# CS 639: Program Analysis, Verification And Testing

# Assignment #4A: Abstract Interpretation

### **Problem Statement:**

In this assignment, we will try to track for safe movements of Kachua. Kachua would move in accordance to the program instructions, and eventually rests at the final position reached at the end of the program. If Kachua rests into an area in a magarmach's (crocodile's) region, the magarmach can eat it. Such a **dangerous region** is usually **rectangular** in shape and can be described by x-coordinate interval and y-coordinate interval e.g, ([x1, x2], [y1, y2]). Given a Turtle program, students need to verify that the Kachua never rests in the magarmach's region. You need to verify this using abstract interpretation with the interval domain.

The magarmach's region will be provided as a JSON file with the same name as the Turtle program. Eg. if the Turtle file is "foo.tl", then the magarmach's region will be in "foo.json"; a sample JSON file is given below:

{

"reg" : [

[2, 5],

[8, 9]

]

}

where (2,5) is the top-left corner and (8,9) is the bottom-right corner of the rectangle. The Turtle programs provided to you will only contain arithmetic operations + (plus) and - (minus), and all the relational operators. The rotations can only be in multiples of 90 degrees.

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# IMPLEMENTATION:

The main task in this assignment is to track the movements of kachua throughout the program and finding out the eventual possible range of the coordinates where kachua rests. We also have a “Magarmach’s” region which is specified as 2 pairs of ‘x’ and ‘y’ coordinates which forms a rectangular area. Hence, the main aim to verify that the kachua never rests in the magarmach’s region.

So, in order to do this, concepts of “Abstract Interpretation” is used. In abstract interpretation with the interval domain, we basically convert concrete values in the form of sets to an abstract interval domain where we represent each set by a range of values. This range goes from the minimum value in the set to maximum value.

Now, since the main goal is to find the range of possible values of the x and y coordinates of kachua’s eventual resting position, we initially consider a range which symbolizes the initial X and the Y coordinate form where the kachua starts i.e. it’s initial resting position.

Now, abstract interpretation is done on three metrics:

1. The x-coordinate position of kachua.
2. The y-coordinate position of kachua.
3. The direction in which the kachua is facing.

Note: Since, it is mentioned that the rotations can only be in multiples of 90 degrees, the direction of kachua at any point of time can be any one amongst the direction of 4-axes, i.e. { +x , -x , +y , -y}.

So, at each basic block we maintain 3 things which are the possible range of x and the y coordinates and the direction of kachua.

## Initialization:

Firstly, we have to initialize the ‘In’ of start node of single statement basic blocks. So, to do this we initialize the x-range and the y-range with the initial possible range of starting position of kachua. Also, the initial direction where the kachua faces is along the standard ‘+x’ axis.

# LIMITATIONS:

1. The programs should not have nested if-else structures.

2. In the if conditionals, there should be comparison between two digits, for eg. if(2>5)