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1. Solve the follwing set of equations Ax = b.

lineq1.dat, lineq2.dat, lineq3.dat에 대해 1) Guass-Jordan elimination, 2) LU decomposition, 3) SVD 적용하여 solve한 결과,

- lineq1.dat & Guass-Jordan elimination:

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq1.dat gaussj
File 'lineq_dat/lineq1.dat' read complete. =======
Numerical Recipes run-time error...
gaussj: Singular Matrix
...now exiting to system...
(base) lee@lee 03-LinearEquation %
```

- lineq1.dat & LU decomposition:

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq1.dat ludcmp
File 'lineq_dat/lineq1.dat' read complete. =======
Using LU Decomposition: x = [    1.00000   -3.00000    2.00000    0.00000 ]^t
```

- lineq1.dat & SVD:

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq1.dat svdcmp
File 'lineq_dat/lineq1.dat' read complete. =======
Using SVD: x = [    1.73333   -1.53333   -0.20000   -0.73333 ]^t
```

- lineq2.dat & Guass-Jordan elimination:

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq2.dat gaussj
File 'lineq_dat/lineq2.dat' read complete. =======
Using Gauss-Jordan Elimination: x = [   -2.87357   -0.61236    0.97628    0.63582   -0.55344 ]^t
```

- lineq2.dat & LU decomposition:

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq2.dat ludcmp
File 'lineq_dat/lineq2.dat' read complete. =======
Using LU Decomposition: x = [   -2.87357   -0.61236    0.97628    0.63582   -0.55344 ]^t
```

- lineq2.dat & SVD:

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq2.dat svdcmp
File 'lineq_dat/lineq2.dat' read complete. =======
Using SVD: x = [   -2.87357   -0.61236    0.97628    0.63582   -0.55344 ]^t
```

- lineq3.dat & Guass-Jordan elimination:

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq3.dat gaussj
File 'lineq_dat/lineq3.dat' read complete. =======
Using Gauss-Jordan Elimination: x = [   -0.32661    1.53229   -1.04483   -1.58745    2.92848   -2.21893 ]^t
```

- lineq3.dat & LU decomposition:

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq3.dat ludcmp
File 'lineq_dat/lineq3.dat' read complete. =======
Using LU Decomposition: x = [   -0.32661    1.53229   -1.04483   -1.58745    2.92848   -2.21893 ]^t
```

- lineq3.dat & SVD:

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq3.dat svdcmp
File 'lineq_dat/lineq3.dat' read complete. =======
Using SVD: x = [   -0.32661    1.53229   -1.04482   -1.58745    2.92848   -2.21893 ]^t
```

2. Apply the method of iterative improvement (mprove()) to the above problem and discuss the results.

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq2.dat mprove
File 'lineq_dat/lineq2.dat' read complete. =======
Using LU Decomposition: x = [   -2.87357   -0.61236    0.97628    0.63582   -0.55344 ]^t
Solution x, noise added: x = [   -2.87356   -0.48082    1.73188    1.09447   -0.02067 ]^t
After improvement: x = [   -2.87357   -0.61236    0.97628    0.63582   -0.55344 ]^t
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq3.dat mprove
File 'lineq_dat/lineq3.dat' read complete. =======
Using LU Decomposition: x = [   -0.32661    1.53229   -1.04483   -1.58745    2.92848   -2.21893 ]^t
Solution x, noise added: x = [   -0.32660    1.66383   -0.28922   -1.12880    3.46125   -1.99997 ]^t
After improvement: x = [   -0.32661    1.53229   -1.04483   -1.58745    2.92848   -2.21893 ]^t
```

non-singular matrix (lineq2.dat, lineq3.dat)에 대해 LU decomposition하여 solution을 구한 뒤, solution vector element 각각에 [0, 1] 구간의 random noise를 추가하였다. 이후 mprove()를 한번 호출한 결과, 마지막 결과 (After improvement: ...)와 같이, 다시 원래 solution과 비슷해짐을 확인할 수 있었다.

Numerical Analysis in C에서 'Unless you are starting quite far from the true solution, one call is generally enough.'라고 언급한 대로, noise가 크지 않아 한번의 improvement call로도 noise 추가 전 solution과 비슷한 solution을 얻을 수 있었다.

3. Find the inverse and the determinant of the matrix A in the above problem.

non-singular matrix (lineq2.dat, lineq3.dat)에 대해 matrix A의 inverse matrix를 구한 결과,

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq2.dat inverse
File 'lineq_dat/lineq2.dat' read complete. =======
Using LU Decomposition: inverse of matrix is
   0.35454    0.76694    0.20777   -0.59541    0.25313
   0.03545    0.12669    0.19578   -0.15954    0.05031
  -0.13869   -0.09854   -0.09672    0.12409    0.01642
  -0.05214   -0.30396   -0.02320    0.23462   -0.04458
   0.14911    0.45933    0.05136   -0.17101    0.04249
```

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq3.dat inverse
File 'lineq_dat/lineq3.dat' read complete. =======
Using LU Decomposition: inverse of matrix is
  -0.16221    0.12280    0.02407   -0.01643   -0.02284    0.04613
   0.16941   -0.04112    0.22831   -0.08762    0.18031   -0.39565
  -0.01164    0.12274   -0.11741   -0.18098    0.01591    0.18677
   0.10567   -0.05173   -0.10892    0.29977    0.00086   -0.19054
  -0.05303   -0.04236    0.16051   -0.22403    0.16181    0.01502
  -0.06234   -0.06469   -0.23422    0.35113   -0.36483    0.43463
```

lineq1.dat, lineq2.dat, lineq3.dat 각각에 대해 matrix A의 determinant를 구한 결과,

```
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq1.dat det
File 'lineq_dat/lineq1.dat' read complete. =======
Determinant of matrix A:   -0.00000
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq2.dat det
File 'lineq_dat/lineq2.dat' read complete. =======
Determinant of matrix A: 3835.99951
(base) lee@lee 03-LinearEquation % ./linEq lineq_dat/lineq3.dat det
File 'lineq_dat/lineq3.dat' read complete. =======
Determinant of matrix A: 16178.40137
```