

CS213: Object Oriented Programming
Assignment 1 (7 marks + 3 bonus) – Version 1.0



Cairo University, Faculty of Computers
and Artificial Intelligence

**FACULTY OF COMPUTERS AND AI,
CAIRO UNIVERSITY**

CS213: Programming II
Year 2022-2023
First Semester

Assignment 1 – Version 1.0

Course Instructors:
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Revision History

Version 1.0

By Dr Mohammed El-Ramly 10 Sep 2023

Main Doc

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Objectives

This assignment reviews CS112 (Programming I) concepts and trains students on problem solving using C++ 2D arrays and readymade library code, written by others for us to use into our programs.

Preparation

1. Review C++ syntax and refresh your C++ knowledge.
2. Read this quick tutorial <https://www.codesdope.com/cpp-introduction/>
3. Create a **private GitHub** repo for the project and **use it for development**.

Introduction

Computer vision / image processing algorithms are behind a wide variety of technologies that we use in our everyday lives. Visit the page <https://ai.stanford.edu/~syeeung/cvweb/applications.html> to get an overview of a few applications for this field. Examples are: **image filtering**, which is an important part of photo editors and applications like Potoshop or Instagram; **image matching**, which is used for retrieval and stitching together panoramas; **image segmentation**, which is implemented in the technology behind green screens in filmmaking industry; & **image recognition**, which is required for products like Google image search and Facebook automatic face tagging.

In this assignment, you will develop an image processing tool that can apply different filters (changes) to a given gray (and colored for bonus) bit map image of size 256 x 256. You are given:

- (1) A small library with four functions for loading the pixels of the image into a 2D or 3D array.
The library consists of two files **bmplib.cpp** and **bmplib.h**. You need to include this line at the top of you program to include the library with your code. Put files **bmplib.h** and **bmplib.cpp** in the same directory as your code.

```
#include "bmplib.cpp"
```

The library has two constants defined for you to use in the program. These are:

```
SIZE = 256          // Represents image size of SIZE x SIZE. Needed for all images
RGB = 3             // Number of color bytes for colored images: 3 bytes=24 bits
                    // Needed only for colored images (bonus)
```

The functions available from this library are:

```
// Read pixels from a colored bmp image filename to a SIZE x SIZE x RGB array,
// for example (256 x 256 x 3), named inputImage
int readRGBBMP(const char* filename, unsigned char inputImage[][SIZE][RGB]);

// Write full-color image to the file specified by filename, from 3D matrix
// outputImage of size SIZE x SIZE x RGB, for example (256 x 256 x 3)
int writeRGBBMP(const char* filename, unsigned char outputImage[][SIZE][RGB]);

// Read pixels from a gray scale bmp image file specified by filename to a 2D
// SIZE x SIZE array, for example (256 x 256), named inputImage
int readGSBMP(const char* filename, unsigned char image[][SIZE]);

// Write a gray scale image to the file specified by filename, from 2D matrix
// outputImage of size SIZE x SIZE, for example (256 x 256)
int writeGSBMP(const char* filename, unsigned char outputImage[][SIZE]);
```

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- (2) You are also given a set of colored and gray images to test your program with. To see an image, open it with MS Photos or MS Paint. (Library does not have functions to display images)
- (3) Finally, you are given a small demo program demo2.cpp to show how to use the given functions to open and load an image. The demo does not apply any filters; it just stores the opened image in another file. Images must be in the same folder and directory where the program is. You enter the image name without .bmp.

A pixel in a gray scale bitmap image is stored in one byte with a value between 0 = and 255 = . A pixel in a colored bitmap image is stored in 3 bytes representing Red Green and Blue values of the pixel's color ■ ■ ■. Each value is between 0 (color does not exit) and 255 (max value for this color)

You will develop a program that displays a menu of choices for the user continuously until the user chooses exit. The menu will allow the user to load an image and choose the filter to apply. The user can choose save to store the filter after specifying the name of the target file. The menu is structured according to this hierarchy. **Text in red is the user input.** Some menu options have more choices to select from.

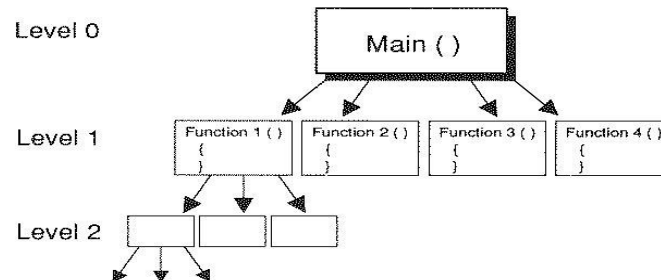
| | |
|---|--|
| Ahlan ya user ya habibi ☺ | |
| Please enter file name of the image to process: | |
| elephant | |
| Please select a filter to apply or 0 to exit: | |
| 1- Black & White Filter | |
| 2- Invert Filter | |
| 3- Merge Filter | Please enter name of image file to merge with: |
| 4- Flip Image | photographer |
| 5- Darken and Lighten Image | Flip (h)orizontally or (v)ertically ? |
| 6- Rotate Image | Do you want to (d)arken or (l)ighten? |
| 7- Detect Image Edges | Rotate (90), (180) or (360) degrees? |
| 8- Enlarge Image | Which quarter to enlarge 1, 2, 3 or 4? |
| 9- Shrink Image | Shrink to (1/2), (1/3) or (1/4)? |
| a- Mirror 1/2 Image | Mirror (l)eft, (r)ight, (u)pper, (d)own side? |
| b- Shuffle Image | New order of quarters ? 4 3 2 1 |
| c- Blur Image | |
| d- Crop Image | Please enter x y l w: 20 20 100 120 |
| e- Skew Image Right | Please enter degree to skew right: 20 |
| f- Skew Image Up | Please enter degree to skew Up: 40 |
| s- Save the image to a file | Please enter target file name: elephantBW |
| 0- Exit | |



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For your program, you should develop each filter in a separate function. Deliver a **system diagram** showing the **different functions** of the system and **their relation** to each other as shown in the figure below.



Instructions

1. It is very important to collect course work marks in order to pass easily and get a good grade. من المهم للغاية حسن أداء أعمال السنة لتنجح بسهولة و تحصل على تقدير مرتفع
2. These instructions must be followed to get the full marks. يجب اتباع هذه التعليمات بكل دقة
3. **Submission is done in two stages:**
 - **PART 1 Deadline Tuesday 10 Oct 2023 – Submit solution v1.0 (6 filters)**
 - **PART 2 Deadline Tuesday 17 Oct April 2023 – Submit solution v2.0 (full solution)**
4. Students will form teams of **three students from the same lab section** (Sections 1 & 2 together, 3 & 4 together, etc.).
5. Please submit **only work that you did yourself**. If you copy work from your friend or book or the net **you will fail the course**. تسليم حلول منقولة من أى مصدر أو مخالفة بالذكاء الاصطناعي يؤدي إلى الرسوب فى هذا المقرر، لا تغش الحل أو تنقله من أى مصدر و تعالى و اسألنى فى أى شئ لا تفهمه نقل أى جزء و لو صغير من الكود من زميل أو أى مصدر أو إعطاء أى كود و لو قليل لأى زميل يعتبر غشاً و يحصل صاحبه على سالب الدرجة.

Task 1 (1 mark) – Group Task

- Each team will develop together the **menu display** function and the **load** and **save** functions. They will work on their individual tasks and then **must integrate and test all the functions** of the program together. If they deliver separate programs not integrated ones, they lose marks.
- Team will create a **private** repo on GitHub and maintain all needed files there **and do their development through the repository** via work cycles of **init, clone, change, add, commit, remote add origin, push**

Task 2 (5 marks) – Individual / Group Task

Each team member will develop 5 individual filters (tasks or functions). Team will divide the work as follows: the student with the smallest last digit in his ID does **filters 1, 4, 7, a, d** the next does **filters 2, 5, 8, b, e** and the student with largest last digit in his ID does **filters 3, 6, 9, c, f**.

There is an online image processing tool that you can try. <http://pinetools.com/grayscale-image>

Student with smallest ID does **filters 1, 4, 7, a, d**

Student with middle ID does **filters 2, 5, 8, b, e**

Student with biggest does **filters 3, 6, 9, c, f**

Team should find more pictures of gray-scale bitmap 256 x 256 to test on.



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Project: Gray Scale Image Processor

An image processing (or photo editing) software like Photo Shop allows you to load an image (like the photographer image here) and apply some changes (called filters) to image and then save it again.

يقوم برنامج معالجة الصور مثل الفوتوشوب مثلاً بتحميل الصورة المرغوبة وإتاحة مجموعة من العمليات تسمى المرشحات للتنفيذ على هذه الصور ، كل منها ينتج عمل تغيير في الصورة ، و فيما يلي شرح للمرشحات المطلوبة و و في أعلام شرح كيف ستقسم على فريق العمل و ما نصيب كل عضو.

Filter 1: Black and White Image

If you apply this function to the loaded image, it will produce another version of the image that is black and white.

You can do this by calculating the average gray level for all pixels in the image. And then every pixel above the average is turned to white (255) and every pixel below average is turned to black (0).

Filter 2: Invert Image

If you apply this function to the loaded image, it will produce the negative of the image and you can store it in the file name you give.

The negative has every black pixel turned to white and every white pixel turned to black and every gray pixel is turned to opposite level of brightness ($255 - \text{pixel value}$).

مرشح العكس: هذا المرشح يعكس الصورة و يعرض النيجاتيف.

Filter 3: Merge Images

In this function, you will be asked to enter the name of another image. Then the program will load this image. The program will create a new image, with every pixel equal the average gray level of the corresponding pixels in the images to merge.

مرشح الدمج: سيحمل البرنامج صورة ثانية بجانب الصور التي حملها أولاً و سينشئ صورة كل نقطة فيها تمثل متوسط مستوى الرمادي في النقطتين المناظرتين في في الصورتين المدمجتين.

Filter 4: Flip Image

This filter allows the user to flip the image horizontally or vertically, as if it is reflected on a mirror. مرشح العكس: ينتج هذا المرشح عكس الصورة على مرآة أفقياً أو رأسياً بحسب اختيار المستخدم.

Filter 5: Rotate Image

This filter allows the user to rotate the image clockwise by 90° , 180° or 270° as the user chooses. مرشح الدوران: هذا المرشح يدير الصورة باتجاه دوران الساعة 90° أو 180° أو 270° درجة





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Filter 6: Darken and Lighten Image

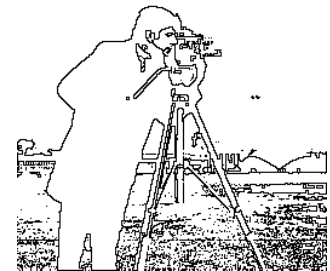
This filter allows the user to make the image darker or lighter by 50%

مرشح الإضاءة : يتيح هذا المرشح تفتيح و تغميق الصورة بنسبة 50% بمعنى زيادة أو تقليل إضاءة الصور بهذه النسبة.



Filter 7: Detect Image Edges

This function finds the edges of the drawings in the image and turns the image into a skeleton version of the original as if it is drawn with pencil without coloring as shown.



Filter 8: Enlarge Image

This filter allows the user to enlarge one of the four quarters of the image into a separate new image.

مرشح التكبير: هذا المرشح يسمح بتكبير أحد أرباع الصورة الأربعة إلى صورة مستقلة 256 في 256 بكسل



Filter 9: Shrink Image

This filter allows the user to shrink the image dimensions to 1/2, 1/3 or 1/4 the original dimensions.

مرشح التصغير: يتيح هذا المرشح تصغير الصورة إلى نصف أو ثلث أو ربع أبعادها الأصلية.



Filter a: Mirror Image

This filter mirrors 1/2 of the image as seen here in order: Left 1/2, Right 1/2, Upper 1/2 and Lower 1/2.

مرشح المراة: يعكس نصف الصورة الأيسر أو الأيمن أو الأعلى أو الأسفل.





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Filter b: Shuffle Image

Assume the image consist of 4 quarters as shown, the user enters the order he wants to the quarters in the new image. **Wrong input is rejected**. Assume he entered **4 3 2 1** he

gets image 1. Or if he enters **3 1 4 2** he gets image 2. User can enter any order he likes.

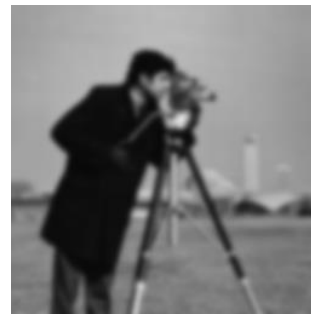
مرشح اللخبطه: هذا المرشح يسمح بإدخال ترتيب جديد لأرباع الصورة فيتم لخبطتها وفق هذا الترتيب الجديد.



Filter c: Blur Image

This filter produces a blurry version of the image.

مرشح الضبابية: هذا المرشح يجعل الصورة ضبابية غير واضحة.



Filter d: Crop Image

This filter allows entering an x, y position and cutting a square of length and width l, w to keep and removing the rest.

مرشح القطع: هذا المرشح يسمح بإدخال أبعاد نقطة على الصورة و أبعاد المستطيل المربع المراد إبقاؤه و حذف الباقي.



Filter e, f: Skew Horizontally / Vertically

This filter skews the image to the right or up with a given degree and compresses it to stay 256x256.

مرشحا الانحراف الأفقي و الرأسى: هذان المرشح يأخذان درجة الانحراف المطلوبة و يقومان بعوج الصورة فى الاتجاه المطلوب مع ضغطها لتظل 256 فى 256.



Task 3 (1 mark) – Individual Task

1. This is to be done by each individual student.
2. Create an account on <https://www.typingclub.com> and log in.
3. Do the **first 200 lessons** and practice for at least 3~5 hours.
4. Make a plan of how you will increase your typing speed and what level you plan to reach (how many words per minute)
5. If your level in typing is high, start from the max lesson you know and do **200 lessons** after.

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Bonus Project: Colored Image Processor (3 marks)

This is a bonus project for the whole team. The will develop a similar program using the same library that does the same functions on **colored images**.

Team must:

- 1) **Develop the all the filters for colored images.**
- 2) **WORK TOGETHER and divide work equally.**
- 3) **Find more pictures of colored bitmap 256 x 256 to test on.**



Submitting the Solution

1. Team will submit into Google Classroom the following:

On Tuesday 10 Oct 2023

- A zip file with the following called:

CS213-2023-YourID-YourID-YourID-A1-Part1.cpp

1. A cpp file with the source code of the integrated program with 6 filers implemented.
2. File should have a header with names of the team and their IDs and emails. It should have enough comments explaining the code.
3. **DO NOT INCLUDE exe files or project files.** Include the library files sent to you and any necessary files to work the program. Max submission size is 2.5 MB

On Tuesday 17 Oct 2022

- A zip file with these 3 files. Name of zip file is:

CS213-2023–SectionNumber-YourID-YourID-YourID-A1-FULL.zip

1. A cpp file with the source code of the integrated program with 15 filters implemented. Name the file

CS213-2023– SectionNumber-YourID-YourID-YourID-A1-FULL.cpp

2. **DO NOT INCLUDE exe files or project files.** Include the library files sent to you and any necessary files to work the program. Max submission size is 2.5 MB.
3. A pdf file with typlingclub.com screen shots of the last level you achieved, **screen shots showing using Git work flow and steps to collaborate on the project**, the function decomposition diagram, algorithms of the filters **and team names and IDs**. Name it:

CS213-2023– SectionNumber-YourID-YourID-YourID-A1-FULL.pdf

4. (Optional) A cpp file with the source code of the whole integrated bonus program:

CS213-2023– SectionNumber-YourID-YourID-YourID-A1Bonus.pdf



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Program Header

Each program should start with a header explaining what it is and who authored it. It should also have the date.

- لابد أن يحتوى كل برنامج على تعليقات وإيضاحات كافية و أن يبدأ بالتعليق التالي:

```
// FCAI - OOP Programming - 2023 - Assignment 1
// Program Name:          xxxxxx.cpp
// Last Modification Date: xx/xx/xxxx
// Author1 and ID and Group:  xxxxx xxxxx
// Author2 and ID and Group:  xxxxx xxxxx
// Author3 and ID and Group:  xxxxx xxxxx
// Teaching Assistant:      xxxxx xxxxx
// Purpose:.....
```

Coding Style

The program should follow proper coding style for C++ as shown below.

1- Variable names must be in mixed case starting with lower case or all lower case separated by _.

```
line, savingsAccount, n_pixels, gray_level, is_valid
```

2. The prefix *n* should be used for variables representing a number of objects.

```
nPoints, nLines, n_lines,
```

3. Iterator variables should be called *i*, *j*, *k* etc.

```
for (int i = 0; i < nTables); i++) { : }
```

4. The prefix *is* should be used for Boolean variables and methods.

```
isSet, isVisible, isFinished, is_found, is_open
```

5. The conditional should be put on a separate line.

```
if (isDone) // NOT: if (isDone) statement1;
    statement1;
```

6. Block *layout should be as illustrated in example 1 below (recommended) or example 2

```
while (!done) {                               while (!done)
    doSomething();                             {
    done = moreToDo();                         doSomething();
}                                              done = moreToDo();
                                              }
```

(Taken from <http://geosoft.no/development/cppstyle.html>)



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Academic Honesty Declaration

يملأ كل فريق هذا القسم و يقدمه للمعيد. TA. Each group should fill this form and submit to the TA.

| | |
|---|--|
| Faculty of Computers and AI | جامعة القاهرة – كلية الحاسبات و الذكاء الاصطناعي |
| OOP Programming– 2023 - Assignment 1 | الفرقة الأولى – برمجة الشيئية – 2023 - المسألة 1 |
| Group المجموعة | Date التاريخ |
| Name..... | اسم الطالب..... |
| Group المجموعة | Date التاريخ |
| Name..... | اسم الطالب..... |
| Group المجموعة | Date التاريخ |
| Name..... | اسم الطالب..... |
| We give oath that we have fully authored all the programs we submitted for Assignment 1 and we did not copy work from the net, from other colleagues or from any sources. | |
| نقسم بالله العظيم نحن الموقعون أدناه أننا قد قمنا بتنفيذ هذه المسألة Assignment 1 بأنفسنا و لم نغش مطلقا أو ننقل جهد غيرنا للحصول على درجات بغير حق أو نعطي مجهودنا للآخرين بغير حق و الله على ما نقول شهيد (من يتخرج من صيغة القسم لسبب ديني يكتب ما يناسب معتقده) | |
| Signature | التوقيع |
| Signature | التوقيع |
| Signature | التوقيع |

Marking Criterion

- | | |
|------------|--|
| 1 marks | For every ONE integrated program with ONE master menu |
| 1 mark x 5 | For each working filter x 5 filters (each student has different filters) |
| 1 mark | For evidence and screen shots that you achieved up to 200 lessons in typing club. |
| -1 mark | If not using good coding style and headers |
| 3 marks | Correct & working bonus project with all filters implemented for colored pictures |