Contents

prob 5

```
clear;

syms x1 x2 x3 lmda
x = [x1; x2; x3];

% equations and performance index
f = 2*x1 + 2*x2^2 + 2*x2*x3 + 4*x3^2;
h = x1^2 + x2^2 + x3^2 - 1;
l_eq = f + lmda * h;

% partial derivatives
grad_l_eq = gradient(l_eq);
eq1 = grad_l_eq(1);
eq2 = grad_l_eq(2);
eq3 = grad_l_eq(3);
eq4 = grad_l_eq(4);

sol1 = solve(eq1, eq2, eq3, eq4);

% compute hessians
Hf = hessian(f);
Hh = hessian(h);
L = Hf + lmda * Hh;
L_fn = matlabFunction(L);

% find positive semidef L
for i = 1:numel(sol1.lmda)

    sprintf('Soln = %d. x1 = %.3g, x2 = %.3g, x3 = %.3g, lmda = %.3g', ...
        i, double(sol1.x1(i)), double(sol1.x2(i)), double(sol1.x3(i)), double(sol1.lmda(i)))

    lmda_dbl = double(sol1.lmda(i));
    L_dbl(:,:,i) = L_fn(lmda_dbl);
    eig_L = round(eig(L_dbl(:,:,i)), 8);

    % pos, semi, neg, or in-definite
    if all(eig_L >= 0)
        disp('Local min found!')
        sprintf('eigvals = [ %.3g, %.3g, %.3g ]', eig_L(1), eig_L(2), eig_L(3))

    elseif all(eig_L <= 0)
        sprintf('Soln %d negative semidefinite', i)
        sprintf('eigvals = [ %.3g, %.3g, %.3g ]', eig_L(1), eig_L(2), eig_L(3))

    elseif all(eig_L < 0)
        sprintf('Soln %d negative definite', i)
        sprintf('eigvals = [ %.3g, %.3g, %.3g ]', eig_L(1), eig_L(2), eig_L(3))

    else
```

```
        sprintf('Soln %d indefinite', i)
        sprintf('eigvals = [ %.3g, %.3g, %.3g ]', eig_L(1), eig_L(2), eig_L(3))

        % check on tangent space
        grad_h = gradient(h);

        % get zLz
        z = sym('z', [3 1]);
        zLz = z.' * L * z;
        zLz_fn = matlabFunction(zLz);
        zLz_soln = subs(zLz, lmda, sol1.lmda(i));

        % substitute nullspace constraint
        zLz_null_soln = subs(zLz_soln, z(3), -z(1)-z(2))

    end

end
```

```
ans =

    'Soln = 1. x1 = -1, x2 = 0, x3 = 0, lmda = 1'

Local min found!

ans =

    'eigvals = [ 2, 5.17, 10.8 ]'


ans =

    'Soln = 2. x1 = 1, x2 = 0, x3 = 0, lmda = -1'


ans =

    'Soln 2 indefinite'


ans =

    'eigvals = [ -2, 1.17, 6.83 ]'


zLz_null_soln =

(6*z1 + 4*z2)*(z1 + z2) - 2*z1*z2 - 2*z1^2


ans =

    'Soln = 3. x1 = 0.227, x2 = -0.373, x3 = -0.9, lmda = -4.41'


ans =
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```
    'Soln 3 negative semidefinite'


ans =

    'eigvals = [ -8.83, -5.66, 0 ]'


ans =

    'Soln = 4. x1 = 0.631, x2 = -0.717, x3 = 0.297, lmda = -1.59'


ans =

    'Soln 4 indefinite'


ans =

    'eigvals = [ -3.17, 0, 5.66 ]'


zLz_null_soln =

2*z1^2*(2^(1/2) - 3) - z2*(2*z1 + 2*z2 - z2*(2*2^(1/2) - 2)) - (2*z2 - (2*2^(1/2) + 2)*(z1 + z2))*(z1 + z2)


ans =

    'Soln = 5. x1 = 0.227, x2 = 0.373, x3 = 0.9, lmda = -4.41'


ans =

    'Soln 5 negative semidefinite'


ans =

    'eigvals = [ -8.83, -5.66, 0 ]'


ans =

    'Soln = 6. x1 = 0.631, x2 = 0.717, x3 = -0.297, lmda = -1.59'


ans =

    'Soln 6 indefinite'


ans =

    'eigvals = [ -3.17, 0, 5.66 ]'
```

```
zLz_null_soln =

2*z1^2*(2^(1/2) - 3) - z2*(2*z1 + 2*z2 - z2*(2*2^(1/2) - 2)) - (2*z2 - (2*2^(1/2) + 2)*(z1 + z2))*(z1 + z2)
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