Programming and Modelling (week 39)

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September 2017

Arrays

We have seen how to define arrays in Fortran:

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real, dimension(1000) :: tab

integer, dimension(1000,100) :: bigtab
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```

→ recurrent problem: the size of arrays has to be defined at compilation, but often their size is provided by the user at runtime.

Concretely:

```
program opla
implicit none
real(8), dimension(123) :: xcoordinates

write(6,*) 'Enter nb of points'
read(5,x) npts
```

Allocatable arrays

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Example

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2. compute/read its size
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```
integer n
real(8), dimension(:), allocatable :: array

write(6,*) 'Enter size of array'
read(5,*) n

allocate(array(n))
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```
integer n
real(8), dimension(:), allocatable :: array

write(6,*) 'Enter size of array'
read(5,*) n

allocate(array(n))
```

```
integer n,m
real(8), dimension(:,:), allocatable :: largearray

write(6,*) 'Enter nb of lines of array'
read(5,*) n

write(6,*) 'Enter nb of columns of array'
read(5,*) m

allocate(largearray(n,m))
```

To be clear:

- to declare a scalar:
```
integer :: npts
real :: x0
```
- to declare a fixed-size array:
```
integer, dimension(100) :: mmm
real, dimension(33) :: xcoords
```
- to declare a variable-size array:
```
integer, dimension(:), allocatable :: mnp
real, dimension(:), allocatable :: values
```

Example 2

```
program example
implicit none
integer :: n
real,dimension(:),allocatable :: xcoords
real,dimension(:),allocatable :: ycoords

write(6,*) 'enter number of points'
read(5,*) n

allocate(xcoords(n))
allocate(ycoords(n))

call random_number(xcoords)
call random_number(ycoords)


!
! do something will the coordinates
!


deallocate(xcoords)
deallocate(ycoords)

end program
```

Example 3

Generate a regular grid of nnx $\times$ nny points in $[0 : 12] \times [0 : 7]$

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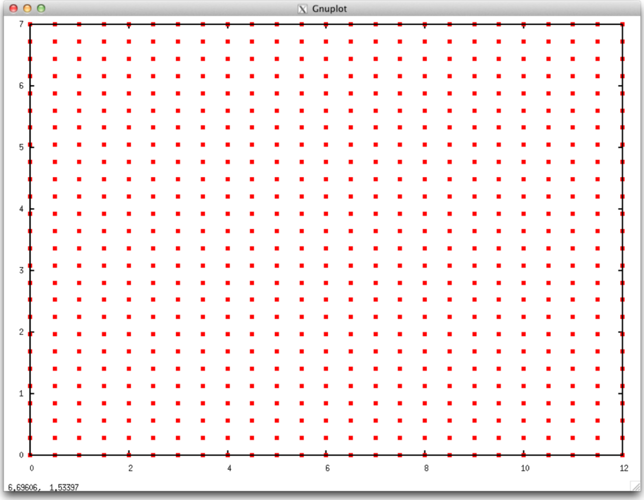
Generate a regular grid of nnx × nny points in $[0:12] \times [0:7]$

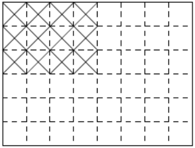


Example 3

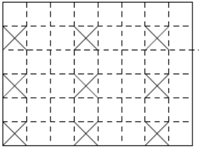
```
program example
implicit none
integer :: i,j,ip,counter
integer :: nnx,nny,np
real :: Lx,Ly,dx,dy
real,dimension(:),allocatable :: gridx
real,dimension(:),allocatable :: gridy

Lx=12
Ly=7

write(6,*) 'how many points in the x direction (nnx) ?'
read(5,*) nnx
write(6,*) 'how many points in the y direction (nny) ?'
read(5,*) nny

np=nnx*nny

allocate(gridx(np))
allocate(gridy(np))

write(6,*) 'total number of points: ',np

dx=Lx/real(nnx-1)
dy=Ly/real(nny-1)

counter=0
do i=1,nnx
   do j=1,nny
      counter=counter+1
      gridx(counter)=(i-1)*dx
      gridy(counter)=(j-1)*dy
   end do
end do

open(unit=345,file='points.dat',action='write')
do ip=1,np
   write(345,*) gridx(ip),gridy(ip)
end do
close(345)

deallocate(gridx)
deallocate(gridy)

end program
```

Manipulating arrays

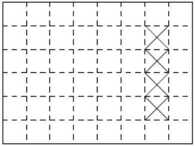
```
REAL, DIMENSION(1:6,1:8) :: P
```



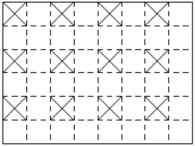
P(1:3,1:4)



P(2:6:2,1:7:3)



P(2:5,7), P(2:5,7:7)



P(1:6:2,1:8:2)

Intrinsic array functions

- minval,maxval
- shape
- size
- sum
- product

Intrinsic array functions - Example

```fortran
program example
implicit none

real, dimension(53) :: tab

call random_number(tab)

write(6,*) 'minimum value in tab ',minval(tab)
write(6,*) 'maximum value in tab ',maxval(tab)
write(6,*) 'shape of tab         ',shape(tab)
write(6,*) 'size of tab          ',size(tab)
write(6,*) 'sum of  all numbers in tab   ',sum(tab)
write(6,*) 'product of all numbers in tab',product(tab)

end program
```

Intrinsic array functions - Example

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program example
implicit none

real, dimension(53) :: tab

call random_number(tab)

write(6,*) 'minimum value in tab ',minval(tab)
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write(6,*) 'sum of  all numbers in tab   ',sum(tab)
write(6,*) 'product of all numbers in tab',product(tab)

end program
```

```
geogarfield ~/Desktop/UD/onderwijs/1320_PROGMOD/LECTURES (master *) $ ./a.out
 minimum value in tab    1.07835531E-02
 maximum value in tab   0.964987576
 shape of tab                   53
 size of tab                    53
 sum of  all numbers in tab      28.6039162
 product of all numbers in tab   1.31217255E-22
```

Intrinsic array functions - Example(2)

```
program example
implicit none

real, dimension(11,13) :: tab

call random_number(tab)

write(6,*) 'minimum value in tab ',minval(tab)
write(6,*) 'maximum value in tab ',maxval(tab)
write(6,*) 'shape of tab         ',shape(tab)
write(6,*) 'size of tab          ',size(tab)
write(6,*) 'sum of  all numbers in tab   ',sum(tab)
write(6,*) 'product of all numbers in tab',product(tab)

end program
```

Intrinsic array functions - Example(2)

```
program example
implicit none

real, dimension(11,13) :: tab

call random_number(tab)

write(6,*) 'minimum value in tab ',minval(tab)
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write(6,*) 'shape of tab         ',shape(tab)
write(6,*) 'size of tab          ',size(tab)
write(6,*) 'sum of  all numbers in tab    ',sum(tab)
write(6,*) 'product of all numbers in tab',product(tab)

end program
```

```
geogarfield ~/Desktop/UD/onderwijs/1320_PROGMOD/LECTURES (master *) $ ./a.out
 minimum value in tab    1.77552104E-02
 maximum value in tab   0.993430555
 shape of tab                   11          13
 size of tab                   143
 sum of  all numbers in tab      73.0963593
 product of all numbers in tab   0.00000000
```

Intrinsic array functions - Example(3)

```
program example
implicit none

real, dimension(11,13) :: tab

call random_number(tab)

write(6,*) 'average of values in in tab ',sum(tab)/size(tab)

end program
```

More intrinsic array functions

Fortran also offers very useful functions in linear algebra:

- dot_product
- matmul
- transpose

More intrinsic array functions - Example 1

Let us define $\boldsymbol{v}_1 = (2, -3, -1)$ and $\boldsymbol{v}_2 = (6, 3, 3)$
We then have the scalar product of these vectors: $\boldsymbol{v}_1 \cdot \boldsymbol{v}_2 = 0$.

More intrinsic array functions - Example 1

Let us define $\mathbf{v}_1 = (2, -3, -1)$ and $\mathbf{v}_2 = (6, 3, 3)$
We then have the scalar product of these vectors: $\mathbf{v}_1 \cdot \mathbf{v}_2 = 0$.

```
program example
implicit none

real, dimension(3) :: vect1
real, dimension(3) :: vect2
real :: prod_scal

vect1=(/2,-3,-1/)
vect2=(/6,3,3/)

prod_scal=vect1(1)*vect2(1)&
         +vect1(2)*vect2(2)&
         +vect1(3)*vect2(3)

write(6,*) 'scalar product is ',prod_scal

write(6,*) 'scalar product is ',dot_product(vect1,vect2)

end program
```

```
thebeast:progmod geogarfield$ ./a.out
 scalar product is    0.0000000
 scalar product is   0.0000000
```

More intrinsic array functions - Example 2

Let us consider two small matrices:

$$\boldsymbol{A} = \begin{pmatrix} 1 & 3 \\ 2 & 4 \end{pmatrix} \qquad \boldsymbol{B} = \begin{pmatrix} -1 & -2 \\ 4 & 1 \end{pmatrix}$$

We wish to compute $\boldsymbol{C} = \boldsymbol{A} \cdot \boldsymbol{B}$.

More intrinsic array functions - Example 2

Let us consider two small matrices:

$$\boldsymbol{A} = \begin{pmatrix} 1 & 3 \\ 2 & 4 \end{pmatrix} \qquad \boldsymbol{B} = \begin{pmatrix} -1 & -2 \\ 4 & 1 \end{pmatrix}$$

We wish to compute $\boldsymbol{C} = \boldsymbol{A} \cdot \boldsymbol{B}$.

```
program example
implicit none

real,dimension(2,2) :: matA
real,dimension(2,2) :: matB
real,dimension(2,2) :: matC

matA(1,1)=1.   ; matA(1,2)=3.
matA(2,1)=2.   ; matA(2,2)=4.

matB(1,1)=-1.  ; matB(1,2)=-2.
matB(2,1)=4.   ; matB(2,2)=1.

matC=matmul(matA,matB)

write(6,*) matC(1,1),matC(1,2)
write(6,*) matC(2,1),matC(2,2)

end program
```

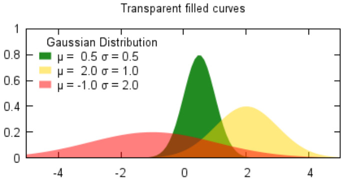
```
thebeast:progmod geogarfield$ ./a.out
   11.000000       1.0000000
   14.000000       0.0000000
```

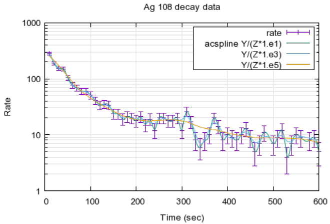
Gnuplot (1)

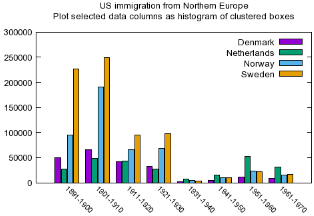
- Gnuplot is a portable command-line driven graphing utility for Linux, MS Windows, OSX, and many other platforms.
- The source code is copyrighted but freely distributed (i.e., you don't have to pay for it).
- It was originally created to allow scientists and students to visualize mathematical functions
- The official website is at this address: `http://gnuplot.info/`

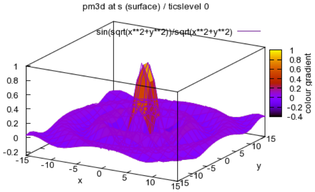
Gnuplot (2)

Here are a few examples of what can be done with gnuplot:









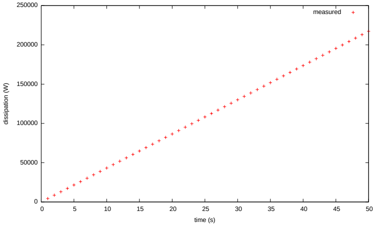
Gnuplot (3)

Let us create the following gnuplot script: *script1*.

`set term postscript eps color`	→ output is set to be a color posts
`set xlabel 'time (s)'`	→ set the label of x-axis
`set ylabel 'dissipation (W)'`	→ set the label of y-axis
`set output 'plot1.eps'`	→ set the name of graphics file
`plot 'datas.dat' title 'measured'`	→ plot the data

We then run gnuplot on this script as follows: `>gnuplot script1`

The following file *plot1.eps* is then generated:



Gnuplot (4)

Physics of the Earth and Planetary Interiors 188 (2011) 47–68

Contents lists available at ScienceDirect

Physics of the Earth and Planetary Interiors

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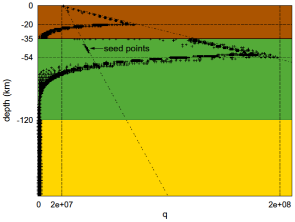
FANTOM: Two- and three-dimensional numerical modelling of creeping flows for the solution of geological problems

Cedric Thieulot *



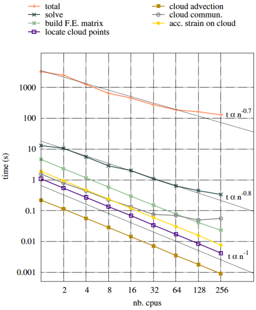


Fig. 17. Average timings for various routines calls.