Lecture 3: Control Flow and Loops

Math 98, Fall 2022

Agenda

- Relations
- Logical statements
- Boolean expressions
- `if-else` statements
  - Exercises
- `for` loops
  - Exercises
- `while` loops
  - `break`
  - Exercises

Relations

The following statements will take value 0 (if false) or 1 (if true)

- $a < b$: a less than b
- $a > b$: a greater than b
- $a <= b$: a less than or equal to b
- $a >= b$: a greater than or equal to b
- $a == b$: a equal to b (note the doubled equals sign!)
- $a \sim= b$: a not equal to b

Logical Statements

- `and(a,b)` or equivalently `a & b`
- `or(a,b)` or equivalently `a | b`
- `not(a)`
- `xor(a,b)`

What do the commands `&&` and `||` do?

Boolean Expressions

A boolean expression is any expression involving relations or logical statements:

$((4 <= 100)|(-2 > 5))\&(\texttt{true}| \sim \texttt{false})$

Boolean expressions evaluate to 1 for true and 0 for false. Note that 0 and 1 are just numbers and are not in a separate class for logicals.

```
>> 5 + true
ans =
6
```

The order of operations is as follows:

1. negation
2. relations
3. and
4. or

if-else Statements: General Structure

This construct is used where the decision to execute one or another set of computations depends on the value of a boolean expression.

```
if   this boolean expression is true
            execute these commands
elseif   this second expression is true instead
            then execute these other commands
else
            do this if those earlier conditions are false
end
```

if-else Statements: Example 1

What does this return?

```
if 4 > 3
        disp('first one!')
elseif pi == 3.14
        disp('second one!')
else
        disp('neither were true!')
end
```

if-else Statements: Example 2

What does this return?

```
if 4 < 3
        disp('first one!')
elseif pi == 3.14
        disp('second one!')
else
        disp('neither were true!')
end
```

if-else Statements: Example 3

What does this return?

```
if 4 < 3
        disp('first one!')
elseif pi == 3.14
        disp('second one!')
elseif false
        disp('third one!')
end
```

if-else Statements: Example 3(b)

What's wrong with this?

```
if 4 < 3
        disp('first one!')
elseif pi == 3.14
        disp('second one!')
elseif
        disp('third one!')
end
```

Exercise: `comparison.m`

Write a script that prompts the user for two numbers (call them x and y). It should output `The numbers are equal` if $x = y$ and `The numbers are not equal` otherwise.

Exercise: `quadroots.m`

Write a script that prompts the user for three integers `a, b, c`. These are the coefficients to the quadratic $p(x) = ax^2 + bx + c$. Display a message saying whether the quadratic has 1) distinct real roots, 2) a repeated root, or 3) complex roots.

`for` Loops: Motivation

Is n prime?

- Try dividing n by 2,3,. . .
- If no smaller number divides n, then n is prime

We need a way to run multiple tests, one after the other.

We also need the function `mod()`, which finds remainders after division:

```
>> mod(17,5)
2
>> mod(33,3)
0
```

for Loops: Description

Used to repeat a set of commands a certain number of times

```
for countVariable = 1 : numberOfIterations

%   do something here
%   this part will run
%   (numberOfIterations) times

end
```

for Loops: Example

Simple Example:

```
>> for i = 1:4
    i + 2
end
ans =
3
ans =
4
ans =
5
ans =
6
```

Nested for Loops: Example

Here is a for loop within a for loop. This is called a nested loop.

```
for i = 1:4
    for j = 1:3
        i+j
    end
end
```

Exercise: `sumCubes.m`

Write a program `sumCubes.m` of the form

```
function S = sumCubes(v)
```

that takes a vector as input and returns the sum of the cubes of its elements. For pedagogical purposes, do this by:

1. Initializing a variable `S = 0` to keep track of the sum
2. Use a `for` loop

Do you know a much simpler way to do this?

Example: `testPrime.m`

Write a function of the form

```
function [isPrime,divisor] = testPrime(n)
```

that takes in an integer n and returns isPrime = true if n is prime and false otherwise. It should return divisor = NaN if the integer is prime and its smallest divisor otherwise.

(This should be obvious, but don't use the built in `MATLAB` function `isprime`)

while Loops: Introduction

A statement to repeat a section of code *until* some condition is satisfied.

```
while [EXPRESSION is true]

%    repeat this part until
%    (EXPRESSION) is false
%    be sure to modify (EXPRESSION) in this loop

end
```

while Loops: Example

Here is a simple example.

```
x = 0;
while x<=3
    x = x+1;
end
```

while Loops: Nontermination

A for loop does "stuff" for a set number of times. A while loop does "stuff" until some condition is no longer satisfied. This may go on forever!

```
x = 0;
while x<=3
    x = x-1;
end
```

while Loops: continue

In both for and while loops, continue skips to the next run of the loop.

```
for i = 0:3:30
    if mod(i,2) == 0
        continue
    end
    fprintf('%d ', i);
end
```

It's often possible to avoid using continue by restructuring your code. Can you do that with the code above?

while Loops: break

The command break terminates the loop.

```
while true
    guess = input('What number am I thinking of? ');
    if guess == 5
        fprintf('Lucky guess \n');
        break
    else
        fprintf('WRONG');
    end
end
```

Can you rewrite this code so that it doesn't use break?

while Loops: In Class Demo

Demonstration of `while`, `continue`, and `break`: `manyFrogs.m`

Exercise: `bisection.m`

Implement a MATLAB function `bisection.m` of the form

```
  function p = bisection(f, a, b, tol)
% f: function handle y = f(x)
% a: Beginning of interval [a, b]
% b: End of interval [a, b]
% tol: user provided tolerance for interval width

% p: approximation to the root
```

Exercise: newton.m

Implement a function newton.m of the form

```
function p = newton(f, df, p0, tol)
% f: function handle y = f(x)
% df: function handle of derivative y' = f'(x)
% p0: initial estimate of the root
% tol: user provided tolerance for accuracy of solution

% p: approximation to the root
```