EE 337: Microprocessors Laboratory (Spring 2024)

Indian Institute of Technology Bombay

Lab 5: 20 points Date: February 7, 2024

1. [4 points] In this experiment, you will learn to display content on the LCD connected to the Pt-51 kit. Download the `lcd.h`, `lcd.c` files and `lcd-control-made-easy.pdf` uploaded along with the hand-out.

   The `lcd-control-made-easy.pdf` has general information about LCD operation which is helpful in understanding the code in `lcd.h`. Also, `lcd.h` has comments for each line, try to understand the comments by going through the code line by line.

   - Compile `lcd.c` with header file `lcd.h` and load the hex file on to the kit. Make sure the output on the LCD screen is as shown below:

     ```
     Pt-51
     IIT Bombay
     ```

   - Study the functions used in the `lcd.h` code and their usage. Modify `lcd.c` to display "EE337-2024" on the first line and your **first name** on the second line (truncate to 16 characters if you have a longer name). **Pad the display lines with spaces such that these are centered on the LCD when displayed.** You should load and run this program on the Pt-51 kit.

2. [8 points] As mentioned in Lab-3, MAC operation is widely used in machine learning applications. One common machine learning problem is the classification problem. Refer to 1. Given a pair of inputs (x_1 and x_2), you need to predict if the inputs falls in class 1 (represented by o) or class 2 (represented by $\times$). The prediction is done by fitting a straight line that separates the data-points belonging to the 2 classes.

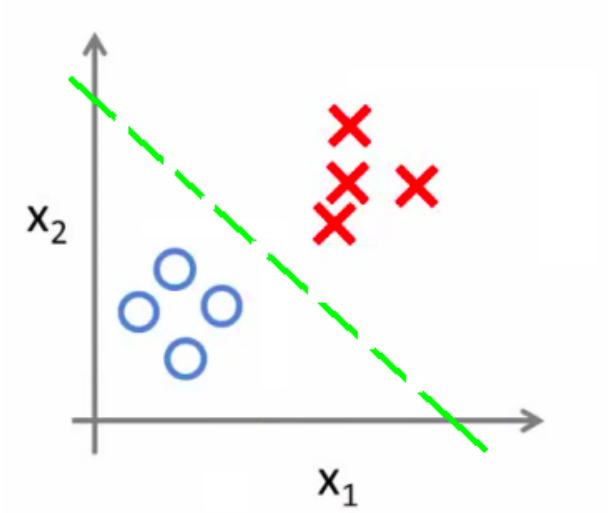

Figure 1: Binary Classification Illustration

In this part, you will read 2 inputs (x_1 and x_2) from the DIP switches present on the Pt-51 board, perform the necessary computations required for classification and display the result on the LCD.

The steps to be followed are provided below.

i) Initialize integers $w_0 = -36$, $w_1 = 5$ and $w_2 = 7$ in your C program.

ii) Display "**Input 1:**" on the LCD and give 5 seconds delay. During this time, use the DIP switches to provide the first input. Then read the value and store it in integer variable x_1.

iii) After 5 seconds, Display "**Input 2:**" on the LCD and give 5 seconds delay. During this time, use the DIP switches to provide the second input. Then read the value and store it in integer variable x_2.

iv) Perform the MAC operation as follows:

$$y = (1 \times w_0) + (x_1 \times w_1) + (x_2 \times w_2)$$

v) If $y < 0$, then the prediction is class 1. If $y \geq 0$, then the prediction is class 2. Refer to 2 for illustration of the computation.

vi) Display "**Prediction:**" in the first line of the LCD and the predicted result, either "**Class 1**" or "**Class 2**" in the second line of the LCD.

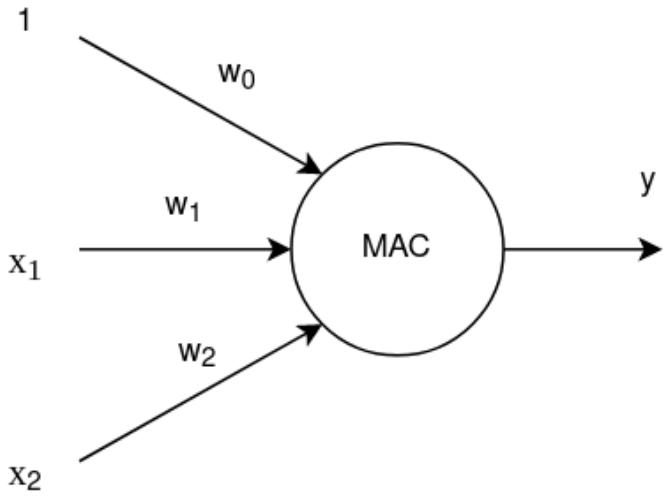

Figure 2: Computation Illustration

3. [8 points] Instead of showing the prediction as Class 1 or Class 2, the probability of the result being in Class 1 and Class 2 can be displayed. To do this, the output of the MAC is fed into sigmoid function (refer to 3).

$$z = \text{sigmoid}(y) = \frac{1}{1 + e^{-y}}$$

The value z gives probability of the given input belonging to Class 2.
The value 1-z gives the probability of the given input belonging to Class 1.

The steps to be followed are provided below.

i) Follow steps i), ii), iii) and iv) from the previous part.

ii) Implement the sigmoid function according to the given equation and find the required probabilities. Note that z will be a float value ranging between 0 & 1.

iii) Create a function `lcd_float()` in `lcd.h` to print float value, correct up-to 3 decimal places. To do this, make a string using ASCII values of the required digits and the decimal point.

iv) Display "**P(Class 1)=**_____" on the first line of the LCD and "**P(Class 2)=**_____" on the second line of the LCD.

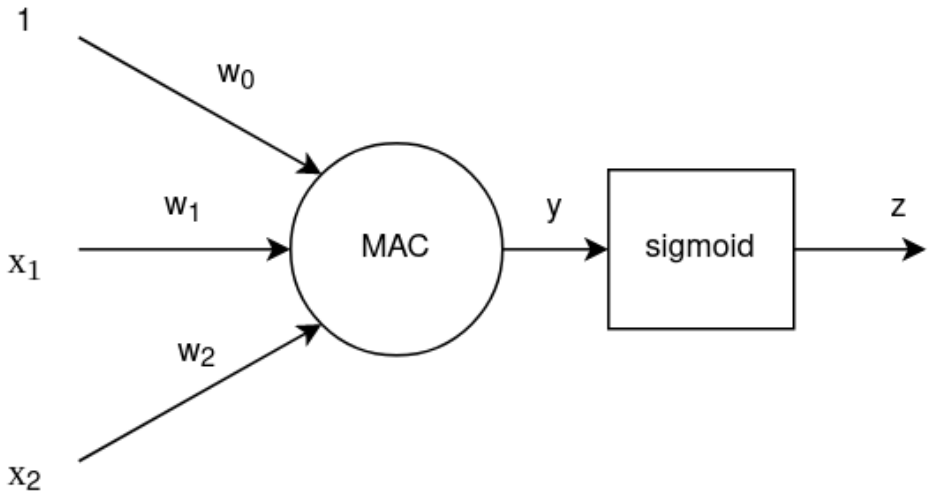

Figure 3: Computation Illustration

TA Checkpoints

1 Check the understanding of LCD operation and the `lcd.c` code.

2 Check the working and LCD output for the give two cases:

- Give inputs $x_1 =$ `4h` and $x_2 =$ `2h`.
- Give inputs $x_1 =$ `0h` and $x_2 =$ `6h`.

3 Check the working and LCD output for same cases as above. Ask explanation for how float values are printed on the LCD.