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% ECE 403
% Assignment 5 Problem 2.10
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%NOTE: THE FUNCTIONS grad_desc, newton, and bfgs HAVE BEEN MODIFIED TO
%OUTPUT ALL THE x_k FOR ALL k IN THE ARRAY xs, WHERE THE LAST ELEMENT
%IS
%THE SOLUTION (IF ONE IS FOUND)
%THEY HAVE ALSO BEEN MODIFIED TO STOP ITERATING AFTER 2000 ITERATIONS
%(ARBITRARY). THIS IS TO PREVENT RUNAWAY TOWARDS AN ASYMPTOTIC
%MINIMUM. SEE
%THE NEW FUNCTIONSN ATTACHED.

clc;
clear all;
close all;
clc;
% convergence epsilon
eps = 1e-6;
% newton correction
dt = 0.1;

% initial points
x01 = [2 ; 3];
x02 = [-3 ; 3];
x03 = [2 ; -3];
x04 = [-3 ; -3];

% gradient descent
disp('Grad descent with x01 = [2 ; 3]:');
xs_gd_01 = grad_desc('beale','grad_beale',x01, eps);
disp('Grad descent with x02 = [-3 ; 3]:');
xs_gd_02 = grad_desc('beale','grad_beale',x02, eps);
disp('Grad descent with x03 = [2 ; -3]:');
xs_gd_03 = grad_desc('beale','grad_beale',x03, eps);
disp('Grad descent with x04 = [-3 ; -3]:');
xs_gd_04 = grad_desc('beale','grad_beale',x04, eps);

disp('Newton with x01 = [2 ; 3]:');
xs_nt_01 = newton('beale','grad_beale','hess_beale',x01,dt,eps);
disp('Newton with x02 = [-3 ; 3]:');
xs_nt_02 = newton('beale','grad_beale','hess_beale',x02,dt,eps);
disp('Newton with x03 = [2 ; -3]:');
xs_nt_03 = newton('beale','grad_beale','hess_beale',x03,dt,eps);
disp('Newton with x04 = [-3 ; -3]:');
xs_nt_04 = newton('beale','grad_beale','hess_beale',x04,dt,eps);

disp('BFGS with x01 = [2 ; 3]:');
xs_bf_01 = bfgs('beale','grad_beale',x01,eps);
disp('BFGS with x02 = [-3 ; 3]:');
xs_bf_02 = bfgs('beale','grad_beale',x02,eps);
disp('BFGS with x03 = [2 ; -3]:');
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xs_bf_03 = bfgs('beale','grad_beale',x03,eps);
disp('BFGS with x04 = [-3 ; -3]:');
xs_bf_04 = bfgs('beale','grad_beale',x04,eps);

x1 = -5:0.01:5;
x2 = -5:0.01:5;
[X1,X2] = meshgrid(x1, x2);

for i=1:length(x1)
    for j=1:length(x2)
        Z(i,j) = log(beale([x1(i);x2(j)]));
    end
end

[xs,k] = grad_desc_path('beale','grad_beale',x04,eps);
ax = [-5 5 -5 5];

figure;
hold on;
contour(X1,X2,Z, 200);
plot(xs_gd_01(2, :), xs_gd_01(1, :), 'ro-');
plot(xs_gd_02(2, :), xs_gd_02(1, :), 'bo-');
plot(xs_gd_03(2, :), xs_gd_03(1, :), 'go-');
plot(xs_gd_04(2, :), xs_gd_04(1, :), 'mo-');
axis(ax);
title('Gradient Descent paths');
hold off;

figure;
hold on;
contour(X1,X2,Z, 200);
plot(xs_nt_01(2, :), xs_nt_01(1, :), 'ro-');
plot(xs_nt_02(2, :), xs_nt_02(1, :), 'bo-');
plot(xs_nt_03(2, :), xs_nt_03(1, :), 'go-');
plot(xs_nt_04(2, :), xs_nt_04(1, :), 'mo-');
axis(ax);
title('Newton paths');
hold off;

figure;
hold on;
contour(X1,X2,Z, 200);
plot(xs_bf_01(2, :), xs_bf_01(1, :), 'ro-');
plot(xs_bf_02(2, :), xs_bf_02(1, :), 'bo-');
plot(xs_bf_03(2, :), xs_bf_03(1, :), 'go-');
plot(xs_bf_04(2, :), xs_bf_04(1, :), 'mo-');
axis(ax);
title('BFGS paths');
hold off;

Grad descent with x01 = [2 ; 3]:
solution:
ans =
    2.999941010052175

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    0.499985007040667
objective function at solution point:
fs =
    5.600913801643887e-10
number of iterations performed:
k =
    538
Grad descent with x02 = [-3 ; 3]:
solution:
ans =
    2.999943937009757
    0.499986265978194
objective function at solution point:
fs =
    5.037640197764979e-10
number of iterations performed:
k =
    493
Grad descent with x03 = [2 ; -3]:
solution:
ans =
    2.999947398762772
    0.499986633348818
objective function at solution point:
fs =
    4.453024880413070e-10
number of iterations performed:
k =
    546
Grad descent with x04 = [-3 ; -3]:
RUNAWAY condition occurred!!!
solution:
ans =
   -3.540198869053584
    1.228533079735133
objective function at solution point:
fs =
    0.836496378991295
number of iterations performed:
k =
    2000
Newton with x01 = [2 ; 3]:
solution:
ans =
    2.999999999999999
    0.500000000000000
objective function at solution point:
fs =
    4.437342591868191e-31
number of iterations performed:
k =
    949
Newton with x02 = [-3 ; 3]:
solution:

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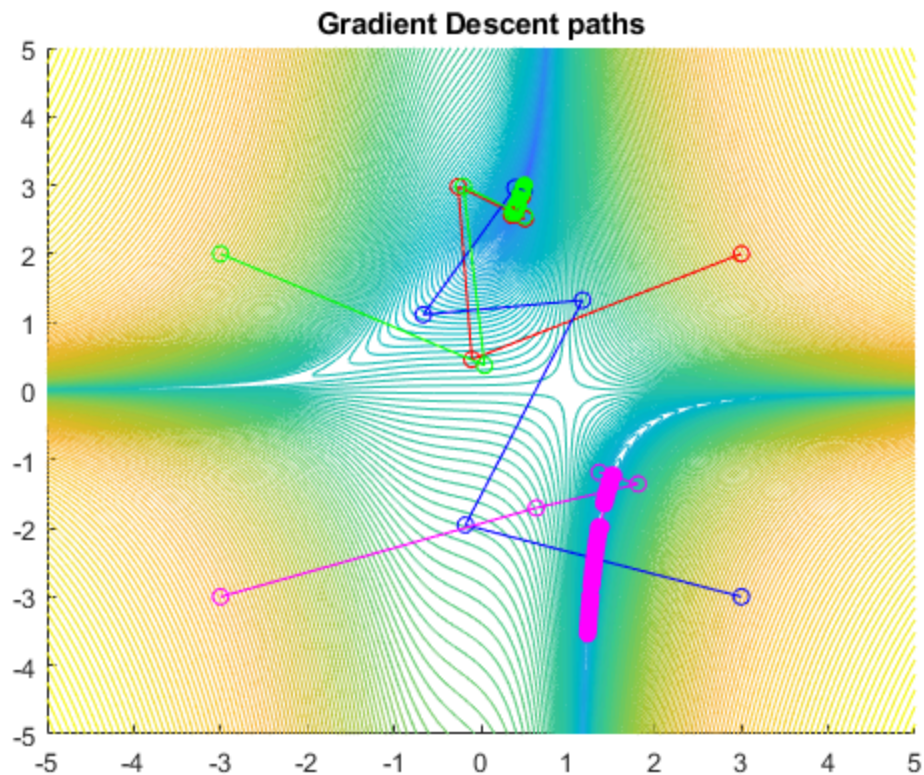
ans =
    3.0000000000000000
    0.5000000000000000
objective function at solution point:
fs =
    4.930380657631324e-32
number of iterations performed:
k =
    19
Newton with x03 = [2 ; -3]:
solution:
ans =
    3.0000000000000000
    0.5000000000000000
objective function at solution point:
fs =
    0
number of iterations performed:
k =
    56
Newton with x04 = [-3 ; -3]:
solution:
ans =
    1.0e+05 *
    -5.692835315482331
    0.000010000017409
objective function at solution point:
fs =
    0.452011609075703
number of iterations performed:
k =
    862
BFGS with x01 = [2 ; 3]:
solution:
ans =
    2.999999799612027
    0.499999965483414
objective function at solution point:
fs =
    1.173683308068150e-14
number of iterations at convergence:
k =
    20
BFGS with x02 = [-3 ; 3]:
solution:
ans =
    3.000000821875945
    0.500000203245752
objective function at solution point:
fs =
    1.081249449034571e-13
number of iterations at convergence:
k =
    25

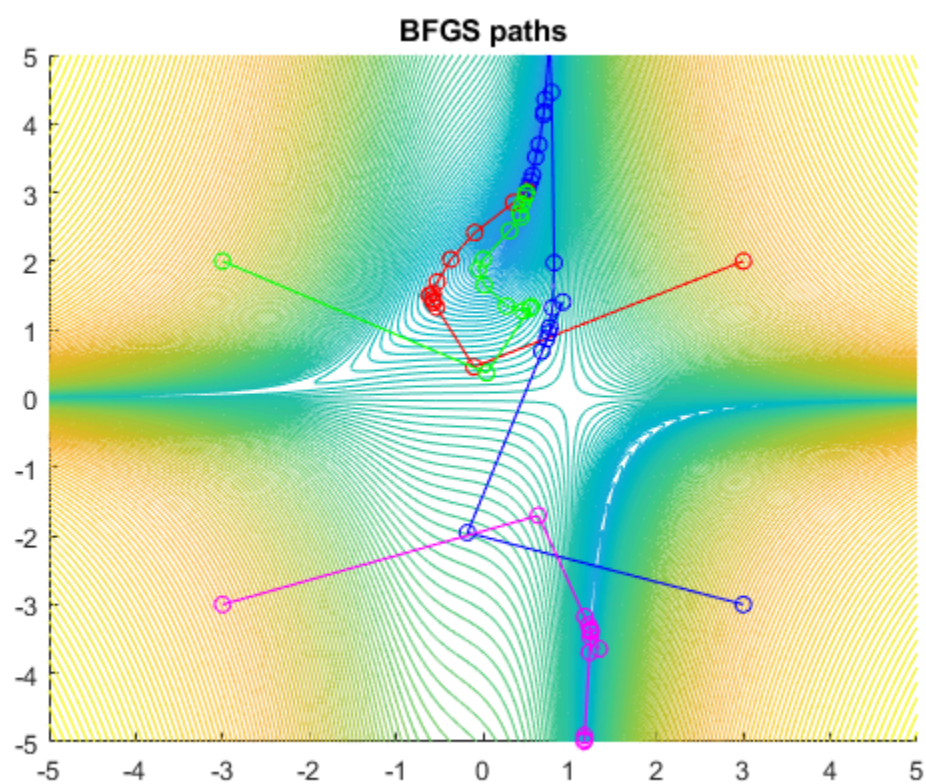
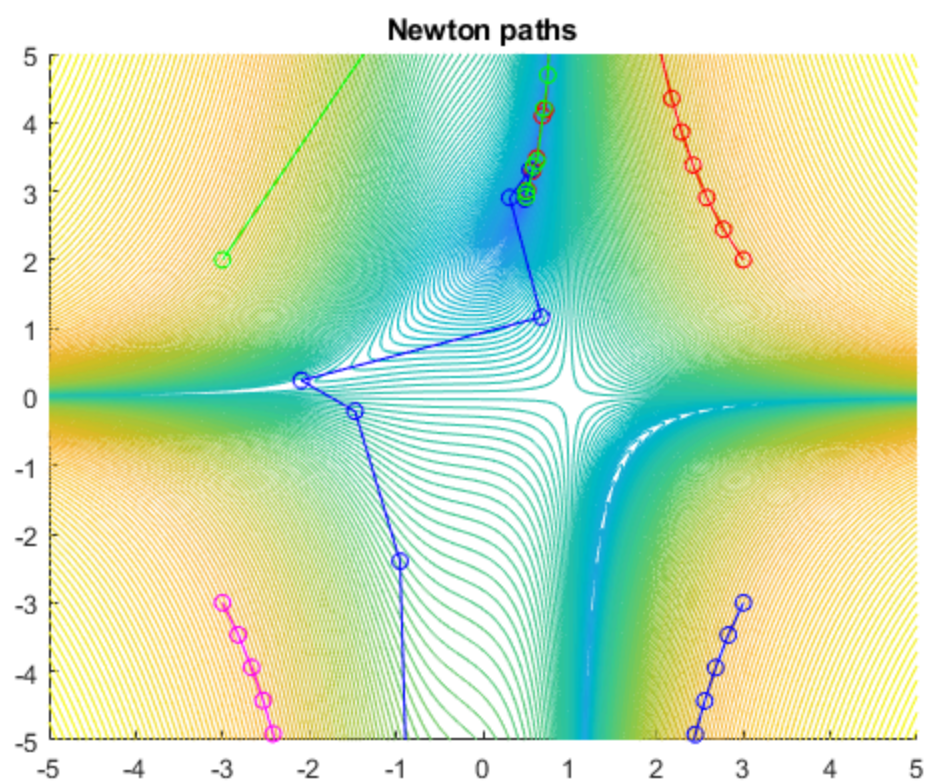
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BFGS with x03 = [2 ; -3]:
solution:
ans =
    2.999999841200989
    0.499999963018287
objective function at solution point:
fs =
    4.168596496909581e-15
number of iterations at convergence:
k =
    19
BFGS with x04 = [-3 ; -3]:
RUNAWAY condition occurred!!!
solution:
ans =
    1.0e+06 *
    -1.466967829759274
    0.0000010000000676
objective function at solution point:
fs =
    0.452009969158088
number of iterations at convergence:
k =
    2000
RUNAWAY condition occurred!!!

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