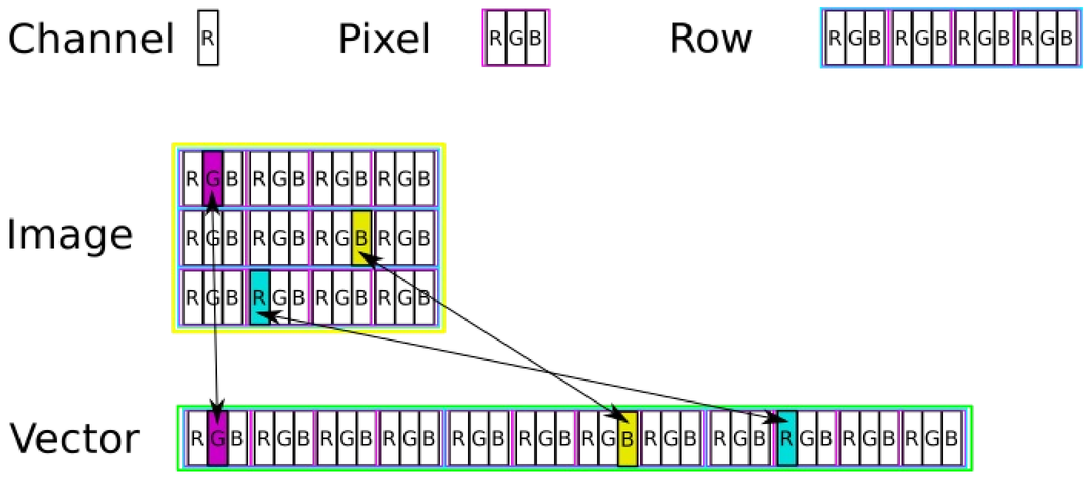
CS 3005: Programming in C++

Image Class

Digital images are rectangular collections of pixels stored in a grid layout. Images are usually stored row by row, starting with the top row. Each row is a collection of pixels (small square areas) stored from left to right. Each pixel is often stored as a collection of three numbers, representing how much red, green, and blue light is in the pixel.

The location of a single number in the image is identified by the row of the pixel (how far from the top of the image), the column of the pixel (how far from the left of the image), and the channel of the number (channel just means red, green, or blue).

Each of the values is a non-negative (0 or positive) integer describing the amount of that primary color to include in the pixel's color.



A channel is a single integer value. It represents how much of that color is in a pixel.

A pixel is a group of three channels: one for red, one for green, and one for blue.

A row is a horizontal group of pixels. The number of pixels in a row is equal to the width of the image.

A column is a vertical group of pixels. They are not adjacent in memory, but are all the same distance from the left of the image.

An image is a vertical group of rows. The number of rows in an image is equal to the height of the image.

A one-dimensional vector stores all of the channels for an image in a line. Organized into pixels and rows.

In the diagram above, notice how each channel is located in the vector. In the document below, and in your notes from class, find the arithmetic for locating a channel based on its row, column, and channel number.

Assignment

In this assignment, you will update the project from the previous assignment by adding a program to create an image and display the image in ASCII (all text) characters. In order to complete this task, you will be required to create an `Image` class used to store image information in your program, and a few more functions to interact with the user.

Potential Session

This is an example of what the program may look like to a user.

```
$ ./ascii_image
Image height? 40
Image width? 80
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                                      ..;;;;;;;;;;;;;;;;;;;;;;;+++++++++++++++++
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$
```

Programming Requirements

The following files must be updated or created and stored in the `src` directory of your repository.

Create `Image.h`

This file must include the declaration of the `Image` class.

Image Class Data Storage

The Image class needs to store 3 integers for each pixel in the image. There are `height` rows of pixels in the image, and each row holds `width` pixels. That is a total of `height` times `width` times 3 integers for the data values. One way to store this many values is to have a `std::vector` as a data member, that is `resize()`'d when `setWidth()` or `setHeight()` is called.

When a channel is set'd or get'd, into a pixel channel identified by `row`, `column` and `channel`, the index into the vector is calculated using `(row * width * 3 + column * 3) + channel`.

The class will also need data members for width and height.

Image Class Methods

Your `Image` class must have the following methods.

- `Image( );` The default constructor. A default Image has 0 height and 0 width. The data vector should be resized to fit the width and height.
- `Image( const int& height, const int& width )`; A constructor with parameters for the height and width. The data members should be set according to theparameters. The data vector should be resized to fit the width and height.
- `int getHeight( ) const;` Returns the height of the Image.
- `int getWidth( ) const;` Returns the width of the Image.
- `bool indexValid( const int& row, const int& column, const int& channel ) const;` Checks if row, column, and channel are all within the legal limits. Returns true if they all are, and false otherwise.

- `int index( const int& row, const int& column, const int& channel ) const;` Returns the index into the data vector for the location specified by row, column, and channel.
- `int getChannel( const int& row, const int& column, const int& channel ) const;` Returns an `int` representation of the value in the data vector at the location specified by row, column, and channel. Channel is 0, 1, or 2 for red, green, or blue. Uses the `index` method. Returns -1 if the row, column, or channel is not valid. Uses the `indexValid` method to check.
- `void setHeight( const int& height );` Change the height of the Image. The state of any new or existing pixels after this call is undetermined. Only non-negative values of `height` should be accepted. If the value is not accepted, make no changes. If a change is made, be sure to resize the data vector.
- `void setWidth( const int& width );` Change the width of the Image. The state of any new or existing pixels after this call is undetermined. Only non-negative values of `width` should be accepted. If the value is not accepted, make no changes. If a change is made, be sure to resize the data vector.
- `void setChannel( const int& row, const int& column, const int& channel, const int& value );` Change the value of the location specified by row, column, and channel. Only store if the row, column, and channel are valid (uses `indexValid` to check). If any of these is not valid, no changes should be made. Uses the `index` method to calculate the location.

Create `Image.cpp`

This file must implement all of the methods of the `Image` class declared in `Image.h`.

Update `image_menu.h`

Add the following function declarations to the file. Don't forget to include `Image.h` in this file too.

- `void drawAsciiImage( std::istream& is, std::ostream& os, const Image& image );`
- `void diagonalQuadPattern( std::istream& is, std::ostream& os, Image& image );`
- `int assignment2( std::istream& is, std::ostream& os );`

Create `image_drawing.cpp`

This file must include the implementations for these new functions:

- `void diagonalQuadPattern( std::istream& is, std::ostream& os, Image& image )` This function uses `getInteger` to ask the user for the "Image height? " and "Image width? ". It then configures the `image` with the specified size. Next, the function assigns values to the image according to the following rules: The top half of the image have a red channel of 0. The bottom half have a red channel of 255. The left half of the image has a blue channel of 0. The right half has a blue channel of 255. The green channel of each pixel is calculated as `( 2*row + 2*column ) % 256`. The top half of the image is described by those rows with row numbers less than half of the height. All other rows are considered to be the bottom half. For example, if the image height is 8, then rows 0,1,2,3 are the top half, and rows 4,5,6,7 are the bottom. Note that $^{8}/_{2}$ is 4. As another example, if the image height is 7, then $^{7}/_{2}$ is 3. That makes rows 0,1,2 the top half and rows 3,4,5,6 the bottom half.

Create `image_output.cpp`

This file must include the implementations for these new functions:

- `void drawAsciiImage( std::istream& is, std::ostream& os, const Image& image );` This function will display a rectangle of ASCII (text) characters in an attempt to represent the strength of each pixel. The strength of a pixel is calculated as the sum of the red, green, and blue values of the pixel, divided by `765.0`. This division, and its result, must be floating point values (think `double`). Depending on this pixel strength, a character will be displayed for the pixel. `>= 1.0 -> @`, `>= 0.9 -> #`, `>= 0.8 -> %`, `>= 0.7 -> *`, `>= 0.6 -> |`, `>= 0.5 -> +`, `>= 0.4 -> ;`, `>= 0.3 -> ~`, `>= 0.2 -> -`, `>= 0.1 -> .`, `>= 0.0 -> Space`. Display each row of the image as a line of text. Display all rows of the image.

Update `controllers.cpp`

Add the following functions:

- `int assignment2( std::istream& is, std::ostream& os );` Creates an `Image` object. Calls `diagonalQuadPattern` to configure the image. Calls `drawAsciiImage` to display the image. Returns 0.

Create `ascii_image.cpp`

This file must include the implementations of the following functions:

- `int main( );` This function should call `assignment2`, passing in `std::cin` and `std::cout` as the input and output streams to use. This function should return what `assignment2` returns.

Update `Makefile`

This file must now also include the rules to build the program `ascii_image`. The following commands should work correctly.

- `make hello` - builds the hello program
- `make questions_3` - builds the questions_3 program
- `make ascii_image` - builds the ascii_image program
- `make` - builds all programs

Additional Documentation

- C++ Reference
- Examples from class

Show Off Your Work

To receive credit for this assignment, you must

- use git to add, commit and push your solution to your repository for this class.
- successfully pass all unit tests and acceptance tests

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