Lecture 22

While Loops

Announcements for This Lecture

Assignments

- A6 due on **Wednesday**
  - First two should be done
  - Start Algorithm by weekend
  - **Next Week**: Partition/Update
- A7 will be last assignment
  - Will talk about next week
  - Posted on Wednesday
- There is lab next week
  - **No lab** week of Turkey Day

Prelim 2

- **TONIGHT**, 5:15 or 7:30
  - **K – Z** at 5:15pm
  - **A – J** at 7:30 pm
  - See website for room
  - Conflicts received e-mail
- Will have 4-5 questions
  - Might drop short answer
  - Similar to previous years
- Graded by the weekend

Recall: For Loops

```
# Print contents of seq
x = seq[0]
print(x)
x = seq[1]
print(x)
…
x = seq[len(seq)-1]
print(x)
```

The for-loop:

```
for x in seq:
    print(x)
```

- Key Concepts
  - **loop sequence:** `seq`
  - **loop variable**: `x`
  - **body**: `print(x)`
  - Also called **repetend**

Important Concept in CS: Doing Things Repeatedly

1. Process each item in a sequence
   - Compute aggregate statistics fo
     such as the mean, median, stan
   - Send everyone in a Facebook group an appointment time

```
for x in sequence:
    process x
```

2. Perform *n* trials or get *n* samples.
   - A4: draw a triangle six times to m
   - Run a protein-folding simulati

```
for x in range(n):
    do next thing
```

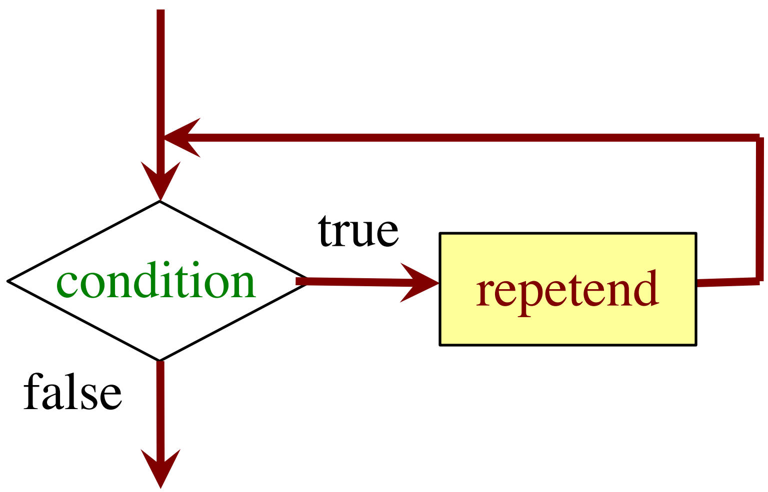
3. Do something an unknown number of times
   - CUAUV team, vehicle keeps moving until reached its goal

????

Beyond Sequences: The **while-loop**

```
while <condition>:
    statement 1
    …
    statement n
```

repetend or **body**



- Relationship to for-loop
  - Broader notion of "still stuff to do"
  - Must explicitly ensure condition becomes false
  - *You* explicitly manage what changes per iteration

While-Loops and Flow

```
print('Before while')
count = 0
i = 0
while i < 3:
    print('Start loop '+str(i))
    count = count + i
    i = i + 1
    print('End loop ')
print('After while')
```

Output:

```
Before while
Start loop 0
End loop
Start loop 1
End loop
Start loop 2
End loop
After while
```

while Versus for

```
# process range b..c-1
for k in range(b,c)
    process k
```

```
# process range b..c-1
k = b
while k < c:
    process k
    k = k+1
```

Must remember to increment

```
# process range b..c
for k in range(b,c+1)
    process k
```

```
# process range b..c
k = b
while k <= c:
    process k
    k = k+1
```

Range Notation

- m..n is a range containing n+1-m values
  - 2..5 contains 2, 3, 4, 5. Contains 5+1 – 2 = 4 values
  - 2..4 contains 2, 3, 4. Contains 4+1 – 2 = 3 values
  - 2..3 contains 2, 3. Contains 3+1 – 2 = 2 values
  - 2..2 contains 2. Contains 2+1 – 2 = 1 values
  - 2..1 contains ???

What does 2..1 contain?

A: nothing
B: 2,1
C: 1
D: 2
E: something else

Range Notation

- m..n is a range containing n+1-m values
  - 2..5 contains 2, 3, 4, 5. Contains 5+1 – 2 = 4 values
  - 2..4 contains 2, 3, 4. Contains 4+1 – 2 = 3 values
  - 2..3 contains 2, 3. Contains 3+1 – 2 = 2 values
  - 2..2 contains 2. Contains 2+1 – 2 = 1 values
  - 2..1 contains ???
- The notation m..n, always implies that m <= n+1
  - So you can assume that even if we do not say it
  - If m = n+1, the range has 0 values

while Versus for

```
# incr seq elements
for k in range(len(seq)):
    seq[k] = seq[k]+1
```

Makes a **range object**.

```
# incr seq elements
k = 0
while k < len(seq):
    seq[k] = seq[k]+1
    k = k+1
```

while is more flexible, but requires more code to use

Patterns for Processing Integers

range a..b-1

```
i = a
while i < b:
    process integer i
    i = i + 1
```

```
# store in count # of '/'s in  String s
count = 0
i = 0
while i < len(s):
    if s[i] == '/':
        count= count + 1
    i= i +1
# count is # of  '/'s in s[0..s.length()-1]
```

range c..d

```
i= c
while i <= d:
    process integer i
    i= i + 1
```

```
# Store in double var. v the sum
# 1/1   + 1/2 + ...+ 1/n
v = 0;     # call this 1/0 for today
i = 1
while i <= n:
    v = v + 1.0 / i
    i= i +1
# v= 1/1   + 1/2 + ...+ 1/n
```

while Versus for

```
# table of squares to N
seq = []
n = floor(sqrt(N)) + 1
for k in range(n):
    seq.append(k*k)
```

```
# table of squares to N
seq = []
k = 0
while k*k < N:
    seq.append(k*k)
    k = k+1
```

A for-loop requires that you know where to stop the loop **ahead of time**

A while loop can use complex expressions to check if the loop is done

while Versus for

Fibonacci numbers:

$F_0 = 1$

$F_1 = 1$

$F_n = F_{n-1} + F_{n-2}$

```python
# Table of n Fibonacci nums
fib = [1, 1]
for k in range(2,n):
    fib.append(fib[-1] + fib[-2])
```

```python
# Table of n Fibonacci nums
fib = [1, 1]
while len(fib) < n:
    fib.append(fib[-1] + fib[-2])
```

Sometimes you do not use the loop variable at all

Do not need to have a loop variable if you don't need one

Cases to Use while

Great for when you must **modify** the loop variable

```
# Remove all 3's from list t
i = 0
while i < len(t):
    # no 3's in t[0..i–1]
    if t[i] == 3:
        del t[i]
    else:
        i = i+1
```

```
# Remove all 3's from list t
while 3 in t:
    t.remove(3)
```

Cases to Use **while**

Great for when you must **modify** the loop variable

```
# Remove all 3's from list t
i = 0
while i < len(t):
    # no 3’s in t[0..i–1]
    if t[i] == 3:
        del t[i]
    else:
        i = i+1
```

Stopping point keeps changing.

```
# Remove all 3's from list t
while 3 in t:
    t.remove(3)
```

The stopping condition is not a numerical counter this time. Simplifies code a lot.

Cases to Use while

- Want square root of c
  - Make poly $f(\mathrm{x}) = x^2 - c$
  - Want root of the poly (x such that $f(x)$ is 0)
- Use **Newton's Method**
  - x_0 = GUESS (c/2??)
  - $x_{n+1} = x_n - f(x_n)/f'(x_n)$
    $= x_n - (x_n x_n - c)/(2x_n)$
    $= x_n - x_n/2 + c/2x_n$
    $= x_n/2 + c/2x_n$
  - Stop when x_n good enough

```
def sqrt(c):
    """Return: square root of c
    Uses Newton's method
    Pre: c >= 0 (int or float)"""
    x = c/2
    # Check for convergence
    while abs(x*x – c) > 1e-6:
        # Get x_{n+1} from x_n
        x = x / 2 + c / (2*x)

    return x
```

Recall Lab 9

Welcome to CS 1110 Blackjack.
Rules: Face cards are 10 points. Aces are 11 points.
    All other cards are at face value.

Your hand:
2 of Spades
10 of Clubs

Dealer's hand:
5 of Clubs

Type h for new card, s to stop:

Play until player **stops** or **busts**

Recall Lab 9

Welcome to CS 1110 Blackjack.
Rules: Face cards are 10 points. Aces are 11 points.
All other cards are at face value.

Your hand:
2 of Spades
10 of Clubs

How do we design this as a loop?

Dealer's hand:
5 of Clubs

Play until player **stops** or **busts**

Type h for new card, s to stop:

Recall Lab 9

```
halted = False

while not game.playerBust() and not halted:
    # ri: input received from player
    ri = input('Type h for new card, s to stop: ')

    halted = (ri == 's')

    if (ri == 'h'):
        game.playerHand.append(game.deck.pop(0)
        print('You drew the ' + str(game.playerHand[-1]) +'\n')
```

Recall Lab 9

```
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while not game.playerBust() and not halted:
    # ri: input received from player
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```

Explicit loop variable

Set to False to break the loop

Recall Lab 9

More than one way to stop

```
halted = False

while not game.playerBust() and not halted:
    # ri: input received from player
    ri = input('Type h for new card, s to stop: ')

    halted = (ri == 's')

    if (ri == 'h'):
        game.playerHand.append(game.deck.pop(0)
        print('You drew the ' + str(game.playerHand[-1]) +'\n')
```

Using while-loops Instead of for-loops

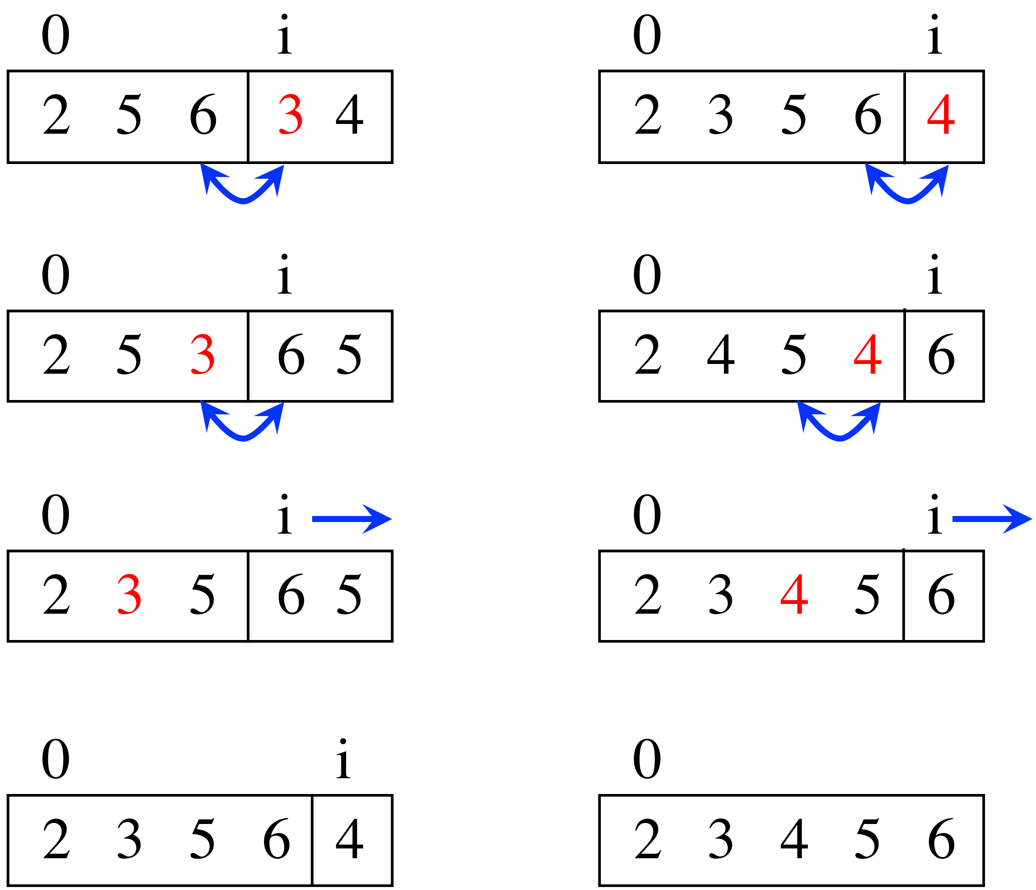
Advantages

- Better for **modifying data**
  - More natural than range
  - Works better with deletion
- Better for **convergent tasks**
  - Loop until calculation done
  - Exact steps are unknown
- Easier to **stop early**
  - Just set loop var to False

Disadvantages

- Performance is **slower**
  - Python optimizes `for`-loops
  - Cannot optimize `while`
- **Infinite loops** more likely
  - Easy to forget loop vars
  - Or get stop condition wrong
- **Debugging** is harder
  - Will see why in later lectures

Our Goal From Here: Sorting



Will see how to do this with `while`-loops