CS 3005: Programming in C++

Color Table Class

Introduction

A color table is an array of colors. It is useful for translating a single number (index) in a range into a color (RGB values), reliably and repeatedly.

We will use a color table to translate Julia set and Mandelbrot set escape counts into colors to create colorful images.

Assignment

In this assignment you will create a class to store a single RGB \([\text{Color}]\), and a class to store a vector of \([\text{Color}]\) objects in a \([\text{ColorTable}]\). You will also modify your project to use these classes to provide users the ability to configure and use colors of their own choosing when creating PPM images from fractal escape values.

The \([\text{ppm_menu}]\) program needs to add a few new commands.

The new commands required are:

- `grid-apply-color-table) Use the grid values to set colors in the output image using the color table.
- `set-color-table-size) Change the number of slots in the color table.
- `set-color) Set the RGB values for one slot in the color table.
- `set-random-color) Randomly set the RGB values for one slot in the color table.
- `set-color-gradient) Smoothly set the RGB values for a range of slots in the color table.

Potential Session

```
# To run all of the commands from a script, throwing away the prompts
$ ./ppm_menu < ppm_menu_assignment_10_sample_session_color_table.txt >> /dev/null
$ ls -l *.ppm
  -rw-r--r-- 1 cgl cgl  750015 Mar 14 09:02 sample-color-image-1.ppm
  -rw-r--r-- 1 cgl cgl 3000017 Mar 14 09:02 sample-color-image-2.ppm
  -rw-r--r-- 1 cgl cgl 3000017 Mar 14 09:02 sample-color-image-3.ppm
```

Programming Requirements

Below, the functions and methods may have a symbol \(\text{CG}?) before them, where \(?\) is a number. This indicates which Code Grinder step requires the function or method to be implemented.

Create \([\text{ColorTable.h}]\) and \([\text{ColorTable.cpp}]\)

These files will be used to declare and define both the \([\text{Color}]\) and the \([\text{ColorTable}]\) classes.

**Color class**

The \([\text{Color}]\) class needs to store the following data:

- The integer representation of red, green and blue channels of a color.

The \([\text{Color}]\) class needs to have the following methods:

- `Color();` Sets all color channels to value 0.
- `Color( const int& red, const int& green, const int& blue );` Sets the color channels to the values provided here. No range checking is applied.
- `int getRed( ) const;` Returns the value of the red channel.
- `int getGreen( ) const;` Returns the value of the green channel.
- `int getBlue( ) const;` Returns the value of the blue channel.
- `int getChannel( const int& channel ) const;` Returns the value of the \([\text{channel}]\)th channel. 0 == red, 1 == green, 2 == blue. Returns -1 if the channel is out of range.
- `void setRed( const int& value );` Changes the red channel to \([\text{value}]\). If \([\text{value}]\) is less than 0, do not make any changes.
- `void setGreen( const int& value );` Changes the green channel to \([\text{value}]\). If \([\text{value}]\) is less than 0, do not
make any changes.

- **void setBlue(const int& value);** Changes the blue channel to `value`. If `value` is less than 0, do not make any changes.

- **void setChannel(const int& channel, const int& value);** Changes the `channel`th channel to `value`. If `value` is less than 0, do not make any changes. 0 == red, 1 == green, 2 == blue. Does not make changes if `channel` is out of range.

- **void invert(const int& max_color_value);** Inverts the red, green and blue channels, using `max_color_value`. If `max_color_value` is less than any of the current color channels (red, green or blue), then make no changes. The inversion is completed by subtracting the current value from `max_color_value`. For example: red = max_color_value - red. This only makes sense if red is >= max_color_value. That's why we make no changes if any channel (red, green or blue) is larger than max_color_value.

- **bool operator==(const Color& rhs) const;** Returns true if `*this` and `rhs` have the same color values. Otherwise, returns false.

Additional support functions for the **Color** class:

- **std::ostream& operator<<(std::ostream& os, const Color& color);** Displays the color to `os` in the following format: "red:green:blue". For example, if the color has red = 13, green = 2 and blue = 45, then the output would be "13:2:45".

**ColorTable** class

Your **ColorTable** class must store the following data.

- A linear collection of **Colors**. (Think `std::vector`.)

Your **ColorTable** class must have the following methods.

- **ColorTable(const size_t& num_color);** Sizes the **Color** collection to `num_color` items.

- **size_t getNumberOfColors();** const; Returns the number of **Color**s stored.

- **void setNumberOfColors(const size_t& num_color);** Resizes the collection to hold `num_color` items. Previous **Color** contents may or may not be preserved.

- **const Color& operator[](const int& i) const;** Returns the `i`th **Color** in the collection. If `i` is out of range, returns a static memory **Color** object with all three channels set to -1. See an example below.

- **Color& operator[](const int& i);** Returns the `i`th **Color** in the collection. If `i` is out of range, returns a static memory **Color** object with all three channels set to -1.

- **void setRandomColor(const int& max_color_value, const size_t& position);** Assigns the `position`th color random values for all three channels. The random values are between 0 and `max_color_value`, inclusive. If `position` is out of range, no change is made. If `max_color_value` is less than 0, no change is made.

- **void insertGradient(const Color& color1, const Color& color2, const size_t& position1, const size_t& position2);** Change the colors from `position1` to `position2`, inclusive, to be gradients from `color1` to `color2`. If `position1` is not less than `position2`, no change is made. If either position is out of range, no change is made.

- **int getMaxChannelValue();** const; Finds the largest value of any RGB value in any color in the table.

Creating a **static Color** object to return in error cases.

```
{
    static Color ec(-1, -1, -1);
    static Color c(-1, -1, -1);
    c = ec;
    return c;
}
```

**Update NumberGrid.h and NumberGrid.cpp**

You will add a method to set a PPM object from the grid numbers, using a **ColorTable** instead of the built in table with 8 colors. Do not remove the previous method. Just add this one. Note, you may need to add an `#include`.

Add this method:

- **void setPPM(PPM& ppm, const ColorTable& colors);** Uses the currently stored grid numbers to configure an image in the PPM object. Sets the width and height of the image to match the width and height of the grid. Sets the maximum color value to the maximum color value of any color in the color table (`getMaxChannelValue()`). For each pixel in the PPM object, sets the color based on the grid number for the pixel. If the color table does not have at least 3 colors, make no changes to the PPM object. Use
the color table item at the last position for any pixels with a maximum number. Use the color table item at the next to last position for any pixels with a 0 grid number. For all other grid numbers, use \( \text{number} \mod (\text{size of the color table} - 2) \) as the index into the color table.

**Update** [image_menu.h] and [image_menu.cpp]

Add the following function declarations to the header file and implementations to the `.cpp` file.

- `void applyGridColorTable( std::istream& is, std::ostream& os, NumberGrid& grid, ColorTable& table, PPM& dst );` - Uses the new `setPPM` method to set the PPM using the grid and color table. Note this is not a replacement for `applyGrid`, this is in addition to that function.
- `void setColorTableSize( std::istream& is, std::ostream& os, ColorTable& table );` - Asks the user for the "Size? ", then applies it to the table.
- `void setColor( std::istream& is, std::ostream& os, ColorTable& table );` - Asks the user for "Position? ", "Red? ", "Green? ", and "Blue? ". The uses them to set a color at the specified position in the color table.
- `void setRandomColor( std::istream& is, std::ostream& os, ColorTable& table );` - Asks the user for "Position? ", then uses `setRandomColor()` to set a random color at that position.

The following functions will require updates to their functionality and/or declarations.

- `void showMenu( std::ostream& os );` - Add to the menu to include the messages shown in the description above.
- `void takeAction( std::istream& is, std::ostream& os, const std::string& choice, PPM& input_image1, PPM& input_image2, PPM& output_image, NumberGrid& grid, ColorTable& table );` - Add clauses to recognize the 5 new commands and call the correct function for each one. Also, note the addition of `ColorTable& table` as the last parameter.
- `int imageMenu( std::istream& is, std::ostream& os );` - Add the declaration of a `ColorTable` object before the `while` loop. This object should have 16 colors in the table, and should be filled with a gradient from 0,255,0 to 255,0,255. It will then be passed to `takeAction()` inside the loop.

**Update** [ppm_menu.cpp]

No changes are required for [ppm_menu.cpp].

**Update** [Makefile]

- This file must include the rules to build the program [ppm_menu].
- A developer must be able to use the command `make` to compile all necessary files and link them to the executable program [ppm_menu].
- The `all` target is expected in the [Makefile].
- The `clean` target is expected in the [Makefile].
- Automatic source and object file calculation are expected in the [Makefile].
- Automatic dependency calculations are expected in the [Makefile].

**Additional Documentation**

- [C++ Reference]
- [Examples from class]
- [Sample Session Input File]
- [Julia set on Wikipedia]
- [Mandelbrot set on Wikipedia]
- [Color Gradient on Wikipedia] (Only marginally useful.)
- [Color Gradient Discussion]
- [Hints on choosing color schemes]
- [Paletton color selection site]

**Sample PPM Images**

- [Sample Output1]
- [Sample Output2]
- [Sample Output3]
Show Off Your Work

To receive credit for this assignment, you must

- complete the unit tests available in CodeGrinder
- zip the source code (.cpp and .h files) and the Makefile and upload to the Canvas submission system
- use git to add, commit and push your solution to your repository for this class.

Additionally, the program must build, run and give correct output.

Extra Challenges (Not Required)

- Create additional methods in the ColorTable class that allow for easy insertion of interesting color patterns. Add the ability to use them from the imageMenu(). For example, can you implement a system to use a color and its complement to make a gradient?
- Create a method of NumberGrid to find the maximum number stored. Add the ability to set the number of colors in the color table to match this number from imageMenu().
- Try other ways to modify the color system to make good color systems. For example, can you make an HSV based color system that would make setting the color more convenient for designers?