Programming with Matlab: Developing and Testing Robust Code

Outline

- overview
- program control structures
- scripts and functions
- Importing Data
- Data Types

Exercise 1:

Run the code - observe an orbit of the satellite of the earth

Run the code - observe an orbit of the satellite of the moon by loading the moonorbittest data

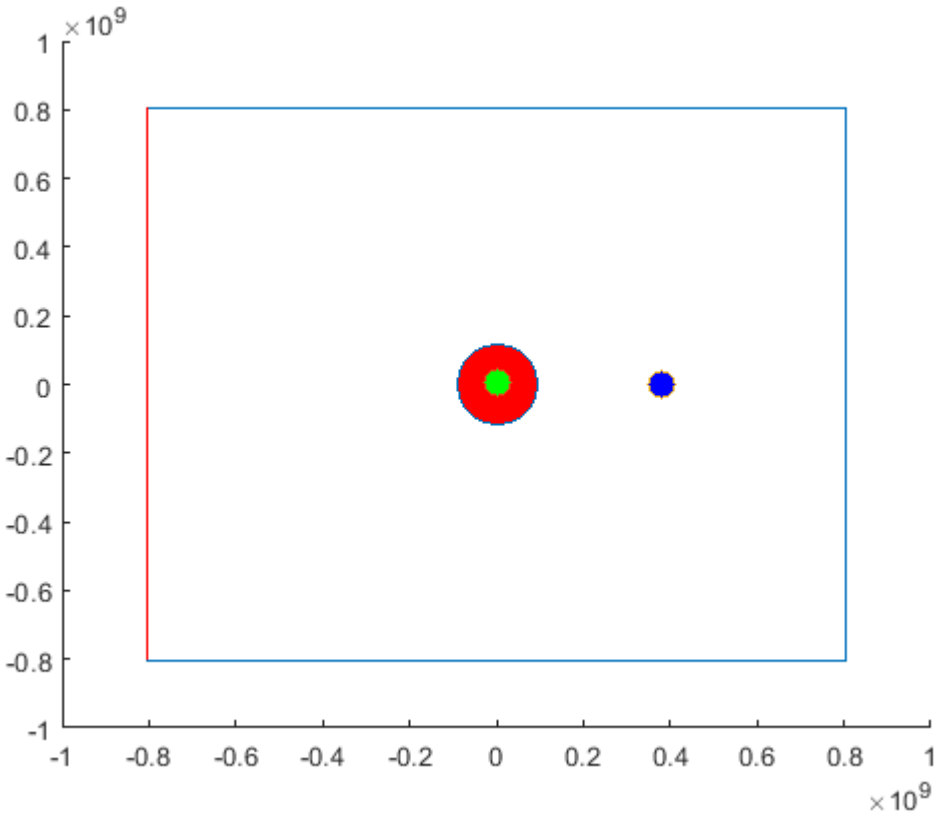
In the case studies file use the code analyzer - and

Run the reports and study the TODO/FIXME reports

```
pwd %need to be in the casestudies/mission-moon/code
```

```
ans =
'C:\Users\mike\proj\matlab-cic6007-2018\matlab_examples\casestudies\mission-moon\code'
```

```
initrocket2themoon
```




```
%change the time step dt to 10
dt=10

% startrocketgraphics %enter this command from the matlab workbench
%playrocket2themoon
```

Moon orbit test

```
load moonorbittest.mat

% startrocketgraphics %enter this command from the workbench
% playrocket2the moon
```

Exercise 2

Add a functions to compute

1. gravaccel, components of the acceleration due to gravity and call these from playrocket2themoon
2. dist, distance between two objects e.g. earth-moon, moon-rocket etc...
3. Adapt code so that moon moves under gravity

Exercise 3: Add data structures

Exercise 4: Add Tests

Further work will add a simple user interface

Exercise

Suppose that two different methods are used to read in vectors `pA` and `pB`. You can see that the vectors look identical, but how would you check for equality?

```
pA = [51.6461 78.1961 0.0004 72.7758 29.4412 15.5017 ]
```

```
pA =
   51.6461   78.1961    0.0004   72.7758   29.4412   15.5017
```

```
pB = [51.6461 78.1961 0.0004 72.7758 29.4412 15.5017 ]
```

```
pB =
   51.6461   78.1961    0.0004   72.7758   29.4412   15.5017
```

Create a variable named `check` which compares whether or not `pA` is equal to `pB` by using the `isequal` function.

```
%%TODO
check = isequal(pA,pB)
```

```
check = logical
   1
```

You have determined that the vectors are not equal, but which element, in particular, is the problem? Use the == operator to determine this.

This time, create a variable named `test` which compares each element of `pA` with each element of `pB`.

```
test=(pA==pB)
```

```
test = 1×6 logical array
   1   1   1   1   1   1
```

Exercise: Assert Functions

Write an `assert` statement that passes when the difference of distance between the earth and moon and the constant dem (`const.dem`) is less than the tolerance value of

tol=50.2e6m

https://en.wikipedia.org/wiki/Lunar_distance_(astronomy)

```
addpath('../matlab_examples/casestudies/mission-moon/code-005-tests/')
load('moonorbittest.mat')
tol=50.2e6
```

```
tol = 50200000
```

```
const.dem
```

```
ans = 381500000
```

```
simdem=dist(state.xe,state.ye,state.xm,state.ym)
```

```
simdem = 3.8150e+08
```

```
%%TODO
assert(abs(simdem-const.dem) < 50)
```

Write an `assert` statement that passes when `const.dem` is equal to `dem`.

```
%%TODO
%assert(isequal(simdem,const.dem))
```

Simple Test

Create a variable `x` containing the value `3`.

```
test=[4 3 2 3 8]
```

```
test =
     4     3     2     3     8
```

```
expect=[16  9  4  9 64];
f =@(x)(x-1).^2+5
```

```
f = function_handle with value:
    @(x)(x-1).^2+5
```

```
%TODO
x = 3;
```

Create a variable `xLoc` that uses == to perform an elementwise comparison between `x` and `test`.

```
%TODO
xLoc = x == test
```

```
xLoc = 1×5 logical array
   0   1   0   1   0
```

Create the variable `xTest` which contains a value of `true`if `f(x)` is equal to `9` and `false` otherwise.

```
%TODO
xTest = isequal(f(x),9)
```

```
xTest = logical
   1
```

Use `assert` to test if `f(test)` is equal to `expect`.

```
%assert(isequal(f(test),expect))
```

```
Assertion failed.
```

Create a script that does the following:

- Create a variable named `x` containing a vector of 100 values between 0 and π.
- Create a variable named `y` that contains the square roots of all the values in `x`.
- Use `assert` to test the behavior of the `sqrt` function to determine if the output given in `y` is real.

```
%TODO script here
%% Test 1
% Create variable x
x = linspace(0,pi);

% Create y
y = sqrt(x);

% Test if result is real valued
assert(isreal(y))
```

Info: When this script is run, it should produce an error since the square root of a negative number is not a real value.

Modify the script so that `x` contains a vector of 100 values between -π and π.

```
%%TODO script here
%% Test 1
% Create variable x
x = linspace(-pi,pi);

% Create y
y = sqrt(x);

% Test if result is real valued
assert(isreal(y))
```

Exercise Practice running unit tests using run tests

Task 1

Run the section of code below.

Next put the code in a script name runroottest.m and run using the command

It will be necessary to fix the test below which is incomplete you may notice that after running the open script, one of the tests is incomplete. Fix the script runroottest so that all the tests run to completion.

```
%% Positive roots are real
x = linspace(0,pi);
y = sqrt(x);
assert(isreal(y))

%% Negative roots are complex
z = linspace(-pi,pi);
y = sqrt(z);
assert(~isreal(y))

%% Sqrt(x) is smaller than x (if x > 1)
%TODO the line below is the missing line
x = linspace(0,pi);  %each section has its own workspace
y = x + 2;
z = sqrt(y);
assert(all(y > z))
```

Task 2

Add the code below to a file called `squareRootTestError`

Run the script `squareRootTestError` from the command line. An error is generated, but how much information do you get from the error message? And are the tests after where the error is generated run?

```
%% Positive roots are real
x = linspace(0,pi);
y = sqrt(x);
assert(isreal(y))

%% Negative roots are complex
z = linspace(-pi,pi);
y = sqrt(z);
assert(~isreal(y))

%% Law of universal linearity
x = linspace(0,pi);
y = linspace(1,42);
z1 = sqrt(x + y);
```

```
z2 = sqrt(x) + sqrt(y);
assert(isequal(z1,z2)) % <-- bad test!

%% Sqrt(x) is smaller than x (if x > 1)
x = linspace(0,pi);
y = x + 2;
z = sqrt(y);
assert(all(y > z))
```

Info: You may have noticed that the script stops execution once it encounters an error.

This time,run the script `squareRootTestError` so that all the tests are run and save the results in a variable with the name `srt`.

solution: Run as

```
srt = runtests('squareRootTestError')
```

Task 3

Add a test to the readconfigtest.m and test that the gravaccel function returns the correct values.

Use the script below as a guide.

Re run the completed test using the runtests command

```
%% Test gx and gy components of gravitational acceleration for  rocket in moon orbit test
load('../moonorbittest.mat')

r2=((state.x-state.xm).^2+(state.y-state.ym).^2);
r=sqrt(r2);
g=const.G*const.mm/r2;

gxtest=g*(state.x-state.xm)/r;
gytest=g*(state.y-state.ym)/r;

%TODO add call to gravaccel to compute gx and gy
[gx,gy]=gravaccel(state.x,state.xm,state.y,state.ym,const.mm);

tol=eps;
%TODO add assert calls to test the values of gx gy
% hint use a tolerance value with lt
assert(lt(    abs(gxtest-gx),tol))
assert(lt(    abs(gytest-gy),tol))
```

Exercise: Write a test Function

Modify the code below so that it is a function test in a file called `squareRootTestFuntion` file so that it is in the form of a test **function**.

```
% TODO:  Convert this test script into a function test.
```

```
%% Positive roots are real
x = linspace(0,pi);
y = sqrt(x);
assert(isreal(y))
%% Negative roots are complex
z = linspace(-pi,pi);
y = sqrt(z);
assert(~isreal(y))
%% Sqrt(x) is smaller than x (if x > 1)
x = linspace(0,pi);
y = x + 2;
z = sqrt(y);
assert(all(y > z))
```

As you might expect, the `sqrt` function throws an error when called with a string as the input.

Call the `sqrt` function with a string to produce an error.

```
sqrt('hello')
```

Use the `verifyError` function to complete this task.

Add another test to the `squareRootTestFunction` file. This test should call the `sqrt` function with a string input and verify that the error thrown has an error identifier equal to `'MATLAB:UndefinedFunction'`.

```
function test = squareRootTestFunction
test = functiontests(localfunctions);
end

function testPositiveRootsAreReal(testcase)
x = linspace(0,pi);
y = sqrt(x);
verifyTrue(testcase,isreal(y))
end

function testNegativeRootsAreComplex(testcase)
z = linspace(-pi,pi);
y = sqrt(z);
verifyFalse(testcase,isreal(y))
end

function testSqrtXIsSmallerThanX(testcase)
x = linspace(0,pi);
y = x + 2;
z = sqrt(y);
verifyGreaterThan(testcase,y,z)
end

function testStringInput(testcase)
verifyError(testcase,@() sqrt('hello'),'MATLAB:UndefinedFunction')
end
```