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Sokoban Game (Chest Pusher) Design and Implementation Based on FPGA and Verilog

Yalan Zhang *

School of Information Technology and Electrical Engineering, University of Queensland, St Lucia QLD 4067, Australia

Abstract

This paper presents a project that is inspired by the popular puzzle game Sokoban. It is a combination of entertainment and strategic thinking. The aim of this project us to explores the feasibility of implementing entertainment game on the highly parallel FPGA platform. In the game design, the PS/2 keyboard was used as input, and VGA was used as outputs for user to control the movement character to push the boxes to their designed positions.

Keywords

Sokoban, FPGA, VGA, Verilog, Game design.

1. Introduction

Developing a game must also consider many factors, such as development cycle, development cost and security [1, 2]. FPGA has the advantages of high integration, fast speed, low power consumption, small size and reliability. Implementing games with FPGA chips with encryption function can often effectively prevent games from being cracked or pirated [3, 4, 5].

The Video Graphics Array (VGA) display interface is a common interface for ordinary computers. VGA has better compatibility, rich colors, and relatively simple interface and timing. In addition, since VGA is still the standard supported by most manufacturers, it has a wide range of applications in intelligent control systems [6, 7].

In this project, the game design uses the FPGA to imitate Sokoban. The PS/2 keyboard was used as input, and VGA was used as outputs. To control each game process, multiple independent state machines are included to simplify the collision detection of the active blocks. Fixed bricks are placed at different places to increase the difficulty. The project consists of 5 levels with increasing difficulty. A start menu and an end screen would be displayed depending on the state of the game. A timer is displayed on the FPGA board's hex digits while the game is playing to show the player.

2. Game Design and Implementation

Two inputs, data_in and data_ready are given by the PS/2 keyboard, and each key hold a corresponding keycode. The starting menu of this game is a dynamic page that displays in between levels, to start the game, the user would need to press Enter. If the user presses the Enter key during the game, the level will restart. The "R" key would reset the entire game and start over. If the code matches arrow keys, then player may control the character and boxes in some condition. We also define life_sign to determines the player's control over the character. If life_sign equals to one, the character can be moved, if life_sign is zero, the player loses the control of the character.

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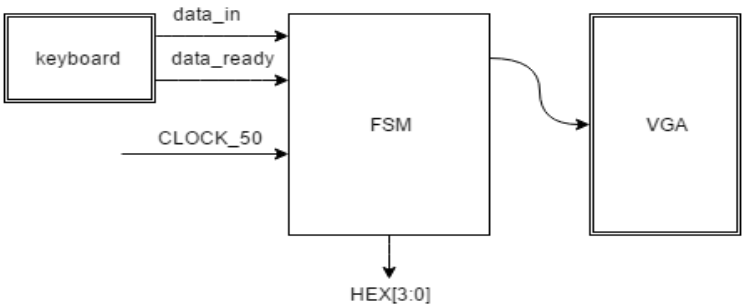

Figure 1: Implementation of Keyboard Module

Under the circumstances where the player has the control over the character, the input data from the keyboard is loaded, and the character position can be controlled by the arrow keys, the box can also be pushed by the character. In general, different cases can be determined by scanning the x-y coordinates of the character and a desired element. For a left/right check, whether the character shares the same y coordinate with the element shall be determined. Then proceed to check if the difference in the x-coordinates is +/- 15, and if so, the character is horizontally adjacent to this element. To determine if there is a second neighboring element, we repeat the same x-y coordinate scanning. To check the vertical state of the map, simply start the same procedure with x-coordinate first and then y-coordinate.

Two signals win_num and win_sign was defined, which win_num keeps track of levels passed and win_sign determines if the player have passed all 5 levels. Two dynamic blue lines are designed to be placed at the bottom of the screen which corresponding to second and minute changes on hex display. The above progress bar add one piece of blue block for every second. After ten seconds, the bottom one will add one block which represents the tens digit of seconds.

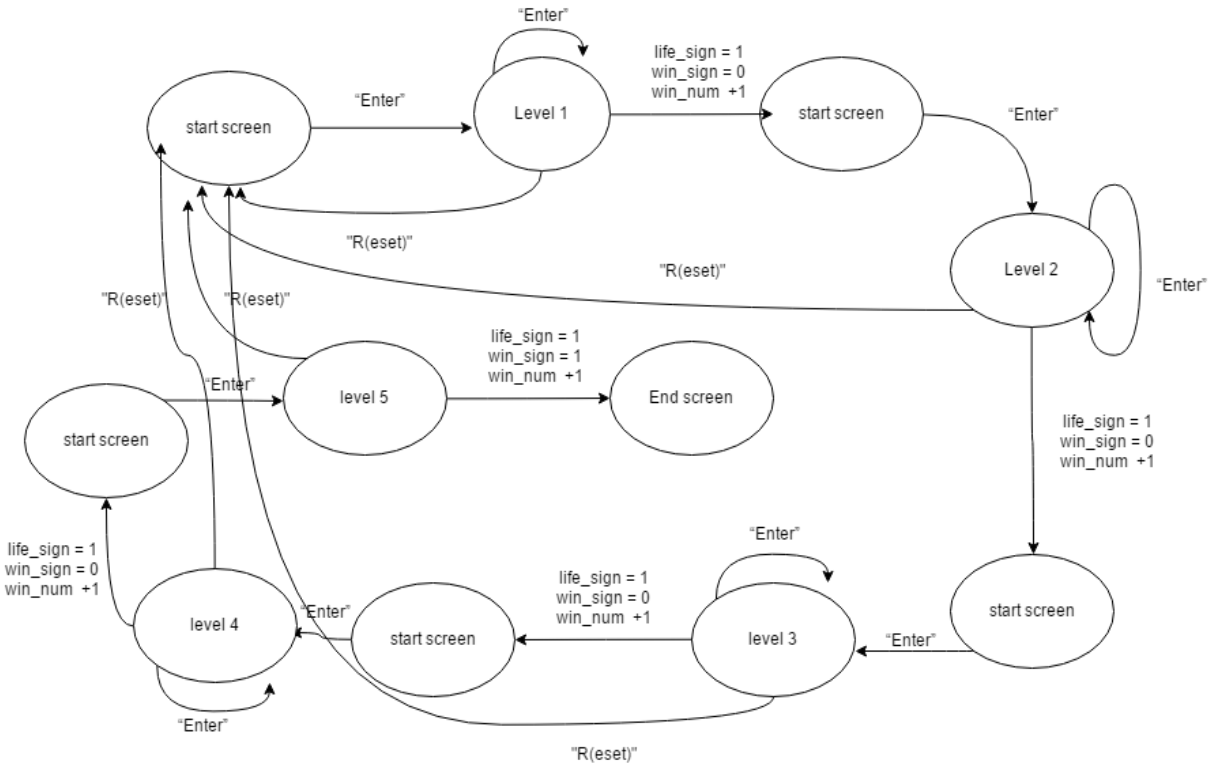

Figure 2: Game Design Block Diagram

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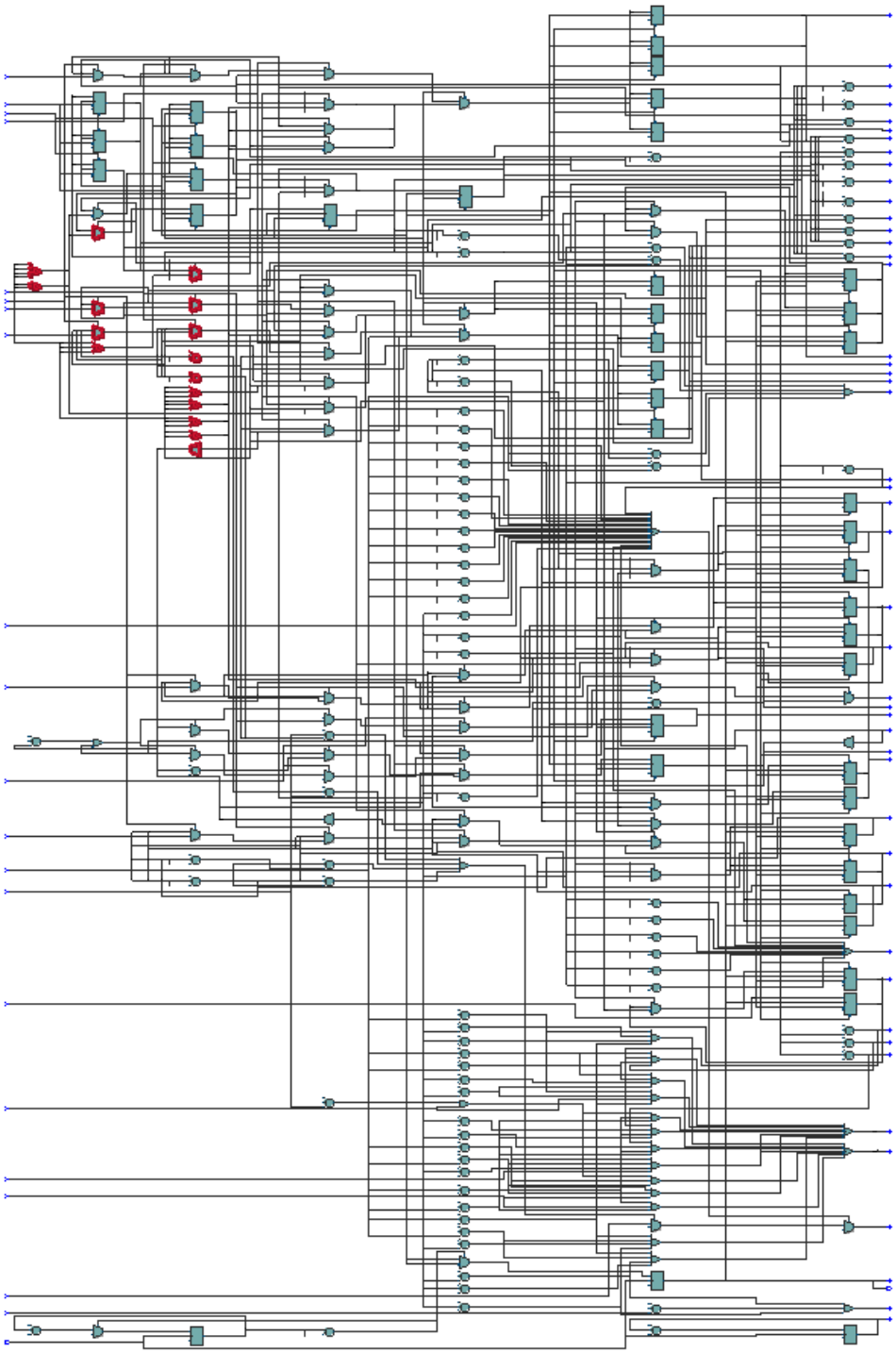

Figure 3: Verilog Schematics

3. Results and Limitation

The game was implemented successfully. Each level of the game was connected seamlessly as planned. And the game can restart by pressing the 'Enter' on the keyboard when the level is unsolvable. Besides, a better user experience is introduced using keyboard, provides a more familiar gaming environment for the players.

In the proposed design, the game shall end automatically if a box is in a dead end. However, this idea was not implemented successfully at the end.

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