An Introduction to Function M-Files

David Arnold
College of the Redwoods

Abstract. In this activity readers will learn how to program rudimentary function M-files. An example of a function M-file is used in a call to Matlab's `quad` command, a numerical integration routine.
Prerequisites. Some introductiory knowledge of Matlab's vector structure, particularly Matlab's element wise operations on vectors such as `.*` and `.^`(See Matlab and vectors). Familiarity with saving files (See Graphing Polar Equations in Matlab). Readers should have experience with parametric equations and the arc length formula.

Introduction

Consider the parametric equations

$$x = 2\cos t$$
$$y = 3\sin t$$

over the time interval $0 \le t \le 2\pi$. To calculate the length of this path one employs the arc length formula.

$$L = \int_0^{2\pi} \sqrt{\left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2}\, dt$$
$$L = \int_0^{2\pi} \sqrt{(-2\sin t)^2 + (3\cos t)^2}\, dt$$
$$L = \int_0^{2\pi} \sqrt{4\sin^2 t + 9\cos^2 t}\, dt$$
$$L = \int_0^{2\pi} \sqrt{4(1-\cos^2 t) + 9\cos^2 t}\, dt$$
$$L = \int_0^{2\pi} \sqrt{4 + 5\cos^2 t}\, dt$$

Because this last integral has no closed-form solution, you need to invoke some numerical routine (such as the trapezoid or Simpson's rule) to obtain a decimal approximation for the integral. You are going to use Matlab's `quad` command to approximate the integral, but you must first write a function M-file to evaluate the integrand.

Writing the Function M-File

Open a new document in Matlab's Editor/Debugger by

- Clicking on the new document icon on Matlab's toolbar, or
- Selecting New M-file from the File menu.

Enter the following code in the document window.

```
function y=f(t)
y=sqrt(4+5*cos(t).^2);
```

This code bears some explaining.

- All function M-files must begin with the key word `function`.
  - The keyword `function` sets function M-files apart from ordinary script files. Script files

are just lines of code that you want executed in sequence. A function M-file expects input from the user and returns output.

- You must give your function a name. In this case, the function's name is `f`. If you wanted to name the function `fred`, then the first line of the function M-file would read as follows: `function y=fred(t)`.
- In the line `function y=f(t)`, the variable `t` represents the input to the function `f`; the variable `y` represents the output.
- Your function M-file must calculate each of its output variables before concluding.
  - The line `y=sqrt(4+5*cos(t).^2)` computes the output of the function `f`. Note that the output is *vectorized*, allowing the variable `t` to contain either a single number or a vector of values footnote . It is always wise to vectorize your code in this manner.

Save the file in your home directory (on the H: drive, if working on the school network footnote) with the name `f.m`. You must always save the function M-file with the name given the function in the first line of code. Thus, if the first line of your function M-file were `function y=fred(t)`, you would be required to save the files as `fred.m`.

Test the function with the following command.

```
>> f(pi)

ans =

     3
```

Note that the function M-file behaves very much like ordinary function notation. If you did not receive 3 for your output, there could be a number of reasons.

- You could have an error in your function M-file.
  - Repair the error and save the result.
  - Return to Matlab and type `clear f` at the prompt to clear the old function from memory.
  - Enter `f(pi)` again.
- If you are working at school, make sure the current directory is your home directory.
  - Type `pwd` at the Matlab prompt to test the "present working directory." If the present working directory is not the H: drive, enter `cd H:` at the Matlab prompt to change to the H: drive.
- If you are working at home, use the Path Browser tool to make the directory in which you saved the file `f.m` the current directory.

Using the Quad Command

Type `help quad` at the Matlab prompt to get a complete description of the use of this command. In this example, use will use the `quad` command in its simplest form, `quad('f',a,b)`, where

- `'f'` is a string (strings in Matlab are delimited with `' '`)containing the name of the function M-file written for the integrand.
- `a` and `b` are the lower and upper bounds of the integral, respectively.

Therefore, all that is left to do is enter the following command at the Matlab prompt.

```
>> quad('f',0,2*pi)

ans =
```

```
15.8654
```

Thus,

$$L = \int_0^{2\pi} \sqrt{4 + 5\cos^2 t}\, dt$$
$$L \approx 15.8654$$

Homework

1. Consider the path defined parametrically by the equations
$$x = t^2$$
$$x = t^3$$
on the time interval $0 \leq t \leq 1$.
   a. Set up the integral defining the length of the path over the indicated time interval.
   b. Write a function M-file for the integrand developed in part (a). Remember to vectorize your code with appropriate use of symbols such as `.*` and `.^`. Obtain a printout of this file.
   c. Use Matlab's `quad` command to approximate the integral developed in part (a). Use the Print Selection option to obtain a printout of this call to the `quad` command.