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Term Project

Overview:

For our numerical methods project in MATLAB, we plan to implement a range of methods for solving various mathematical problems. we will begin by choosing the methods we want to implement and writing the code for each one. Once we have implemented and tested all the methods, we will create a main menu system that allows the user to select the method they want to use. By doing this, we will ensure that the methods are combined into a single menu for ease of access. Depending on the user's selection, the appropriate numerical method will be called and the results will be displayed. Finally, we will include examples to showcase the results.

We also included a description of each function. By doing so, the user can use the "help" command in MATLAB to read about each function's inputs, outputs, and algorithm. This will make it easier for the user to understand how to use each function and how it works. We believe that providing a detailed description of each function will make our project more user-friendly and informative, as well as help the user develop a better understanding of numerical methods in general. Overall, we hope that this project will be an effective tool for those seeking to learn and use numerical methods in MATLAB.

```
close all; clear all; clc;
main_menu()
```

```
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0. Exit
choice = 1
Please Enter The following:
func = function_handle with value:
    @(x)x^10-1
xl = 0
xu = 1.3000
es = 1.0000e-04
maxit = 50
Output:
root = 1.0000
fx = -5.2452e-06
ea = 6.1989e-05
iter = 21
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  28. Display Example Code of Using polyfit() and polyval() to fit polynomial to data and evaluate it
0. Exit
choice = 2
Please Enter The following:
func = function_handle with value:
    @(x)x^10-1
xl = 0
xu = 1.3000
es = 1.0000e-04
maxit = 50
Output:
root = 1.0000
fx = -1.6447e-04
ea = 5.0424e-04
iter = 50
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0. Exit
choice = 3
Please Enter The following:
func = function_handle with value:
    @(x)x^10-1
xr = 0.5000
es = 1.0000e-04
maxit = 50
Output:
```

```
root = 0
ea = 100
iter = 50
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0. Exit
choice = 4
Please Enter The following:
func = function_handle with value:
    @(x)exp(-x)-x
dfunc = function_handle with value:
    @(x)-exp(-x)-1
xr = 0.5000
es = 1.0000e-04
maxit = 50
Output:
root = 0.5671
ea = 2.2106e-05
iter = 3
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0. Exit
choice = 5
Please Enter The following:
func = function_handle with value:
    @(x)exp(-x)-x
xrold = 0.3000
xr = 0.5000
es = 1.0000e-04
maxit = 50
Output:
root = 0.5671
ea = 4.5510e-06
iter = 4
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0. Exit
choice = 6
Please Enter The following:
A = 3×3
     0     2     5
     2     1     1
     3     1     0
b = 3×1
     1
     1
     2
The solution of the linear system is:
x = 3×1
   -2.0000
    8.0000
   -3.0000
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0. Exit
choice = 7
Please Enter The following:
A = 3×3
    3.0000   -0.1000   -0.2000
    0.1000    7.0000   -0.3000
    0.3000   -0.2000   10.0000
b = 3×1
    7.8500
  -19.3000
   71.4000
The solution of the linear system is:
x = 3×1
    3.0000
   -2.5000
    7.0000
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0. Exit
choice = 8
Please Enter The following:
A = 3×3
    -1     3     5
    -2     4    -5
     0     2    -1
b = 3×1
     7
    -3
     1
The solution of the linear system is:
x = 3×1
     1
     1
     1
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0. Exit
choice = 9
```

```
Please Enter The following:
A = 3×3
    3.0000   -0.1000   -0.2000
    0.1000    7.0000   -0.3000
    0.3000   -0.2000   10.0000
b = 3×1
    7.8500
  -19.3000
   71.4000
L = 3×3
    1.0000         0         0
    0.0333    1.0000         0
    0.1000   -0.0271    1.0000
U = 3×3
    3.0000   -0.1000   -0.2000
         0    7.0033   -0.2933
         0         0   10.0120
The solution is:
    3.0000
   -2.5000
    7.0000

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0. Exit
choice = 10
```

```
Please Enter The following:
A = 3×3
    0.8000   -0.4000         0
   -0.4000    0.8000   -0.4000
         0   -0.4000    0.8000
b = 3×1
    41
    25
   105
es = 1.0000e-04
maxit = 50
The solution is:
x = 3×1
  173.7499
  244.9999
  253.7500
err = 5.1629e-05
iter = 22
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0. Exit
choice = 11
Please Enter The following:
x = 1×10
     0     2     4     6     9    11    12    15    17    19
y = 1×10
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     5     6     7     6     9     8     8    10    12    12
y_model = 
'ymodel = 4.8881+0.35915x'
Correlation Coefficient: 0.89288
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0. Exit
choice = 12
Please Enter The following:
x = 1×8
    10    20    30    40    50    60    70    80
y = 1×8
          25          70         380         550         610        1220⋯
The solution is:
   -1.2941    1.9842
y_model = 
'fmodel = 0.27414x\^1.9842'
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0. Exit
choice = 13
Please Enter The following:
x = 1×6
    0.4000    0.8000    1.2000    1.6000    2.0000    2.3000
y = 1×6
         800         985        1490        1950        2850        3600
The solution is:
y_model =
'549.8153*e^(0.81273)*x'
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0. Exit
choice = 14
Please Enter The following:
x = 1×7
         0    1.0000    2.5000    3.0000    4.5000    5.0000    6.0000
y = 1×7
    2.0000    5.4375    7.3516    7.5625    8.4453    9.1875   12.0000
xx = 3.5000
The interpolated y value is:
yint = 7.7422
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```

```
  26. Display Example Code of Using roots() to find Roots of Equations
  27. Display Example Code of Using tic-toc to get the average time for a method
  28. Display Example Code of Using polyfit() and polyval() to fit polynomial to data and evaluate it
0. Exit
choice = 15
Please Enter The following:
x = 4×1
    3.0000
    4.0000
    2.5000
    5.0000
y = 4×1
    7.0000
    3.0000
    6.5000
    1.0000
xx = 3.4000
The interpolated y value is:
yint = 5.8256
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0. Exit
choice = 16
Please Enter The following:
Define the data points:
x = 4×1
```

```
    2.5000
    3.0000
    4.0000
    5.0000
y = 4×1
    6.5000
    7.0000
    3.0000
    1.0000
Output:
s0 = 4×1
    6.5000
    7.0000
    3.0000
    1.0000
s1 = 3×1
    1.9565
   -0.9130
   -3.4783
s2 = 4×1
         0
   -5.7391
    2.2174
         0
s3 = 3×1
   -3.8261
    2.6522
   -0.7391
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0. Exit
choice = 17
Please Enter The following:
a = 4
b = 5.2000
n = 6
The approximation of above integral is: 2
Warning: fplot will not accept character vector or string inputs in a future release. Use fplot(@(x)log(x))
instead.
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0. Exit
choice = 18
Please Enter The following:
a = 0
b = 10
Warning: fplot will not accept character vector or string inputs in a future release. Use fplot(@(x)sin(x))
instead.
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0. Exit
choice = 19
Please Enter The following:
dydt = function_handle with value:
    @(t,y)y.*t.^3-1.5*y
Interval of independent variable
tspan = 1×2
     0     1
y0 = 1
h = 0.2500
The solution is:
t = 5×1
         0
    0.2500
    0.5000
    0.7500
    1.0000
y = 5×1
    1.0000
    0.6250
    0.3931
    0.2579
    0.1884
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0. Exit
choice = 20
Please Enter The following:
dydt = function_handle with value:
    @(t,y)y.*t.^3-1.5*y
Interval of independent variable
tspan = 1×2
     0     1
y0 = 1
h = 0.2500
es = 1.0000e-03
maxit = 50
The solution is:
t = 5×1
         0
    0.2500
    0.5000
    0.7500
    1.0000
y = 5×1
    1.0000
    0.6853
    0.4763
    0.3476
    0.2831
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0. Exit
choice = 21
Please Enter The following:
dydt = function_handle with value:
    @(t,y)y.*t.^3-1.5*y
Interval of independent variable
tspan = 1×2
     0     1
y0 = 1
h = 0.2500
The solution is:
t = 5×1
         0
    0.2500
    0.5000
    0.7500
    1.0000
y = 5×1
    1.0000
    0.6957
    0.4907
    0.3631
    0.2979
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  28. Display Example Code of Using polyfit() and polyval() to fit polynomial to data and evaluate it
0. Exit
choice = 22
Please Enter The following:
dydt = function_handle with value:
    @(t,y)y.*t.^3-1.5*y
Interval of independent variable
tspan = 1×2
     0     1
y0 = 1
h = 0.2500
The solution is:
t = 5×1
         0
    0.2500
    0.5000
    0.7500
    1.0000
y = 5×1
    1.0000
    0.6880
    0.4799
    0.3514
    0.2865
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0. Exit
choice = 23
Please Enter The following:
func = function_handle with value:
    @(x)sin(x)
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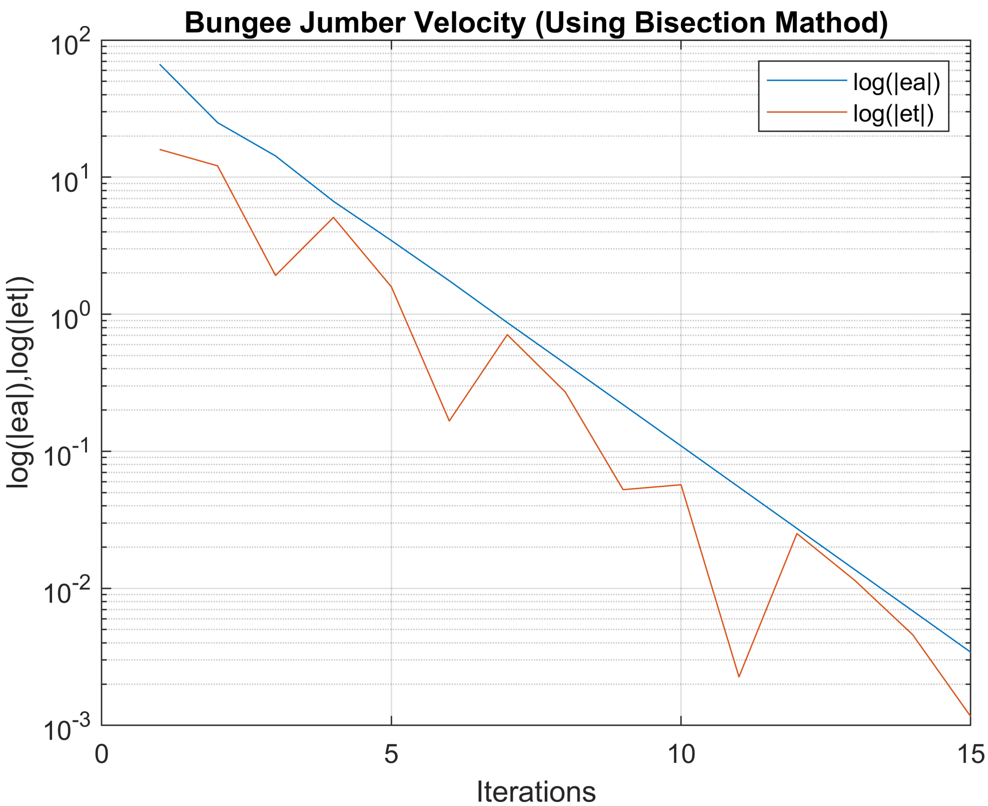
0. Exit
choice = 24
fm = @(m) sqrt(9.81*m/0.25)*tanh(sqrt(9.81*0.25/m)*4)-36;
for i=1:15, [mass(i) fx ea(i) iter(i)] = bisection_method(fm,40,200,1e-8,i); end
et = abs(mass-142.7376)/142.7376*100;
semilogy(iter,ea,iter,et);
```

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0. Exit
choice = 25
help fzero
fx = @(x) x.^4-6*x.^3+12*x.^2-10*x+3;
options = optimset('display', 'iter');
fzero(fx,0.5,options)

Search for an interval around 0.5 containing a sign change:
 Func-count    a          f(a)             b          f(b)        Procedure
    1             0.5        0.3125           0.5        0.3125   initial interval
    3        0.485858      0.341696      0.514142      0.285104   search
    5            0.48      0.354332          0.52      0.274268   search
    7        0.471716       0.37276      0.528284      0.259442   search
    9            0.46      0.399959          0.54      0.239447   search
   11        0.443431      0.440771      0.556569      0.213049   search
   13            0.42      0.503389          0.58      0.179293   search
   15        0.386863      0.602331      0.613137      0.138197   search
   17            0.34      0.764739          0.66     0.0919714   search
   19        0.273726       1.04441      0.726274     0.0466322   search
   21            0.18       1.55486          0.82     0.0127138   search
   23       0.0474517       2.55187      0.952548    0.00021876   search
   25           -0.14       4.65205          1.14   -0.00510384   search

Search for a zero in the interval [-0.14, 1.14]:
 Func-count    x          f(x)             Procedure
   25            1.14   -0.00510384        initial
   26          1.1386   -0.00495569        interpolation
   27         1.09172   -0.00147263        interpolation
   28         1.09172   -0.00147263        bisection
   29         1.08924   -0.00135791        interpolation
   30         1.05993  -0.000417626        interpolation
   31         1.05993  -0.000417626        bisection
   32         1.05563  -0.000334673        interpolation
   33         1.03846  -0.000111607        interpolation
   34         1.03846  -0.000111607        bisection
   35         1.03097  -5.84773e-05        interpolation
   36         1.02297  -2.39462e-05        interpolation
```

```
   37         1.02297  -2.39462e-05        bisection
   38         1.01163   -3.1273e-06        interpolation
   39         1.00998  -1.97629e-06        interpolation
   40          1.0072  -7.42997e-07        interpolation
   41          1.0072  -7.42997e-07        bisection
   42         1.00497     -2.45e-07        interpolation
   43         1.00391  -1.19698e-07        interpolation
   44         1.00293  -5.01862e-08        interpolation
   45         1.00293  -5.01862e-08        bisection
   46         1.00199  -1.57971e-08        interpolation
   47         1.00158  -7.84009e-09        interpolation
   48         1.00118  -3.26748e-09        interpolation
   49         1.00118  -3.26748e-09        bisection
   50          1.0008  -1.01845e-09        interpolation
   51         1.00063  -5.07131e-10        interpolation
   52         1.00047  -2.11092e-10        interpolation
   53         1.00047  -2.11092e-10        bisection
   54         1.00032  -6.57572e-11        interpolation
   55         1.00025  -3.27525e-11        interpolation
   56         1.00019  -1.36291e-11        interpolation
   57         1.00019  -1.36291e-11        bisection
   58         1.00013  -4.24727e-12        interpolation
   59          1.0001  -2.11919e-12        interpolation
   60         1.00008   -8.7752e-13        interpolation
   61         1.00008   -8.7752e-13        bisection
   62         1.00005  -2.75335e-13        interpolation
   63         1.00004  -1.35891e-13        interpolation
   64         1.00003  -5.59552e-14        interpolation
   65         1.00003  -5.59552e-14        bisection
   66         1.00002  -1.77636e-14        interpolation
   67         1.00002  -8.88178e-15        interpolation
   68         1.00001  -4.44089e-15        interpolation
   69         1.00001  -4.44089e-15        bisection
   70         1.00001  -1.77636e-15        interpolation
   71               1   1.77636e-15        interpolation
   72         1.00001  -1.77636e-15        bisection
   73         1.00001  -8.88178e-16        bisection
   74               1  -1.77636e-15        bisection
   75               1             0        bisection

Zero found in the interval [-0.14, 1.14]
ans = 1.0000
fzero(fx,0.5)
ans = 1.0000
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  24. Display Example Code of Plotting (iteration vs. log(|ea|) and log(|et|)) for Bisection Method
  25. Display Example Code of Using fzero() to find Roots of Equations
  26. Display Example Code of Using roots() to find Roots of Equations
  27. Display Example Code of Using tic-toc to get the average time for a method
  28. Display Example Code of Using polyfit() and polyval() to fit polynomial to data and evaluate it
0. Exit
choice = 26
help roots
f(x)=x^3-5x^2+7x-3
roots([1,-5,7,-3])
ans = 3×1 complex
   3.0000 + 0.0000i
   1.0000 + 0.0000i
   1.0000 - 0.0000i
f(x)=x^10-1
roots([1,0,0,0,0,0,0,0,0,-1])
ans = 9×1 complex
  -0.9397 + 0.3420i
  -0.9397 - 0.3420i
  -0.5000 + 0.8660i
  -0.5000 - 0.8660i
   0.1736 + 0.9848i
   0.1736 - 0.9848i
   1.0000 + 0.0000i
   0.7660 + 0.6428i
   0.7660 - 0.6428i
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0. Exit
choice = 27
help tic
help toc
To get the average time for a method, you can use tic/toc to time many repetitions of
the same method and then divide the elapsed time by the repetitions (50,000 for example)
The following problem is solved using GaussPivot() and its timing in micoseconds is reported,
then using GaussSeidel() with default tolerance, and its timing in micoseconds is reported.
And, finally the same is done with left division.
A = [4  1 -1  0  0   0  0  0;
     1  6 -2  1 -1   0  0  0;
     0  1  5  0 -1   1  0  0;
     0  2  0  6 -1   0 -1 -1;
     0  0 -1 -1  6  -1  0 -1;
     0  0 -1  0 -1   5  0  0;
     0  0  0 -1  0   0  4 -1;
     0  0  0 -1 -1   0 -1  5];
b = [3 -6 -5  0 12 -12 -2  2]';
Repetitions = 50000;
tic;
for i = 1:Repetitions, x = gauss_pivot(A,b); end
t1 = toc;
Average time by gauss_pivot (in micro seconds) = t1/Repetitions*1000000 = 105.890538
tic;
for i = 1:Repetitions, x = gauss_seidel_method(A,b); end
t1 = toc;
Average time by gauss_seidel_method (in micro seconds) = t1/Repetitions*1000000 = 37.238898
tic;
for i = 1:Repetitions, x = A\b; end
t1 = toc;
Average time by Left Division (in micro seconds) = t1/Repetitions*1000000 = 5.565770
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0. Exit
choice = 28
help polyfit
help polyval
x = [1 2 3 4 5 6 7];
y = [0.5 2.5 2 4 3.5 6 5.5];
p = polyfit(x,y,1);
polyfit model = 0.071429+0.83929x
y(3.5) = polyval(p,3.5) = 3.0089
Exiting the program.
Thank You!
```