HO CHI MINH CITY UNIVERSITY OF TECHNOLOGY
OFFICE FOR INTERNATIONAL STUDY PROGRAM
FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING

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COMPUTER SYSTEM AND PROGRAMMING
C PROJECT REPORT

IMAGE TO BINARY BITMAP CONVERTER

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I. Requiremnts

- ✓ Use subroutines as much as possible.
- ✓ Create user interface as clear and beautiful as possible.
- ✓ Check range for every value input and output appropriately.
- ✓ The program should be organized so well for structure programming.
- ✓ The program needs to comment as mamy as possible.
  The detail explanation of the program will be describe more here.
- ✓ Convert the image file .BMP of 256 grey levels to binary image .BMP.

II. Features

- Friendly UI.
- Drag and drop file input.
- Currently support 8bpp and 24bpp bitmap image.
- Builtin help screen.
- Print the image to the console window.
- Convert the image into binary (monochrome) bitmap image (1bpp) with progress displayed.

III. Instructions

- User will be greeting with a welcome screen.
- If you're first using the program, type "h" or "help" to show the instructions.
- User inputs a bitmap image file path with drag and drop supported.
- Type "p" for print or "c" to convert.
- Print:
  + Console and font will be resized for better viewing.
  + Press <Enter> once, then please maximize the window by clicking on the middle icon at the top right corner.
  + Press <Enter> again to print monochrome version of the image.
  + Press <Enter> after printing to restore console size and font.
- Convert:
  + The image will be converted to monochrome bitmap file and saved at the same location as the input.

IV. Images

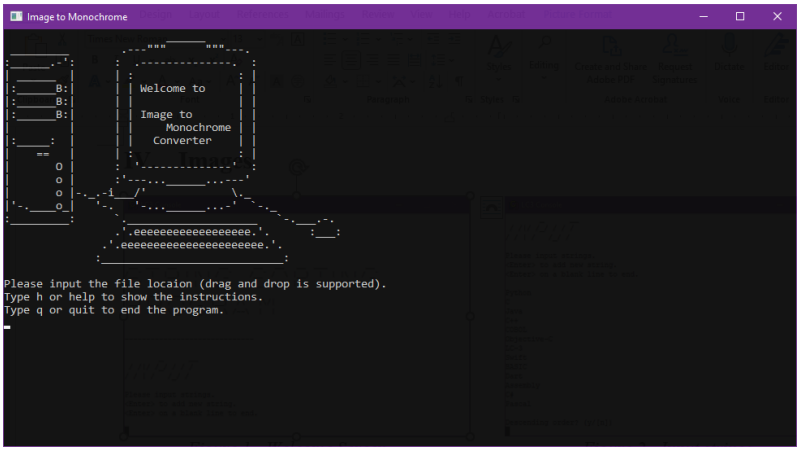


Figure 1 - Welcome Screen

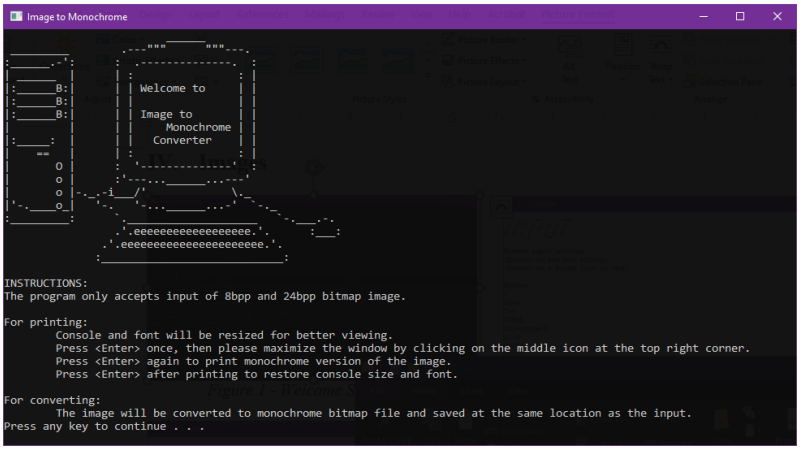


Figure 2 – Instructions

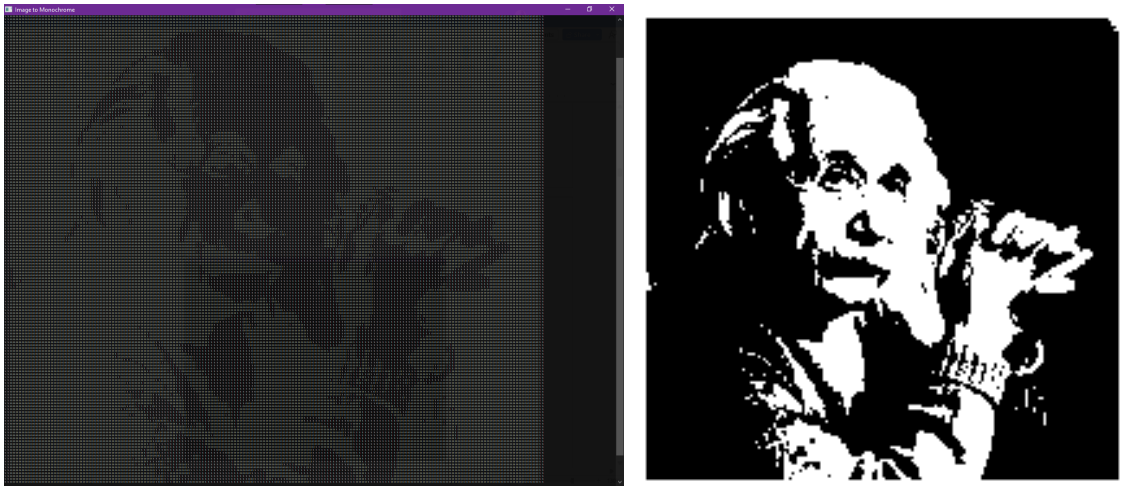
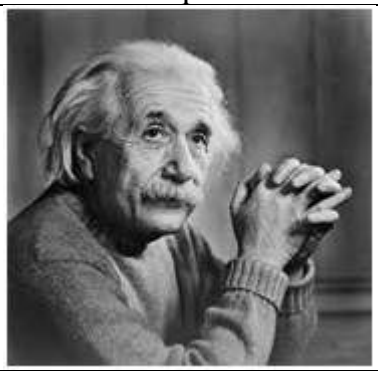
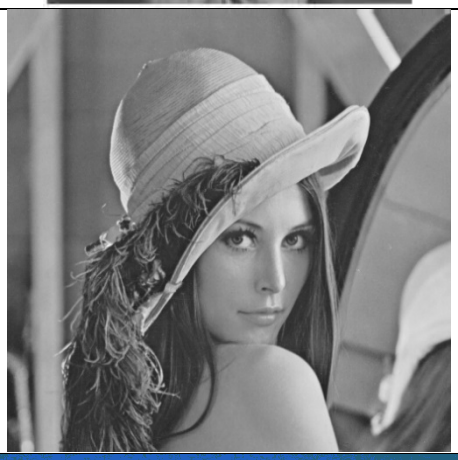
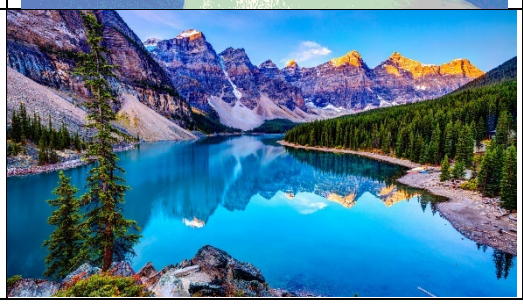
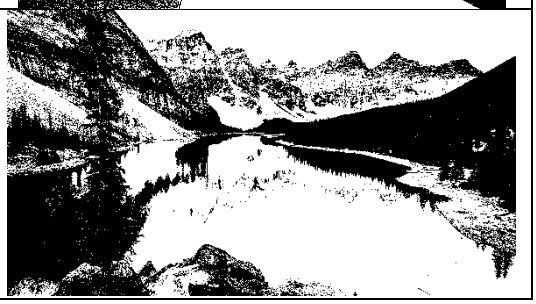


Figure 3 - Image printed in console and converted bitmap image

V. Demonstration

	Input	Output
8bpp grayscale, 186x182 px		
8bpp grayscale, 512x512 px		
8bpp colored, 512x384 px		
24bpp, 1920x1080		

VI. Understanding bitmap file format

The BMP file format, also known as bitmap image file, device independent bitmap (DIB) file format and bitmap, is a raster graphics image file format used to store bitmap digital images, independently of the display device (such as a graphics adapter), especially on Microsoft Windows and OS/2 operating systems. [1]

1. File structure

There are 8 parts that construct a bitmap file. But there are only 3 that we need to consider. (… are unimportant parts)

Structure name	Size	Purpose
Bitmap file header	Fixed - 14 bytes	Store general information about the bitmap image file.
DIB file header	Fixed – 62 bytes	Store detailed information about the bitmap image and define the pixel format.
…		
Pixel array	Variable – depends on image bpp and size	Define the actual values of the pixels.
…		

2. Bitmap and DIB header

	Offset	Size	Purpose
Bitmap file header	00	2 bytes	Identifier (usually BM)
	02	4 bytes	Size of bmp file
	06	4 bytes	Reserved
	0A	4 bytes	Offset to pixel array
DIB file header	0E	4 bytes	DIB header size
	12	4 bytes	Image width
	16	4 bytes	Image height
	…		
	1C	2 bytes	Bit per pixel
	…		
	36	4 bytes	Start of color table first color table entry (for 1bpp)
	40	4 bytes	last color table entry (for 1bpp)
	…		

3. Pixel format

- 1bpp: Image only consists of two colors, which predefined at offset 36 and 40. Each bit defines one pixel of the image.
- 8bpp: Image supports 256 colors. Each byte is an index into color table.
- 24bpp: Image supports $2^{24} = 16\,777\,216$ colors. Each pixel defined by 3 bytes, each byte is the strength of blue, green, red.
- 2bpp, 4bpp, 16 bpp, 32bpp: Learn more at [1]

4. Pixel array

- First pixel that defines in the pixel array is the left-bottom pixel of the image.
- So pixels are stored "bottom-up", starting in the lower left corner, going from left to right, and then row by row from the bottom to the top of the image.
- Bytes in a row in the pixel array must be multiple of four bytes. Thus, each row must consists of $\text{RowSize} = \left\lfloor \frac{\text{BitsPerPixel} \cdot \text{ImageWidth} + 31}{32} \right\rfloor \times 4$.
- So padding bytes must be appended to the end of the rows in order to bring up the length of the rows to a multiple of four bytes. They can be any values.

VII. Algorithm

1. Turning BGR to grayscale [2]

- For 8bpp image: each byte represents an index to color table. Each color in color table is 4 bytes (blue, green, red, alpha)
  For 24bpp image: 3 bytes of a pixel are the strengths of blue, green, red
- To turn BGR to grayscale color, apply this formula (luminosity method)

$$\text{gray} = 0.3r + 0.59g + 0.11b$$

2. Getting color bytes

- For 8bpp image: location of pixel (x, y) is

$$p = \text{offset} + (h - y - 1)\text{RowSize} + x$$

  With blue value at 54[1] $+ 4p$, green at $54 + 4p + 1$ and red at $54 + 4p + 2$.
- For 24bpp image: location of pixel (x, y) is

$$p = \text{offset} + (h - y - 1)\text{RowSize} + 3x$$

  With blue value at p, green at $p + 1$ and red at $p + 2$.

VIII. Functions

1. Image processing

- Libraries: stdio, iostream, malloc

a. Read a byte/bytes [3]

- Purpose: get the value in specific location.
- Input: file pointer, location to byte, number of bytes
- Output: the value (char or int)

```
uchar getByte(FILE *fp, int location) {
	uchar byte;
	fseek(fp,location,SEEK_SET);
	fread(&byte,1,1,fp);
	return byte;
}

uchar getBytes(FILE *fp, int location, int numberOfBytes) {
	uchar byte;
	fseek(fp,location,SEEK_SET);
	fread(&byte,1,numberOfBytes,fp);
	return byte;
}
```

[1] 54 is the location of the color table.

b. Check whether a bitmap file or not [3]

- Read first two bytes if equals to 19778 = 42 4D = BM or not.
- Input: file pointer
- Output: 0 or 1

```
int IsBitMap(FILE *fp) {
	ushort s;
	fread(&s,1,2,fp);
	return s==19778 ? 1 : 0;
}
```

c. Get width, get height, get bpp, get offset to image array [3]

```
//Get the width of the picture, in 18-21 bytes
int getWidth(FILE *fp) {
	int width;
	fseek(fp,18,SEEK_SET);
	fread(&width,1,4,fp);
	return width;
}

//Get the height of the picture, in 22-25 bytes
int getHeight(FILE *fp) {
	int height;
	fseek(fp,22,SEEK_SET);
	fread(&height,1,4,fp);
	return height;
}

//Get the number of bits of each pixel in 28-29 bytes
ushort getBit(FILE *fp) {
	ushort bit;
	fseek(fp,28,SEEK_SET);
	fread(&bit,1,2,fp);
	return bit;
}

//Get the starting position of data, in 10-13 bytes
uint getOffSet(FILE *fp) {
	uint OffSet;
	fseek(fp,10L,SEEK_SET);
	fread(&OffSet,1,4,fp);
	return OffSet;
}
```

d. Turn an array of 8 binary integers into a character (a byte)

- Example: {0,1,1,1,0,0,0,1} → 71
- Input: binary array
- Output: a byte

```
char BitToByte(int *num) {
	char result = 0;
	for (int i = 0; i < 8; ++i )
		result |= (num[i] == 1) << (7 - i);
	return result;
}
```

e. Integer to four bytes (characters)

- Example: 1078 → 36 04 00 00
- Input: an integer, 4-bytes array pointer
- Output: 4-bytes array

```
void ToFourBytes(unsigned long n, char bytes[4]){
	bytes[0] = (n >> 24) & 0xFF;
	bytes[1] = (n >> 16) & 0xFF;
	bytes[2] = (n >> 8) & 0xFF;
	bytes[3] = (n >> 0) & 0xFF;
}
```

f. Printing monochrome image

- Use the algorithm from VII.2 to get location of pixels and turn pixel data into grayscale using VII.1.
- Since the pixels are stored "bottom-up", we will print from the last row up to the top.
- Input: file pointer, width, height, bpp

```
void printImage(FILE *fp, int width, int height, int bpp) {
	uint offset = getOffSet(fp);

	int rowSize = int((bpp*width*1.0 + 31)/32)*4;

	for(int i = height - 1; i >= 0; i--) {
		for(int j = 0; j < width; j++) {
			float gray = 0;
			uchar red = 0, green = 0, blue = 0;
			if(bpp == 8){
				uchar index = getByte(fp, offset+ i*rowSize + j);
				uint location = 54 + index * 4;
				blue = getByte(fp, location);
				green = getByte(fp, location + 1);
				red = getByte(fp, location + 2);
			} else if(bpp == 24) {
				blue = getByte(fp, offset + i*rowSize + j*3);
				green = getByte(fp, offset+ i*rowSize + j*3 + 1);
				red = getByte(fp, offset + i*rowSize + j*3 + 2);
			}

			gray = 0.3*red + 0.59*green + 0.11*blue;
			if(gray <= 127)
				printf("0");
			else
				printf("1");
		}
		printf("\n");
	}
}
```

g. Convert the image into monochrome array

- Use the algorithm from VII.2 to get location of pixels and turn pixel data into grayscale using VII.1.
- In this function, we will convert from top for ease.
- A new array with size RowSize × height is created to store binary value of each pixel.
- After the conversion, every 8 bits in the array will be convert into a byte using BitToByte function which described at section d.
- Input: file pointer, width, height, bpp, data size pointer
- Output: monochrome data array (8 bits), data size

```
char *GetMonochromeData(FILE *fp, int width, int height, int bpp, unsigned
long *dataSize) {
	uint offset = getOffSet(fp);
```

```
	int rowSize = int((bpp*width*1.0 + 31)/32)*4;

	unsigned long newRowSizeInBits = int((1*width*1.0 + 31)/32)*4*8;

	char *monochromeBits = (char *)calloc(newRowSizeInBits * height,
sizeof(char));

	int progressCounter = 5;
	system("cls");
	printf("Converting... Please wait... (Ctrl+C to break)\nProgress: 0
%%");
	for(int i = 0; i < height; i++) {
		for(int j = 0; j < width; j++) {
			float gray = 0;
			uchar red = 0, green = 0, blue = 0;
			if(bpp == 8){
				uchar index = getByte(fp, offset+ i*rowSize + j);
				uint location = 54 + index * 4;
				blue = getByte(fp, location);
				green = getByte(fp, location + 1);
				red = getByte(fp, location + 2);
			} else if(bpp == 24) {
				blue = getByte(fp, offset + i*rowSize + j*3);
				green = getByte(fp, offset+ i*rowSize + j*3 + 1);
				red = getByte(fp, offset+ i*rowSize + j*3 + 2);
			}

			gray = 0.3*red + 0.59*green + 0.11*blue;

			if(gray <= 127)
				*(monochromeBits + i*newRowSizeInBits + j) = 0;
			else
				*(monochromeBits + i*newRowSizeInBits + j) = 1;
		}
		for(int k = j; k < newRowSizeInBits; k++) {
			*(monochromeBits + i*newRowSizeInBits + j) = 0;
		}
		// Print progress
		int progress = i*100.0/height;
		if(progress % 5 >=4) {
			system("cls");
			printf("Converting... Please wait... (Ctrl+C to
break)\nProgress: %d %%", progress);
		}
	}

	*dataSize = newRowSizeInBits*height/8;

	char *monochromeData = (char *)calloc(*dataSize, sizeof(char));
	for(unsigned long i = 0; i < *dataSize; i++) {
		int byte[8];
		for(unsigned long j = 0; j < 8; j++)
			byte[j] = monochromeBits[8*i+j];
		monochromeData[i] = BitToByte(byte);
	}
	return monochromeData;
}
```

h. Make a bitmap binary image file array [4]

- The function create an entire bitmap file array including header, DIB header and pixel array based on the file format (VI).
- Four bytes values (eg. width, heigh, file size etc.) are created using ToFourByte function which described at section e.
- Input: bitmap array pointer, width, height, binary data pointer, data size
- Output: bitmap array

```
void BMPmake(char *bitmap, int width, int height, char *data, int dataSize)
{
	// -- FILE HEADER -- //

	// bitmap signature
	bitmap[0] = 'B';
	bitmap[1] = 'M';

	// file size
	unsigned long fileSize = 62 + dataSize;
	char fileSizeBytes[4];
	ToFourBytes(fileSize, fileSizeBytes);
	bitmap[2] = fileSizeBytes[3]; // 40 (dib) + 14 (header) + 12 (data)
	bitmap[3] = fileSizeBytes[2];
	bitmap[4] = fileSizeBytes[1];
	bitmap[5] = fileSizeBytes[0];

	// reserved field (in hex. 00 00 00 00)
	for(int i = 6; i < 10; i++) bitmap[i] = 0;

	// offset of pixel data inside the image
	bitmap[10] = 62;
	for(int i = 11; i < 14; i++) bitmap[i] = 0;

	// -- DIB HEADER -- //

	// header size
	bitmap[14] = 40;
	for(int i = 15; i < 18; i++) bitmap[i] = 0;

	// width of the image
	char widthBytes[4];
	ToFourBytes(width, widthBytes);
	bitmap[18] = widthBytes[3];
	bitmap[19] = widthBytes[2];
	bitmap[20] = widthBytes[1];
	bitmap[21] = widthBytes[0];

	// height of the image
	char heightBytes[4];
	ToFourBytes(height, heightBytes);
	bitmap[22] = heightBytes[3];
	bitmap[23] = heightBytes[2];
	bitmap[24] = heightBytes[1];
	bitmap[25] = heightBytes[0];

	// reserved
	bitmap[26] = 1;
	bitmap[27] = 0;
```

```
        // number of bits per pixel
        bitmap[28] = 1; // 1 bit
        bitmap[29] = 0;

        // compression method (no compression here)
        for(int i = 30; i < 34; i++) bitmap[i] = 0;

        // size of pixel data
        char dataSizeBytes[4];
        ToFourBytes(dataSize, dataSizeBytes);
        bitmap[34] = dataSizeBytes[3];
        bitmap[35] = dataSizeBytes[2];
        bitmap[36] = dataSizeBytes[1];
        bitmap[37] = dataSizeBytes[0];

        // unimportant
        for(int i = 38; i < 54; i++) bitmap[i] = 0;

        // color table 0x00000000, 0xffffff00
        bitmap[54] = 0;
        bitmap[55] = 0;
        bitmap[56] = 0;
        bitmap[57] = 0;

        bitmap[58] = 0xff;
        bitmap[59] = 0xff;
        bitmap[60] = 0xff;
        bitmap[61] = 0;

        // -- PIXEL DATA -- //
        for(unsigned long i = 62; i < fileSize; i++) {
                bitmap[i] = data[i - 62];
        }
}
```

i. Write a new binary bitmap image [4]

- The function writes the bitmap file array (created from BMPmake) to a file.
- Input: bitmap array, file size, file location (file name included)

```
void BMPwrite(char *bitmap, unsigned long fileSize, char *location) {
        FILE *file;
        file = fopen(location, "wb");
        for(unsigned long i = 0; i < fileSize; i++) {
                fputc(bitmap[i], file);
        }
        fclose(file);
}
```

2. UI related (Windows only)

- Used for printing the image.
- The functions will scale the window and font size for better printing.
    - Window size will be set maximum as the resolution (needed to press the maximize button).
    - Font size will be set as resolution/image width.
- Windows 7 partially supported (unstable)
  Windows 8, Windows 8.1 untested
  Windows 10, Windows 11 fully supported
- Libraries: stdio.h , windows.h, cwchar.

a. char to wchar

- wChar is used for Unicode UTF-16 strings, a standard/native string encoding used in Win32.
- Input: char*
- Output: wchar_t*

```
static wchar_t* charToWChar(const char* text)
{
    const size_t size = strlen(text) + 1;
    wchar_t* wText = new wchar_t[size];
    mbstowcs(wText, text, size);
    return wText;
}
```

b. Get screen resolution [5]

```
void GetDesktopResolution(int& horizontal, int& vertical) {
      RECT desktop;
      // Get a handle to the desktop window
      const HWND hDesktop = GetDesktopWindow();
      // Get the size of screen to the variable desktop
      GetWindowRect(hDesktop, &desktop);
      // The top left corner will have coordinates (0,0)
      // and the bottom right corner will have coordinates
      // (horizontal, vertical)
      horizontal = desktop.right;
      vertical = desktop.bottom;
}
```

c. Get current font width

```
int GetCurrentFontWidth(){
      CONSOLE_FONT_INFO fontInfo;
      GetCurrentConsoleFont(GetStdHandle(STD_OUTPUT_HANDLE), FALSE, &fontInfo);

      return fontInfo.dwFontSize.X;
}
```

d. Set console window and font size [6] [7]

- Input: width, height, text width, text height, font name

```
void SetConsoleSize(int width, int height, int textWidth, int textHeight, char*
fontName){
      // Font size preset
      int defaultTextSize[3][2] = {{4, 6}, {6, 8}, {8, 8}};

      COORD coord;
      coord.X = width + 2; // Defining our X and
      coord.Y = height + 2;  // Y size for buffer.

      SMALL_RECT rect;

      rect.Top = 0;
      rect.Left = 0;
      rect.Bottom = coord.Y-1; // height for window
      rect.Right = coord.X-1;  // width for window

      HANDLE hwnd = GetStdHandle(STD_OUTPUT_HANDLE); // get handle
      SetConsoleScreenBufferSize(hwnd, coord);       // set buffer size
      SetConsoleWindowInfo(hwnd, TRUE, &rect);       // set window size

      CONSOLE_FONT_INFOEX cfi;
      cfi.cbSize = sizeof(cfi);
      cfi.nFont = 0;
```

```
        cfi.dwFontSize.X = textWidth;         // Width of each character in the font
        cfi.dwFontSize.Y = textHeight;        // Height
        cfi.FontFamily = FF_DONTCARE;
        cfi.FontWeight = FW_NORMAL;
        std::wcscpy(cfi.FaceName, charToWChar(fontName));
        SetCurrentConsoleFontEx(GetStdHandle(STD_OUTPUT_HANDLE), FALSE, &cfi);

        // If set fails (Windows 7), then set using font size preset
        if(GetCurrentFontWidth() != textWidth){
                int i = 0;
                while(textWidth > defaultTextSize[i][0] && i < 3) i++;
                cfi.dwFontSize.X = defaultTextSize[i][0];
                cfi.dwFontSize.Y = defaultTextSize[i][1];
                SetCurrentConsoleFontEx(GetStdHandle(STD_OUTPUT_HANDLE), FALSE,
&cfi);
        }
}
```

e. Set print size

- Font size will be set as resolution/image width.
- Input: image width, image height

```
void SetPrintSize(int width, int height){
        int horizontal, vertical;
        GetDesktopResolution(horizontal, vertical);

        SetConsoleSize(width, height, horizontal/width, horizontal/width, "Raster
Fonts");
}
```

f. Set default console size

- Window width, height: 120, 30
- Font width, height: 8, 16
- Font name: Consolas

```
        void SetDefaultConsoleSize(){
                SetConsoleSize(120, 30, 8, 16, "Consolas");
        }
```

IX. Complete code

1. Main

```
#include <stdio.h>
#include <conio.h>
#include <string.h>

#include "bmpLib.h"
#include "bmpWrite.h"
#include "UILib.h"

char const *title = "                                  ______\n\
 _________          .---\"\"\"      \"\"\"---.\n\
:______.-':      :  .--------------.  :\n\
| ______  |      | :                : |\n\
|:______B:|      | | Welcome to     | |\n\
|:______B:|      | |                | |\n\
|:______B:|      | | Image to       | |\n\
|         |      | |     Monochrome | |\n\
|:_____:  |      | |   Converter    | |\n\
|    ==   |      | :                : |\n\
|       O |      :  '--------------'  :\n\
|       o |      :'---...______...---'\n\
|       o |-.-.-i___/'             \\.-\\n\
|'-.____o_|   '-.   '-...______...-'  `-._\n\
:_________:      `.____________________   `-.___.-.\n\
                .'.eeeeeeeeeeeeeeeee.'.      :___:\n\
              .'.eeeeeeeeeeeeeeeeeeeee.'.\n\
             :_____________________________:\n\n";

char const *end = "             .-\"\"\"-.\n\
            / .===. \\\n\
            \\/ 6 6 \\/\n\
            ( \\___/ )\n\
 _____ooo__\\_____/___________\n\
/Thanks for using my program!  \\\n\
| Creator: Luong Trien Thang    |\n\
| Semester - Class: 212 - TT03  |\n\
| Lecturer: Dang Thanh Tin      |\n\
|           Tran Anh Khoa       |\n\
```

```
|               15 May 2022   |\n\
 \\_____________________ooo_______/\n\
             |  |  |\n\
             |_ | _|\n\
             |  |  |\n\
             |__|__|\n\
             /-'Y'-\\\n\
            (__/ \\__)";


int main() {
main: {
            SetConsoleTitle("Image to Monochrome");                 // Set console title
            system("cls");                                          // Clear screen
            SetDefaultConsoleSize();                                // Set default console size
            fflush(stdin);                                          // Clear input buffer(s)
            printf(title);                                          // Print title art

            char pathInput[265] = "";                               // path string
            char path[260] = "";                                    // real path
            printf("Please input the file locaion (drag and drop is supported).\nType h or help to show the
instructions.\nType q or quit to end the program.\n");
            gets(pathInput);                                        // get path string

            printf("\n");

            if(strcmp(pathInput, "h") == 0 || strcmp(pathInput, "help") == 0) {
                  system("cls");
                  printf(title);

                  printf("INSTRUCTIONS:\n");
                  printf("The program only accepts input of 8bpp and 24bpp bitmap image.\n");
                  printf("\n");
                  printf("For printing:\n");
                  printf("\tConsole and font will be resized for better viewing.\n");
                  printf("\tPress <Enter> once, then please maximize the window by clicking on the middle icon at
the top right corner.\n");
                  printf("\tPress <Enter> again to print monochrome version of the image.\n");
                  printf("\tPress <Enter> after printing to restore console size and font.\n");
```

```
                printf("\n");
                printf("For converting:\n");
                printf("\tThe image will be converted to monochrome bitmap file and saved at the same location as
the input.\n");
                system("pause");
                goto main;
        } else if(strcmp(pathInput, "q") == 0 || strcmp(pathInput, "quit") == 0) {
                goto end;
        }
        if(pathInput[0] == '"')   // If the path contains " (double quotes), remove it then copy to path
                strncpy(path, pathInput + 1, strlen(pathInput) - 2);
        else
                strcpy(path, pathInput);                                        // Else, just copy

        FILE *fp=fopen(path,"r");                                               // Open file

        if(fp == NULL) {                                                        // If file not found
                printf("ERROR: File not found\n");
                goto restartPrompt;
        }

        if(!IsBitMap(fp)) {                                                     // Check whether a bitmap file
                printf("ERROR: Format error. Or not a bitmap file!\n");
                fclose(fp);
                goto restartPrompt;
        }

        int width = getWidth(fp);                                               // Get width, height, bpp
        int height = getHeight(fp);
        int bpp = getBpp(fp);

        printf("File path: %s\nSize: %dpx x %dpx\nBit per pixel: %d\n", path, width, height, bpp);

        if(bpp == 1){                                                   // If bpp = 1 (monochrome, binary image)
                printf("ERROR: The file is already in monochrome (1bpp).\n");
                fclose(fp);
                goto restartPrompt;
        }
        else if(bpp != 8 && bpp != 24) {                                // Else if bpp is not 8 or 24
```

```
            printf("ERROR: The file is not in 8bpp or 24bpp.\n");
            fclose(fp);
            goto restartPrompt;
        }


        printf("Do you want to print image or convert to monochrome? (p: print, c: convert) ");
ask:
        char pc = getch();                                  // Get character from keyboard
        printf("\n");
        if(pc == 'p') {                                     // PRINT!
            system("pause");
            SetPrintSize(width, height);                    // Set window and font size

            getch();
            printImage(fp, width, height, bpp);             // Print binary image to console

            getch();
            system("cls");                                  // Print end, clear screen
            SetDefaultConsoleSize();                        // Revert console size when done
        } else if (pc == 'c') {                             // CONVERT!
            unsigned long dataSize;
            char *dataPtr;
            dataPtr = GetMonochromeData(fp, width, height, bpp, &dataSize);  // Get monochrome data

            unsigned long fileSize = 62 + dataSize;// Filesize = 62 (file header + DIB header) + dataSize
            char bitmap[fileSize];

            char outputLocation[260] = "";
            strncpy(outputLocation, path, strlen(path) - 4);    // Remove ".bmp" at the end of the path
            strcat(outputLocation, "_mono.bmp");                // Add "_mono.bmp" to the end of the path

            BMPmake(bitmap, width, height, dataPtr, dataSize);  // Make a bitmap file array
            BMPwrite(bitmap, fileSize, outputLocation);         // Write the array to the location

            free(dataPtr);                                      // Free the bitmap array
            system("cls");
            printf("Conversion completed. Your file is located at\n%s", outputLocation);
            printf("\n");
```

```
            } else {                                                    // If not "p" or "c"
                  printf("Please type p to print or c to convert. ");
                  goto ask;
            }
      }

restartPrompt:{
            printf("Restart program? (y/[n]) ");
            if(getch() == 'y')
                  goto main;
      }

end: {
            system("cls");
            printf(end);
      }

      return 0;
}
```

2. bmpLib

For read and process image.

a. bmpLib.h

```
#include "bmpLib.cpp"

int IsBitMap(FILE *fp);
int getWidth(FILE *fp);
int getHeight(FILE *fp);
ushort getBit(FILE *fp);
uint getOffSet(FILE *fp);
uchar getByte(FILE *fp, int location);
int printImage(FILE *fp, int width, int height);
```

b. bmpLib.cpp

```
#include <stdio.h>
#include <malloc.h>
#include <iostream>
#define BM 19778
#define ushort unsigned short
#define uint unsigned int
```

```c
#define uchar unsigned char

//Judge whether it is a bitmap, in 0-1 bytes
int IsBitMap(FILE *fp) {
	ushort s;
	fread(&s,1,2,fp);
	return s==BM ? 1 : 0;
}

//Get the width of the picture, in 18-21 bytes
int getWidth(FILE *fp) {
	int width;
	fseek(fp,18,SEEK_SET);
	fread(&width,1,4,fp);
	return width;
}

//Get the height of the picture, in 22-25 bytes
int getHeight(FILE *fp) {
	int height;
	fseek(fp,22,SEEK_SET);
	fread(&height,1,4,fp);
	return height;
}

//Get the number of bits of each pixel in 28-29 bytes
ushort getBit(FILE *fp) {
	ushort bit;
	fseek(fp,28,SEEK_SET);
	fread(&bit,1,2,fp);
	return bit;
}

//Get the starting position of data, in 10-13 bytes
uint getOffSet(FILE *fp) {
	uint OffSet;
	fseek(fp,10L,SEEK_SET);
	fread(&OffSet,1,4,fp);
	return OffSet;
```

```
}

//Get the byte in a location
uchar getByte(FILE *fp, int location) {
	uchar byte;
	fseek(fp,location,SEEK_SET);
	fread(&byte,1,1,fp);
	return byte;
}

void printImage(FILE *fp, int width, int height, int bpp) {
	int i,j;

	int size = width * height;
	uint offset = getOffSet(fp);
	ushort bit = getBit(fp);

	int rowSize = int((bpp*width*1.0 + 31)/32)*4;

	for(int i = height - 1; i >= 0; i--) {
		for(int j = 0; j < width; j++) {
			float gray = 0;
			uchar red = 0, green = 0, blue = 0;
			if(bpp == 8){
				uchar index = getByte(fp, offset + i*rowSize + j);
				uint location = 54 + index * 4;
				blue = getByte(fp, location);
				green = getByte(fp, location + 1);
				red = getByte(fp, location + 2);
			} else if(bpp == 24) {
				blue = getByte(fp, offset + i*rowSize + j*3);
				green = getByte(fp, offset + i*rowSize + j*3 + 1);
				red = getByte(fp, offset + i*rowSize + j*3 + 2);
			}

			gray = 0.3*red + 0.59*green + 0.11*blue;
			if(gray <= 127)
				printf("0");
			else
```

```
                        printf("1");
                }
                printf("\n");
        }
}

char BitToByte(int *num) {
        char result = 0;
        for (int i = 0; i < 8; ++i )
                result |= (num[i] == 1) << (7 - i);

        return result;
}

char *GetMonochromeData(FILE *fp, int width, int height, int bpp, unsigned long *dataSize) {
        uint offset = getOffSet(fp);

        int rowSize = int((bpp*width*1.0 + 31)/32)*4;

        unsigned long newRowSizeInBits = int((1*width*1.0 + 31)/32)*4*8;

        char *monochromeBits = (char *)calloc(newRowSizeInBits * height, sizeof(char));

        int progressCounter = 5;
        system("cls");
        printf("Converting... Please wait... (Ctrl+C to break)\nProgress: 0 %%");
        for(int i = 0; i < height; i++) {
                for(int j = 0; j < width; j++) {
                        float gray = 0;
                        uchar red = 0, green = 0, blue = 0;
                        if(bpp == 8){
                                uchar index = getByte(fp, offset+ i*rowSize + j);
                                uint location = 54 + index * 4;
                                blue = getByte(fp, location);
                                green = getByte(fp, location + 1);
                                red = getByte(fp, location + 2);
                        } else if(bpp == 24) {
                                blue = getByte(fp, offset + i*rowSize + j*3);
                                green = getByte(fp, offset+ i*rowSize + j*3 + 1);
```

```
                        red = getByte(fp, offset+ i*rowSize + j*3 + 2);
                }

                gray = 0.3*red + 0.59*green + 0.11*blue;

                if(gray <= 127)
                        *(monochromeBits + i*newRowSizeInBits + j) = 0;
                else
                        *(monochromeBits + i*newRowSizeInBits + j) = 1;
        }
        for(int k = j; k < newRowSizeInBits; k++) {
                *(monochromeBits + i*newRowSizeInBits + j) = 0;
        }
        // Print progress
        int progress = i*100.0/height;
        if(progress % 5 >=4) {
                system("cls");
                printf("Converting... Please wait... (Ctrl+C to break)\nProgress: %d %%", progress);
        }
    }

    *dataSize = newRowSizeInBits*height/8;

    char *monochromeData = (char *)calloc(*dataSize, sizeof(char));
    for(unsigned long i = 0; i < *dataSize; i++) {
        int byte[8];
        for(unsigned long j = 0; j < 8; j++)
                byte[j] = monochromeBits[8*i+j];
        monochromeData[i] = BitToByte(byte);
    }
    return monochromeData;
}
```

3. bmpWrite

For writing bitmap file.

a. bmpWrite.h

```
#include "bmpWrite.cpp"

void BMPmake(char *bitmap, int width, int height, char *data, int dataSize);
void BMPwrite(char *bitmap, int fileSize);
```

```
void WriteFile(char *data);
```

b. bmpWrite.cpp

```
#include <stdio.h>

void ToFourBytes(unsigned long n, char bytes[4]){
	bytes[0] = (n >> 24) & 0xFF;
	bytes[1] = (n >> 16) & 0xFF;
	bytes[2] = (n >> 8) & 0xFF;
	bytes[3] = (n >> 0) & 0xFF;
}

void BMPmake(char *bitmap, int width, int height, char *data, int dataSize) {
	// -- FILE HEADER -- //

	// bitmap signature
	bitmap[0] = 'B';
	bitmap[1] = 'M';

	// file size
	unsigned long fileSize = 62 + dataSize;
	char fileSizeBytes[4];
	ToFourBytes(fileSize, fileSizeBytes);
	bitmap[2] = fileSizeBytes[3]; // 40 (dib) + 14 (header) + 12 (data)
	bitmap[3] = fileSizeBytes[2];
	bitmap[4] = fileSizeBytes[1];
	bitmap[5] = fileSizeBytes[0];

	// reserved field (in hex. 00 00 00 00)
	for(int i = 6; i < 10; i++) bitmap[i] = 0;

	// offset of pixel data inside the image
	bitmap[10] = 62;
	for(int i = 11; i < 14; i++) bitmap[i] = 0;

	// -- DIB HEADER -- //

	// header size
	bitmap[14] = 40;
	for(int i = 15; i < 18; i++) bitmap[i] = 0;
```

```
// width of the image
char widthBytes[4];
ToFourBytes(width, widthBytes);
bitmap[18] = widthBytes[3];
bitmap[19] = widthBytes[2];
bitmap[20] = widthBytes[1];
bitmap[21] = widthBytes[0];

// height of the image
char heightBytes[4];
ToFourBytes(height, heightBytes);
bitmap[22] = heightBytes[3];
bitmap[23] = heightBytes[2];
bitmap[24] = heightBytes[1];
bitmap[25] = heightBytes[0];

// reserved
bitmap[26] = 1;
bitmap[27] = 0;

// number of bits per pixel
bitmap[28] = 1; // 1 bit
bitmap[29] = 0;

// compression method (no compression here)
for(int i = 30; i < 34; i++) bitmap[i] = 0;

// size of pixel data
char dataSizeBytes[4];
ToFourBytes(dataSize, dataSizeBytes);
bitmap[34] = dataSizeBytes[3];
bitmap[35] = dataSizeBytes[2];
bitmap[36] = dataSizeBytes[1];
bitmap[37] = dataSizeBytes[0];

// unimportant
for(int i = 38; i < 54; i++) bitmap[i] = 0;
```

```
	// color table 0x00000000, 0xffffff00
	bitmap[54] = 0;
	bitmap[55] = 0;
	bitmap[56] = 0;
	bitmap[57] = 0;

	bitmap[58] = 0xff;
	bitmap[59] = 0xff;
	bitmap[60] = 0xff;
	bitmap[61] = 0;

	// -- PIXEL DATA -- //
	for(unsigned long i = 62; i < fileSize; i++) {
		bitmap[i] = data[i - 62];
	}
}

void BMPwrite(char *bitmap, unsigned long fileSize, char *location) {
	FILE *file;
	file = fopen(location, "wb");
	for(unsigned long i = 0; i < fileSize; i++) {
		fputc(bitmap[i], file);
	}
	fclose(file);
}
```

4. UILib

a. UILib.h

```
#include "UILib.cpp"

void GetDesktopResolution(int& horizontal, int& vertical);
void SetConsoleSize();
void SetDefaultConsoleSize();
void SetPrintSize(int width, int height);
int GetCurrentFontWidth();
```

b. UILib.cpp

```
#include <windows.h>
#include <stdio.h>
#include <cwchar>
#include "wtypes.h"
```

```
void GetDesktopResolution(int& horizontal, int& vertical) {
	RECT desktop;
	// Get a handle to the desktop window
	const HWND hDesktop = GetDesktopWindow();
	// Get the size of screen to the variable desktop
	GetWindowRect(hDesktop, &desktop);
	// The top left corner will have coordinates (0,0)
	// and the bottom right corner will have coordinates
	// (horizontal, vertical)
	horizontal = desktop.right;
	vertical = desktop.bottom;
}

static wchar_t* charToWChar(const char* text)
{
    const size_t size = strlen(text) + 1;
    wchar_t* wText = new wchar_t[size];
    mbstowcs(wText, text, size);
    return wText;
}

int GetCurrentFontWidth(){
	CONSOLE_FONT_INFO fontInfo;
	GetCurrentConsoleFont(GetStdHandle(STD_OUTPUT_HANDLE), FALSE, &fontInfo);

	return fontInfo.dwFontSize.X;
}

void SetConsoleSize(int width, int height, int textWidth, int textHeight, char* fontName){
	int defaultTextSize[3][2] = {{4, 6}, {6, 8}, {8, 8}};

	COORD coord;
	coord.X = width + 2;                    // Defining our X and
	coord.Y = height + 2;                   // Y size for buffer.

	SMALL_RECT rect;

	rect.Top = 0;
```

```
        rect.Left = 0;
        rect.Bottom = coord.Y-1;                    // height for window
        rect.Right = coord.X-1;                     // width for window

        HANDLE hwnd = GetStdHandle(STD_OUTPUT_HANDLE); // get handle
        SetConsoleScreenBufferSize(hwnd, coord);       // set buffer size
        SetConsoleWindowInfo(hwnd, TRUE, &rect);       // set window size

        CONSOLE_FONT_INFOEX cfi;
        cfi.cbSize = sizeof(cfi);
        cfi.nFont = 0;
        cfi.dwFontSize.X = textWidth;                  // Width of each character in the font
        cfi.dwFontSize.Y = textHeight;                 // Height
        cfi.FontFamily = FF_DONTCARE;
        cfi.FontWeight = FW_NORMAL;
        std::wcscpy(cfi.FaceName, charToWChar(fontName));
        SetCurrentConsoleFontEx(GetStdHandle(STD_OUTPUT_HANDLE), FALSE, &cfi);

        if(GetCurrentFontWidth() != textWidth){
                int i = 0;
                while(textWidth > defaultTextSize[i][0] && i < 3) i++;
                cfi.dwFontSize.X = defaultTextSize[i][0];
                cfi.dwFontSize.Y = defaultTextSize[i][1];
                SetCurrentConsoleFontEx(GetStdHandle(STD_OUTPUT_HANDLE), FALSE, &cfi);
        }
}

void SetPrintSize(int width, int height){
        int horizontal, vertical;
        GetDesktopResolution(horizontal, vertical);

        SetConsoleSize(width, height, horizontal/width, horizontal/width, "Raster Fonts");
}

void SetDefaultConsoleSize(){
        SetConsoleSize(120, 30, 8, 16, "Consolas");
}
```

X. Appendix

The source code will be available on Github after 15th May, 2022 via this link.

XI. References

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