Basics of Programming

L04: Loops

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Resources and Acknowledgements

- Intro to Programming with C++
  - Abhiram Ranade, Prof CSE, IIT Bombay
- A first course in programming
  - https://introcs.cs.princeton.edu/python/home/
  - https://introcs.cs.princeton.edu/java/home/
- Python for everybody
  - https://www.py4e.com
- Turtle Graphics
  - https://docs.python.org/3/library/turtle.html

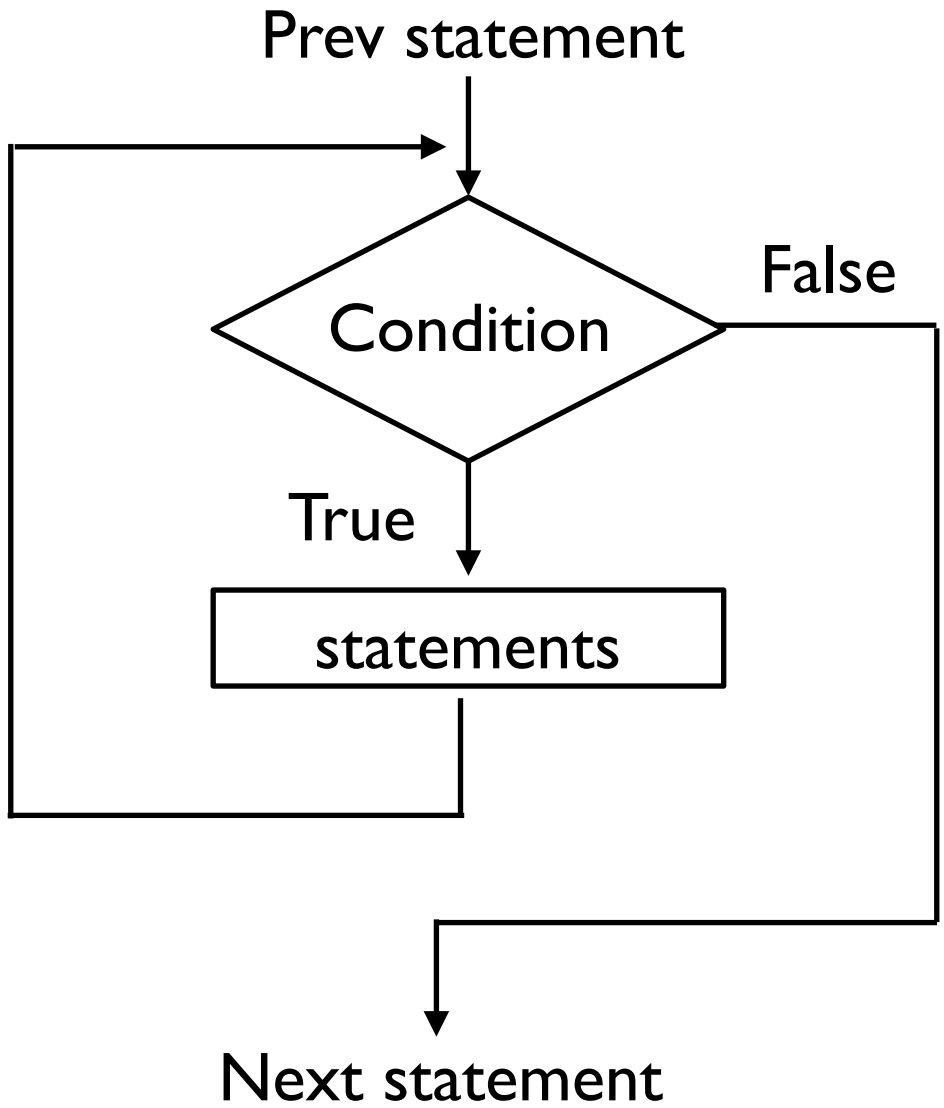
Review: Lecture 03

- Turtle graphics
  - multiple turtles
  - overlapping polygons
- If statement
  - Conditional ifs, Nested ifs
  - Complex conditions
  - `pass` statement
- Simple loops, early closure of loops
  - break, continue
- Exercises
  - Make carrom board, GCD implementation
  - Sort 4 (and 5) numbers.
  - Max subsequence, smallest palindrome >n.

Loop: While

- Loop statements
  - `while`, `for`
- General structure
  - while (condition)
    - body # statements
- Each execution of the body is called iteration.
- Execution ends when condition becomes false
- Body can be any number of statements
- For program to halt
  - condition must become false at some point
  - typically, condition involves some variables
    - Value of variables changes for halting condition

While Flowchart



A Bad While Loop

- Spot the issue in following program segment

```
n=int(input("enter max even number"))
even=2
while (even != n):
 print(even)
 even = even + 2

print("All even numbers up to ", n)
```

- What should be the changes in this program
  - Ensure that condition terminates (halts)

Loop: `for` statement

- `for` statement (3 parts)
  - Initialize an index variable to some value
  - Use a while loop to test terminating (exit) condition
  - Modify the index variable
- It is generally used when count of iterations are kind of known in advance
- Use while loop when count of iterations are unknown
  - Depending upon use case under consideration

Use Cases: `for/while` loop

- Write first `n` powers of 2

```
for i in range(n+1):
  print(2**i)
```

- Write largest power of 2 greater than `n`

```
power=1
while (2**power < n):
  power = power + 1
print("power of 2(>n)", 2**power)
```

Use Cases: `for/while` loop

- Write sum of first `n` even numbers

```
sum = 0
for i in range(n):
  sum = sum + 2*(i+1)
print(sum)
```

- Write a product of first n natural numbers

```
prod = 1
for i in range(1,n+1):
  prod = prod * i
print(prod)
```

Use Cases: `for/while` loop

- Compute `sqrt(num)` till `10` decimal places using newton's method
- Steps:
  - initalize variable `temp = num`
  - repeat below till `(temp - num/temp)` < 10^{-10}
    `temp=(num/temp + temp)/2.0`
- Code

```
val = num
while (abs(val - num/val)>10**-10):
  val=(val + num/val)/2.0
print(val)
```

Nesting: Loop and Conditions

- Compute prime factorization of `n`
  - e.g. for `n=24`, prime factorization is `2*2*2*3`
- Code

```
val = n
factor=2
while (val>factor):
  if (val % factor == 0):
    print(factor)
    val = val // factor
  else:
   factor = factor + 1
print(val)
```

Loop Termination in Block

- Keep computing square and cube of given integer
  - Until user decides to exit (enters 0)

```
while True:
  n=int(input("Enter a number: "))
  if (n == 0):
    break
  print("n^2=", n*n, ", n^3=", n*n*n)

print("Thanks for using the program")
```

Python Programming Considerations

- Should we use TAB in program for indentations?
  - It should be avoided. Many editors treat it differently.
- Can a statement be spread over multiple lines
  - Yes, but be careful
  - Understand how python treats indentation
    - Within parenthesis, splitting works just fine

```
n = (1 + 2  + 3
  + 4)
```

    - Otherwise, use backslash(\) as the last character

```
n = 1 + 2  + 3 \
  + 4
```

- How to create empty body of statement
  - use `pass` statement

Python Programming Considerations

- Can we use non-boolean expression in conditions?
  - It is not recommended.
  - numeric `0` and empty string is considered `False`.
- Can we change index variable in `for` loop?
  - Yes, but it is not recommended.
  - It may become too difficult to debug.
  - What is the output of following

```
for i in range(10):
  print(i)
  i = i + 2
```

- What is the value of index variable upon exit in `for` loop with `range(n)`?
  - `n`

Exercise

- What does following program do

```
n=10
f=0
g=1
for i in range(n):
  f=f+g
  g=f-g
  print(f)
```

- Answer: ?

Home Work

- `H01`: Compose a program that takes one command-line argument `n`, and
  - writes an `n`-by-`n` table such that there is an `*` in row `i` and column `j`
    - if the `gcd` of `i` and `j` is `1`, i.e.
      - `i` and `j` are relatively prime
    - a space in that position otherwise

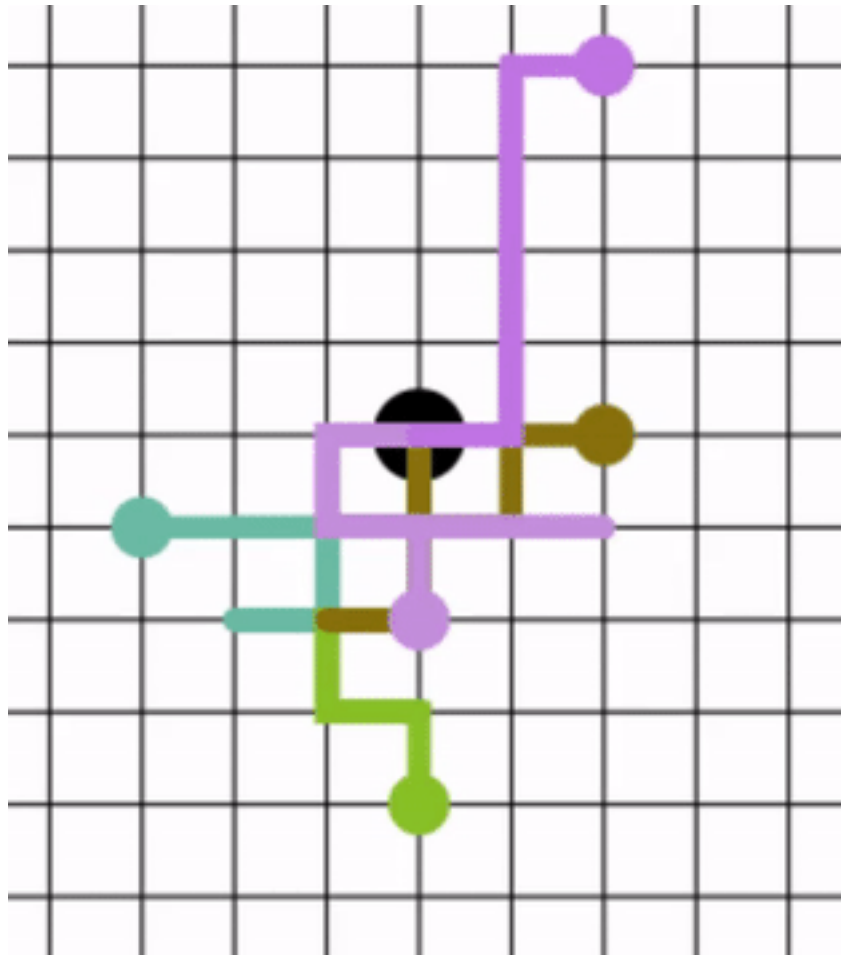
Home Work

- `H02`: Ramajunjan's taxi number identification using `while` loop (and not `for` loop)
  - Given command-line argument `n`, and
  - Identify if $n=a^3+b^3=c^3+d^3$, where
    - All `a, b, c, d` are distinct positive integers

Home Work

- `H03`: 2D random walk
  - ref: https://en.wikipedia.org/wiki/Random_walk
  - A two dimensional random walk simulates the behavior of a particle moving in a grid of points.
    - At each step, the random walker moves north, south, east, or west.
    - Each move is with probability `1/4`, independent of previous moves.
    - Compose a program that takes a command-line argument `n` and estimates how long it will take a random walker to hit the boundary of a square of size `2n+1`-by-`2n+1` starting at the centre point.
    - Image of 2D Random walk

2D Random Walk



Home Work

- `H04`: Median of 5 numbers in max 6 comparisons
  - ref:http://mathcs.wilkes.edu/~bracken/cs328/fa2014/median5.pdf
  - Take 5 integers at command line arguments
    - Find the median of these 5 numbers.
    - First use the normal logic you can think of
    - See if you can optimize it using max 6 comparisons
      - See the reference

Home Work

- `H05`: Let us make a deal (Game Show)
  - A contestant is presented with three doors.
  - Behind one of them is a valuable prize.
  - After contestant chooses a door, host opens one of the other two doors (not the one containing the prize)
  - The contestant is then given the choice to switch to the other unopened door.
  - Should the contestant do so?
  - Write a program to answer this question
    - Run the logic 1000 times to answer
      - Should the contestant switch to other door?

Questions