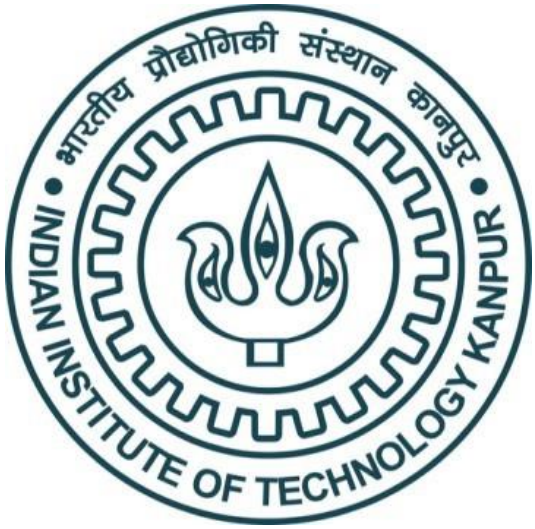
Assignment 4 Report

CS 639: Program Analysis Verification And Testing

Abstract Interpretation

November 11, 2023



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INTRODUCTION

The report is for the "Abstract Interpretation". In this assignment, the primary objective is 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 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, we need to verify that the Kachua never rests in the magarmach's region.

It involves determining the potential range of values for the x and y coordinates of Kachua's eventual resting position. This is initially represented by a range symbolizing Kachua's initial resting position.

Abstract interpretation is applied to three key metrics:

i. *The x-coordinate position of Kachua.*
ii. *The y-coordinate position of Kachua.*
iii. *The directional orientation of Kachua.*

Given the constraint that rotations occur solely in multiples of 90 degrees, Kachua's direction is confined to one of four axes: {+x, -x, +y, -y}.

Consequently, at each basic block, meticulous records are maintained for the potential ranges of x and y coordinates, along with Kachua's directional orientation.

Workflow of the codes submitted

1. Initialization conditions:

We must set the 'In' parameters for the start node of single-statement basic blocks. To achieve this, we initialize the x-range and y-range with the potential starting position of Kachua. Additionally, the initial direction Kachua faces is aligned with the standard '+x' axis.

2. Transfer Function:

The “transferFunction” code performs abstract interpretation for a turtle program's coordinate ranges and direction. It handles move commands, adjusting the turtle's position and direction based on the program's instructions. The code processes conditional statements, determining possible ranges for subsequent blocks. It utilizes abstract intervals to represent coordinate sets, ensuring a comprehensive analysis of potential turtle positions and directions during program execution. By updating the abstract intervals at each basic block, the code effectively captures the evolving state of the turtle, facilitating precise tracking of its potential resting positions and facing directions.

With an initial x-coordinate range of [-20,50] and facing '+x', executing 'forward 30' expands the x-coordinate range to [-20,80]. Also, If the current basic block's 'in' direction is '-y' and it contains 'right 90', the 'out' direction becomes '-x'.

3. Meet Function:

The `meet` function takes a list of predecessor states and computes the meet over these states. It gathers information about the final x and y coordinate ranges, direction, and whether the turtle is in "bot" mode from each predecessor. The function then determines the meet value based on different cases: if there is only one predecessor, if there are two predecessors with

different bot statuses, if there are multiple predecessors with the same direction, or if the directions of the paths are different, indicating an unsafe condition. The final meet value includes the updated coordinate ranges, direction, and bot status.

Assumptions

The initial range of the starting position of kachua is considered to be [0,0] for both x and y axes.

Limitations

I have not addressed repeat statements in the kachua program due to complexities. Opting for safety, I declare 'Kachua is unsafe' when repeats are encountered. This ensures correctness, avoiding false negatives where the kachua might enter a hazardous region. Which leads the solution to **“Sound”** but not precise.