

**FACULTY OF COMPUTERS AND AI,
CAIRO UNIVERSITY****CS112: Structured Programming****Year 2023-2024****Second Semester****Assignment 3 + Grand Competition – Version 7.0****Course Instructors:****Dr. Mohammad El-Ramly****Revision History**

| | | | |
|--------------------|-------------------------|---------------|------------------------------------------|
| Version 1.0 | By Dr Mohammed El-Ramly | 30 March 2018 | Main Doc |
| Version 2.0 | By Dr Mohammed El-Ramly | 2 April 2018 | Bonus added |
| Version 3.0 | By Dr Mohammed El-Ramly | 9 April 2018 | Added more filters |
| Version 4.0 | By Dr Mohammed El-Ramly | 25 March 2022 | Adapted for 21/22 |
| Version 5.0 | By Dr Mohammed El-Ramly | 31 March 2022 | Less 7/4 delivery |
| Version 6.0 | By Dr Mohammed El-Ramly | 18 March 2024 | Youssef/Nada/NwLibrary Total upgrade. |
| Version 7.0 | By Dr Mohammed El-Ramly | 28 March 2024 | Minor chngs/Library updte |

CS112: Structured Programming

Assignment 3 (8+ 2 + 3) + Grand Competition – Version 7.0



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Objectives

This assignment reviews CS112 (Programming I) concepts and trains students on problem solving using C++ arrays and readymade library code, written by others for us to use in our programs and encourages them to learn the basic ideas of image processing.

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/~syyeung/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 Photoshop 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 and **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 image of any size and the four popular image formats. You are given:

- (1) A small library with four functions for loading the pixels of the image into an array. The library has two files **stb_image.h** and **stb_image_write.h** and a file for class **image** called **Image_Class** **version 2**. You **only** need to include this line at the top of your program to include the library with your code. Put these files in the same directory as your code.

```
#include "Image_Class.h"
```

- (2) A set of images to work on (but you can bring your own).

- (3) A description of the filters required.

- (4) A **playlist to show how to use the library**:

<https://www.youtube.com/playlist?list=PLT8-zF1fr5DiXUgC7GXaFWnMVgdoAFLZM>

- (5) A **FAQ page** answers many of the questions you may have.

<https://docs.google.com/document/d/1zZq50D00oFrj9NsFo0dEXAOX66dnLQB5-OtRz3xLNE0/edit?usp=sharing>

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 image resulting from applying the filter after specifying the name of the target file. The program will loop until the user chooses exit.

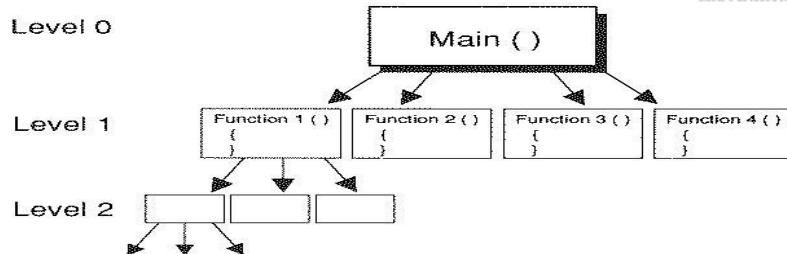
For your program, you should develop each filter in a separate function. Deliver a **system diagram** showing the **different functions** of the system and **their relation** to each other as shown in the figure below. Put this diagram in a shared doc and put the link in the code.

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Instructions

1. It is very important to collect coursework marks in order to pass easily and get a good grade.
من المهم للغاية حسن أداء أعمال السنة لنجاح بسهولة وتحصل على تقدير مرتفع
2. These instructions must be followed to get the full marks. يجب اتباع هذه التعليمات بكل دق
3. The assignment includes three levels:
 - Hero level - where students implement 12 filters
 - Beast level - where student will do 3 extra filters
 - Winged Dragon level - students will make 3 extra filters and GUI
مستوى التنين المجنح مستوى الجنين المجنح
This level will be a competition with judges and prizes and presentations
4. Part 1 Due Date: 27 Mar 2024 (Deliver ANY 5 filters + a menu. Any five are OK)
5. Part 2A / 2B Due Date: 13 April 2024 (P2A Deliver 12 filters) (Bonus P2B deliver 15 filters)
6. Part 3 - Competition (18 + 2 filters and GUI) Due Date: 15 April 2024
7. Students will form teams of three students from the same lab or section.
8. 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 مقلولة من أي مصدر أو مخلقة بالذكاء الاصطناعي يؤدي إلى
الرسوب في هذا المقرر، لا تغش الحل أو تنقله من أي مصدر و تعالى و اسألنى في أي شئ لا تفهمه نقل أي جزء ولو صغير
من الكود من زميل أو أي مصدر أو إعطاء أي كود ولو قليل لأى زميل يعتبر غشا و يحصل صاحبه على سالب الدرجة.

Task 0 – Basics of Image Representation

Images in computer systems are represented as a matrix of pixel values. Each pixel holds numbers related to the intensity of the composition of Red, Green, and Blue (RGB values). These values range from 0-255 providing a wide range of color variations. If Red is 0 it means that there is no Red component in the image

Applying image filters involves processing each pixel in an image according to a specific algorithm or set of rules. These algorithms manipulate the pixel values to achieve desired effects such as blurring, sharpening, adjusting colors, and adding artistic effects.

Assume a 3x3 Image, each pixel (cell) contains 3 channels R G B, for example:

| | | |
|-------------------------------------------|--------------------|-----------------------------|
| Red 255, Green 255, Blue 255 = White | 0, 0, 0 = Black | 255, 0, 0 = Red |
| 124, 124, 124 Gray scale (equal channels) | 255, 0, 255 = Pink | 255, 255, 0 = Yellow |
| 0, 255, 255 = Bright blue | | X, Y, Z is some other color |

Watch more: <https://youtu.be/pmY7pOQCOr8?list=PL6p1q8upS1ABS7L--0dI62PvKSNIJHkrU>
<https://www.youtube.com/watch?v=IZXemaxIxJU>

Applications: <https://www.youtube.com/watch?v=aDpnaxPAmU>
<https://medium.com/@zaheeribrahim346/uses-of-image-processing-840288728703>



Task 1 – Menu and File Loading and Saving (Group Task) - 2 marks

- Each team will collaboratively develop the menu display function, as well as the load and save functions. These functions should support saving images in any format, including JPEG, JPG, PNG, and BMP, and give the user freedom of naming the image. Team members will work on their respective tasks and then integrate and test all program functions together to be called from the menu. Failure to deliver an integrated program will result in a deduction of marks.
- The menu will allow the user to load a new image, apply a filter on the current image or store the image in a new or same file. The menu will loop forever till the user exists.
- The menu will work as follows:
 1. At the start of the program ask the user to load a file to work on. This becomes the current image.
 2. Then the program checks that this file exists and has a suitable extension
 3. Then the program will display a menu of options like this:
 - Load a new image
 - Filter 1 // name the filter
 - Filter 2 //
 -
 - Save the image
 - Exit
 4. After applying any filter, the same menu comes again
 5. Some menu options have other sub-options. For example, framing filter will ask if s/he wants a simple or fancy frame and will ask about the color.
 6. The current image becomes the result of the last filter
 7. This can be the same dimensions or a new image in cases of merge, resize, rotate, etc.
 8. The user can load a new current image to work on.
 9. At any point, s/he can save the current image.
 10. S/he is asked if he wants to save on the same file or change file name.
 11. The saving function verifies that the extension is a valid one. (.jpg, .bmp, etc.)
 12. At any point he can load a new current image and s/he is asked if s/he wants to save the current one before loading a new one.
 13. At any point s/he can exit and s/he is asked if he wants to save before exit.



Task 2 – Using Github (Group Task) - 1 mark

- The team will create a **private** repo (Not public so no one steals your code) 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**
 - The team will demo their repo to the TA.

Task 3 – Baby Photoshop for Image Processing (Individual/Group Task) - 5 marks

Each team member will develop 4 individual filters. The member with the smallest ID will do filters 1, 4, 7, 10 and the member with the middle ID will do 2, 5, 8, 11 and the member with the largest ID will do 3, 6, 9, 12. **All team** are responsible for integrating all filters and testing them and ensuring they work properly. **Team should find more images to test on.**

An image processing (or photo editing) software like PhotoShop allows you to load an image and apply some changes (called filters) to it and then save it again. **Some filters will apply on the same image and some will result in a new image to store (with the same name or a new one) or ignore it.**

يقوم برنامج معالجة الصور مثل الفوتوشوب مثلاً بتحميل الصورة المرغوبة و إتاحة مجموعة من العمليات تسمى المرشحات للتنفيذ على هذه الصور ، كل منها يتيح عمل تغيير في الصورة ، و فيما يلى شرح للمرشحات المطلوبة و في أعلى شرح كيف ستقسام على فريق العمل و ما نصيب كل عضو، بعض الفلاتر ستنطبق على نفس الصورة و بعضها سيعمل صورة جديدة بابعاد جديدة يجب أن تسأل المستخدم هل يريد تخزينها أم لا و هل بنفس الاسم او اسم جديد.

Filter 1: Grayscale Conversion

A grayscale image is an image where each pixel is represented by a single Sample indicating the intensity of light or shade. In grayscale images, there is no color information, only varying shades of gray from black to white. The intensity value of each pixel determines its brightness, with lower values representing darker shades and higher values representing lighter shades.

صورة بدرجات الرمادي هي صورة يتم فيها تمثيل كل بكسل بعينة واحدة عادةً، تشير إلى شدة الضوء أو الظل. في الصور بدرجات الرمادي، لا توجد معلومات عن الألوان، بل هناك فقط درجات متفاوتة من الرمادي من الأسود إلى الأبيض. تحدد قيمة الشدة لكل بكسل سطوعه، حيث تُمثل القيم الأقل قدرات أظلم والقيم الأعلى أعلى قدرات أفتح

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Filter 2: Black and White

Black and white images also lack color, but they typically have only two colors: black and white (0 and 255). There are no intermediate shades of gray in a true black and white image. Each pixel is either black (representing darkness or absence of information) or white (representing brightness or presence of information). In digital imaging, black and white images are often created by converting color images to grayscale and then applying a threshold to convert shades of gray to either black or white.

الصور الأبيض والأسود تفتقر أيضاً إلى الألوان، ولكنها عادة ما تحتوي على لونين فقط: الأسود والأبيض (0 و 255). لا توجد درجات رمادية وسطى في الصورة الأبيض والأسود الحقيقة. كل بكسل إما أن يكون أسوداً (ممثلًا للظلمة أو عدم الوجود للمعلومات) أو أبيضاً (ممثلًا للسطوع أو وجود المعلومات). في التصوير الرقمي، غالباً ما يتم إنشاء الصور الأبيض والأسود عن طريق تحويل الصور الملونة إلى درجات الرمادي ثم تطبيق حد معين لتحويل درجات الرمادي إما إلى الأسود أو الأبيض.



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Filter 3: Invert Image

Inverting colors is a simple yet powerful image processing operation that transforms the colors of an image by reversing each pixel's RGB values. This operation effectively produces a photographic negative effect, where light areas become dark and vice versa.

تعتبر عملية عكس الألوان عملية معالجة صور بسيطة ولكنها قوية تقوم بتحويل ألوان الصورة عن طريق عكس قيم الاحمر والاخضر والازرق لكل بكسل. تؤدي هذه العملية بفعالية إلى إنتاج تأثير سلبي فوتوغرافي، حيث تصبح المناطق الساطعة مظلمة والعكس صحيح

Design and implement an algorithm for inverting image colors.



Filter 4: Merge Images

Merging two images typically involves combining them in some way to create a single composite image. If the two images are the same size, then we only need to merge them directly. However, if the images are of different sizes, we need to **allow two options: (1) resize the smaller image or both images to the biggest height and the biggest width and then merge and (2) the other option is to merge the common area of the smaller width and the smaller height. You must allow both.** For grand competition, allow dragging one picture on the other to show which area will overlap.

دمج صورتين عادةً ما ينطوي على دمجهما بطريقة ما لإنشاء صورة مركبة واحدة جديدة. إذا كانت الصورتان بنفس الابعاد، فإننا نحتاج فقط لدمجها مباشرةً. ومع ذلك، إذا كانت الصور ذات أحجام مختلفة، فإننا علينا تغيير حجم الصورة الأصغر أو الاتنين باستعمال فلتر تغيير الحجم ، أو قص الصورة الأكبر بحيث تندمج الصورة الصغرى مع الجزء المماثل من الكبيرة و يمكن ايضاً لو حجمهما مختلف دمج المساحة المشتركة منهما ، يعني مثلاً صورة 500 في 1000 و أخرى 1000 في 500 سيتم عمل صورة جديدة 500 في 500 تشمل الجزء المشتركة منهما.

Create a Function for merging two images.



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Filter 5: Flip Image

Flipping an image involves mirroring its contents horizontally or vertically. Horizontal Flip: Also known as a left-right flip, this operation reflects the image along a vertical axis. Vertical Flip: Also known as a top-bottom flip, this operation reflects the image along a horizontal axis.

قلب الصورة يتضمن عكس محتوياتها أفقياً أو عمودياً القلب الأفقي: المعروف أيضاً بالقلب اليمين-اليسار، هذه العملية تعكس الصورة على محور رأسى القلب العمودي: المعروف أيضاً بالقلب الأعلى-السفلي، هذه العملية تعكس الصورة على محور أفقي

Develop an algorithm for applying Flipping effects to images.



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Flipped Vertical



Flipped Horizontally

Filter 6: Rotate Image

This filter allows the user to rotate the image clockwise by 90°, 180° or 270° as the user chooses.

مرشح الدوران: هذا المترشح يدير الصورة باتجاه دواران الساعة 90 أو 180 أو 270 درجة



Rotate 90 degrees



Rotate 180 degrees



Rotate 270 degrees

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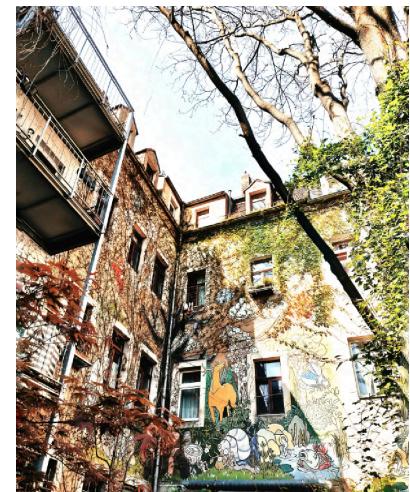
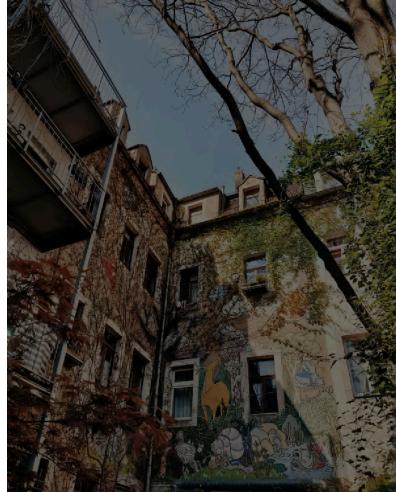
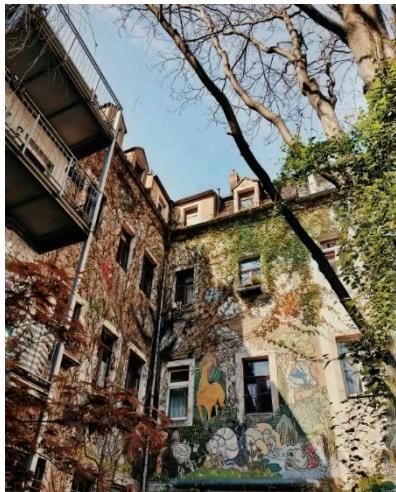


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Filter 7: Darken and Lighten Image (Two filters in this task)

This filter allows the user to make the image darker or lighter by 50% from the original image. For grand competition, allow the user to choose the level of darkening or lighting from 0 to 100%. Use a slider or a suitable GUI element.

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



Filter 8: Crop Images

Cropping: Cropping an image involves removing portions of the image from one or more sides, effectively changing its composition. Unlike resizing, cropping does not necessarily preserve the original details

التقطيع: عملية تقطيع الصورة تتضمن إزالة جزء من الصورة من جهة أو أكثر، مما يغير تكوينها بشكل فعال. على عكس تغيير الحجم، التقطيع لا يحافظ بالضرورة على التفاصيل الأصلية.

Create an algorithm for cropping where the user can specify the dimensions to crop to, provided that the dimensions are smaller than or equal to the original image.

You will take x and y input as the starting point (upper left corner of the part to keep) and W x H as the dimensions of the area to cut. This area is cut and stored in a new image or with the same name if the user wants



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cropped at `corner(700,700)` with dimensions `600x600`

Filter 9: Adding a Frame to the Picture

When we hang photos on the wall, we put them in a frame. This filter adds a frame (a simple one or a fancy one) in the requested color. أضف إطاراً للصورة إما إطاراً بسيطاً أو إطاراً مزخرف حسب خيار المستخدم

For grand competition, allow a variety of colors and types of frames to choose from.



Filter 10: Detect Image Edges

Edge detection is a fundamental technique in image processing used to identify and highlight the boundaries of objects within an image. The goal of edge detection is to find areas in an image where the intensity or color changes abruptly, indicating the presence of an edge or a boundary between different objects or regions.

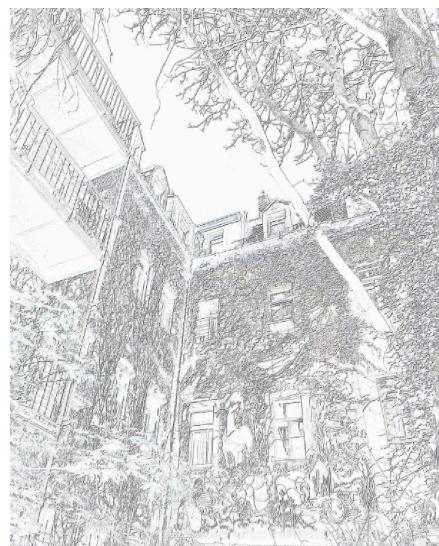
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الكشف عن الحواف هو تقنية أساسية في معالجة الصور تُستخدم لتحديد وإبراز حدود الأجسام داخل الصورة. الهدف من كشف الحواف هو العثور على المناطق في الصورة حيث يتغير التباين أو اللون بشكل حاد، مما يشير إلى وجود حافة أو حدود بين أجسام أو مناطق مختلفة (قد يكون من الأسهل تحويل الصورة لأبيض و أسود ثم اكتشاف الحواف عليها)



Filter 11: Resizing Images

Resizing an image involves changing the dimensions of the entire image while maintaining the same image details. User can enter new dimensions or can enter a ratio of reduction or increase.

تغيير حجم الصورة: ينطوي تغيير حجم الصورة على تغيير أبعاد الصورة بأكملها مع الحفاظ على نفس تفاصيل الصورة

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Original image: 1000 x 700

Resized to 500x500 :

Resized to 1280 x 800:



Filter 12: Blur Images

Blurring an image is a technique used in image processing to reduce the level of detail or sharpness in an image, resulting in a smoother appearance. **For grand competition, allow different levels of blurring.**

تقوم عملية تشویش الصورة بتقنية مستخدمة في معالجة الصور لتقليل مستوى التفاصيل أو الحدة في الصورة، مما ينتج عنه مظهراً أكثر نعومة.

Develop an algorithm for applying blur effects to images.

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Task 4 – Bonus Filters (Individual / Group Task) - 2 marks

Each team member can do an extra filter. Team members can decide which filter each one does. These filters are driven from the Land of Wano. There are 6 filters to choose from.

The Land of Wano

The Land of Wano is a mysterious and isolated country in the world of One Piece. It's inspired by feudal Japan, with samurai, ninja, and traditional Japanese culture prevalent throughout. Wano is known for its closed borders, keeping outsiders away and maintaining its own unique way of life.

أرض وانو هي بلد غامض وعزل في عالم ون بيس. إنها مستوحاة من اليابان الفيدالية، مع وجود الساموراي والنينجا والثقافة اليابانية التقليدية في كل مكان. وانو مشهورة بحدودها المغلقة، حيث تبقى الأجانب بعيداً وتحافظ على طريقة حياتها الفريدة

Filter 13: Wano doesn't have good natural sunlight. Can you fix that?

وانو لا تمتلك أشعة شمس طبيعية جيدة، هل يمكنك تصحيح ذلك؟

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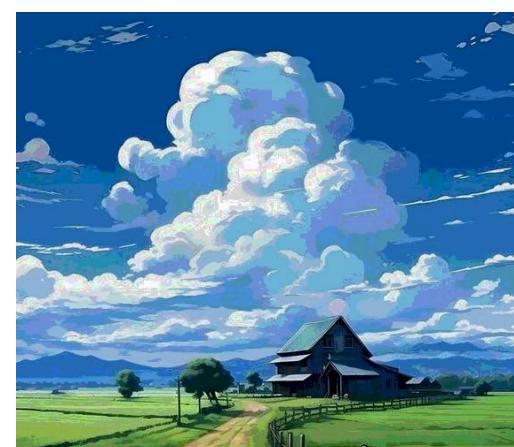


Filter 14: Oil painting is famous in Wano. Can you prove you are a Samurai and oil paint images?

الرسم بالزيت مشهور في وانو فهل يمكنك إثبات أنك ساموراي وترسم صوراً بالزيت؟

Notice how in Oil painted images the sky, water, and lights look why do you think that happened?

لاحظ كيف تبدو السماء والماء والأضواء في صور الرسم بالزيت، لماذا تعتقد أن ذلك حدث؟

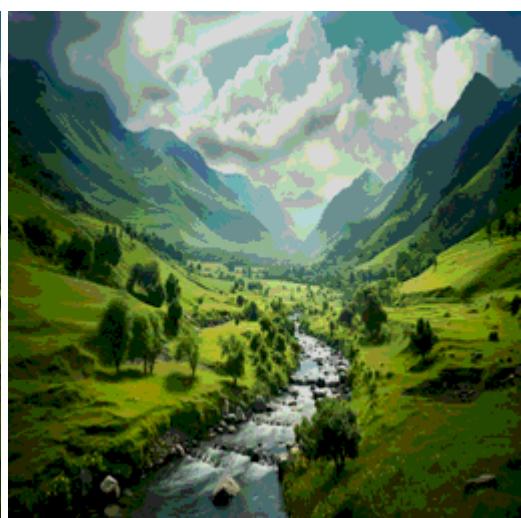
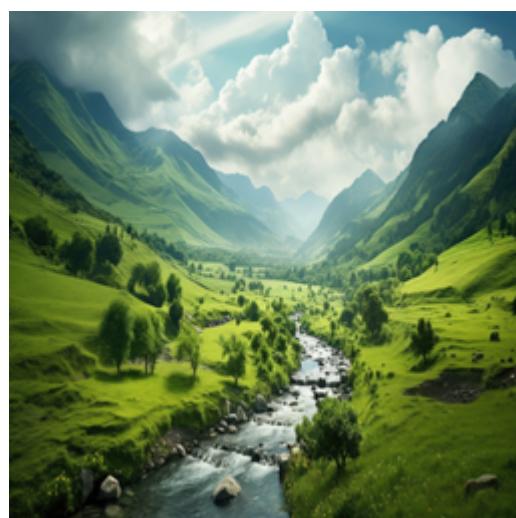
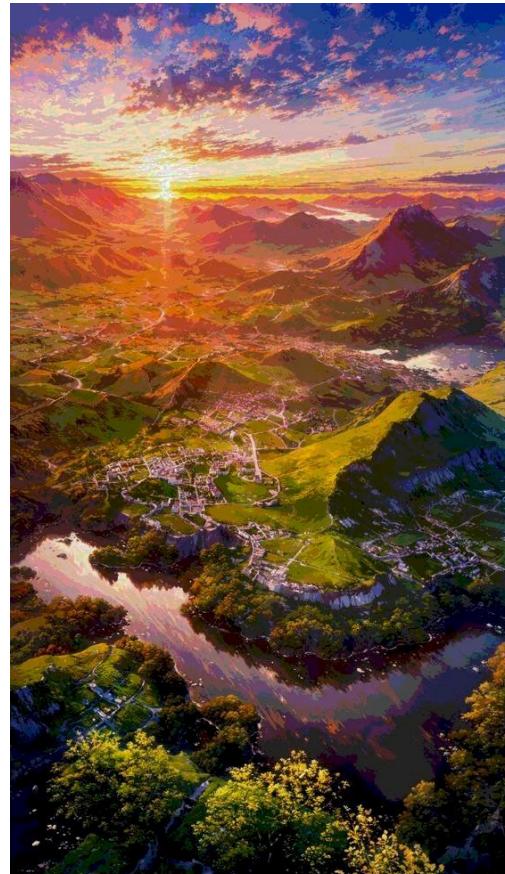


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Filter 15: Wano villagers use old Den Den Mushi (televisions) to view the news. Can you implement their TV images?

This is the effect you need to add to the image which is like how old TA screens used to add to images <https://www.shutterstock.com/image-vector/no-tv-signal-on-retro-televisor-516537094>

يستخدمون دن دن موشى القديمة لمشاهدة الأخبار. هل يمكنك تنفيذ صور التلفزيون الخاصة بهم؟





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Filter 16: Wano looks so purple at night can you make Luffy look purple?

وانو تبدو باللون الأرجواني في الليل، هل يمكنك جعل لوفي باللون الأرجواني بشكل كافٍ؟



Filter 17: Samurais are passionate about capturing the world in infrared photography—let's empower their pursuit !

الساموراي يحبون التقاط الصور الأشعة تحت الحمراء، لنساعدهم في ذلك



Filter 18: Image Skewing Filter

A skew image filter is a digital image processing technique used to distort or skew an image. It can be employed for various purposes such as correcting perspective distortion, creating artistic effects, or simulating 3D perspectives.

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Develop an algorithm for applying Skew effects to images as shown below. User can enter the degree of skewness needed along the vertical axis.

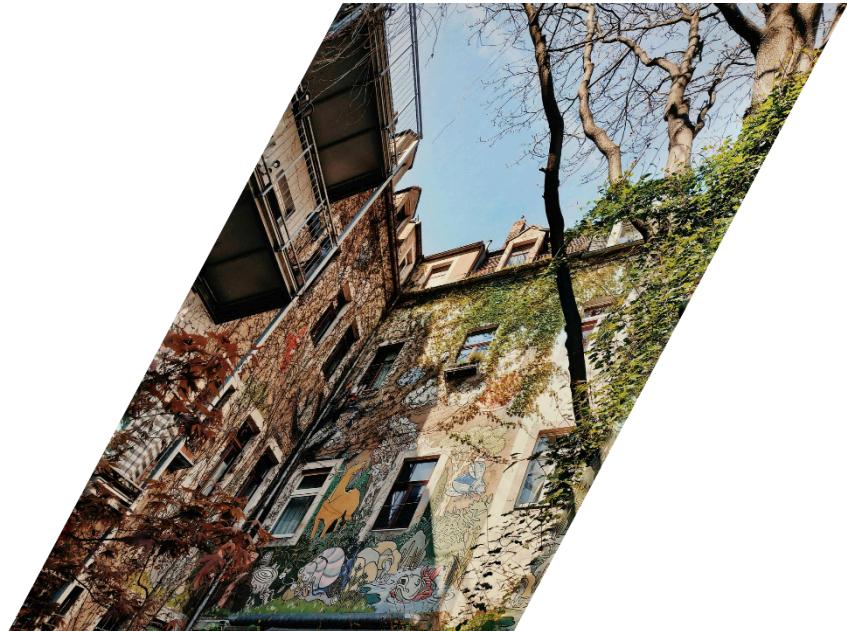


Image skewed by 40 degrees

Task 5 – Grand Competition (Group Task) - 3 marks + Prizes

1. Team will implement all filters mentioned in this document (12 + 6 + 2) and will implement a GUI to show the images and modifications as they happen. See some sample simple videos of work of students from previous years. **Some filters will have harder requirements for this task.**
2. **The team will implement 2 additional filters of their choice not included in this document.**
3. Team will implement exception handling so the program repeats the menu and recovers in case of error and exceptions are thrown.
4. Team will submit for competition separately and a panel will judge the submissions.
5. **There are prizes for best projects.**

How to Submit

In all cases, submit only code. NO word. NO pdf. NO exe. DO NOT submit the library files.

Part 1 (5 filters) - All students submit this

Submit a .cpp file that has a header that explains the file and all team details and IDs and section and who did which filter. Then the file should have a menu that displays the options to choose from.

Name the file: **CS112_A3_Part1_SectionNum_YourID_YourID_YourID.cpp.**



CS112: Structured Programming

Assignment 3 (8+ 2 + 3) + Grand Competition – Version 7.0

Cairo University, Faculty of Computers
and Artificial Intelligence

If you plan to do the bonus or the competition. Submit ONLY in one of these.

Part 2-A Hero Level (12 filters - Tasks 1, 2, 3) - Submit here if you are not doing bonus

Submit a .cpp file that has a header that explains the file and all team details and IDs and section and who did which filter. Then the file should have a menu that displays the options to choose from saving, loading and the 12 available filters.

Name the file: **CS112_A3_Part2A_SectionNum_YourID_YourID_YourID.cpp**.

Part 2-B Beast Level (15 filters - Tasks 1, 2, 3, 4) - Submit here if doing bonus T4 (Same link like Hero)

Submit a .cpp file that has a header that explains the file and all team details and IDs and section and who did which filter. Then the file should have a menu that displays the options to choose from saving, loading and the 15 available filters.

Name the file: **CS112_A3_Part2B_SectionNum_YourID_YourID_YourID.cpp**.

Part 3 Winged Dragon (20 filters - Tasks 1, 2, 3, 4, 5) - Submit here if you are doing bonus T4 + T5

Submit a zip file that has the following:

1. **All code files** you developed and the header files of the library files given to you.
2. **The project file** you created that contains the code files.
3. Do not include any additional files or libraries like Qt or others. **Do NOT include exe files**.
4. Main .cpp file that should have a header that explains the file and all team details and IDs and section and who did which filter. Then the file should have a menu that displays the options to choose from saving, loading and the available filters.
5. A .txt read me file that explains in details what is needed to set up and run the code and what tools and versions of these tools you used. And a list of all filters done and an EXPLANATION of new filters you did. Add video link here also.
6. A pdf explaining with cover page, names and logos and explaining the 2 new filters with sample images.
7. A .txt or .html link to a video showing your program working (not the code) and different options in it and sample output for every filter. Video should have FCAI logo and date and names of authors and should explain that this is done as part of CS112 Structured Programming at FCAI, Cairo University under supervision of Dr Mohammad El-Ramly.

Name the file: **CS112_A3_Part3_YourID_YourID_YourID.zip**