CSCE 735
Parallel Computing
Minor Project

1. Below are the steps to compile and execute the code:
   - We load the module : module load intel/2020a
   - We create the executable file : icc -qopenmp -o Rinverse.exe Rinverse.cpp
   - We execute the batch job : sbatch Rinverse.grace_job

   The batch job looks like this :

```
#!/bin/bash
##ENVIRONMENT SETTINGS; CHANGE WITH CAUTION
#SBATCH --export=NONE                #Do not propagate environment
#SBATCH --get-user-env=L             #Replicate login environment
#
##NECESSARY JOB SPECIFICATIONS
#SBATCH --job-name=JobExample2       #Set the job name to "JobExample2"
#SBATCH --time=1:30:00               #Set the wall clock limit to 6hr and 30min
#SBATCH --nodes=1                    #Request 1 node
#SBATCH --ntasks-per-node=48          #Request 8 tasks/cores per node
#SBATCH --mem=8G                     #Request 8GB per node
#SBATCH --output=output.%j      #Send stdout/err to "output.[jobID]"
#
##OPTIONAL JOB SPECIFICATIONS
##SBATCH --mail-type=ALL              #Send email on all job events
##SBATCH --mail-user=email_address    #Send all emails to email_address
#
##First Executable Line
#
module load intel/2020a         # load Intel software stack
#

./Rinverse.exe 11 11
./Rinverse.exe 11 10
./Rinverse.exe 11 9
./Rinverse.exe 11 8
./Rinverse.exe 11 7
./Rinverse.exe 11 6
./Rinverse.exe 11 5
./Rinverse.exe 11 4
./Rinverse.exe 11 3
./Rinverse.exe 11 2
./Rinverse.exe 11 1
```

2. I ran the program for various matrix size and leaf matrix sizes. The results which best illustrated the features were depicted by matrix size 11 for various leaf matrix sizes.

Leaf Matrix Size	Speedup	Efficiency
11	1	0.0208
10	6.06	0.1262
9	12.96	0.27
8	14.46	0.3013

7	12.08	0.2517
6	8.49	0.1769
5	5.37	0.1119
4	3.62	0.0754
3	1.73	0.0360
2	0.89	0.0185
1	0.48	0.01

I get the max speedup at Leaf Matrix size 8 of speedup 14.46 and efficiency 0.3013.

3. I tested the code on different matrix sizes and different leaf matrix sizes. Below are the results obtained for matrix sizes 10 and 11.

```
Matrix Size = 1024,  Leaf Matrix Size = 1024, Error = 0, Execution Time =   0.5503
Matrix Size = 1024,  Leaf Matrix Size = 512, Error = 0, Execution Time =   0.1065
Matrix Size = 1024,  Leaf Matrix Size = 256, Error = 0, Execution Time =   0.0562
Matrix Size = 1024,  Leaf Matrix Size = 128, Error = 0, Execution Time =   0.0618
Matrix Size = 1024,  Leaf Matrix Size = 64, Error = 0, Execution Time =   0.0721
Matrix Size = 1024,  Leaf Matrix Size = 32, Error = 0, Execution Time =   0.1064
Matrix Size = 1024,  Leaf Matrix Size = 16, Error = 0, Execution Time =   0.1625
Matrix Size = 1024,  Leaf Matrix Size = 8, Error = 0, Execution Time =   0.2292
Matrix Size = 1024,  Leaf Matrix Size = 4, Error = 0, Execution Time =   0.4178
Matrix Size = 1024,  Leaf Matrix Size = 2, Error = 0, Execution Time =   1.0309
```

```
Matrix Size = 2048,  Leaf Matrix Size = 2048, Error = 0, Execution Time =   5.2356
Matrix Size = 2048,  Leaf Matrix Size = 1024, Error = 0, Execution Time =   0.8633
Matrix Size = 2048,  Leaf Matrix Size = 512, Error = 0, Execution Time =   0.4037
Matrix Size = 2048,  Leaf Matrix Size = 256, Error = 0, Execution Time =   0.3620
Matrix Size = 2048,  Leaf Matrix Size = 128, Error = 0, Execution Time =   0.4333
Matrix Size = 2048,  Leaf Matrix Size = 64, Error = 0, Execution Time =   0.6161
Matrix Size = 2048,  Leaf Matrix Size = 32, Error = 0, Execution Time =   0.9739
Matrix Size = 2048,  Leaf Matrix Size = 16, Error = 0, Execution Time =   1.4439
Matrix Size = 2048,  Leaf Matrix Size = 8, Error = 0, Execution Time =   3.0199
Matrix Size = 2048,  Leaf Matrix Size = 4, Error = 0, Execution Time =   5.8783
Matrix Size = 2048,  Leaf Matrix Size = 2, Error = 0, Execution Time =  10.9091
```

For a fixed matrix size, we see that the speedup and efficiency first increases with decrease in leaf matrix size upto a certain extent. There after the speedup and efficiency starts to decrease. For different matrix sizes this trend still holds true, however the value of maximum speedup and efficiency is different.
For matrix size 10 : Max Speedup – 14.46 and Max Efficiency – 0.3013
For matrix size 11 : Max Speedup – 9.79 and Max Efficiency – 0.2040