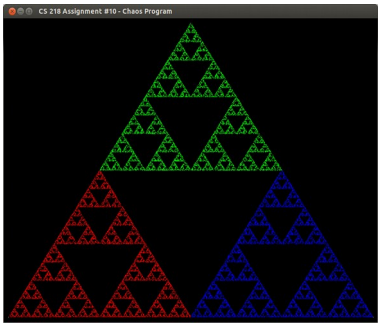
**CS 218 – Assignment #10, Chaos**

Purpose: Become more familiar with data representation issues, program control instructions, function handling, and operating system interaction.
Due: Friday (6/28)
Points: 200 (grading will include functionality, documentation, and coding style)

## Assignment:




Write a simple assembly language program to plot a series of points on the screen using the provided algorithm. The number of points to plot must be read from command line (as octal). For example:

```
ed-vm% ./chaos -it 177777 -rs 100
```

The required format for the command line is "**`-it <octalNumber>`**" and "**`-rs <octalNumber>`**" (in that order). The program must read the iterations specifier ('-it') and the rotation speed (-rs) as octal numbers, and ensure the numbers are valid. Additionally, the program must ensure that thes numbers with the specified range (provided defined constants), inclusive. The values are unsigned. If there are any errors, the program should display an appropriate error message (pre-defined) and terminate.

The provided C++ main program calls routines to check and read the command line arguments. The openGL system will call a user-written routine, *drawChaos()*, to plot the points. All functions must follow the standard calling convention as discussed in class.

## Chaos Point Plotting Algorithm

Implement the following algorithm to generate the initial three points (***x***,***y***), where ***i***=0 to 2, positions for plotting:

$$initX[i] = \sin\left((rSpeed + (i * dStep)) * \frac{pi}{180}\right) * scale$$

$$initY[i] = \cos\left((rSpeed + (i * dStep)) * \frac{pi}{180}\right) * scale$$

Implement the following algorithm to generate (***x***,***y***) positions for plotting:

```
seed = 987123
for i = 1 to iterations do
      s = rand(seed)
      seed = s
      n = s mod 3
      x = x + ( (init_x[n] - x) / 2 )
      y = y + ( (init_y[n] - y) / 2 )
      set color (r,g,b)
      plot (x, y)
end_for
```

*Note*, for the color 0=>red (255,0,0), 1=>green (0,255,0), and 2=>blue (0,0,255).

**Submission:**
When complete, submit:

- A copy of the source file via the class web page (assignment submission link) by 11:55 PM. ***Assignments received after the allotted time will not be accepted!***

**Scoring**
Scoring will include functionality, documentation, and coding style.

- ~30 pts -> Documentation and coding style
- ~75 pts -> Command line routine (with complete error checking)
- ~95 points -> Display Chaos points (including random number generation)

**OpenGL Installation**
For this assignment, we will be using the openGL (graphics library) to provide some basic windowing capabilities. As such, the OpenGL development libraries must be installed. This can be done via the command line with the following commands.

```
sudo apt update
sudo apt upgrade
sudo apt install libgl1-mesa-dev
sudo apt install freeglut3 freeglut3-dev
```

It will take a few minutes to install each. You must be connected to the Internet during the installation. *Note*, after the installation, a re-install of Virtual Box Guest Additions may be required.

**Independent Assembly**
Your functions must be placed into a *separate file* and linked with the provided main. Only the functions file, not the provided main, will be submitted on-line. As such, you must not change the provided main! A template of the functions file will be provided that includes the string definitions. The program must be linked with the OpenGL libraries. A compile, assembly, and link script file (**`asm10`**) is provided and must be used. *Note*, the script file will require execute privilege (i.e., **`chmod +x asm10`**). To assemble/link script can be executed as follows:

```
ed-vm% ./asm10 chaos a10prs
```

Assuming the main file is named **`chaos.cpp`** and the functions file is named **`a10prs.asm`**.

**Rotation Speed**
Before the plotting is performed, the rStep value should be set as follows;

$$rStep = \frac{rotateSpeed}{rScale}$$

Before leaving the function, the ***rSpeed*** value should be incremented by ***rStep***.

The function is called repeatedly which generates the animation (based on the changing ***rSepeed*** value between successive calls). The template already includes some of the applicable openGL initialization calls (which must not be removed).

**Random Number Generation**

To generate a pseudo random number, use the *linear congruential generator* method. It is fast, simple, and (if instantiated with the right constants) gives reasonable pseudo-random numbers. The next random number is generated from the previous one by:

$$R_{n+1} = (A \times R_n + B) \bmod 2^{16}$$

The initial random number $R_n$ (on which the rest are based on is referred to as the "seed"). The value for A must be a prime number. For our purposes, set A=9421, B=1, and SEED to 987123. *Note*, to provide a random number between 0 and 2, the plot points algorithm uses the "mod 3" function (remainder after division).

**Testing**

A script file to execute the program on a series of predefined inputs will be provided. The test script executes the program and performs a series of error tests (with expected output). Refer to the examples for output formatting and error handling. The test script, named **`a10tst`**, can be executed as follows:

```
ed-vm% ./a10tst chaos
```

The expected error will be shown and then the program is executed (with the specified error).

**Debugging -> Command Line Arguments**

When debugging a program that uses command line arguments, the command line arguments must be entered ***after*** the debugger has been started. The debugger is started normally (**`ddd <program>`**) and once the debugger comes up, the initial breakpoint can be set. Then, when you are ready to run the program, enter the command line arguments. This can be done either from the menu (Propgram -> Run) or on the GDB Console Window (at bottom) by typing **`run <commandLineArguments>`** at the (gdb) prompt (bottom window).

**Open GL Plotting Functions:**

In order to plot points with openGl, a series of calls is required. First, the draw color must be set, the point plot mode must be turned on. Then, the points can be plotted in a loop. Once all the points have been plotted, the plot mode can be ended and the points dispalyed.

The following are the sequence of calls required:

```
glColor3ub(r,g,b) ;
glBegin(GL_POINTS);

// plot calculations loop
        glVertex2d(x,y);

glEnd ();
glFlush ();
glutPostRedisplay();
```

The calls must be performed at assembly level with the appropriate argument transmission. For example, to set a draw color of red, **`glColor3ub (255, 0, 0)`**, and set point plot mode, **`glBegin(GL_POINTS)`**.

The code would be as follows:

```
mov     rdi, 255
mov     rsi, 0
mov     rdx, 0
call    glColor3ub

mov     rdi, GL_POINTS
call    glBegin
```

Assuming the variables ***x*** and ***y*** are delcared as quad words and set to valid floating points values, the call to **`glVertex2d(xPnt,yPnt)`** would be as follows:

```
movsd   xmm0, qword [xPnt]
movsd   xmm1, qword [yPnt]
call    glVertex2d
```

This call would be iterated in a plot loop (unless a single point is to be plotted).

The calls for **`glEnd()`**, **`glFlush()`**, and **`glutPostRedisplay()`** are as follows:

```
call    glEnd
call    glFlush
call    glutPostRedisplay
```

These function calls should not be included in the loop. They tell openGL to call the draw function again (which will re-draw the circle with sligtly dififerent parameters).

## OpenGL Errors

Note, some VM's may generate errors, similar to the below, which can be ignored:

```
libGL error: pci id for fd 4: 80ee:beef, driver (null)
OpenGL Warning: Failed to connect to host. Make sure 3D acceleration is enabled for this VM.
libGL error: core dri or dri2 extension not found
libGL error: failed to load driver: vboxvideo
```

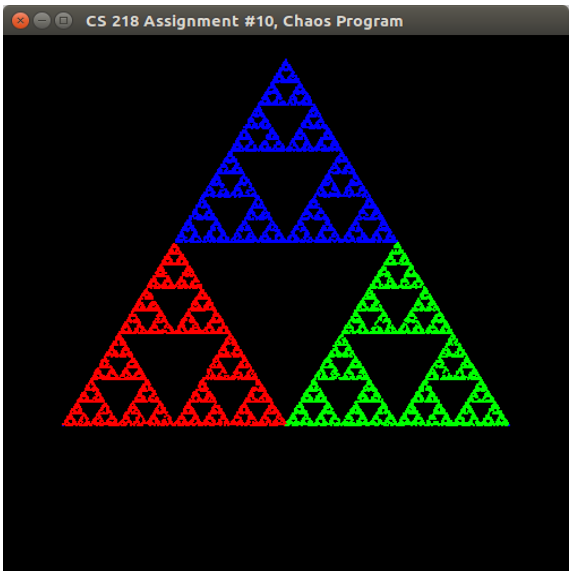
## Example Executions (with errors):

Below are some example executions with errors in the command line. The program should provide an appropriate error message (as shown) and terminate.

```
ed-vm% ./chaos
Usage: chaos -it <octalNumber> -rs <octalNumber>
ed-vm%
ed-vm% ./chaos -it 177777
Error, invalid or incomplete command line argument.
ed-vm%
ed-vm% ./chaos -ot 177777 -rs 121
Error, iterations specifier incorrect.
ed-vm%
ed-vm% ./chaos -it 7 -rs 20
Error, iterations value must be between 377 (8) and 177777 (8).
ed-vm%
ed-vm% ./chaos -it 177777 -rs 177777
Error, rotation speed value must be between 0 (8) and 100000 (8).
ed-vm%
```

**Example I/O:**
A correct output will appear similar to the following:

```
ed-vm% ./chaos -it 177777 -rs 100
```




*Note*, the window can be terminated by typing 'q' or 'x' (while the mouse is in the window) or clicking on the **x** in the upper left corner.

*Note*, the image should rotate at a rate based on the used provided rotate speed.