EECS 3216 Project Proposal: Snake Royale using VGA Output on the DE10-Lite Board

Team Members:

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Project Description

Our project aims to design and implement the classic Snake game using the DE10-Lite FPGA board, with real-time VGA output to display the game on an external monitor. The project will integrate both hardware and software components, leveraging the FPGA's capabilities for combinational and sequential logic. The game will feature interactive gameplay, including snake movement, collision detection, score tracking, and progressive difficulty levels.

This project will demonstrate the integration of FPGA-based hardware design with software-driven control systems, showcasing our ability to combine digital logic, embedded systems, and real-time data processing. Additionally, we will explore advanced techniques such as adaptive difficulty algorithms and real-time analytics to enhance the gameplay experience.

Project Objectives

1. Hardware Implementation:
    - Design combinational logic for real-time snake movement based on user inputs (buttons or switches).
    - Implement sequential logic for game state management, including collision detection, score tracking, and level progression.
    - Develop a VGA controller module to display the game in real-time on an external monitor.
2. Software Integration:
    - Utilize Verilog on the DE10-Lite board to handle advanced game logic, such as adaptive difficulty and score analytics.
3. System Integration:
    - Integrate FPGA-based hardware modules (e.g., VGA controller, movement logic) with ps2 keyboard for seamless integration.
    - Develop a modular and scalable design to support future enhancements, such as multiplayer modes or additional game features.

4. Advanced Features:
    - Implement adaptive difficulty algorithms that adjust game speed and complexity based on player performance.
    - Add real-time data analytics to track and display player statistics (e.g., score trends, reaction times).

Methodologies

1. Hardware Design:

    - Use Verilog or VHDL to design and implement FPGA modules for VGA output, movement logic, and collision detection.
    - Optimize resource utilization on the FPGA to ensure efficient operation within the DE10-Lite's constraints.
2. Software Development:
    - Figure out better ways to handle game logic and real-time analytics.
    - Develop communication protocols between the FPGA and custom interfaces.
3. Testing and Validation:
    - Create testbenches for each hardware module to verify functionality and performance.
    - Conduct system-level testing to ensure seamless integration between hardware and software components.
4. Advanced Techniques:
    - Implement real-time data analytics to enhance gameplay and provide insights into player behavior.

Expected Deliverables

1. Functional Snake Game:
    - A fully playable Snake game with real-time VGA output, user controls, and score tracking.
    - Support for multiple difficulty levels and adaptive gameplay.
2. Hardware and Software Code:
    - Verilog/VHDL code for FPGA modules (e.g., VGA controller, movement logic).
3. Documentation:
    - A detailed design document outlining the system architecture, module descriptions, and integration process.
    - A user manual explaining how to play the game and customize settings.
    - A final report summarizing the project's objectives, methodologies, results, and challenges.
4. Demonstration:
    - A live demo showcasing the game's features, including VGA output, user controls, and advanced functionalities.
    - A technical poster summarizing the project's key achievements and innovations.

Key Components of the System

1. FPGA Modules:
    - VGA Controller: Handles real-time display output.
    - Movement Logic: Processes user inputs and controls snake movement.
    - Collision Detection: Detects collisions with walls, obstacles, and the snake itself.
    - Game Logic: Manages game states, scoring, and level progression.
    - Real-Time Analytics: Tracks and analyzes player performance.

Roles and Responsibilities

- Kanwarjot Singh Bharaj: Hardware designer, responsible for FPGA modules (VGA controller, movement logic) and system integration.
- Fares Trad: Lead software developer, responsible for ARM HPS programming (game logic, analytics).
- Joshua Keppo: Testing and validation lead, responsible for creating testbenches, conducting system-level testing, and debugging.
- Kyle Williamson: Documentation and presentation lead, responsible for writing the design document, user manual, and preparing the final demo.

Advanced and Cross-Disciplinary Concepts

1. Real-Time Data Analytics:
    - Track and analyze player performance metrics (e.g., score trends, reaction times) to provide insights and enhance gameplay.
2. Cyber-Physical Systems:
    - Explore the integration of physical inputs (e.g., buttons, switches) with digital outputs (e.g., VGA display) to create an interactive gaming experience.
3. Sensor Networks:
    - Investigate the use of additional sensors (e.g., accelerometers) for alternative control schemes.

Conclusion

This project will demonstrate our ability to design and implement a complex system that integrates FPGA-based hardware with software-driven control systems. By incorporating advanced techniques like adaptive difficulty and real-time analytics, we aim to create an innovative and engaging Snake game that showcases our skills in digital design, embedded systems, and cross-disciplinary problem-solving. We seek approval for this ambitious project and look forward to delivering a high-quality implementation.