

ESE5023 Assignment 06

12132206

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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

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

d : days of the year

$$h = 15^\circ \times (\text{LST} - 12)$$

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-liangs@login02 fortran_demo4]$ ifort SEA_main.f90 -o SEA_main.x -L. -lsea
```

```
[ese-liangs@login02 fortran_demo4]$ ./SEA_main.x
```

```
2021-12-31
```

```
day of the year    365.0000    364d
```

```
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
```

```
参考结果 : hour angle:-28.43 °
           declination : -23.13 °
           SEA ; 36.61 °
12-31为第364天, -1
```