Contents

set 4, prob 6

```
clear; clc

z = 0;

% First guess
xg0_OG = 1.5 ;
xg0 = xg0_OG ;
```

GN method

```
% no step size adjustment
a_flag = 0;
[xg0_a0, Jg_a0] = GN(a_flag, xg0, z);

% step size adjustment
a_flag = 1;
[xg0_a1, Jg_a1] = GN(a_flag, xg0, z);

% original initial guess
xg0_OG

% solution to initial guess
xg0_a1(end)

% covariance
[~, ~, H, ~] = cost_fn(xg0_a1(end), z);
Pxx = inv(H' * H)

clear Jg
x = [-6 : 0.1 : 6];
for i = 1:length(x)
    Jg(i) = cost_fn( x(i), z);
end
```

```
xg0_OG =

                         1.5


ans =

     -1.49877953906259e-10
```

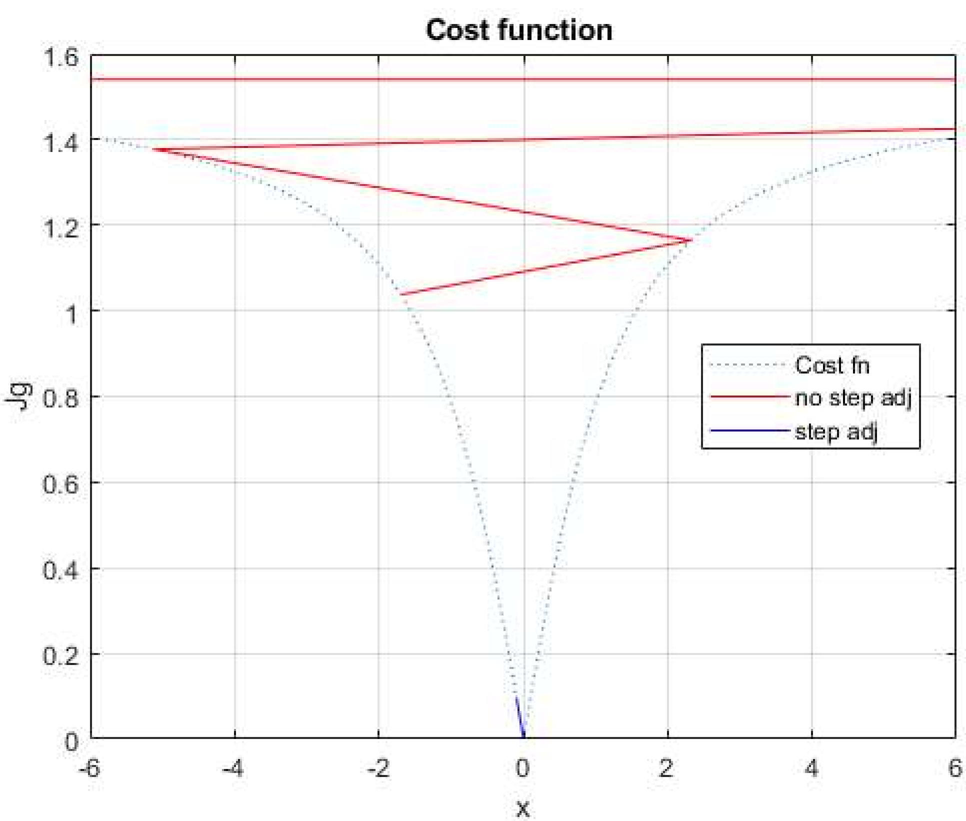
```
Pxx =

     1
```

cost function plot

The cost trajectory without step size adjustment begins to diverge immediately. The cost function (norm of the difference between the measurement, z, and the measurement model, h(x) = atan(x)) asymptotically reaches its max value after just 5 iterations. The step-size adjusted method achives the converged solution after just 3 iterations (of the outer loop). The crude step-size adjustment is sufficient to avoid divergence of the Gauss-Newton algorithm. To choose the step size adjustment more nearly optimally, one can take the derivative of the cost function with respect to a (the step size adjustment variable) and solve for a.

```
ftitle = 'Cost function ';
    figure('name', ftitle)
    plot(x, Jg, ':');
    hold on; grid on;
    plot(xg0_a0(1:5), Jg_a0(1:5), 'r');
    plot(xg0_a1, Jg_a1, 'b');
    legend('Cost fn', 'no step adj', 'step adj', 'location', 'best')
    xlim([-6 6])
    xlabel('x');
    ylabel('Jg');
    title(ftitle);
```



subfunctions

```
function h = h_NL(x)
% Nonlinear measurement h
```

```
    h = atan(x);

end

function H = H_NL(x)
% Full jacobian of h

%     H = (sec(x)).^2;
    H = 1 / (1 + x^2);

end

function [Jg, h, H, dx] = cost_fn(xg, z)

    % NL at guess
    h = h_NL(xg);

    % jacobian at guess
    H = H_NL(xg);

    % Cost function
    Jg = norm(z - h);

    % Gauss-Newton dx
    dx = inv((H' * H)) * H' * (z - h);

end

function [xg0_i, Jg_i] = GN(a_flag, xg0, z)
```

First cost function and step size-adjusted cost function

```
    % First NL, jacobian, and cost fn at guess
    [Jg, h, H, dx] = cost_fn(xg0, z);

    % first a step
    a = 1;

    % First new cost function
    xg = xg0 + a * dx;

    % First new NL, jacobian, and cost fn at guess
    [Jgnew, h, H, ~] = cost_fn(xg, z);
```

The while loop

```
    i_dx = 0;
    i_Jg = 0;
    Jg_i = [];
    xg0_i = [];

    % Outer loop: norm(dx) > e
    while norm(dx) > 0.000001

        if a_flag == 1

            % Inner loop: Jgnew >= Jg
```

```
            while Jgnew >= Jg

                % Next a
                a = a/2;
                if a < eps
                    break
                end

                % Adjust step size and update cost fn
                xg = xg0 + a * dx;
                [Jgnew, h, H, ~] = cost_fn(xg, z);

                % increase inner loop count
                i_Jg = i_Jg + 1;

            end
        end

        % Back to outer loop: norm(idx) > e
        if a < eps
            break
        end

        % Next guess point
        xg0 = xg;
        Jg = Jgnew;

        % Gauss-Newton dx (H, z, and h saved from last iteration)
        dx = inv((H' * H)) * H' * (z - h);

        % first a step
        a = 1;

        % Next step-size adjusted guess
        xg = xg0 + a * dx;

        [Jgnew, h, H, ~] = cost_fn(xg, z);

        % Increase outer loop count and populate Jg, xg0 trajectory
        i_dx = i_dx + 1;
        Jg_i = [Jg_i; Jg];
        xg0_i = [xg0_i; xg0];

    end
```

```
Warning: Matrix is singular to working precision.
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```

```
end
```