Design Proposal for Snake Game Console

EC9040 Advanced Digital Design and Synthesis

07/12/2024

Project Title

Snake Game Console on the Terasic DE2-115 Board

Team Members

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Objective

The objective of this project is to implement the classic **Snake Game** on the Terasic DE2-115 FPGA development board. The game will use the **VGA output** for graphical rendering, **onboard push buttons and switches** for user input, and **16x2 LCD display** for score tracking. This project will demonstrate the application of real-time systems, finite state machines, and interfacing with FPGA peripherals.

Design Approach

1. Overall Architecture

The design will follow a modular approach:

- **Master Control Module**: Controls game start and end, controls game mode.

- **Game Logic Module**: Handles snake movement, food generation, collision detection, and game state transitions.

- **VGA Controller Module**: Generates VGA signals for rendering the game grid and updating graphics in real-time.

- **Input Controller Module**: Captures user inputs from push buttons to control the snake's direction.

- **Score Display Module**: Updates and displays the player's score on the seven-segment displays.

2. Optimization Strategies

- Efficient use of **on-chip memory (Block RAM)** to store the game grid state.

- Minimized logic usage for real-time collision detection using combinational circuits.

- Use of **finite state machines (FSMs)** for modular and optimized game control logic.
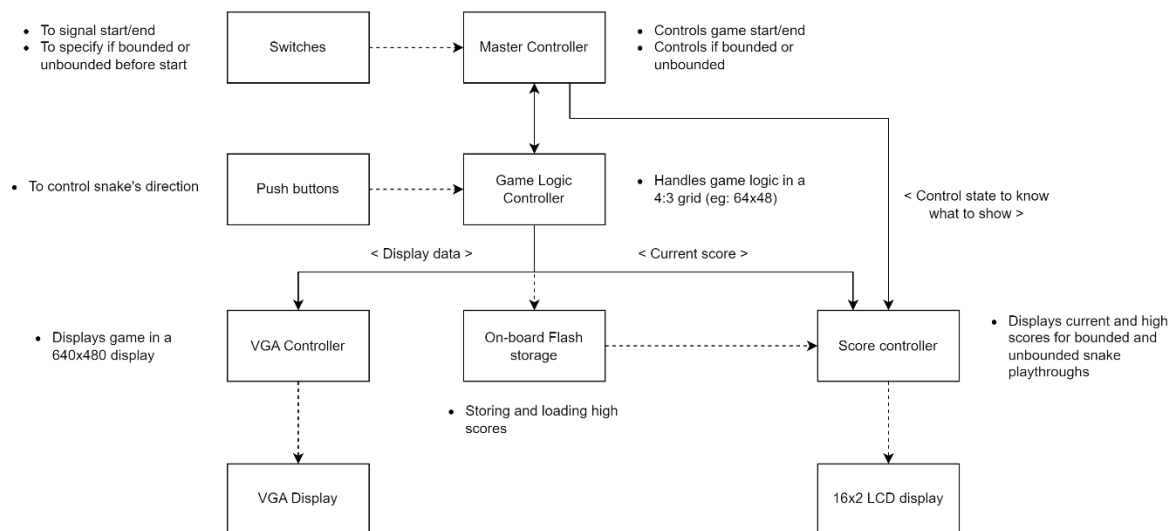
Block Diagram

Figure 1: Proposed architecture

Design Modules

- **Master Controller**

  - Controls game starting and ending

  - Controls game-mode, if whether it's **bounded** or **unbounded**,

    o Bounded – has a border that the snake can collide with.

    o Unbounded – the snake does not collide with boundary and loops around instead.

- **Game Logic Module**

  - Maintains the **snake's position** in a 2D grid stored in memory.

  - Generates random positions for food.

  - Implements logic for detecting:

    o Snake eating food (grow snake, increase score).

    o Collisions (with walls or itself).

- **VGA Controller Module**

  - Implements VGA signal generation for a 640x480 resolution display.

  - Maps the 2D grid onto the screen as a graphical representation:

    o Snake: Green blocks.

    o Food: Red block.

    o Background: Black.

- **Input Controller Module**

- Captures push button inputs for directional controls (up, down, left, right).

- Implements debouncing to ensure stable signals.

- **Score Display Module**

  - Uses the 16x2 LCD display to show the player's score.

  - Updates in real-time when the snake eats food.

  - Shows previously recorded high scores (for both game modes) if the game hasn't started yet.

- **Flash storage interface**

  - Interfaces with the flash storage to read and write high scores.

Tools and Resources

Hardware:

- Terasic DE2-115 FPGA Development Board

- VGA Monitor

- Push Buttons (onboard)

Software:

- Quartus Prime (for HDL development)

- ModelSim (for simulation)

- Python (to visualize pixel data output for the VGA ports)

- Terasic DE2-115 board drivers and example code

Timeline

Milestone	Date	Details
Proposal Submission	07/12/2024	Submission of the detailed project proposal.
Game Logic Implementation	Week 10	Implement movement, food generation, and collisions.
Integration and Testing with VGA	Week 11	Integrate modules and debug.
Score Display and Finishing	Week 13	Implement scoring and refine game features.
Final Submission	Week 14	Deliver report, code, and simulation results.

Expected Deliverables

1. **HDL Code**: Fully functional Verilog (or VHDL) implementation of the game.

2. **Simulation Results**: Verification of game logic, VGA output, and input controls in ModelSim.

3. **Demonstration**: A live demonstration of the Snake Game running on the DE2-115 board.

4. **Final Report**: Comprehensive documentation of the design process, including optimizations, testing, and results.