Programming Lab 2

Revised 11.04.14

Computer Architecture
CSCI 361, Fall 2014

Due: November 14, 2014 at 11:59 pm

Overview

In this lab, you will write a SPIM program that renders bit-mapped characters. This will be a visual representation of a character using a matrix of binary numbers, such as that shown in Table 1.

–	–	–	–	X	–	–	–	–
–	–	–	X	X	X	–	–	–
–	–	X	–	X	–	X	–	–
–	–	X	–	X	–	–	–	–
–	–	–	X	X	–	–	–	–
–	–	–	–	X	X	–	–	–
–	–	–	–	X	–	X	–	–
–	–	X	–	X	–	X	–	–
–	–	–	X	X	X	–	–	–
–	–	–	–	X	–	–	–	–

Table 1: Example–the vector [16, 56, 84, 80, 48, 24, 20, 84, 56, 16] produces the $ character.

0	0	0	0	1	0	0	0	0
0	0	0	1	1	1	0	0	0
0	0	1	0	1	0	1	0	0
0	0	1	0	1	0	0	0	0
0	0	0	1	1	0	0	0	0
0	0	0	0	1	1	0	0	0
0	0	0	0	1	0	1	0	0
0	0	1	0	1	0	1	0	0
0	0	0	1	1	1	0	0	0
0	0	0	0	1	0	0	0	0

Table 2: The vector from Table 1 visualized as binary digits.

Implementation

You are given a vector of ten integer numbers. Each number represents a row of a bit-mapped character. This will produce a matrix of nine columns and ten rows. Each cell of your matrix corresponds to one bit. Use the minus character '−' to represent zero, and use an uppercase 'X' to represent one.

You should implement your program in the following manner:

- Download the template file `template.s` from D2L. Rename this file to:

  `[lastname]_[firstname].prog2.s`.

  Do not include the brackets in your file name.

- You should store your vectors as word arrays, e.g.:

```
.data
seq1:  .word 16 56 84 80 48 24 20 84 56 16
seq2:  ...
```

- You will create a procedure `newline` that prints out a single EOL character ('\n').

- You will create a helper procedure `rowprint` that prints a single row of your matrix. You will need to pass this function an integer to display. This function will iterate, printing a single binary character ('–' or 'X') for each bit in the number. You only need to display the nine least significant bits of this integer. You should print out one blank space ' ' between each character for proper formatting (e.g., Table 1). Use all proper MIPS calling conventions here and throughout the entire assignment.

- You will create a procedure `charprint` that prints out the entire bit-mapped character. You will pass this function an argument corresponding to the address of the word array to print. This function will call `rowprint` ten times, once for each row of the character. Use some form of branching structure to accomplish this. After your loop, call `newline`.

- In your `main` procedure, you will conduct the experiments necessary to answer the questions below. You must perform all the logical and arithmetic operations discussed in the lab questions in SPIM. Correct lab questions without accompanying code will not receive credit. Comment each exercise in your main with the lab question number (e.g., B.3, or C.2, etc), or create a separate procedure for each.

- You are encouraged to write additional procedures as useful. As a general rule, any block of code you reuse should become its own procedure.

- Heavily comment your code. Make sure your code is readable and organized. Following the guidance of the template: document your methods indicating what the procedure does, the arguments to pass, and, if applicable, the values returned.

Lab Questions

Part A:

1. Given this sequence [60, 66, 157, 293, 329, 329, 334, 304, 131, 124], what character appears on the screen?
2. Given this sequence [0, 56, 72, 80, 102, 420, 296, 274, 236, 0], what character appears on the screen?
3. What vector do you need to print the letter "A" as seen in Figure 1?
4. What vector do you need to print the letter "B" as seen in Figure 1?

Part B:

In this part, you will visualize the results of logical operations.

- $\boldsymbol{X}$ = [65, 34, 20, 8, 20, 34, 65, 0, 0, 0], and
- $\boldsymbol{Y}$ = [8, 8, 8, 127, 8, 8, 8, 0, 0, 0].

1. What symbol is produced by the sequence $\boldsymbol{X}$?
2. What symbol is produced by the sequence $\boldsymbol{Y}$?
3. What symbol is produced by the operation $\boldsymbol{Z} = \boldsymbol{X} \wedge \boldsymbol{Y}$?
4. What symbol is produced by the operation $\boldsymbol{Z} = \boldsymbol{X} \vee \boldsymbol{Y}$?
5. What symbol is produced by the operation $\boldsymbol{Z} = \boldsymbol{X} \oplus \boldsymbol{Y}$?

Part C:

In this part, you will visualize the results of arithmetic operations.

- $\boldsymbol{A}$ = [0, 60, 64, 128, 128, 128, 128, 64, 60, 0]
- $\boldsymbol{B}$ = [0, 248, 132, 130, 130, 130, 130, 132, 248, 0]

1. What symbol is produced by the sequence A?
2. What symbol is produced by the sequence B?
3. Calculate $\boldsymbol{C} = \boldsymbol{A} + \boldsymbol{B}$. Store this vector. There is no question to answer.
4. Calculate $\boldsymbol{D} = \boldsymbol{B} - \boldsymbol{A}$. Store this vector. There is no question to answer.
5. What symbol is produced by the operation $\boldsymbol{E} = \boldsymbol{C} - \boldsymbol{D}$?
6. What symbol is produced by the operation $\boldsymbol{F} = \boldsymbol{C} + \boldsymbol{D}$?

Extra Credit

Write an additional procedure named `animate`. This procedure should take in the address of vector as its argument. This procedure should begin by calling `charprint` to render the character. Next, your code should shift each integer of the vector right by one digit and print your character again. Repeat this entire process until the character no longer appears on the screen.

Begin with vector $\boldsymbol{Q}$ = [0, 868, 1736, 3472, 3360, 3360, 3472, 1736, 868, 0].

Part D:

1. What is the minimal number of shifts required to move the character off the righthand side of the screen? (+5 pts)
2. What character is produced by this vector? (+5 pts)

Answers to the above extra credit lab questions without a correct implementation of the above function will not receive any points.

Submission

Collaboration is not permitted and each student must complete this exercise independently.

On D2L, find the "quiz" marked 'Lab2'. Complete the quiz to submit your answers to these lab questions. You should first answer all of the lab questions, offline and at your leisure. Once you have completed all the questions, you should then type them into D2L.

Once you begin the quiz you will have only 60 minutes to type in your answers and will be unable to change submitted answers. The D2L quiz questions will be automatically graded, so follow all instructions carefully and answer precisely. All answers can be typed on a standard US keyboard and you will not need copy & paste any nonstandard unicode characters. Understand these limitations before beginning the D2L quiz.

Complete this exercise before the deadline. This lab questions are worth 70 points. Correct answers without submitting your correct code will not receive credit. The remaining 30 points will be awarded based on the quality of your program comments.

Submit your program as file `[lastname]_[firstname].prog1.s` to the D2L dropbox folder named Lab 2 before 11:59pm on November 14. Late submissions will not be accepted.

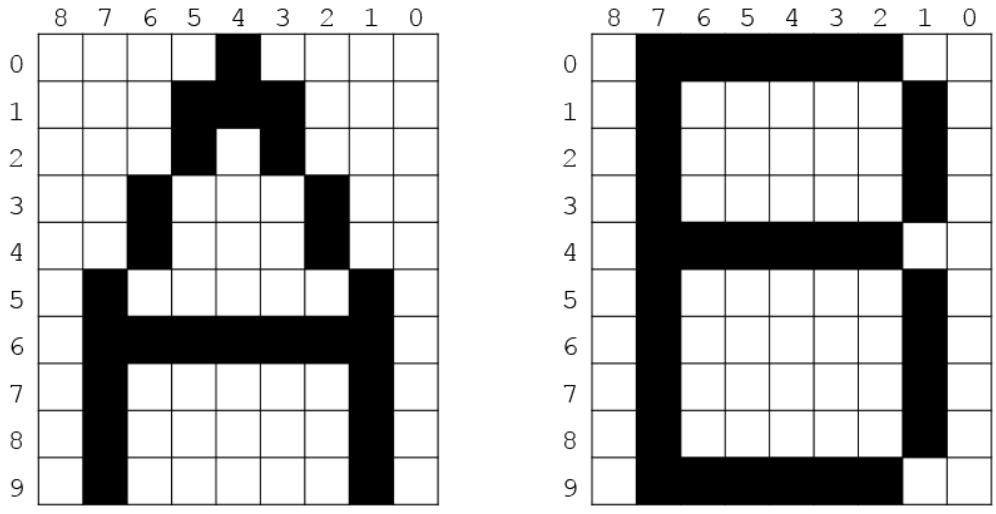

Figure 1: Representations of A and B