GEORGIA STATE UNIVERSITY

Department of Computer Science

CSC 3210 Computer Organization Programming

Lab Section:

Lab 4: Pong on Game Boy Advance

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**1 Introduction**

This lab aims to explore the usage of array, heap, and stack in RISC-V assembly.

* + The first task asks for the implementation of the Insertion Sort algorithm. This Task requires understanding of array manipulation.
  + The second task asks for the implementation of a recursion for the ToH problem. To understand recursion, is to understand the working of stack and heap in RISC-V assembly.
  + This lab aims to explore I/O interrupts, simulation, and object-oriented programming on embedded systems.

**2 Apparatus**

* Butano
* C++
* DevkitARM
* GBA Emulators (mGBA)
* Butano guideline

**3 Methods**

**3.1 Task 1**

Run the insertion\_sort.c file in the Snowball server. This is to show how the Insertion Sort algorithm works in the C language.

Convert the algorithm to RISC-V and run three sperate cases.

* A sorted array
* A reversed sorted array that also has negative integers
* An unsorted array with very large integer,

These cases show how RISC\_V interacts with array and its elements. It also shows limitation of the memory and how to circumvent it.

Setting up DevkitARM to be able to use Butano.

Download and install Butano.

Install mGBA to be able to run the game.

Compile some examples from Butano to make sure the program is working.

**3.2 Task 2**

This task asks you to demonstrate your understanding of the ToH problem and solve it using recursion, in RISC-V assembly. Also, the task wants to implement the algorithm using different numbers of disks and to find out the largest number of disks the code can handle. Heap and stack are required for recursion. Stack is where the functions are stored and executed in a LIFO order. Heap is where variables are allocated.

Using the example as a template.

Delete one paddle of the current one.

Rotate the sprite to make sure the paddle is vertical

Set the paddle to the bottom of the screen.

Set a score on the upper right corner. The score will increase by one everytime the ball hit the paddle. The score will return to 0 everytime the game reset.

Set the limit for the ball so that the ball will bounce after touching top, left, and right border.

Set the limit for the bottom border so that the game will reset if the ball hit the bottom.

**4 Results and Discussion**

In Task 1, three arrays are sorted successfully using insertion sort algorithm in RISC-V, but there are some variances in the results. Depending on the type of input array, the time complexity can go from O(n) to O(n2).

In Task 2, the ToH recursive solution in RISC-V can solve the cases of 3,4 and 7 disks. If the number of disks is increased, the time to solve the problem increases exponentially.

After confirming the Butano environment is working, we can use the template file in side Butano to start the program.

1. **Conclusions**

This lab successfully demonstrates the application of array, heap, and stack in RISC-V assembly. Different input arrays will affect the time of the algorithm to produce outputs. A large input in a recursion can create problems for the machine. Therefore, it is important to understand the size of the data structure that you are working with to choose the best approach.

This lab asks to design a simple Pong game based on certain requirements. The process of designing and creating the game requires the student to engage with different aspect of software designing. Designing the paddle board and its interaction show the inner working of how to use I/O devices to interact with a program. The lab also introduce the concept of simulation and the idea of running a program on different type of computer architecture. Finally, the lap introduce objected-oriented programming and its usage in real-world programming.