
```
%Roll number : AM25M807
%Name : NIRAJ KUMAR SINGH
%Assignment: Numerical Derivative Assignment 5 (Q1)
% -----
%Clear workspace and command window

clc;
clear all;
close all;

% Define symbolic variable and test function
syms t
test_func = exp(t) * cos(t);

% Create function handles for numerical evaluation
func_handle = matlabFunction(test_func);
derivative_exact = matlabFunction(diff(test_func, t));

% Define numerical differentiation schemes
diff_forward = @(func, point, step) (func(point + step) - func(point)) /
step;
diff_backward = @(func, point, step) (func(point) - func(point - step)) /
step;
diff_centered = @(func, point, step) (func(point + step) - func(point -
step)) / (2 * step);

% Store methods in cell array with corresponding names
numerical_methods = {diff_forward, diff_backward, diff_centered};
scheme_labels = ["Forward Difference", "Backward Difference", "Central
Difference"];

% Analysis function for each differentiation method
function [] = AnalyzeMethod(label, diff_scheme, target_func, exact_deriv,
eval_point, initial_step)
    step_sizes = [];
    error_values = [];

    fprintf("\n\n===== %s Analysis =====\n\n", label)

    error_threshold = 1e-6;
    iteration = 0;
    current_error = inf;
    current_step = initial_step;

    while (current_error > error_threshold) || iteration == 0
        % Calculate numerical derivative
        numerical_result = diff_scheme(target_func, eval_point, current_step);
        exact_result = exact_deriv(eval_point);

        % Compute relative error
        current_error = abs((numerical_result - exact_result) / exact_result);
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    % Store data for plotting
    step_sizes = [step_sizes, current_step];
    error_values = [error_values, current_error];

    % Update step size and iteration counter
    current_step = current_step / 1.5;
    iteration = iteration + 1;

    fprintf("%d | %.8f | %.8f | error = %.2e\n", iteration,
numerical_result, exact_result, current_error);
end

    % Create error plot
    plot(error_values, step_sizes)
    xlabel('Step Size (h)');
    ylabel('Relative Error');
    title(sprintf('Convergence Analysis: %s', label));
    legend show;
    grid on;
    hold on;
end

% Set evaluation parameters
evaluation_point = 1.5;
starting_step = 1;

% Execute analysis for each method
for method_idx = 1:length(numerical_methods)
    AnalyzeMethod(scheme_labels{method_idx}, numerical_methods{method_idx},
    ...
                func_handle, derivative_exact, evaluation_point,
starting_step)
end

===== Forward Difference Analysis =====

1 | -10.07694940 | -4.15344024 | error = 1.43e+00
2 | -7.82410570 | -4.15344024 | error = 8.84e-01
3 | -6.45385426 | -4.15344024 | error = 5.54e-01
4 | -5.61831058 | -4.15344024 | error = 3.53e-01
5 | -5.09894233 | -4.15344024 | error = 2.28e-01
6 | -4.76989422 | -4.15344024 | error = 1.48e-01
7 | -4.55823568 | -4.15344024 | error = 9.75e-02
8 | -4.42056138 | -4.15344024 | error = 6.43e-02
9 | -4.33030308 | -4.15344024 | error = 4.26e-02
10 | -4.27080789 | -4.15344024 | error = 2.83e-02
11 | -4.23144507 | -4.15344024 | error = 1.88e-02
12 | -4.20533671 | -4.15344024 | error = 1.25e-02
13 | -4.18799046 | -4.15344024 | error = 8.32e-03
14 | -4.17645264 | -4.15344024 | error = 5.54e-03
15 | -4.16877248 | -4.15344024 | error = 3.69e-03

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16		-4.16365757		-4.15344024		error = 2.46e-03
17		-4.16024994		-4.15344024		error = 1.64e-03
18		-4.15797922		-4.15344024		error = 1.09e-03
19		-4.15646586		-4.15344024		error = 7.28e-04
20		-4.15545715		-4.15344024		error = 4.86e-04
21		-4.15478478		-4.15344024		error = 3.24e-04
22		-4.15433656		-4.15344024		error = 2.16e-04
23		-4.15403777		-4.15344024		error = 1.44e-04
24		-4.15383859		-4.15344024		error = 9.59e-05
25		-4.15370580		-4.15344024		error = 6.39e-05
26		-4.15361728		-4.15344024		error = 4.26e-05
27		-4.15355826		-4.15344024		error = 2.84e-05
28		-4.15351892		-4.15344024		error = 1.89e-05
29		-4.15349269		-4.15344024		error = 1.26e-05
30		-4.15347521		-4.15344024		error = 8.42e-06
31		-4.15346355		-4.15344024		error = 5.61e-06
32		-4.15345578		-4.15344024		error = 3.74e-06
33		-4.15345060		-4.15344024		error = 2.49e-06
34		-4.15344714		-4.15344024		error = 1.66e-06
35		-4.15344484		-4.15344024		error = 1.11e-06
36		-4.15344331		-4.15344024		error = 7.39e-07

===== Backward Difference Analysis =====

1		-1.12986689		-4.15344024		error = 7.28e-01
2		-1.84527333		-4.15344024		error = 5.56e-01
3		-2.47255622		-4.15344024		error = 4.05e-01
4		-2.96662578		-4.15344024		error = 2.86e-01
5		-3.33204914		-4.15344024		error = 1.98e-01
6		-3.59225110		-4.15344024		error = 1.35e-01
7		-3.77322754		-4.15344024		error = 9.15e-02
8		-3.89724882		-4.15344024		error = 6.17e-02
9		-3.98143585		-4.15344024		error = 4.14e-02
10		-4.03823206		-4.15344024		error = 2.77e-02
11		-4.07639520		-4.15344024		error = 1.85e-02
12		-4.10197034		-4.15344024		error = 1.24e-02
13		-4.11907961		-4.15344024		error = 8.27e-03
14		-4.13051209		-4.15344024		error = 5.52e-03
15		-4.13814545		-4.15344024		error = 3.68e-03
16		-4.14323955		-4.15344024		error = 2.46e-03
17		-4.14663793		-4.15344024		error = 1.64e-03
18		-4.14890454		-4.15344024		error = 1.09e-03
19		-4.15041607		-4.15344024		error = 7.28e-04
20		-4.15142397		-4.15344024		error = 4.85e-04
21		-4.15209598		-4.15344024		error = 3.24e-04
22		-4.15254404		-4.15344024		error = 2.16e-04
23		-4.15284275		-4.15344024		error = 1.44e-04
24		-4.15304191		-4.15344024		error = 9.59e-05
25		-4.15317468		-4.15344024		error = 6.39e-05
26		-4.15326320		-4.15344024		error = 4.26e-05
27		-4.15332221		-4.15344024		error = 2.84e-05
28		-4.15336155		-4.15344024		error = 1.89e-05
29		-4.15338778		-4.15344024		error = 1.26e-05

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30 | -4.15340526 | -4.15344024 | error = 8.42e-06
31 | -4.15341692 | -4.15344024 | error = 5.61e-06
32 | -4.15342469 | -4.15344024 | error = 3.74e-06
33 | -4.15342987 | -4.15344024 | error = 2.49e-06
34 | -4.15343333 | -4.15344024 | error = 1.66e-06
35 | -4.15343563 | -4.15344024 | error = 1.11e-06
36 | -4.15343717 | -4.15344024 | error = 7.39e-07

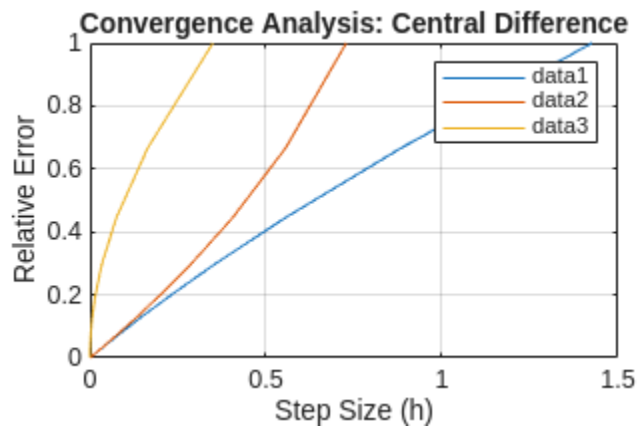
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===== Central Difference Analysis =====

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1 | -5.60340815 | -4.15344024 | error = 3.49e-01
2 | -4.83468952 | -4.15344024 | error = 1.64e-01
3 | -4.46320524 | -4.15344024 | error = 7.46e-02
4 | -4.29246818 | -4.15344024 | error = 3.35e-02
5 | -4.21549574 | -4.15344024 | error = 1.49e-02
6 | -4.18107266 | -4.15344024 | error = 6.65e-03
7 | -4.16573161 | -4.15344024 | error = 2.96e-03
8 | -4.15890510 | -4.15344024 | error = 1.32e-03
9 | -4.15586947 | -4.15344024 | error = 5.85e-04
10 | -4.15451997 | -4.15344024 | error = 2.60e-04
11 | -4.15392013 | -4.15344024 | error = 1.16e-04
12 | -4.15365353 | -4.15344024 | error = 5.14e-05
13 | -4.15353503 | -4.15344024 | error = 2.28e-05
14 | -4.15348237 | -4.15344024 | error = 1.01e-05
15 | -4.15345896 | -4.15344024 | error = 4.51e-06
16 | -4.15344856 | -4.15344024 | error = 2.00e-06
17 | -4.15344393 | -4.15344024 | error = 8.91e-07

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