed that game design in Mealy Machine is more understandable and it can be further extended to more advance automation.

Keywords: *Automata Theory, Game Design, Infinite Runner Game, Hungry Bird, Mealy Machines, Game Theory.*

1. INTRODUCTION

Automata theory provides more easiness to implement games that are designed using automata theory whereas it is problematic to design the games by using other methods. A lot of computer software's are designed using the principles of automata theory. In modern research disciplines, automata theory provides ease to solve complex problems. Game design based on Automata theory aids programmer to implement complex games. The use of videos games for educational and learning purpose has become modern trend. In videos games player learns to gain the objectives and challenges in each stage. The Player also learn that how to tackle challenges and tough/severe situation in their life in a responsive manner. Games can play vital role in behavior management also video games are very interactive way to memorize new concepts for students and players.

In general, it has been observed that the story writers of games are not programmers, so it is very difficult for programmers to understand the working of games without game design document. Automata theory can play a vital role in bridging the gap between story writers and programmers.

The design of the game "Hungry bird" is presented in this paper using Mealy Machines. It is very easy for programmers to understand the working of game due to Mealy machines, because these machines are self-descriptive so programmers can easily understand and they can program it without any ambiguity.

Mealy machines are faster as compared to Moore machines also mealy have less number of states. It is easy to understand and implement as compare to Moore machines. In this paper we selected mealy machines to present game design because mealy machines are faster due to immediate output on every change in input.

The game under discussion has only one level but it's endless until you collide with enemy. These types of games are Clock games which are based on Time, Score and at times with bonus points as well. We present the working of Game, its background, actors, scores, and other game in section 3. The distribution of content in this paper is structured as follows: Section 2 consists of Literature Review. Section 3 elaborates game design methodology. Experimental results are presented in Section 4 and References and Conclusions in section 5.

2. RELATED WORK

Game development from 1970s had followed huge success from conventional desktop and arcade online video games to massive multiplayer online games but the last decade has shown a growing interest in virtual, augmented reality and Real Time Interactive games. The typical interaction between humans, computers and intelligent systems has changed greatly from conventional mouse, keyboard, joys sticks to gesture based, voice and sensory feedback systems.

Qureshi [1] demonstrated the game design of arcade games using DFA and NDFA. In that game there were various levels for each level he defined DFA to demonstrate the working of the level. The state routing of enemies and few default weapons from a set Q and some weapons depending upon the input letter from player game; is designed and constructed using DFSA and NDFSA but it is difficult to understand as compare to Mealy and Moore machines.

Abbas [2] presented the design of game Roller Coaster and they also used DFA and NDFA. This game was also level based games and all the levels are static no dynamic game objects were included so in dynamics games objects it will be difficult to present it using NFA and DFA because NFA should be converted to DFA for implementation.[2]

This paper focuses on persuasive game design which is based on three factors gamification process (game elements must be motivational based on game rules that transfer game elements to real world elements), game world (design game scenarios designed immersive enough to affect the game user's behavior in real world), behavioral design models to induce behavioral changes from game world to real world. [3]

Most of the Game theory so far has been concerned with discrete game, finite number of players, moves, events, challenges. Game genre then encompasses from automated to intelligent game having abstract rules. Creative designs share some problems i.e. using Artificial Intelligence to make dynamic story board or artifacts while game mechanics describing the evolution of game over time and player input to influence game state. This paper emphasizes on formalizing game mechanics and then Artificial Intelligence to convert game mechanics to audio-visual effect based on common sense reasoning about games verbs and nouns. [4]

This paper illustrates the learning curve of software engineering principles based on game design. Practical implementation of game design can help learn software engineering principles which includes graphics, Artificial intelligence, principles of Human Computer Interaction in spectrum of computer science from high level design techniques to low level implantation details. This Paper discusses game development from requirement elicitation, game design complexities, design pattern to implementation and testing. [5]

Game design is not a singular entity but a combination of design elements including game challenges either explicit (emerge due to our design) or implicit (challenges we specify as design), game genre, and game story combining all the elements. This paper focuses on these game design elements and that the elements require interaction among themselves for a good gameplay, much in the same way as cellular automation devised by John Horton Conway; The game of life. [6]

Most of the work presented in game design of level based games has static objects in each level. The techniques used will fail when there will be dynamic objects for example; if there will be objects generating randomly on stages with the passage of time. In this paper we present a game "Hungry Runner" which is infinite runner game with dynamic objects.

In this paper we present the solution to describe the game design of infinite runner games which have dynamics objects. We will use Mealy Machines to present this game to overcome the limitation of static game objects in level based games. Using Mealy machines it becomes easier to design such games.

3. METHODOLOGY

The Game Hungry bird is endless runner until player hits any hurdle, enemy or fuel runs out. This game is made using infinite loops with some condition on which it breaks the loop and exit to Game End state. These games have Seven States. .

Game Description:

1) **Running State:** Game will be in running state and all the game objects will performing according to job assigned.
2) **Game Over State:** Game will goes to game over state when player hits the enemy, hurdle or fuel barrel ends.
3) **Jump State:** Health bar will decrease when player is in jump state on "S" input.
4) **Fly State:** Player will be in fly state when "SS" input comes and it will decrease fuel.

- There will be two background images creating an impression of live/animated moving background while player will be still at its position.
- Four different types of hurdles will come from horizontal path and the player has to avoid them.
- Player can jump by input "S" and on S pressed player will be fly.
- Player will move on input "UP ARROW, DOWN ARROW, LEFT ARROW, and RIGHT ARROW.
- Fuel will be subtracted from Fuel barrel on jump and fly.
- Fuel will be added on catching fuel bonus barrel.

- Player will collect coin and it will be added in score.
- Score will be increasing on distance cover by player.

- State will be changed from Running state to Game End state on following conditions:
    - Fuel Barrel ends
    - Player collides with hurdle

Defining input alphabet:
Σ Move = {UP_ARROW, DOWN_ARROW, RIGHT_ARROW, LEFT_ARROW}
Σ Action= {S, SS}
Σ Game= {GS GE, CC, HH, FE,-F, C+, D+}

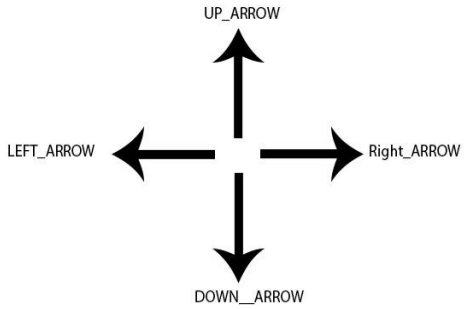

Figure 1- Player Motion Controls

Description of input alphabet:
1. Σ Move: defines movement of player UP_ARROW, LEFT_ARROW, DOWN_ARROW, LEFT_ARROW (refer to Figure 1).

2. Σ Action: defines action of player S (Player Jumps), SS (Players Flies).

3. Σ Game: This state represent different situations during game execution GS (Game starts) GE (Game Ends) CC (Coin Collected) FE Fuel Ends) –F (Fuel Subtracted) C+ (coin added) D+ (distance add) HH (hurdle hits).

Background (BG)
There will be two background images. When background 1 is live, background 2 will be in waiting state parallel to background 1 and vice versa; creating an impression of live/animated moving background while player will be still at position.
There are 4 main situations in game

1) Fuel ends
2) Player collects coin
3) Player collects fuel
4) Player collides with hurdle or Enemy

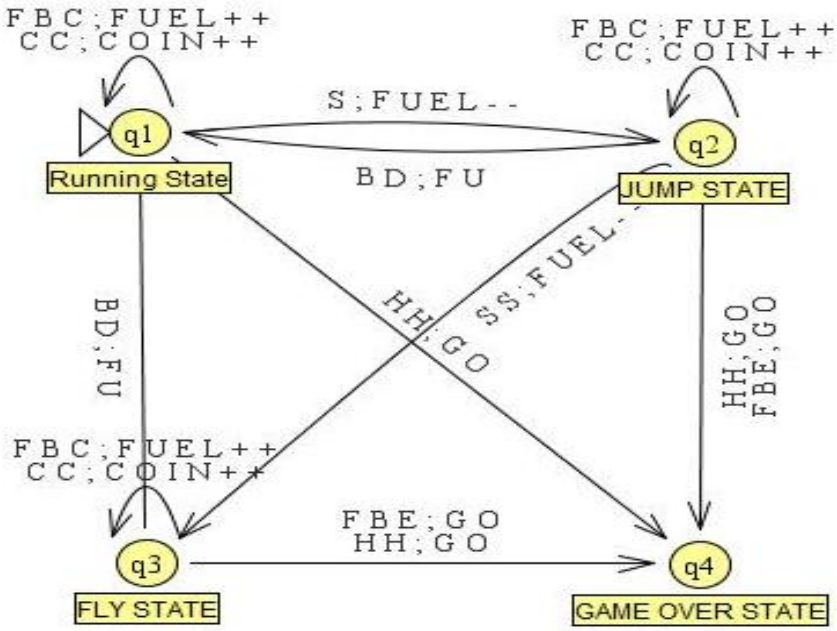

Fig. 2. Main Design Mealy Machine

A mealy machine diagram represents the game design, its states and their respective input and possible outcomes.

Transition State Table

Table 1: Transition Table Mealy Machine

Present State	**Next State**							**Output**						
Running State	**Input**	CC	FBC	S		HH		**Input**	**CC**		FBC	S		HH
	State	Q1	Q1	Q2		Q4		**Output**	COIN++		FUEL++	FUEL--		GO
Jump State	**Input**	CC	FBC	SS	BD	HH	FBE	**Input**	CC	FBC	SS	BD	HH	FBE
	State	Q2	Q2	Q3	Q1	Q4	Q4	**Output**	COIN++	FUEL++	FUEL-	FU	GO	GO
Fly State	**Input**	CC	FBC	BD	HH	FBE		**Input**	CC	FBC	BD	HH		FBE
	State	Q3	Q3	Q1	Q4	Q4		**Output**	COIN++	FUEL++	FU	GO		GO
Game Over State	HALT STATE													

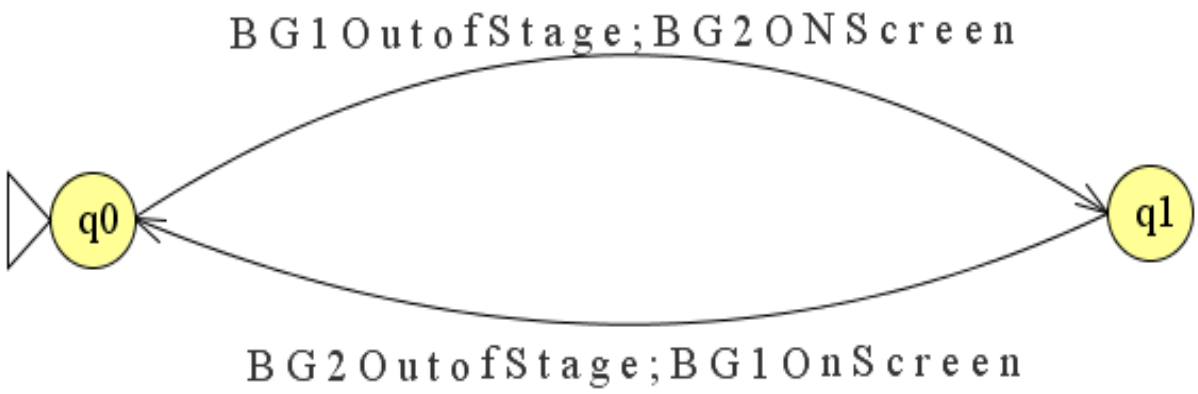

Fig. 3. Mealy Machine - Background Movement

There will be two background images creating an impression of live/animated moving background as shown in figure

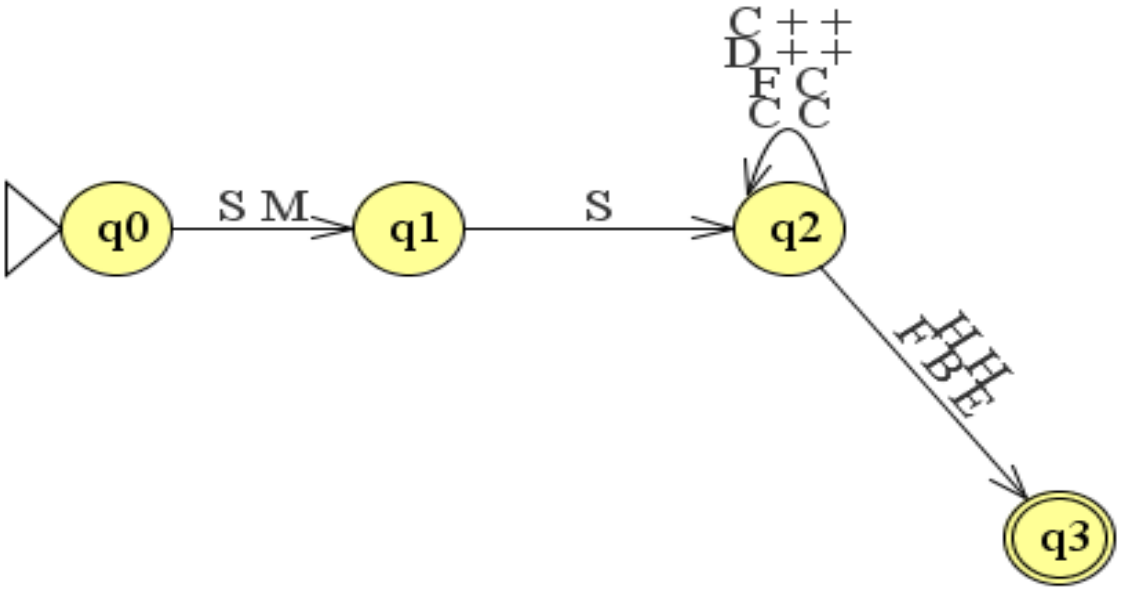

Fig. 4. State Machine - Flow of Game

4. EXPERIMENTAL RESULTS

As we designed automata for the game and from results it have been successfully programmed using game design presented above in paper using automata Theory. We observed it is easy to implement the game using automaton design.

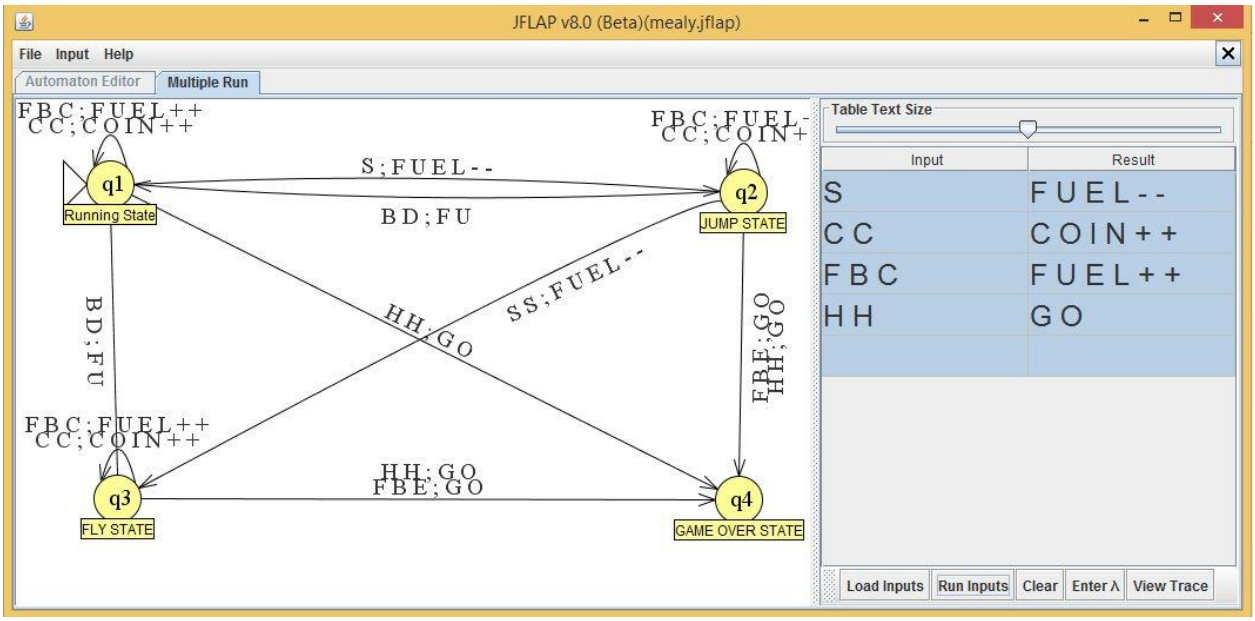

Fig. 5. Experimental Results _ Mealy Machine

Figure 5 illustrates game scenario; its states, possible input and their corresponding output using mealy machine as design model. We tested the model by giving some possible inputs.

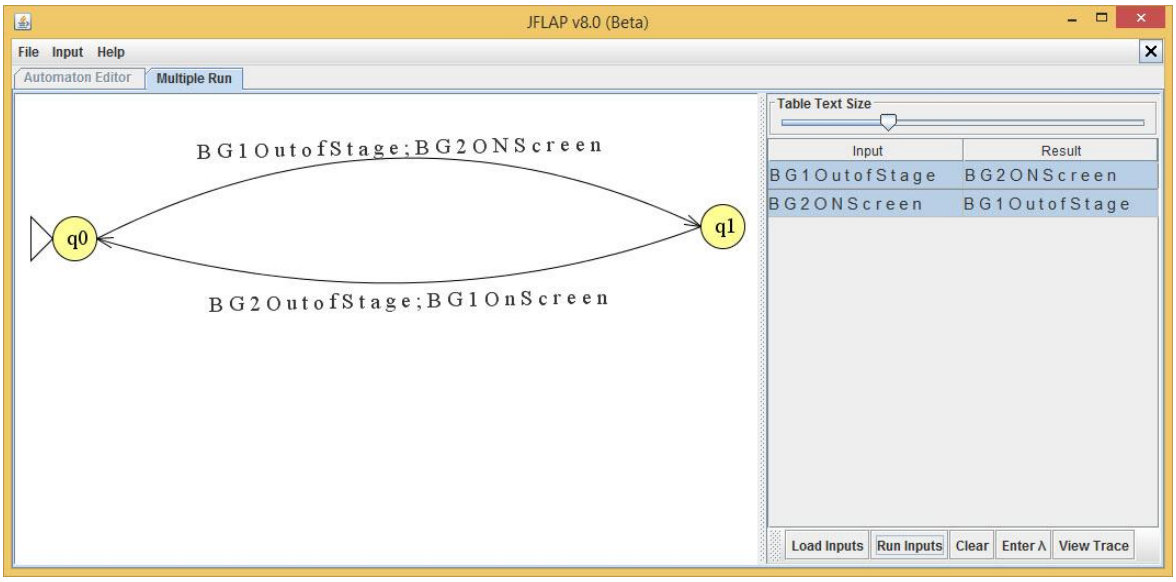

Fig. 6. Figure 5 Experimental Results _ Background Mealy Machine

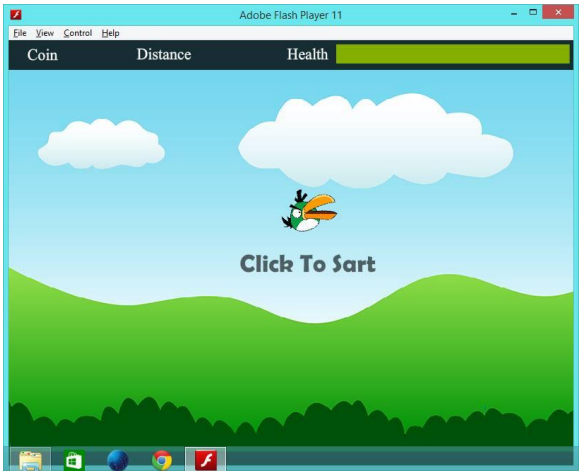

Fig. 7. Game is Click to Start State

Game is in Click to start sate at presented in state machine. So we successfully program the game according to design presented using automata theory.

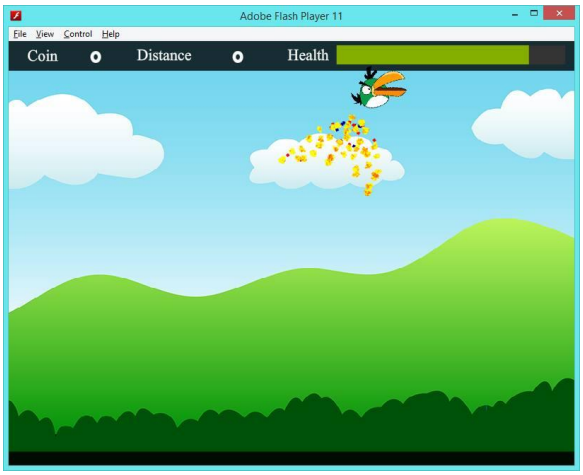

Fig. 8. Game is in running state

Game is in running state we can observe Bird is in "Fly State" and there is subtraction in fuel as well. Similarly distance is keep adding as bird is covering some distance. We can also observe "Coin Collection" is also displayed which are counting the coins collected.

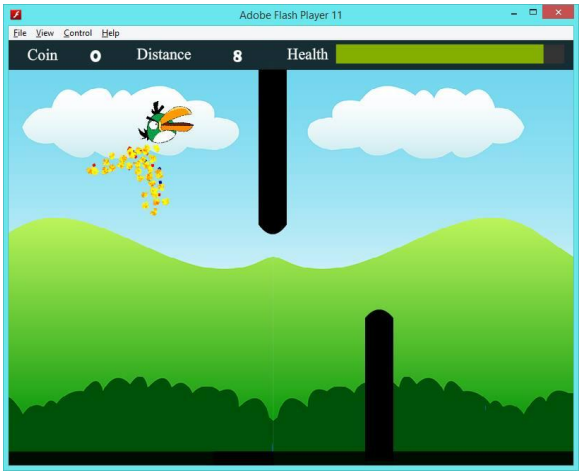

Fig. 9. Game running and Hurdles are coming

We Observed that Hurdles comes and when player will hit it will goes to Game Over State as presented it Game Design.

5. CONCLUSION

This paper concisely presents the game design of Infinite runner game using automaton tools. A group of research participants are working on the project implementation using automaton and computational theory tools as presented. Game design based on automation has a very fewer bugs as compared to any other game design strategy. This approach eliminates need of case diagrams and software engineering principles and most importantly all invalid input are taken care of at the design phase.

The future scope on this research can subsume to enhance game design to include artificial intelligence using complexity theory. Behavioral model of game design will be kept general so they can be applied to similar games with minimum structural customization and the only difference will be the input alphabet and state scenarios. The research may be extended to solve real life complex problems.

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