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A Review Paper on games Designed & Implemented on FPGA

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Abstract: In present days' computer and information technology as a lot of develop and became a part of daily human life. One of the computer applications is games and are very important in human life which gives relaxation and makes stress free. Particularly handheld based games are becoming crazier and more popular. The scientists and engineers have always thought of creating new things for entertainment. The electronics gave big opportunities to the engineers to create intersecting and attractive games for all the generations of people with more upgraded version. Electronic games have big market to earn money. Electronic games can be implemented may hardware platforms one such is on Field Programmable Gate Arrays (FPGAs). This paper gives review on the different approaches to design and implement games on FPGA.

Keywords: FPGA, Game, Implementation, HDL, Model, Design.

I. INTRODUCTION

Peoples have interest in games. There are many games in the world. Electronic circuits can be used to create games. One such Electronic circuit is FPGA. The reconfigurable hardware resources like FPGA boards play great role to implement communication and transfer data between multiple FPGA and other electronic devices. There are different games like Chess, Snake, Space Shoot, Pong, Reversi, Tennis etc.
First, game is modeled using HDL, synthesized after satisfying the output of model and implemented on FPGA. In the implementation different algorithms and modeling techniques are used.
The organization of this document is as follows. In Section II (Different games), games with rules are discussed. In Section III (Implementation), methods of implementation of games with advantages and drawbacks if any are given. In Section IV(Conclusion), a conclusion is given based on games implemented on FPGA.

II. DIFFERENT GAMES FROM LITERATURE

Different games that are developed and in application are present in this section II.

A. Smart Chess:
Chess board consist of 32 pieces like Rook (4), Bishop (4), Knight (4), Queen (2), King (2) & pan (16). These pieces are equally divided between 2 players. Player wins the game if he kill's opposite players king. The rules for the movements of pieces on the board of the game are Rook: Moves horizontally or vertically, Bishop: Moves diagonally, Knight: Moves in the shape of L for two square and can jumps on other pieces on the chessboard, Queen: Moves at paths that collect the both paths of the rook and bishop pieces at the chessboard, King: Moves such as the queen piece with only one square, Pan: Move single step either to the straight ahead or diagonally one step in the case of attack.

B. Snake game:
The game consists of Snake, Border and Apples. This game is played by one person. In this game player controls a snake to eat apples generated at random locations in the play area. The snake gets longer and harder to control the more apples it consumes. Player loses the game if the head of the snake collides with its own body, or if the snake hits one of the borders.
The game rules are as follows:
1. Snake move on screen with a constant velocity.
2.The player has to use the Controller to change the direction of snake so as to make it hit the apples.
3. If player fail to prevent the head of 'Snake' from hitting the Border or its own body he losses.
4.When the Snake hit any Apple, its length increases.

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C. Space Shoot Game:
The game contains a spaceship and aliens which are to be killed using the missile and collect scores. The game is over when all aliens are shot.

D. Pong game:
The Pong game consists of two blades and a ball. In this game paddles and ball are drawn, back ground is painted and displayed on a computer display. The ball moves automatically hitting the top and bottom edge of the screen and the paddles when the ball it's hit by a player. If a player misses the ball, then he gets a goal, so the ball goes off the screen to the right or left side. For Eg. left player gives a goal to the right player, if a player misses the ball on the right. After this it will be a new ball on the left, so the left player serves. The ball will move straight from left to right as long as the right player manages to hit the ball. The ball starts its automatic movement from the right, if the right player scores a goal, then. The game is repeated until it it's stopped. The player, who manages to give the most goals, wins.

E. Electronic Reverse game:
This game is simple and popular. It is suitable for anybody over 6 years old, and the game can be finished within 10 to 60 minutes. This game has highly strategy component without any lucky chance. Players need technique of observation and strategy planning to win the game.

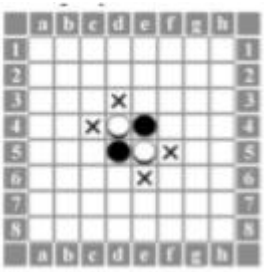

Fig. 1 Beginning of the game

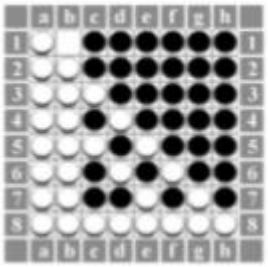

Fig. 2 Win of the game

The game board has 8 x 8 grids, the squares on the reverse board are referred to using coordinate notation in order to record games and allow the discussion of strategy. At the beginning of the game there are 4 discs placed in the center of the board as shown in Fig. 1[5], the player has black disc can place disc first, where the X locations denote the allowable positions for black player, then in alternative way to place disc each player. All the opponent's discs will be flipped to current player's (i.e. change disc color), if the opponent's disc is enclosed by current player's disc in horizontal, vertical, and diagonal direction. When no more locations can be placed the game is over, then by counting discs of both players' the player with most discs is the winner which is shown in the fig. 2 [5].

F. Control logic in the scoreboard of tennis
Scoreboards on tennis courts use paper ones where chair umpire must continually rotate lists in order to change the result. Electronic systems make it easy. The rules of the tennis game are a player wins a game in case of winning four points in a row/ winning one point after A (advantage)/ winning seven points in Tie Break phase of the game and minimum two points more than other player.

G. BloKus Duo game:
This game is played on played on a 12 x 12 square board. Two players play this game and each one has 17 different shaped tiles as shown in in Fig. 3 [7]. Tiles can be rotated in 8 possible ways. All rotations of tile 'P' are illustrated in Fig. 4. Players alternatively put one of their tiles on the board according to two primary rules:

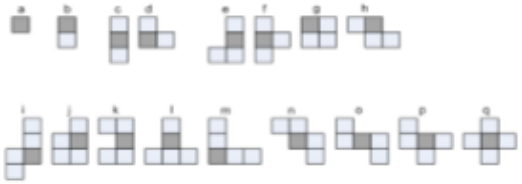

Fig. 3 Existing tiles

Fig. 4 Different Rotations of tiles

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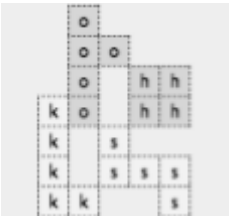

Fig. 5 Allowed move

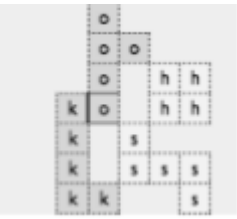

Fig.6 Prohibited move

1.Newly placed tile must have at least one corner-to -corner contact with a tile of the same color.
2.Newly placed tile must not have edge-to-edge contact with any tile of the same color. But there is no limitation for two opposite color tiles for putting on board.

There are some other rules for starting and finishing the game:
1.On the First move players must cover either (4,4) or (9,9) on the board.
2. When it is not possible for a player to place a tile on the board, it must pass.
3. The game continues until both players pass, one player plays all its tiles, or one player makes an invalid move.
Figures 2.5 and 2.6 shows examples for allowed and prohibited moves of the tiles.
There are also some rules for calculating scores of the players:
1.Basic score is given by minus total number of squares of unplaced tiles.
2.If a player played all 17 tiles, the player score will be 15.
3.If the last tile he puts on the board is 'a', the bounce increases to 20.
4.Invalid move results in immediate loss of game.

H. Galaxian game
Galaxian is developed by Japanese company Namco. The game can be controlled by the keyboard as well as LTM touch screen directly to make convenient operation. Seven grades were set up for the game to increase the game's executable and difficulty. Gamers get only three challenging opportunities, if it fails, the game is over.

I. Tetris game
Tetris game is a classic logic control game. Tetris game is a popular television and handheld game. Game consist of 2 modes. Game consist of 7 types of blocks in normal mode and 11 types of blocks in expert mode. Game players can move and rotate blocks.

J. Dice game
In this game 2 players play the game. The 2 players roll the dice. Player who got larger number win the game & who got smaller number lose the game[fail]. If 2 players get the same number they have to start the game again

III. RELATED WORK ON FPGAS BASED GAMES IMPLEMENTATION

An intelligent chessboard [1] predict the next positions for each piece and avoid using computer due to different disadvantages such as headache and blurred vision etc. The chessboard is designed by using low cost and simple electronics components which compensate computers.

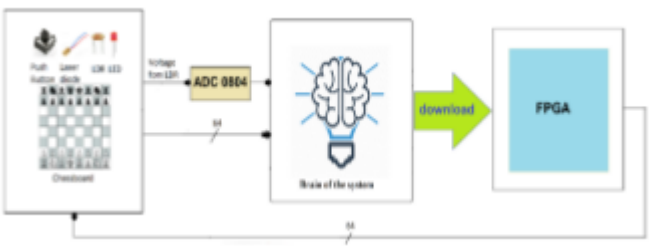

Fig. 7 Block diagram of intelligent chessboard system based on FPGA

This consists of equal distribution of 64 push buttons that are equally distributed, one button for each square on the chessboard; a simple press on any push button of the intelligent chessboard sends a notification with the exact position and the needing to predict the next positions. There are also 64 LASER diodes which are equally distributed as the push

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buttons, one LED for each square of the chessboard. 32 LDR sensors were used for 32 pieces and equally distributed as one sensor for each piece. Pressing of any piece would make the LEDs of chessboard glowed in order to notify the user with the next positions were the pressed piece can move on. Sensors are connected serially with a constant resistance (different for each peace) for each piece. The light falling on the LDR sensor will produces a fixed range of voltage for each piece. In the chess game, there are 8 pawns for each player which can move in different paths and opposite direction; therefore, the range of voltages differ and divided into two team white pawns and black pawns.

The block diagram of intelligent chess game is shown in Fig. 7 [1]. The human brain is amazing and process in smart way. Pieces of the board are trained using Super Vised Feed forward neural networks depending on back propagation algorithm. Table. 1 shows number of neurons in layers of neural networks for pieces of chess board. Number of neurons in layers and activation functions in each network are done using trial and error method.

TABLE.1 NUMBER OF NEURONS IN LAYERS OF NEURAL NETWORKS FOR PIECES

S.No	Piece	Number of neurons in Layer	
		Hidden	Outer
1.	Rook	6	3
2.	Bishop	8	20
3.	Knight	12	11
4.	Queen	4	20
5.	King	9	20

The trained networks of all the pieces are combined together in one system to produce the intelligent chessboard. The system is then converted into VHDL code by using MATLAB that have HDL coder, tested with different states by ISE Design Suite 13.3 and implemented it on FPGA.
The drawbacks of this game are
1.Number of neurons in layers and activation functions in each network are not taken with exact values.
2.There is no control on hardware parts by designer since VHDL coder is used.

The Snake game is played by one player with a handheld controller. The controller interface directly with FPGA. The FPGA drives the VGA monitor. virtual implementation snake game is shown in fig. 8 [2].

Fig. 8 Block diagram of Snake game based on FPGA

The controller consists of 4 pull – downed push buttons that are used to move the 'Snake' in the game. The state of the buttons is read by the FPGA which then updates the direction of the snake.
FPGA drives the VGA monitor by generating 5 signals, 'RED', 'GREEN', and 'BLUE' which are used to turn the colours of individual pixels on or off, and 'H-Sync' and 'V-Sync', which are used to synchronize the Horizontal and Vertical scans of the monitor.
The snake game is modelled using HDL, shown in fig. 9 is a top module snake which takes input from controller, clock and start button and is interconnected to all the other modules. This module implements the game logic and gives the output to the VGA monitor driving circuit. The snake module internally consists of 4 modules which are Clock reducing, Switch input, VGA generation, Random grid and Switch input.
Module VGA generates the H-Sync and VSync signals needed by the VGA monitor to synchronize the horizontal and vertical scans of the monitor. The pixel_x and pixel_y counter signals that represent the current scan coordinates and are used by other modules to generate their 'on' signals.
Module CLK_reduce generates a 25 MHz clock by reducing the on-board 50MHz clock as the main module operates on a reduced clock.

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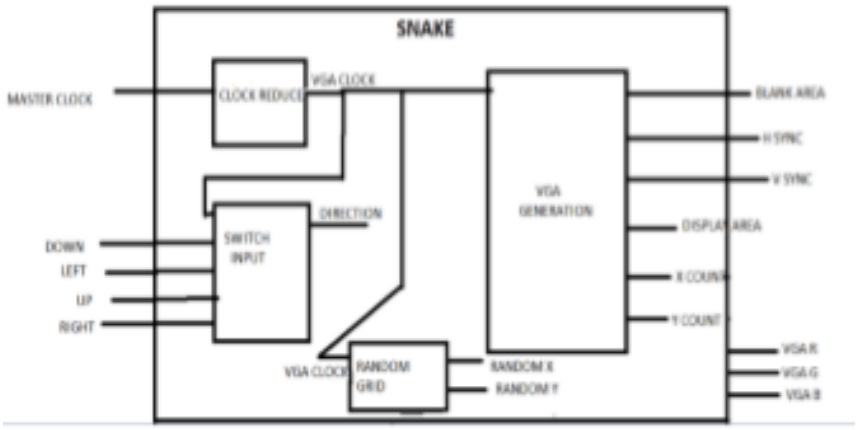

Fig. 9 Top level Snake module with submodules

Module SW Input is responsible for controlling the input to the main unit. As we need to attach a 4 output controller to the game, to move the 'Snake' in specified direction the input is handled by this module.
Module RandomGrid generates a random position of pixel x and pixel y for the apple's new position.
Snake game used the Terasic DE0-Nano FPGA Development Board. DEO-Nano features a Altera cyclone IV FPGA with 22,320 logic elements, 2Kb EEPROM, 64 Mb serial configuration memory device and 32MB of SDRAM. For connecting to real-world sensors the DE0-Nano includes a 3-axis accelerometer device, 13 bit analog devices, and National Semiconductor 8-channel 12-bit A/D converter. A built in USB Blaster for FPGA Programming is included in DE0-Nano board, and the board can be powered either by an external power source or from USB port. The board includes expansion headers that can be used to attach various Terasic daughter cards or other devices, such as motors and actuators. Inputs and outputs include 2 pushbuttons, 8 user LEDs and a set of 4 dip-switches.

The block diagram of Space shoot game [3] is shown in Fig. 10. It consist of 7 modules: mouse control, game control, text display, and graphic display, storage unit, multiplexing unit and VGA. The graphic display module and text display module share VGA control through multiplexing units; game control modules, ps/2 control module and memory module complete data exchange through the storage of data bit. The shown block diagram defines the entire game structure. Main input of the game comes from the ps/2 mouse giving the status of left, right and middle button. This data in the form of signals is connected to the three signals nes_a, nes_left and nes_right of the graphics module. This module takes these signals as an indication to move the spaceship left or right or to shoot the targets. Each of the module is explained below in detail.

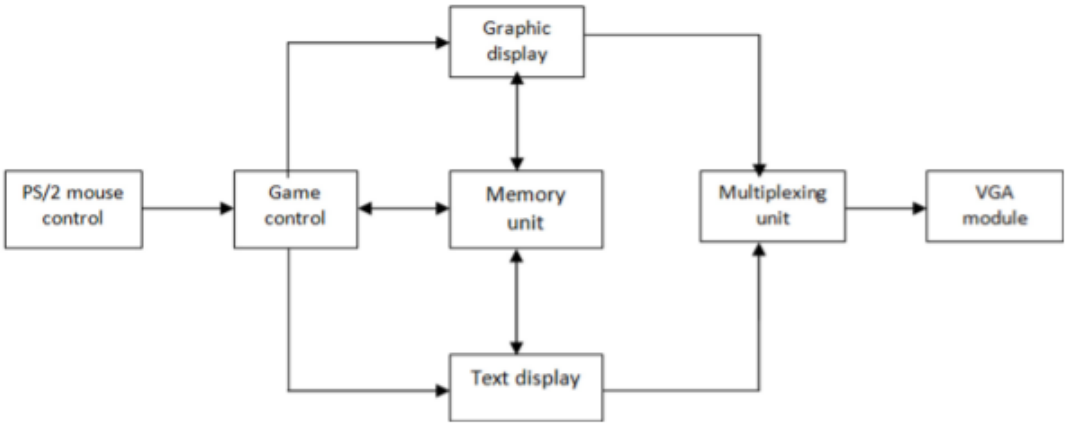

Fig. 10 Block diagram of Space shoot game

Mouse control: A mouse generates a clock and data signal when moved; otherwise, these signals remain high indicating the idle state. Each time the mouse is moved, the mouse sends three to the host.
Game control: The game control mainly comprises of movement of the spaceship and shooting of the aliens. This requires that when pixels of the missile and the pixels of the aliens are equal, aliens are shot and they are dead. The spaceship only moves left or right and so the aliens. For this we there are four states: left, right, up and down.

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VGA Module: The perform of VGA module within the game is to translate coordinate and component settings info received from the graphic show module and therefore the text show module into VGA management signal, so properly show the image info by a monitor. A VGA monitor has 3 color signals (red, inexperienced and blue) that set one in every of these colors on or off on the screen. The intensity of every of these colors sets the ultimate color seen on the show.
Graphics area unit processed and keep in Block Random Access recollections (BRAM) and area unit GPU. A Graphics process Unit (GPU) may be a dedicated circuit that operates on a cargo area (frame buffer) for the aim of providing show output.

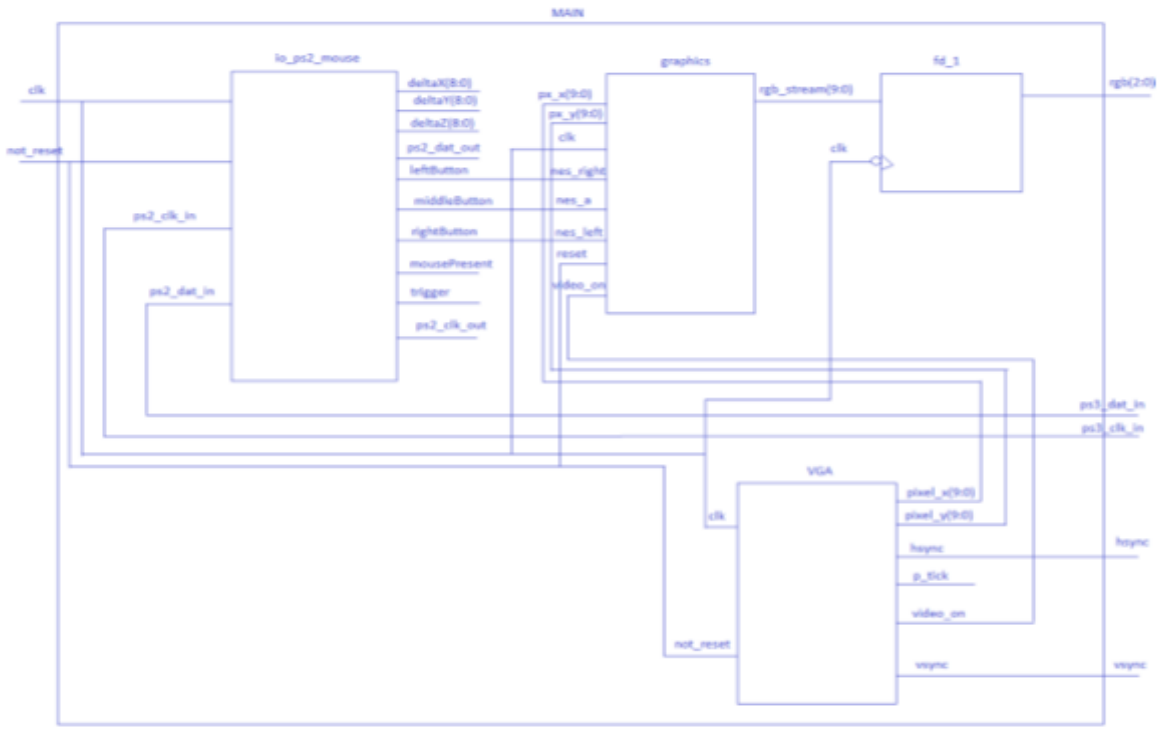

Fig. 11 Data path architecture of the space shoot game

Fig. 12 FPGA Synthesis block diagram

The data path architecture of the space shoot game is shown in Fig. 11. It consists of mainly three modules which are graphics, VGA and io_ps2_mouse.
The synthesis is finished on Spartan 3E FPGA and therefore the supporting diagram is shown in Fig.12. Synthesis diagram explains that from wherever the input to the planning is returning and wherever it goes for the any method and management. The most input of this game is ps2 which provides the standing of 3 buttons i.e. left, right and middle in its initial computer memory unit. This standing is received by the graphics module and it permits these signals to move the starship. All this is often processed by the Xilinx Spartan 3E board. Once the info is processed then the output is showed the most output that is that the monitor screen through the VGA controller.

The Pong game is on the FPGA board that is connected via VGA port to a computer monitor. Fig. 13[4] shows the diagram of reek game. The sport may be controlled with mouse, keyboard or four push buttons from the FPGA board. Background color of the paddles and therefore the ball is configurable in software package. The background is white, the paddles area unit red and blue, and therefore the ball is inexperienced. 2 players will play the sport with the four push buttons on the board. If the board is oriented in traditional position, with the four push buttons right below, the primary player, with blue paddle, can have the primary a pair of push buttons (BTN0 movement up, BTN1 movement down) and therefore the second player, with red paddle, can have the last a pair of push buttons (BTN2 movement up, BTN3 movement down).

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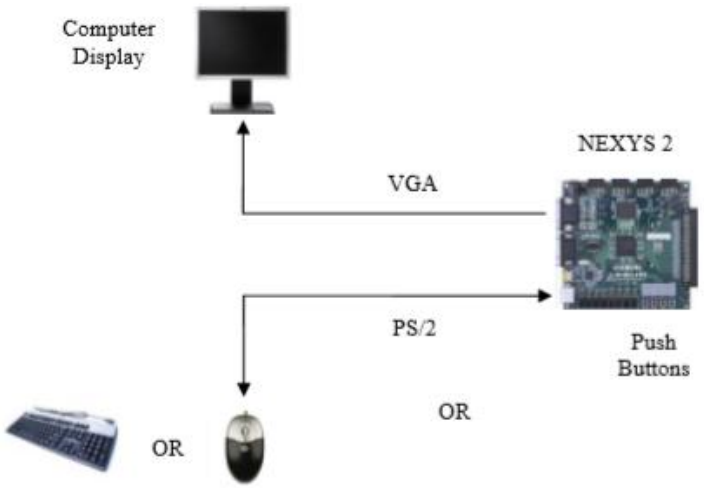

Fig. 13 Block diagram of pong game

Fig. 14 shows pong game chip that internally consist of VGA sync, one for the graph part for drawing the balls and paddles and a D-latch for creating a delay for timing.

A VGA controller circuit should generate vertical adjust signals – VS and horizontal adjust signals – HS and a coordinate delivery of video information on a component clock. HDL code is written for modules of game chip, simulated and enforced mistreatment Spartan-3E FPGA on NEXYS a pair of development board.

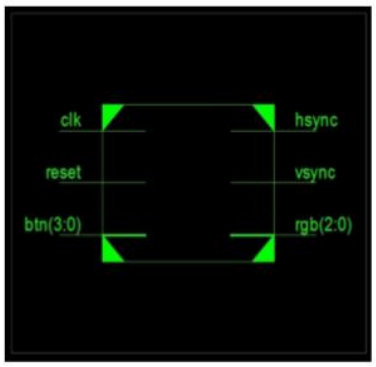

Fig. 14 Pong game chip

Reversi game [5] is constituted with a matrix LED as the game board. Discs of both players are represented by red and blue LEDs independently. During the game the LED will be changed to opposite color to represent the flip of discs. Player uses slightly panel to move the disc, and ensure the situation to put the disc. Game is enforced with a software package and hardware integrated embedded system. The silicon chip can check the legal position of the disc, calculate the player's discs, and then show the scores on a 7-segment semiconductor diode straightaway. A multiprocessing unit (Artificial Intelligence) is established on FPGA for Min-Max algorithmic program for the Disc move with heuristic analysis functions.
Game carries with it reverse hardware module (Parallel process unit), a matrix semiconductor diode controller, a memory bit screen controller, a VGA show controller, Associate in Nursing embedded softcore Nios II computer hardware and a few peripheral parts. Electronic reversi game used Associate in Nursing Altera DE2-70 FPGA development board.
Advantages are:
1. Minimum resources with Software/hardware integration.
Draw backs are:
2. It is combination of Hardware and software package, however not solely hardware.

The management a part of sign of court game shown in Fig. fifteen [6] that carries with it totally different modules. The chair umpire (referee) assign points to players by pressing players button, and controller mechanically updates values of games and sets. This approach considerably helps the umpire, and reduces the danger of displaying wrong result by

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pressing the incorrect button. These modules area unit sculptural in VHDL, simulated and enforced on FGGA EP2c35F6726 that belongs to the Cyclone II Altera.

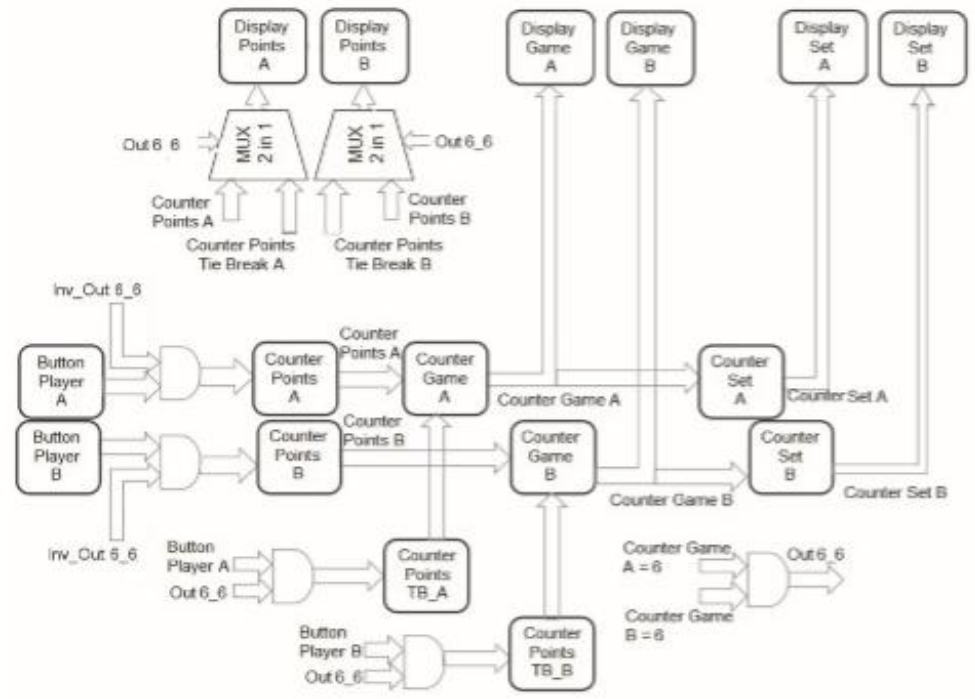

Fig. 15 Block diagram of control system

The game is implemented using heuristic algorithm on FPGA. At each step of game, all possible movements are founded, then ranked each move according to strategies developing the game, disrupting other players and survive. After ranking the moves. Finally, one of the highest score move is selected.
The game consists of hardware platform and software. The design of the hardware platform is the QuartusII10.1, the software platform is Nios II EDS 10.1 and the programming language is C and VHDL.

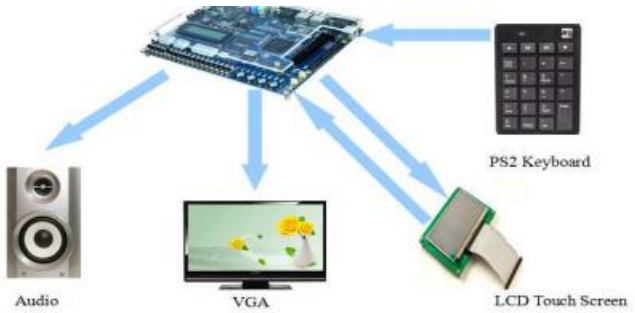

Fig.16 Game system architecture

The above fig.16 [8] shows architecture of game system. The game consists of VGA module, LTM touch screen module, Audio output module, PS2 keyboard module, general IO, data and instruction memory, the central processor and other modules.
The game system is divided into hardware and software components. The fig.17 [8] shows hardware realization. The hardware provides management interface and perform tasks operations for the peripherals. The hardware consists of PS2, VGA, Audio and LTM controllers etc.
The design of the hardware platform is that the QuartusII10.1, the code platform is Nios II EDS 10.1 and the programming language is C and VHDL. Based on the SPOC Builder tool, the reconfigurable IP cores of the VGA display, LTM touch screen were designed. This configurable IP core is variable, highly flexibility, plasticity and it are able to do additional purposeful enlargement and development within the same resource.

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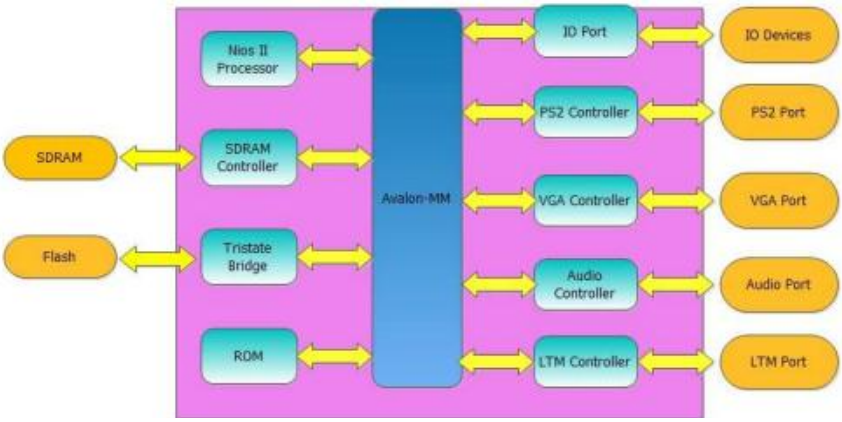

Fig.17 Block diagram of Hardware realization

The main body of the game consist of controlling input, processing logic, and displaying output. Controlling input part includes PS/2 interface keyboard. Players use keyboards to select the game mode, control the game process, and complete the movement and rotation of the blocks. Logic process part is employing a FPGA chip to finish. FPGA chip communicates with the controlling input and displaying output part through the corresponding interface. The VGA signal is transmitted to outer using Display. With an external monitor shows games screen, visual operation is complete.

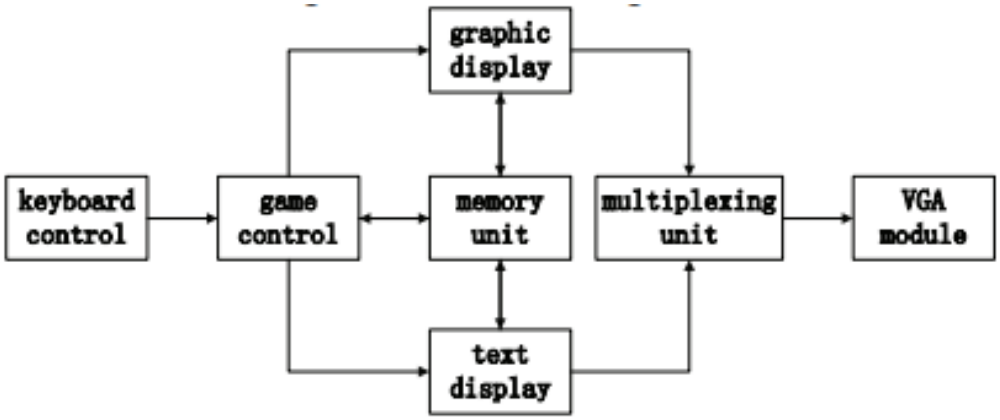

Fig.18 Program module structure

The module structure of program of Tetris game is shown in fig. 18 [9]. he game consists of seven modules: keyboard management module, game management module, text show module, and graphic show module, storage unit, multiplexing unit and VGA modules. The game program is completed in ISE12.3 environments victimization VHDL language. In the validation experiment Xilinx's spartan-3AN FPGA starter boards, a PS/2 interface keyboard, and a CRT monitors are used.

An interface between 2 FPGAs victimization I/O interface obtainable within FPGAs for the aim of reliable communication. The fig.19 shows Block diagram of the high speed communication link between the two FPGAs. The two FPGAs are connected via RS-232 port, to transfer information from one FPGA to a different & the other way around.

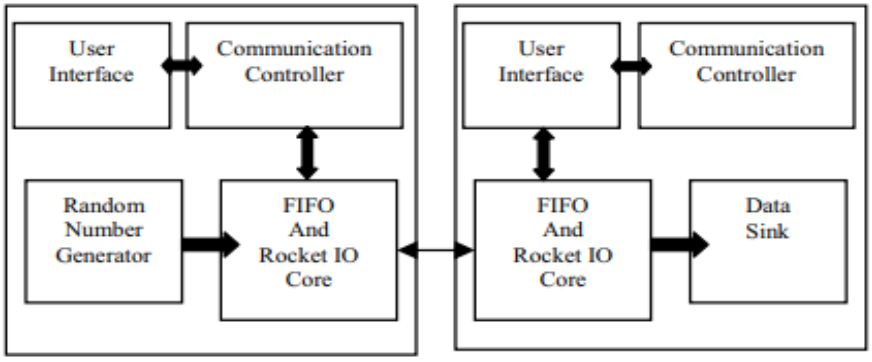

Fig.19 Block diagram of the high speed communication link between the two FPGAs

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The Random Number Generator is used to create information. Game was designed using two Altera FPGA boards, implemented in Verilog language. Using Linear Feedback Shift Register algorithm the two players generate a random number, then using RS-232 cross cable it sends their number to each other. Finally, the values are compared and whoever gets the larger number wins the game.

IV. CONCLUSION

This Paper presents different games that are Designed and Implemented on FPGAs. It was observed that design and implantation is easy and fast with FPGAs. This requires modelling of games using HDLs, simulation, synthesis and implementation. Various algorithms and style of modeling's are used in implementation of games. Finally, this review gives future scope to develop and implement faster and innovative games.

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