

```
% Question 6 - Hw4 - CVXMATLAB - Arani : 810100511
```

```
clear;  
clc;
```

```
% Given COnstants
```

```
m = 50;  
n = 40;
```

```
% state to make the random seed fixed  
randn('state',0)
```

```
A = randn(m,n);
```

```
X_tilde = sign(randn(n,1));
```

```
s = [0.5, 1, 2, 3];
```

```
y = zeros(1,length(s));
```

```
x_i = zeros(n,length(s));
```

```
x_ii = zeros(n,length(s));
```

```
x_iv = zeros(n,length(s));
```

```
for i = 1 : length(s)  
    b = A*X_tilde + s(i)*randn(m,1);  
    % i  
    x_i(:, i) = sign( pinv(A) * b ); % pinv --> sudo inverse  
    f_i(i) = norm(A*x_i(:,i)-b);  
    % ii  
    [y(i), z, Z] = to_solve(A, b, n);  
    x_ii(:,i) = sign(z);  
    f_ii(i) = norm(A*x_ii(:,i)-b);  
    %d
```

```
for j = 1 : 100 % for 100 samples  
    N = randn(n,1); % normal random -->Gaussian  
    N = (Z^0.5)*N + z; % variance : Z , mean : z  
    x_d(:, j) = sign(N);  
    obj(j) = norm(A*sign(N) - b);  
end
```

```
[~, idx] = min(obj);
```

```
x_iv(:, i) = x_d(:, idx);
f_iv(i) = norm(A*x_iv(:,i)-b);
```

end

Calling SDPT3 4.0: 861 variables, 41 equality constraints

```
-----
num. of constraints = 41
dim. of sdp      var = 41,   num. of sdp blk = 1
*****
SDPT3: Infeasible path-following algorithms
*****
version predcorr gam expon scale_data
HKM      1      0.000 1      0
it pstep dstep pinfeas dinfeas gap      prim-obj      dual-obj      cputime
-----
0|0.000|0.000|3.5e+01|6.0e+00|1.2e+06| 8.018151e+04  0.000000e+00| 0:0:00| chol 1 1
1|0.945|1.000|1.9e+00|9.1e-04|1.2e+05| 8.384126e+03 -3.573333e+04| 0:0:00| chol 1 1
2|1.000|1.000|1.7e-07|9.1e-05|1.8e+04| 1.366135e+03 -1.637683e+04| 0:0:00| chol 1 1
3|0.616|1.000|8.2e-08|9.1e-06|4.9e+03| 1.757837e+02 -4.731964e+03| 0:0:00| chol 1 1
4|1.000|1.000|6.1e-09|9.2e-07|1.5e+03| -5.894433e+02 -2.107652e+03| 0:0:00| chol 1 1
5|0.863|1.000|9.1e-10|9.2e-08|8.9e+02| -1.101247e+03 -1.990287e+03| 0:0:01| chol 1 1
6|1.000|1.000|7.2e-11|9.2e-09|3.0e+02| -1.391430e+03 -1.687832e+03| 0:0:01| chol 1 1
7|1.000|1.000|4.1e-11|9.2e-10|6.8e+01| -1.554365e+03 -1.621923e+03| 0:0:01| chol 1 1
8|1.000|1.000|2.6e-11|9.9e-11|1.2e+01| -1.601008e+03 -1.613215e+03| 0:0:01| chol 1 1
9|0.976|1.000|2.9e-11|1.4e-11|1.8e+00| -1.610631e+03 -1.612447e+03| 0:0:01| chol 1 1
10|1.000|0.974|6.2e-13|7.0e-12|1.1e-01| -1.612236e+03 -1.612345e+03| 0:0:01| chol 1 1
11|0.980|0.986|7.9e-13|1.1e-12|2.2e-03| -1.612338e+03 -1.612340e+03| 0:0:01| chol 1 1
12|0.945|0.983|1.8e-12|1.0e-12|1.2e-04| -1.612340e+03 -1.612340e+03| 0:0:01| chol 1 2
13|0.982|1.000|7.4e-13|1.0e-12|8.8e-06| -1.612340e+03 -1.612340e+03| 0:0:01|
stop: max(relative gap, infeasibilities) < 1.49e-08
-----

number of iterations = 13
primal objective value = -1.61233981e+03
dual objective value = -1.61233982e+03
gap := trace(XZ) = 8.75e-06
relative gap = 2.71e-09
actual relative gap = 2.71e-09
rel. primal infeas (scaled problem) = 7.37e-13
rel. dual " " " = 1.00e-12
rel. primal infeas (unscaled problem) = 0.00e+00
rel. dual " " " = 0.00e+00
norm(X), norm(y), norm(Z) = 4.0e+01, 1.6e+03, 1.8e+03
norm(A), norm(b), norm(C) = 7.4e+00, 7.4e+00, 7.1e+02
Total CPU time (secs) = 0.57
CPU time per iteration = 0.04
termination code = 0
DIMACS: 2.7e-12 0.0e+00 5.4e-12 0.0e+00 2.7e-09 2.7e-09
-----
```

```
Status: Solved
Optimal value (cvx_optval): +16.4217
```

Calling SDPT3 4.0: 861 variables, 41 equality constraints

```
-----
num. of constraints = 41
dim. of sdp      var = 41,   num. of sdp blk = 1
*****
```

SDPT3: Infeasible path-following algorithms

```

version predcorr gam expon scale_data
HKM      1      0.000 1      0
it pstep dstep pinfeas dinfeas gap      prim-obj      dual-obj      cputime
-----
0|0.000|0.000|3.5e+01|6.0e+00|1.2e+06| 8.018151e+04  0.000000e+00| 0:0:00| chol 1 1
1|0.942|1.000|2.0e+00|9.0e-04|1.3e+05| 8.528634e+03 -3.579025e+04| 0:0:00| chol 1 1
2|1.000|1.000|1.8e-07|9.0e-05|1.8e+04| 1.341303e+03 -1.711335e+04| 0:0:00| chol 1 1
3|0.642|1.000|7.9e-08|9.1e-06|4.4e+03| 1.638123e+02 -4.219231e+03| 0:0:00| chol 1 1
4|1.000|1.000|4.8e-09|9.2e-07|1.8e+03| -6.444866e+02 -2.424796e+03| 0:0:00| chol 1 1
5|1.000|1.000|2.1e-10|9.1e-08|8.0e+02| -1.124730e+03 -1.926153e+03| 0:0:00| chol 1 1
6|1.000|1.000|7.2e-11|9.1e-09|3.6e+02| -1.399559e+03 -1.756764e+03| 0:0:00| chol 1 1
7|1.000|0.977|4.2e-11|1.1e-09|5.7e+01| -1.598731e+03 -1.655971e+03| 0:0:00| chol 1 1
8|1.000|1.000|2.5e-11|9.9e-11|1.8e+01| -1.631980e+03 -1.649499e+03| 0:0:00| chol 1 1
9|0.953|0.945|1.4e-11|1.9e-11|1.2e+00| -1.646425e+03 -1.647612e+03| 0:0:00| chol 1 1
10|0.964|0.948|4.9e-13|4.6e-12|6.2e-02| -1.647448e+03 -1.647510e+03| 0:0:00| chol 1 1
11|0.954|0.980|5.0e-14|1.1e-12|2.8e-03| -1.647500e+03 -1.647503e+03| 0:0:00| chol 1 2
12|1.000|1.000|7.1e-13|1.0e-12|2.8e-04| -1.647502e+03 -1.647503e+03| 0:0:00| chol 1 1
13|0.967|0.979|2.9e-12|1.0e-12|1.1e-05| -1.647502e+03 -1.647502e+03| 0:0:00|
stop: max(relative gap, infeasibilities) < 1.49e-08

```

```

-----
number of iterations      = 13
primal objective value    = -1.64750248e+03
dual   objective value    = -1.64750249e+03
gap := trace(XZ)          = 1.07e-05
relative gap              = 3.25e-09
actual relative gap       = 3.25e-09
rel. primal infeas (scaled problem) = 2.87e-12
rel. dual      "      "      "      = 1.02e-12
rel. primal infeas (unscaled problem) = 0.00e+00
rel. dual      "      "      "      = 0.00e+00
norm(X), norm(y), norm(Z) = 3.8e+01, 1.6e+03, 1.7e+03
norm(A), norm(b), norm(C) = 7.4e+00, 7.4e+00, 7.1e+02
Total CPU time (secs)    = 0.19
CPU time per iteration   = 0.01
termination code         = 0
DIMACS: 1.1e-11 0.0e+00 5.1e-12 0.0e+00 3.2e-09 3.3e-09
-----

```

Status: Solved
 Optimal value (cvx_optval): +46.1696

Calling SDPT3 4.0: 861 variables, 41 equality constraints

```

-----
num. of constraints = 41
dim. of sdp var = 41, num. of sdp blk = 1
*****

```

SDPT3: Infeasible path-following algorithms

```

version predcorr gam expon scale_data
HKM      1      0.000 1      0
it pstep dstep pinfeas dinfeas gap      prim-obj      dual-obj      cputime
-----
0|0.000|0.000|3.5e+01|6.0e+00|1.2e+06| 8.018151e+04  0.000000e+00| 0:0:00| chol 1 1
1|0.945|1.000|1.9e+00|9.3e-04|1.2e+05| 8.193738e+03 -3.454389e+04| 0:0:00| chol 1 1
2|1.000|1.000|1.7e-07|9.3e-05|1.7e+04| 1.359239e+03 -1.593797e+04| 0:0:00| chol 1 1
3|0.630|1.000|8.0e-08|9.3e-06|4.5e+03| 2.128551e+02 -4.263377e+03| 0:0:00| chol 1 1
4|1.000|1.000|5.4e-09|9.4e-07|1.6e+03| -5.953811e+02 -2.189984e+03| 0:0:00| chol 1 1
5|0.998|1.000|2.1e-10|9.4e-08|7.5e+02| -1.087493e+03 -1.834008e+03| 0:0:00| chol 1 1
6|1.000|1.000|6.5e-11|9.3e-09|3.3e+02| -1.323403e+03 -1.649280e+03| 0:0:00| chol 1 1

```

```

7|1.000|0.988|4.2e-11|1.0e-09|5.1e+01|-1.509799e+03 -1.560460e+03| 0:0:00| chol 1 1
8|1.000|1.000|2.8e-11|1.0e-10|1.2e+01|-1.543671e+03 -1.555282e+03| 0:0:00| chol 1 1
9|0.949|0.935|1.8e-11|2.1e-11|1.2e+00|-1.552936e+03 -1.554106e+03| 0:0:00| chol 1 1
10|1.000|1.000|4.0e-14|4.6e-12|2.2e-01|-1.553799e+03 -1.554019e+03| 0:0:00| chol 1 1
11|0.975|0.981|4.6e-14|1.1e-12|5.6e-03|-1.553996e+03 -1.554002e+03| 0:0:00| chol 1 1
12|0.978|0.987|2.0e-12|1.0e-12|1.2e-04|-1.554002e+03 -1.554002e+03| 0:0:00| chol 2 2
13|0.946|0.988|1.2e-12|1.0e-12|6.9e-06|-1.554002e+03 -1.554002e+03| 0:0:00|
stop: max(relative gap, infeasibilities) < 1.49e-08

```

```

-----
number of iterations = 13
primal objective value = -1.55400172e+03
dual objective value = -1.55400173e+03
gap := trace(XZ) = 6.90e-06
relative gap = 2.22e-09
actual relative gap = 2.22e-09
rel. primal infeas (scaled problem) = 1.23e-12
rel. dual " " " = 1.01e-12
rel. primal infeas (unscaled problem) = 0.00e+00
rel. dual " " " = 0.00e+00
norm(X), norm(y), norm(Z) = 3.7e+01, 1.5e+03, 1.7e+03
norm(A), norm(b), norm(C) = 7.4e+00, 7.4e+00, 6.9e+02
Total CPU time (secs) = 0.15
CPU time per iteration = 0.01
termination code = 0
DIMACS: 4.5e-12 0.0e+00 5.9e-12 0.0e+00 2.2e-09 2.2e-09
-----

```

```

-----
Status: Solved
Optimal value (cvx_optval): +128.058

```

Calling SDPT3 4.0: 861 variables, 41 equality constraints

```

-----
num. of constraints = 41
dim. of sdp var = 41, num. of sdp blk = 1
*****
SDPT3: Infeasible path-following algorithms
*****
version predcorr gam expon scale_data
HKM 1 0.000 1 0
it pstep dstep pinfeas dinfeas gap prim-obj dual-obj cputime
-----
0|0.000|0.000|3.5e+01|6.1e+00|1.3e+06| 8.018151e+04 0.000000e+00| 0:0:00| chol 1 1
1|0.947|1.000|1.8e+00|8.4e-04|1.3e+05| 8.143350e+03 -3.884438e+04| 0:0:00| chol 1 1
2|1.000|1.000|1.7e-07|8.4e-05|1.9e+04| 1.095847e+03 -1.772078e+04| 0:0:00| chol 1 1
3|0.678|1.000|7.1e-08|8.5e-06|6.0e+03|-1.035438e+02 -6.147986e+03| 0:0:00| chol 1 1
4|1.000|0.922|7.7e-09|1.4e-06|1.5e+03|-8.805584e+02 -2.414509e+03| 0:0:00| chol 1 1
5|0.864|1.000|1.1e-09|8.6e-08|9.6e+02|-1.452108e+03 -2.416807e+03| 0:0:00| chol 1 1
6|1.000|0.974|8.6e-11|1.1e-08|2.0e+02|-1.784872e+03 -1.985163e+03| 0:0:00| chol 1 1
7|1.000|1.000|1.9e-11|8.6e-10|7.3e+01|-1.890720e+03 -1.963570e+03| 0:0:00| chol 1 1
8|0.949|0.946|1.3e-11|1.3e-10|5.0e+00|-1.945841e+03 -1.950886e+03| 0:0:00| chol 1 1
9|0.964|0.979|1.1e-11|1.4e-11|2.4e-01|-1.950091e+03 -1.950331e+03| 0:0:00| chol 1 1
10|0.954|0.981|4.8e-13|2.4e-12|1.1e-02|-1.950300e+03 -1.950311e+03| 0:0:00| chol 1 1
11|0.977|1.000|4.5e-12|1.0e-12|7.2e-04|-1.950310e+03 -1.950311e+03| 0:0:00| chol 1 2
12|0.949|0.987|2.7e-13|1.0e-12|3.7e-05|-1.950311e+03 -1.950311e+03| 0:0:00|
stop: max(relative gap, infeasibilities) < 1.49e-08

```

```

-----
number of iterations = 12
primal objective value = -1.95031055e+03
dual objective value = -1.95031059e+03
gap := trace(XZ) = 3.69e-05
relative gap = 9.46e-09

```

```

actual relative gap      = 9.46e-09
rel. primal infeas (scaled problem) = 2.69e-13
rel. dual      "      "      "      = 1.01e-12
rel. primal infeas (unscaled problem) = 0.00e+00
rel. dual      "      "      "      = 0.00e+00
norm(X), norm(y), norm(Z) = 3.5e+01, 1.8e+03, 1.9e+03
norm(A), norm(b), norm(C) = 7.4e+00, 7.4e+00, 7.6e+02
Total CPU time (secs) = 0.16
CPU time per iteration = 0.01
termination code      = 0
DIMACS: 1.0e-12  0.0e+00  5.5e-12  0.0e+00  9.5e-09  9.5e-09
-----

```

```

-----
Status: Solved
Optimal value (cvx_optval): +271.129

```

% Comparison:

disp(f_iv)

```

4.1623    7.1787   12.2781   17.0952

```

disp(f_ii)

```

4.1623    7.1787   12.2781   17.0952

```

disp(f_i)

```

4.1623    7.1787   24.6281   31.8045

```

to_solve function:

```

function [y, zz, ZZ] = to_solve(A, b, n)
    cvx_begin sdp
        variable z(n);
        variable Z(n,n) symmetric;
        minimize( trace(A'*A*Z) - 2*b'*A*z + b'*b )
        subject to
            [Z, z; z' 1] >= 0
            diag(Z)==1;
    cvx_end
    y = cvx_optval;
    zz = z;
    ZZ = Z;
end

```