Assignment 1 of
Computational Astrophysics in NTHU

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1 Written Assignments

Q1 : Angry Bird

If we **ignore air resistance**, the distance R of angry bird moving in horizontal direction will be Eq.1.

$$R = \frac{v_{0y}^2 \sin 2\theta}{g} \tag{1}$$

So I think the error will come from $\sin\theta = x - \frac{\theta^3}{3!} + \frac{\theta^5}{5!} - \frac{\theta^7}{7!} + ...$ and gravity constant g=9.8....., because there will be calculated by approximation.

And then, I consider projectiles **with air resistance** $F_D = cv^2$, we can do two orthogonal coordinates analysis:

$$y = v_{0y}t - \frac{1}{2}(g + \frac{c(v_{0y})^2}{m})t^2 \tag{2}$$

$$x = v_{0x}t - \frac{1}{2}(\frac{c(v_{0x})^2}{m})t^2 \tag{3}$$

When a bird hit the ground, i.e. $y = 0$, Eq.2. can be written as:

$$t = \frac{2mv_{0y}}{mg + c(v_{0y})^2} \tag{4}$$

So during time t, angry bird fly distance R, we substitute Eq.4. into Eq.3 to get R'.

$$R' = \frac{2mv_{0x}v_{0y}}{mg + c(v_{0y})^2} - \frac{1}{2}\frac{4mv_{0x}^2 v_{0y}^2}{(mg + c(v_{0y})^2)^2} = \frac{mv_0^2 \sin 2\theta}{mg + c(v_0 \sin\theta)^2} - \frac{1}{2}\frac{mv_0^4(\sin 2\theta)^2}{(mg + c(v_0 \sin\theta)^2)^2} \tag{5}$$

In this condition, because air resistance need to consider bird's mass m, and the mass is not given, so m need to be assumed. Air resistance coefficient is another variable need to be assumed, since it is relative to bird's cross-section area.

About approximations and possible errors, I think it is like the condition of projectile ignore air resistance. The function $\sin\theta$ will make calculation have error.

Q2 : forward error & backward error

For question number 2, the problem told us that:

$$y = f(x) = \cos(x) = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + ... \tag{6}$$

$$\hat{y} = 1 - \frac{x^2}{2!} \tag{7}$$

Forward error will be the error between Eq.6. & Eq.7. ,i.e.

$$Forward error : |\hat{y} - y| = -\frac{x^4}{4!} + \frac{x^6}{6!} + ... \tag{8}$$

Backward error will be the error $\triangle x$ of variable we give into the function.

$$1-\frac{x^2}{2!}+\frac{x^4}{4!}-\frac{x^6}{6!}+...=y=\hat{y}(x+backerror)=1-\frac{(x+\triangle x)^2}{2!} \tag{9}$$

After we elimination equation, we can get the relation of $\triangle x$:

$$2x\triangle x+\triangle x^2=2(\frac{x^4}{4!}-\frac{x^6}{6!}+...) \tag{10}$$

The question give us the condition number for $x=1$. So we can use this condition into Eq.3 & Eq.5. to acquire the forward error $=0.0403$;backward error $=0.03952$

Q3 : Simulate all stars in our Milky Way

I search the internet and find [1] : a real number, which is with 4 kind, will spend 4 bytes(32 bits) space in our computer.

The problem say that we have 250 billion($*10^9$)stars in our Milky Way, and each stars need to record 10 variables.So we can calculate the total space we need to use is

$$4(bytes)*10(variables)*250*10^9(numberofstars)=1*10^{13}(bytes)=10(TB)$$

2 Programming Assignments

Q1 : git
Q2 : Output of typing "which" and the version of gcc/gfortran

(a) github (b) folder which was tracked by git

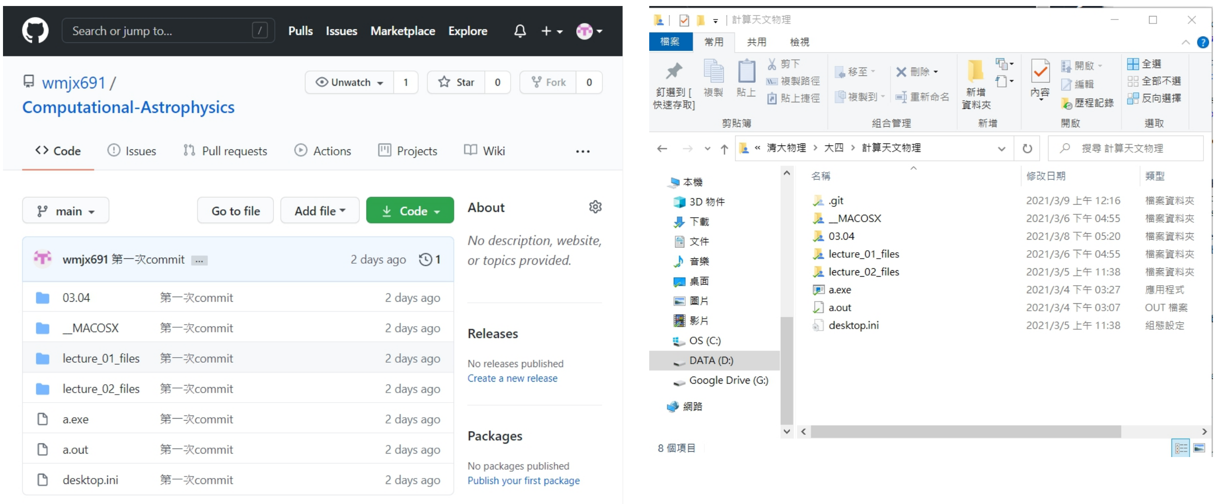

Figure 1: Using git to commit files onto github

Fig.2 is the output of the command "which gcc/gfortran". I consider this command means where is location of this applicant be installed at.

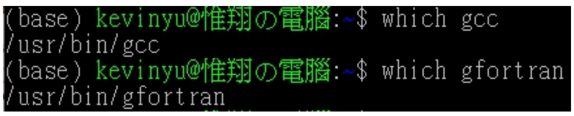

Figure 2: Output of the command "which gcc/gfortran".

In Fig.3, there are the version of them. gfortran was written as the repaired type of gcc. So I think that why them have the same version.

[1]space demand of fortran data type, in page 3 https://jupiter.math.nctu.edu.tw/ smchang/fortran/fortran90.pdf

(a) gfortran (b) gcc

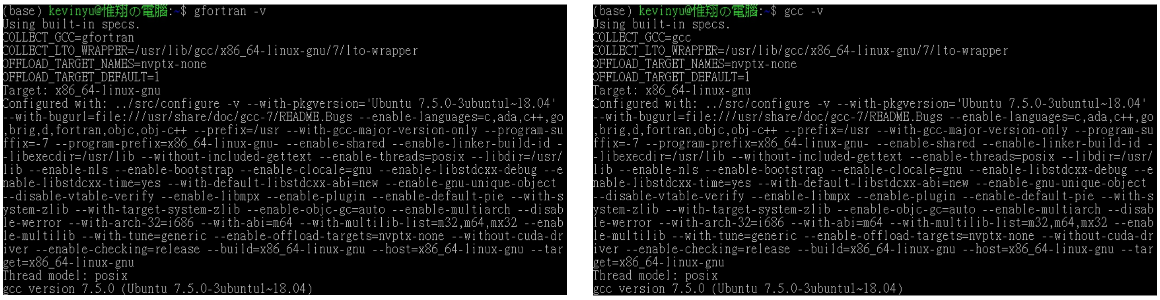

Figure 3: The version of application in my machine

Q3 & Q4 : The version of Python & jupyter

In Fig.4, the version of Python is 3.7.6, jupyter notebook is 6.0.3

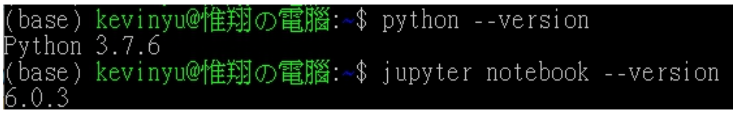

Figure 4: The version of "python" & "jupyter" in my computer.

Q5 : To install GNUPLOT

My machine was installed WSL system, so gnuplot can not launch a new window to show the figure what I want to plot.I search the internet and find a website [2] teach how to fix this problem, and successfully launch a new window to show sin(x) in Fig.5.

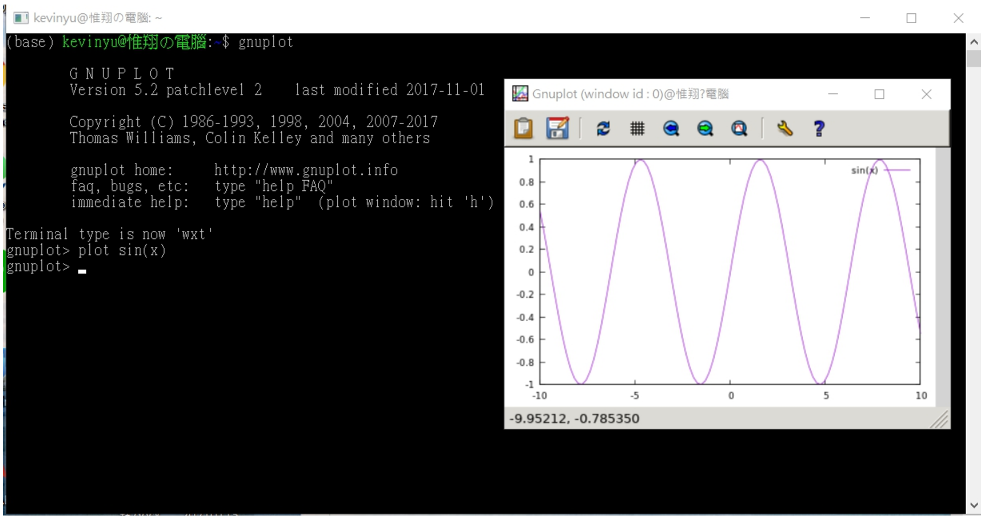

Figure 5: plot sin(x) in WSL

(But I also discussed with I-Fan(一璠), one of our classmate, his computer could show the window in the beginning when he installed gnuplot by following my reference website. However, after reboost his computer, his WSL then could not output the plot...... we are still working on it.)

[2]how to install gnuplot in WSL http://rocksaying.tw/archives/2018/wsl-run-linux-desktop-software.html