Physics 40: Laboratory Fourteen

Thursday, May 14, 2020

Goals:

Vector normalization; Participation Ratio; Matrix Multiplication; Localized Modes.

[1] In Lab 13 we used some linear algebra software ('Numerical Recipes') to diagonalize a matrix. Let's learn a bit about what more simple linear algebra codes look like. Here's a code which computes the length of a vector and 'normalizes' it:

```
#include <stdio.h>
#include <math.h>
int main(void)

{
int i,N;
double patronus[1024],length;

printf("\nEnter the length N of the vector   ");
scanf("%d",&N);

for (i=0; i<N; i=i+1)
{
    printf("\nEnter vector component %4d   ",i);
    scanf("%lf",&patronus[i]);
}

length=0.0;
for (i=0; i<N; i=i+1)
{
      length=length+patronus[i]*patronus[i];
}
length=sqrt(length);
printf("\nYour vector has length   %12.6lf \n",length);

for (i=0; i<N; i=i+1)
{
      patronus[i]=patronus[i]/length;
      printf("\nComponent %d of your normalized vector: %12.6lf \n",i,patronus[i]);
}

return 0;
}
```

[HW7-5] Explain what it means to 'normalize' a vector.

[HW7-6] Modify the preceding code to compute the 'participation ratio' P of a vector. You should keep all of the code: the input of the vector, the calculation of its length, its normalization, and then finally add one more loop which gets P. What do you get for P for the vectors:

$$\vec{v}_1 = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \qquad \vec{v}_2 = \begin{bmatrix} 1 \\ 1 \\ 0 \\ 1 \\ 0 \\ 0 \\ 1 \\ 1 \end{bmatrix} \qquad \vec{v}_3 = \begin{bmatrix} 2.5 \\ 2.7 \\ 3.0 \\ 3.1 \\ 2.6 \\ 2.9 \\ 3.0 \\ 2.8 \end{bmatrix} \qquad \vec{v}_4 = \begin{bmatrix} 4 \\ 5 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 4.5 \end{bmatrix} \qquad \vec{v}_5 = \begin{bmatrix} -0.1 \\ 0.2 \\ 0.1 \\ -0.3 \\ 3 \\ 2 \\ 0.1 \\ -0.2 \end{bmatrix}$$

Discuss why these values 'make sense'.

[HW7-7] One of the most basic linear algebra procedures is multiplying a vector by a matrix. In the 'BLAS' package (http://www.netlib.org/blas/) the function is called 'dgemm'. We'll see here how dgemm works. Write a code which
(a) initializes the elements of a 5x5 matrix $\mathcal{M}$ to have the values

```
  3.0   1.0  -0.5   0.4   1.2
  1.0   4.0   0.7   0.2  -0.9
 -0.5   0.7  -3.2   0.3  -0.1
  0.4   0.2   0.3   3.5   0.8
  1.2  -0.9  -0.1   0.8  -3.7
```

(b) reads in a five component vector $\vec{v}$; and
(c) Computes $\vec{w} = \mathcal{M}\vec{v}$. Then use your code to get $\vec{w}_1 = \mathcal{M}\vec{v}_1$ and $\vec{w}_2 = \mathcal{M}\vec{v}_2$ for

$$\vec{v}_1 = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \qquad \vec{v}_2 = \begin{bmatrix} 1 \\ 2 \\ 1 \\ -2 \\ 1 \end{bmatrix}$$

[2] Preview of coming attractions: We may delay python one more lab and use this machinery in combination with Lab 13 to learn about localized and extended modes!