ESE5023 Assignment 06
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1. Matrix multiplication

1.1 [5 points] Write a program Main.f90 to read fortran_demo1/M.dat as the matrix M, and fortran_demo1/N.dat as the matrix N.

1.2 [5 points] Write a subroutine Matrix_multip.f90 to do matrix multiplication.

1.3 [5 points] Call the subroutine Matrix_multip() from Main.f90 to compute M*N; write the output to a new file MN.dat, values are in formats of f9.2

First write two programs **createM.f90** and **createN.f90** to generate two matrices filled with random numbers, for example here: M is a 5×3 matrix, N is a 3×4 matrix.

After run the **createM.f90** and **createN.f90**, two matrices are stored in M.dat and N.dat, respectively.

Matrix multiplication can be done by looping the elements in matrices, multiplying and summing. Whereas, Fortran provides a direct function **matmul(A, B)** to calculate the results of matrix A and B multiplication. Notice that the dimensions of A, B must be suitable for this calculation. Please see the **Matrix_multip.f90** and **Main.f90** for the details of the matrix multiplication.

2. Calculate the Solar Elevation Angle

2.1 [5 points] Write a module Declination_angle that calculates the *declination angle* on a given date.

2.2 [10 points] Write a module Solar_hour_angle that calculates the *solar hour angle* in a given location for a given date and time.

2.3 [5 points] Write a main program (Solar_elevation_angle.f90) that uses module Declination_angle and Solar_hour_angle to calculate and print the SEA in a given location for a given date and time.

2.4 [5 points] Create a library (libsea.a) that contains Declination_angle.o and Solar_hour_angle.o.
Compile Solar_elevation_angle.f90 using libsolar.a. Print the SEA for Shenzhen (22.542883N, 114.062996E) at 10:32 (Beijing time; UTC+8) on 2021-12-31.

To calculate the solar elevation angle:

$$\sin(\alpha) = \sin(\varphi)\sin(\delta) + \cos(\varphi)\cos(\delta)\cos(h)$$

α: solar elevation angle

δ: declination angle
φ: latitude
h: solar hour angle

$$\delta = sin^{-1}(\sin(-23.44°)\cos(\frac{360}{365.24}(d+10)) + \frac{360}{\pi} \times 0.0167\sin(\frac{360}{365.24}(d-2)))$$

d: days of the year

$$h = 15° \times (\mathrm{LST} - 12)$$

LST: local solar time in 24-hour format
More details are presented in **Declination_angle.f90** and **Solarhour_angle.f90.**

Create and link the library:

```
[ese-liangsj@login02 fortran_demo4]$ ifort SEA_main.f90 -o SEA_main.x -L. -lsea
[ese-liangsj@login02 fortran_demo4]$ ./SEA_main.x
 2021-12-31
 day of the year      365.0000
 Declination angle is (degree):       23.35037
 Solar hour angle (degree) is :      -22.05000
 The solar elevation angle for Shenzhen at 10:32 2021-12-31 will be (degree):
    21.62326
 program finished
```