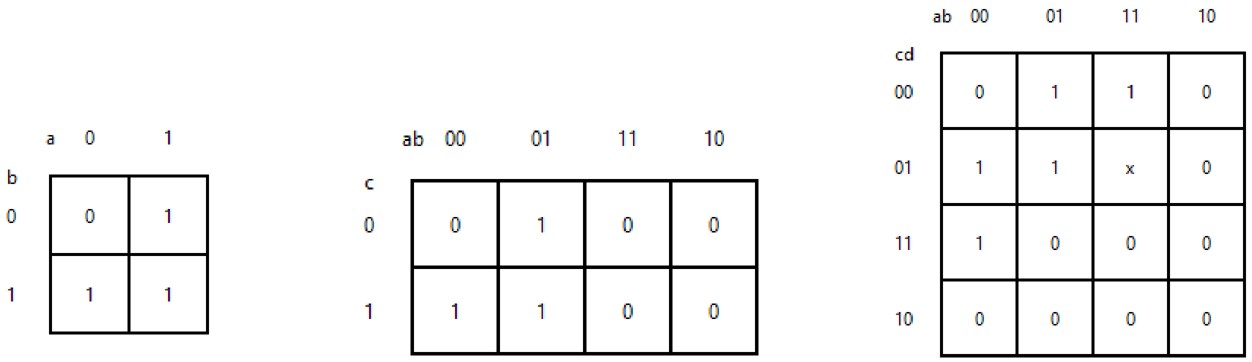
COL215 - Software Assignment 1

Karnaugh Maps

Submission Deadline: 21 Aug 2022

1 Introduction

In this assignment we will construct and manipulate Karnaugh Maps (K-maps). Examples of K-Maps are shown below (Figure 1), representing a function of 2, 3, 4 boolean/binary variables a, b, c, and d. For each $abcd$ combination, the function can have one of the following values: `TRUE` (1), `FALSE` (0), and `DON'T CARE` (x). `DON'T CARE` implies that the output value of the function is not relevant, so can be either 0 or 1.



b \ a	0	1
0	0	1
1	1	1

(a) an example k-map of 2 variables

c \ ab	00	01	11	10
0	0	1	0	0
1	1	1	0	0

(b) an example k-map of 3 variables

cd \ ab	00	01	11	10
00	0	1	1	0
01	1	1	x	0
11	1	0	0	0
10	0	0	0	0

(c) an example k-map of 4 variables

Figure 1: K-maps of different sizes

2 Problem Description

For a K-map with 4 variables, the rows of the K-map are labelled with ab values, and columns are labelled with cd values. Note the sequence of values $[00, 01, 11, 10]$. This is a K-map property (adjacent cells have only one variable changing values).

A `REGION` in the K-map is identified by two co-ordinates: the top-left corner, and bottom-right corner (note that the regions can wrap around the edges). Regions correspond to TERMS (e.g., $ab'c$), which are the product of LITERALS. Literals can be a boolean variable or its complement (e.g., a or b'). Here is the way to find the region corresponding to a term.

- If a variable a appears in *uncomplemented form* (e.g., ab), then the region has $a = 1$ in all its cells.
- If a variable a appears in *complemented form* (e.g., $a'b$), then the region has $a = 0$ in all its cells.
- If a variable k does not appear in the term, then the region has both cells with $k = 0$ and cells with $k = 1$.

Given a function and a term, write a program to:

- highlight the corresponding K-map region, and
- report whether the region is LEGAL. A legal region can consist of 1s and x's, but cannot contain any 0s.

2.1 Graphic Module

You are given a utility (`K_map_gui_tk.py`) that takes as input a function's output values for all input combinations, and displays the corresponding K-map. Get familiar with the utility. Sample usage of the utility is provided in the `test.py` file. You will need to work with functions of 2 to 4 variables for the assignment.

2.1.1 Instructions to use the Module

1. creating a K-map (L is a n * n 2D list):

```
root = kmap(L)
```

2. drawing region with $(x1, x2)$ as the top-left coordinate, $(x2, y2)$ as the bottom-right coordinate:

```
root.draw_regions(x1, y1, x2, y2, color)
# color can be 'red', 'green', 'blue', 'yellow' etc
```

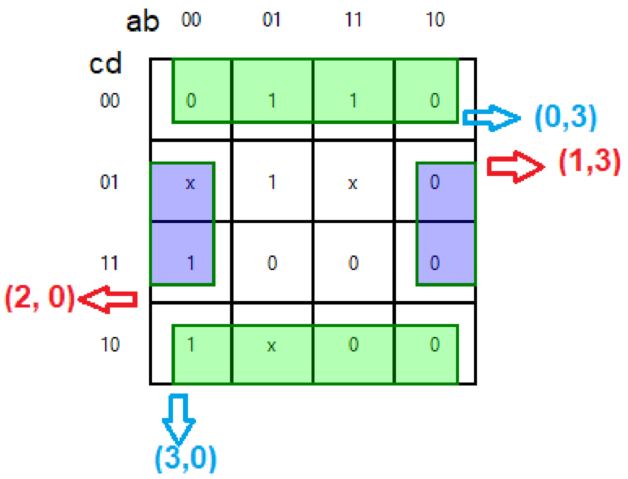
3. display the K-map:

```
root.mainloop()
```

2.1.2 Using the Code for Wrapping Region

```
from K_map_gui_tk import *

root = kmap([[0,1,1,0], ['x',1,'x',0], [1,0,0,0], [1,'x',0,0]])
root.draw_region(1,3,2,0,'blue')
root.draw_region(3,0,0,3,'green')
root.mainloop()
```

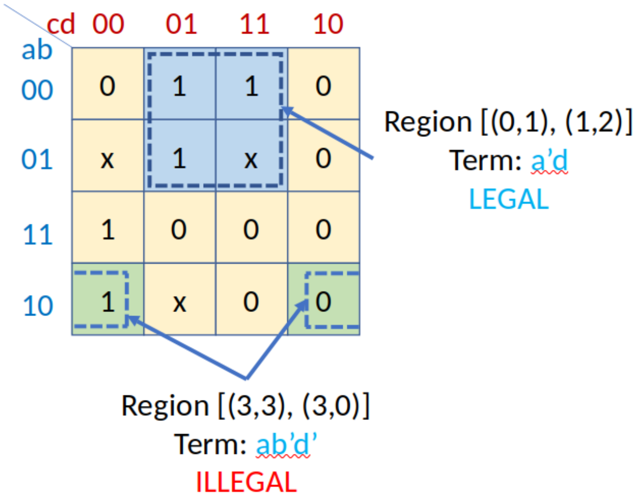


	00	01	11	10
00	0	1	1	0
01	x	1	x	0
11	1	0	0	0
10	1	x	0	0

Figure 2: Output of the above code (arrows are for reference)

2.2 Example Test Case

Refer to Figure 3 for an example on the correspondence between terms/regions and how to identify `LEGAL` and `ILLEGAL` regions.



ab \ cd	00	01	11	10
00	0	1	1	0
01	x	1	x	0
11	1	0	0	0
10	1	x	0	0

Region [(0,1), (1,2)]
Term: a'd
LEGAL

Region [(3,3), (3,0)]
Term: ab'd'
ILLEGAL

Figure 3: K-map with two highlighted regions: one is legal, the other is not

The region specified by $[(0,1),(1,2)]$ (term: $a'd$) is LEGAL since it only has 1 and x. However, the region $[(3,3),(3,0)]$ (term $ab'd'$) is ILLEGAL since it also has a 0.

3 Submission Instructions

You are required to submit the following on Gradescope:

1. Python file named ⟨**entry_number1_number2**⟩**_assignment_1.py** containing the function

```
is_legal_region(kmap_function, term):
    """
    determines whether the specified region is LEGAL for the K-map function
    Arguments:
        kmap_function: n * m list containing the kmap function
        for 2-input kmap this will 2*2
            3-input kmap this will 2*4
            4-input kmap this will 4*4
        term: a list of size k, where k is the number of inputs in function (2,3 or 4)
            (term[i] = 0 or 1 or None, corresponding to the i-th variable)
    Return:
        three-tuple: (top-left coordinate, bottom right coordinate, boolean value)
                     each coordinate is represented as a 2-tuple
    """
    # your code here
```

2. A short report (1-2 pages) explaining your approach and the test cases you have run.

3. You have to form a group of 2 students for the assignment.
   - Group will remain same for subsequent assignment, no change allowed.
   - Only one submission per group needed to be done via gradescope. Gradescope help link: https://help.gradescope.com/article/m5qz2xsnjy-student-add-group-members

4. Post your doubt in the following thread on Piazza: https://piazza.com/class/l6kqptxu7sz6i2?cid=8