Contents

Homework Introduction

```
% Geneva Porter, 2019.10.10
% Homework 2, Math 693A
% Professor Uduak George, SDSU

% This assignment minimizes the Rosenbrock function:
%
%                f(x) = 100(x2-x1^2)^2 + (1-x1)^2
%
% The initial step length is alpha_0 = 1, and each step length used by each
% method is reported at each iteration. First, the initial point (1.2,1.2)
% is used, then the more difficult point (-1.2, 1) is used for each method.
% The suggested value of c is used, as shown below. Since we know that the
% minimum of the Rosenbrock function is at (0,0) from straightforward
% analysis, the iteration stops when the absolute value of f or the norm of
% the gradient is less than our tolerance, 10^(-8). Only the initial
% values, the first few iterations, and the last iteration are shown in the
% output. The function line_search2() contains the algorithm that produces
% these results, while armijo() and zoom() have supporting roles if
% checking conditions and interpolating, respectively. The same limits on
% the plots are used fro Homework 1, to make a more truthful visal
% comarison between the results.
```

Establishing Parameters

```
clear
clc

alpha       = 1.0;
c1          = 1e-4;
tolerance   = 1e-8;

param = [alpha, c1, tolerance];

p1          = [ 1.2; 1.2];
p2          = [-1.2; 1.0];
```

Setting Up Functions

```
x    = sym('x', [2,1]);
f(x) = 100*(x(2) - x(1)^2)^2 + (1 - x(1))^2;
```

```
NE = "Newton";
SD = "steepest descent";
```

Iterating Methods and Printing Results:

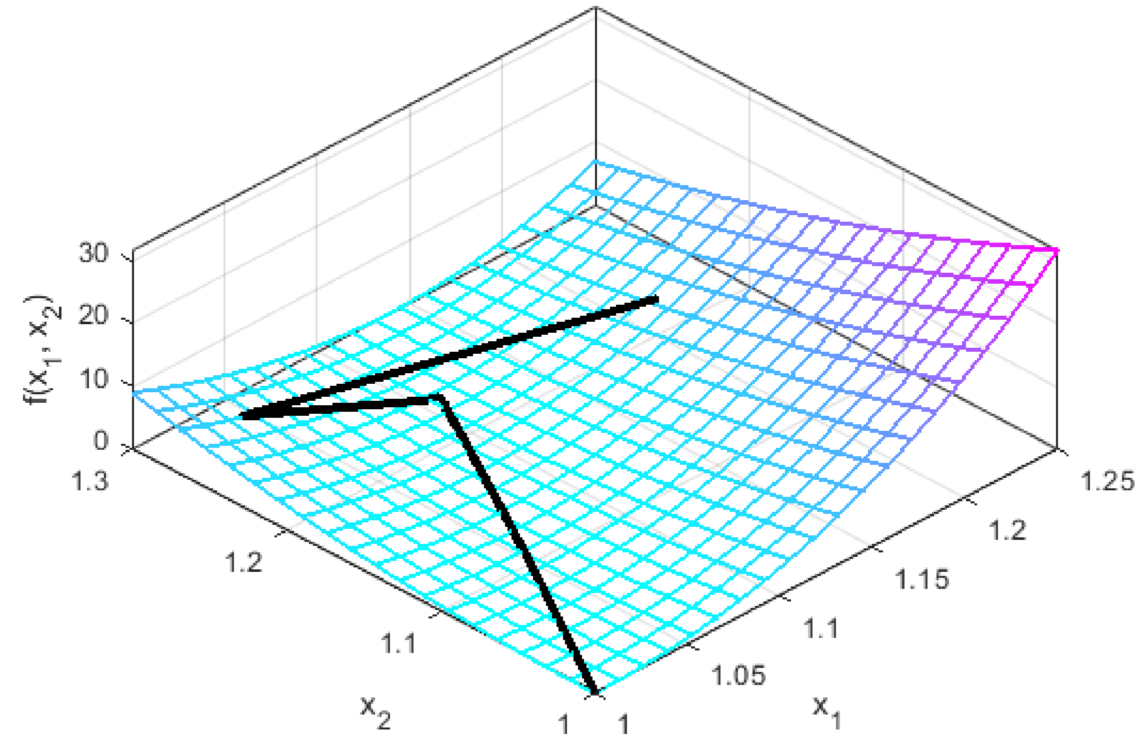
```
SD_point1 = line_search2(SD, f, p1, param);
figure(1)
plot_search(SD_point1, SD, f, [1 1.25 1 1.3]);

SD_point2 = line_search2(SD, f, p2, param);
figure(2)
plot_search(SD_point2, SD, f, [-1.5 1 0 1.5]);

newton_point1 = line_search2(NE, f, p1, param);
figure(3)
plot_search(newton_point1, NE, f, [1 1.3 1 1.5]);

newton_point2 = line_search2(NE, f, p2, param);
figure(4)
plot_search(newton_point2, NE, f, [-2 2 0 1.5]);
```

```
6627 iterations using steepest descent method,
starting at point (1.2, 1.2):
  Columns 1 through 3

    'x_1'                  'x_2'                  'f(x_0)'
    [1.200000000000000]    [1.200000000000000]    [    5.800000000000000]
    [1.033436323075138]    [1.269161388342503]    [    4.048085233966373]
    [1.103817575930140]    [1.235081932118467]    [    0.038562615658022]
    [1.107371729613175]    [1.233425256012042]    [    0.016645384392140]
    [1.109860336251211]    [1.232219908597111]    [    0.012087778546316]
    [1.107623575099180]    [1.225553196413348]    [    0.011745852600763]
    [1.106885755170250]    [1.225794458183938]    [    0.011460370901938]
    [1.106965519810849]    [1.225607886835325]    [    0.011447155498363]
    [1.106762273471622]    [1.225520785373598]    [    0.011433950062202]
    [1.106842189895229]    [1.225334224994542]    [    0.011420756866418]
    '...'                  '...'                  '...'
    [1.000099936023075]    [1.000200407399983]    [1.001480971702811e-08]

  Columns 4 through 6

    'p_k1'                  'p_k2'                  'alpha'
    [-0.923548958248274]    [ 0.383480536296861]    [    0.180351756598577]
    [ 0.900038827676451]    [-0.435809716131708]    [    0.078198018452936]
    [ 0.906371557532932]    [-0.422481478523410]    [    0.003921298780281]
    [ 0.899991457637111]    [-0.435907531685596]    [    0.002765144732117]
    [-0.318086018041949]    [-0.948061857225686]    [    0.007031937982688]
    [-0.950475762919470]    [ 0.310798687421055]    [7.762638014714978e-04]
    [ 0.393109285121972]    [-0.919491756325684]    [2.029070378601373e-04]
    [-0.919151763260955]    [-0.393903587308211]    [2.211238093105806e-04]
    [ 0.393761011673693]    [-0.919212851131722]    [2.029566697490118e-04]
    [-0.919593860001149]    [-0.392870376394285]    [2.211390105159159e-04]
    '...'                   '...'                   '...'
```

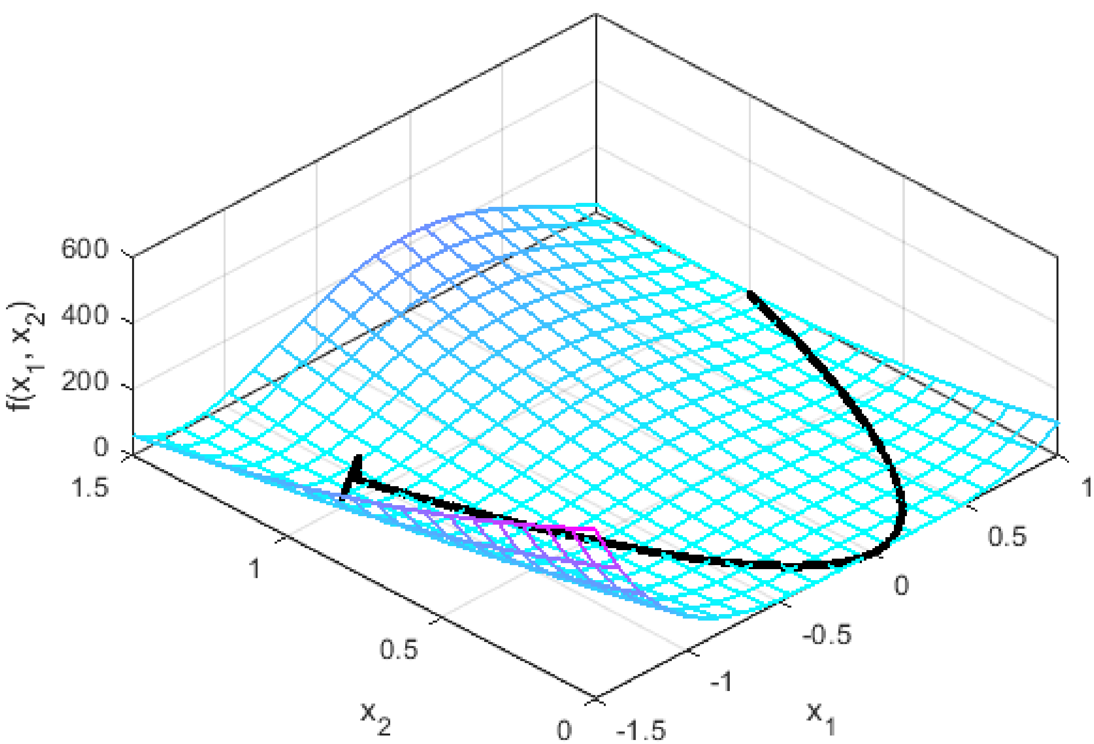
```
    [ 0.097517931168010]    [-0.995233768066936]    [3.745572530042390e-07]


6881 iterations using steepest descent method,
starting at point (-1.2, 1):
  Columns 1 through 3

    'x_1'                   'x_2'                   'f(x_0)'
    [-1.200000000000000]    [                 1]    [   24.199999999999996]
    [-0.916318512018655]    [1.115788362441365]    [   11.298089684996789]
    [-0.994944861015709]    [1.071196455859775]    [    4.640468010929330]
    [-1.018893827010255]    [1.057467810530828]    [    4.113270812541807]
    [-1.022771347118127]    [1.053562891613034]    [    4.097231417689490]
    [-1.013638267104267]    [1.039531165204547]    [    4.069304250535435]
    [-1.015274596282474]    [1.034970437105471]    [    4.063085575236064]
    [-1.010551734631548]    [1.033272513476861]    [    4.056857102881972]
    [-1.012171391369010]    [1.028692839466808]    [    4.050599316337403]
    [-1.007441725683817]    [1.026981894809291]    [    4.044325821453820]
    '...'                   '...'                   '...'
    [ 0.999900320108144]    [0.999799848708090]    [1.000031213358606e-08]

  Columns 4 through 6

    'p_k1'                  'p_k2'                  'alpha'
    [ 0.925847643695199]    [ 0.377896997426612]    [    0.306401911711012]
    [-0.869846671295194]    [-0.493322175091158]    [    0.090391044297473]
    [-0.867563176792082]    [-0.497326989288166]    [    0.027604866867564]
    [-0.704612978454513]    [-0.709591819705851]    [    0.005503049512906]
    [ 0.545511335573054]    [-0.838103443950270]    [    0.016742236903776]
    [-0.337708386619763]    [-0.941250787838542]    [    0.004845391003124]
    [ 0.941033792204609]    [-0.338312580210983]    [    0.005018801333225]
    [-0.333424361446613]    [-0.942776853340131]    [    0.004857643665972]
    [ 0.940362582962182]    [-0.340173797586900]    [    0.005029619181884]
    [-0.328664843798693]    [-0.944446621281891]    [    0.004872163096365]
    '...'                   '...'                   '...'
    [-0.603082816355400]    [ 0.797678579765584]    [2.437680288699989e-07]


6 iterations using Newton method,
starting at point (1.2, 1.2):
  Columns 1 through 3

    'x_1'                  'x_2'                  'f(x_0)'
    [1.200000000000000]    [1.200000000000000]    [    5.800000000000000]
    [1.195918367346939]    [1.430204081632653]    [    0.038384034418534]
    [1.155211833944910]    [1.332844172672881]    [    0.024369673077798]
    [1.038864772751658]    [1.065703377416048]    [    0.019834529150520]
    [1.028381541813993]    [1.057458697412834]    [8.067196756568187e-04]
    [1.000610399330343]    [1.000449934893181]    [5.985313884626810e-05]
    '...'                  '...'                  '...'
    [1.000610399330343]    [1.000449934893181]    [5.985313884626810e-05]

  Columns 4 through 6

    'p_k1'                      'p_k2'                      'alpha'
    [    -0.004081632653061]    [     0.230204081632653]    [                1]
    [    -0.195267745952617]    [    -0.467031908145227]    [0.208465218889279]
```

```
    [    -0.116347061193252]    [    -0.267140795256833]    [                  1]
    [    -0.010483230937665]    [    -0.008244680003214]    [                  1]
    [    -0.027771142483650]    [    -0.057008762519653]    [                  1]
    [-5.288289136091240e-04]    [-2.870670660005789e-04]    [                  1]
    '...'                       '...'                       '...'
    [-5.288289136091240e-04]    [-2.870670660005789e-04]    [                  1]


74 iterations using Newton method,
starting at point (-1.2, 1):
  Columns 1 through 3

    'x_1'                   'x_2'                   'f(x_0)'
    [-1.200000000000000]    [                 1]    [   24.199999999999996]
    [-1.175280898876405]    [1.380674157303371]    [    4.731884325266608]
    [-1.169506856532501]    [1.367103734083076]    [    4.706801288027877]
    [-1.163652474014490]    [1.353412209840210]    [    4.681437573320078]
    [-1.157715081337509]    [1.339596188397116]    [    4.655784501627521]
    [-1.151691866413390]    [1.325652111181518]    [    4.629832950916547]
    [-1.145579864546080]    [1.311576246141735]    [    4.603573324923889]
    [-1.139375946925083]    [1.297364675670632]    [    4.576995518494118]
    [-1.133076807999017]    [1.283013283427893]    [    4.550088879626142]
    [-1.126678951594787]    [1.268517739935414]    [    4.522842167841702]
    '...'                   '...'                   '...'
    [ 0.999375560425685]    [0.998718192552522]    [5.009351845592296e-07]

  Columns 4 through 6

    'p_k1'                     'p_k2'                   'alpha'
    [    0.024719101123595]    [ 0.380674157303371]    [                 1]
    [    1.938395770052881]    [-4.555708012051582]    [0.002978773702001]
    [    1.922451331208427]    [-4.495997473003121]    [0.003045269559220]
    [    1.906345261054518]    [-4.435971888263945]    [0.003114542154707]
    [    1.890072777551050]    [-4.375623497633452]    [0.003186763491681]
    [    1.873628862338257]    [-4.314944198883448]    [0.003262119830756]
    [    1.857008244228283]    [-4.253925525856300]    [0.003340813181783]
    [    1.840205381196065]    [-4.192558624713001]    [0.003423062985487]
    [    1.823214440697427]    [-4.130834228128959]    [0.003509108013527]
    [    1.806029278127930]    [-4.068742627230016]    [0.003599208520566]
    '...'                      '...'                    '...'
    [6.203060750052824e-04]    [ 0.001273155686318]    [                 1]
```

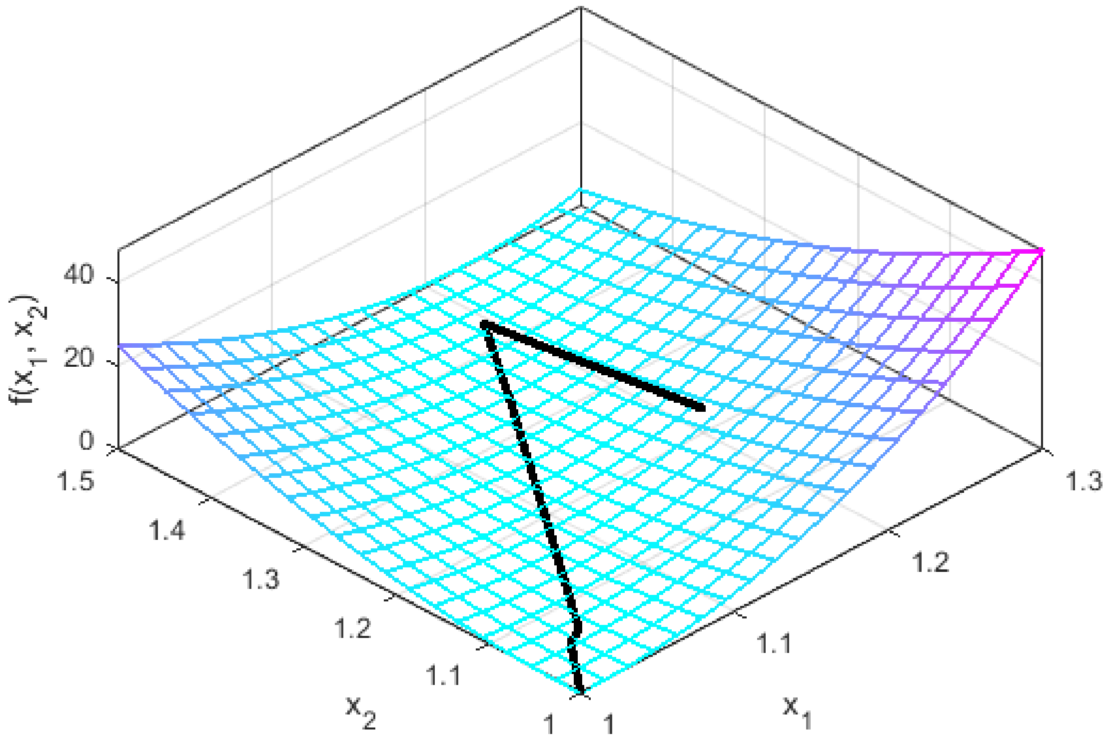
Backtracking line search using steepest descent method
for $f(x_1, x_2) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2$ starting at (1.2, 1.2)



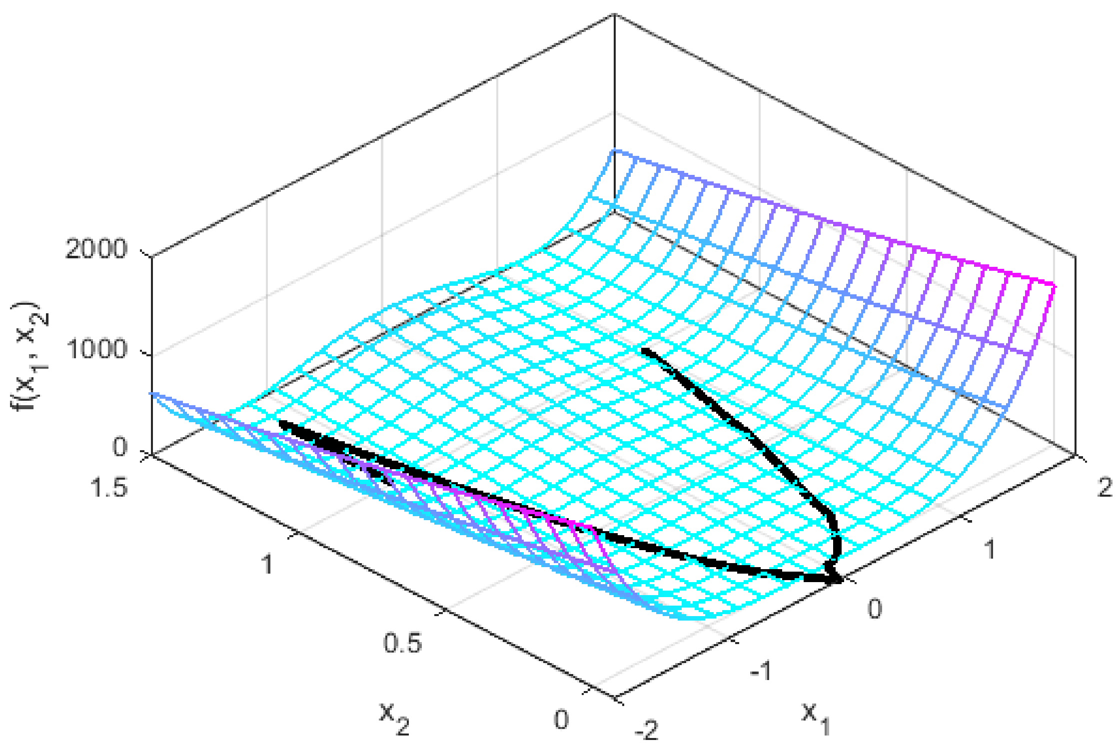
Backtracking line search using steepest descent method
for $f(x_1, x_2) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2$ starting at (-1.2, 1)



Backtracking line search using Newton method
for $f(x_1, x_2) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2$ starting at (1.2, 1.2)



Backtracking line search using Newton method
for $f(x_1, x_2) = 100(x_2 - x_1^2)^2 + (1 - x_1)^2$ starting at (-1.2, 1)



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